THÜNEN

LRTAP
Long-range Transboundary Air Pollution

ICP Forests

30 years

of monitoring the effects of long-range transboundary air pollution on forests in Europe and beyond

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Christian Schmidt, Federal Minister of Food and Agriculture

ICP Forests can look back on 30 years of cross-border co-operation in the environmental monitoring of forests. The first Task Force Meeting of ICP Forests was held in Freiburg/Breisgau on 4 October 1985.

Let us travel back in time: 30 years ago, the industrialised states of the northern hemisphere had just experienced an unparalleled economic boom. Things that earlier generations could only dream of had become affordable for broad sections of the population. However, the negative consequences of material wealth had also become evident. Scientists pointed to environmental damage. Gases emitted from industrial plants, power stations, agricultural operations, and motor vehicles were also causing damage far away from their sources. Action had to be taken. After many years of preparatory work, the Geneva Convention on Long-Range Transboundary Air Pollution was concluded in 1979.

Alarming changes were also observed in forests: sparse tree canopies, dead trees, acidification of the soils, damage to fine roots. The term "Waldsterben" (forest decline) became widespread in the media and was also coined in other languages. Forest scientists from different nations met to develop joint monitoring methods. This was the birth of ICP Forests.

To our relief, we can see today that the gloomy forecasts of the 1980s have not come true. Many things have changed for the better. Was it all pure hysteria? Certainly not! Our forests would not be in as good a state as they are now without the measures taken since 1979. And we would know less about them without the monitoring system that was introduced in 1985 and which has been continually refined ever since.

Today, the environmental monitoring of forests no longer merely serves to evaluate the effects of air pollutants. It has also become an indispensable source of information for forestry and environmental policy, for the sustainable management and use of forests, and for forest and environmental scientists. I wish ICP Forests continued success in its work.

Christian Schmidt,
Member of the German Bundestag
Federal Minister of Food and Agriculture

30 Years of ICP Forests – an environmental programme getting high societal attention

The worsening of forest condition in parts of central Europe in the late 1970s and early 1980s, commonly called "Waldsterben" (forest dieback), gave rise to serious public concern about the future performance and even survival of forests in Europe. After receiving a high level of attention in the media, the matter was made a top priority on the political agenda – leading to the establishment of systematic forest monitoring for the assessment and evaluation of forest conditions in Europe. Shortly after its establishment as a method in Bavaria in 1983, crown condition assessment, carried out by estimating the amount of leaves or needles in relation to a fully foliated reference tree, became an accepted method. A 16 km by 16 km grid was established across Europe, comprising approximately 6 500 plots. This was later called the Level I network. Since 1985, these monitoring activities have been pursued under the umbrella of the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP) and its Working Group on Effects (WGE) within the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests). Soon, data on soil conditions and foliar element concentrations were collected on a considerable number of these plots, allowing analyses of the relationships between tree response and site factors to be carried out.

Ten years later, the ICP Forests programme was expanded to include more advanced, in-depth monitoring – the so-called Level II monitoring aimed at improving the understanding of cause-effect relationships in forests. Over time, a total of 860 intensive monitoring plots were set up. One or both parts of the programme have been carried out at least temporarily in 40 European countries (the USA and Canada have contributed with results from their own networks), and this has produced a wealth of information from a total of 13 domains (covering atmosphere, soil, tree stand, and vegetation), all collected using standardised methods and stored in a continuously updated database.

As chairman of the Working Group on Effects, I would like to express my thanks to all who have supported the programme, but in particular to the Federal Republic of Germany for supporting the programme's co-ordinating centre throughout the 30 years, and the European Commission. Over the first 20 years, the European Commission co-financed the programme under specific regulations, and between 2009 and 2011, the programme received support for its further development through an EU LIFE+ project. The integrated monitoring approach of ICP Forests, with its Level I and Level II networks, provides unique and highly valuable data sets on the condition, productivity, nutrition and diversity of forest ecosystems. The data can serve as a basis for projections of future forest conditions and risks. This facilitates an understanding of the interaction between atmospheric deposition and the role and functioning of forest ecosystems, including the protection of soils and waters. The programme may also help to quantify a range of ecosystem services such as carbon sequestration. Beyond its contribution to a deeper understanding of air pollution and the effects of climate change on forests and the societal services they provide, ICP Forests under the Working Group on Effects contributes to our appreciation of the human and natural resources that must be protected both today and in the future.

Peringe Grennfelt
Chair of the Working Group on Effects (WGE) of the LRTAP Convention, IVL Swedish Environmental Research Institute

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The LRTAP Convention – the first legally binding international agreement aiming to control air pollution across the UNECE region

In the late 1960s, large-scale acidification of surface waters in Scandinavia could be clearly connected to air pollution originating in the United Kingdom and central Europe. This ultimately led to a ministerial-level meeting in Geneva in November 1979 within the Framework of the UNECE on the Protection of the Environment, at which the Convention on Long-range Transboundary Air Pollution (LRTAP Convention or CLRTAP) was signed by more than 30 governments, including the USA and Canada, and by the European Community. To date, 51 of the 56 UNECE member states are parties to it. The significance of the decision of these countries to collaborate under the LRTAP Convention can hardly be overrated, as it was the first legally binding international agreement aiming to control air pollution across the UNECE region. (Menz and Seip 2004)

"The atmosphere is one of the largest waste disposal units for mankind. It has handled gaseous and particulate waste from combustion and other human activities for hundreds of years. These activities have had serious consequences such as acid rain, the degradation of valuable ecosystems and agricultural soils, and detrimental impacts on human health." Clearing the Air, 30th Anniversary brochure of the LRTAP Convention, 2009

The Convention entered into force in 1983. Shortly after its establishment, six International Co-operative Programmes (ICPs) and a Task Force were set up under the Working Group on Effects (WGE) to study the effects of air pollution on a wide range of eco- and geosystems (i.e. ICP Forests, ICP Integrated Monitoring, ICP Modelling and Mapping, ICP Vegetation, ICP Waters), on technical materials (ICP Materials), and on human health (Task Force on Health). In combination with the European Monitoring and Evaluation Programme (EMEP), which focuses on the emission and dispersal of air pollutants, a comprehensive system for tracing adverse air-transported substances from source to sink had thus become available.

Stefan Fleck

The LRTAP Convention provides a general framework for collaboration to limit, gradually reduce and prevent air pollution. It has been extended by eight protocols that impose concrete obligations to tackle specific pollutants and environmental problems. The sufficiency and effectiveness of these obligations are regularly reviewed. Initially aimed at reducing the effects of acid rain through control of sulphur emissions, the scope of the Convention was later widened to include nitrogen pollutants, volatile organic compounds (VOCs), heavy metals, and persistent organic pollutants (POPs). The Convention functions within the United Nations Economic Commission for Europe (UNECE), whose members include all the countries of Europe, the Caucasus and Central Asia, as well as the United States and Canada. (UNECE 2009)

ICP Forests – Monitoring forest health in response to extensive forest damage

The International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) was established within the LRTAP Convention in 1985 in response to wide public and political concern about the extensive forest damage observed in central Europe that had been connected with increasing air pollution. Its major objective was to collect and compile data on the condition of forest ecosystems across the UNECE region, and monitor their health and performance over time. Since then, ICP Forests has not only continually been addressing the scientific information needs of the LRTAP Convention, thereby underpinning the advancement of air pollution abatement measures in Europe. For the last 30 years, it has also been collecting quantitative policy-relevant information on monitored and modelled air pollution effects on forests which can be used by a variety of other national and international forest and environmental bodies and programmes besides the LRTAP Convention, such as Forest Europe (formerly the Ministerial Conference on the Protection of Forests in Europe), the Convention on Biological Diversity (CBD), the Framework Convention on Climate Change (UNFCCC), the UN-FAO Global Forest Survey, and EUROSTAT of the European Commission. (ICP Forests 2006)

ICP Forests has defined two major aims, which are still relevant today:

Aim I: To provide a periodic overview of the spatial and temporal variation of forest condition in relation to anthropogenic and natural stress factors (in particular air pollution) by means of European-wide and national, large-scale representative monitoring on a systematic network (Level I).

Aim II: To gain a better understanding of cause-effect relationships between the condition of forest ecosystems and anthropogenic as well as natural stress factors (in particular air pollution) by means of intensive monitoring on a number of selected permanent observation plots spread over Europe, and to study the development of important forest ecosystems in Europe (Level II).

An outstanding feature of the ICP Forests monitoring has been the implementation of standardised methods and additional measures for quality control and assurance in every member state and survey. The transnational standardisation of methods has led to consistent sampling practices across Europe and makes ICP Forests unique in global forest monitoring efforts. All methods are described in the extensive ICP Forests *Manual on methods and criteria for harmonised sampling, assessment, monitoring and analysis of the effects of air pollution on forests* (ICP Forests 2010), which has been developed over the years and is presented by Ferretti and Fischer (2013) together with the respective scientific background of each of the surveys. With the experience and expertise of eight different Expert Panels, ICP Forests is engaged in a continuous process to develop the monitoring methods and standards of each survey still further.

Air pollution is a global issue, and one that continues to increase in many regions as the energy, agricultural, industrial, and traffic sectors keep growing. At present, 42 countries are cooperating in ICP Forests. Of those, 27 are EU member states, so that all EU countries except Malta are participating in the programme. Of the 15 non-EU countries, nine are countries from South-Eastern Europe (SEE) or from Eastern Europe, the Caucasus, and Central Asia (EECCA). ICP Forests will continue to actively promote membership across the wider UNECE region.

“For 30 years, the Convention on Long-range Transboundary Air Pollution has been a consistent voice in the fight against air pollution. As it moves forward, the Convention has already initiated negotiations for stricter pollutant targets for 2020, and has also developed aspirational targets for 2050. It is continuing to engage both Eastern European and Central Asian countries by providing them with the relevant capacity-building tools to join and comply with the Convention’s protocols.

The Convention recognises the importance of working in an integrated manner to combat climate change, and has initiated dialogue with international organizations to explore synergies and solutions.

Realizing the transnational impact of air pollution, the Convention plans to further its global cooperation by providing technical assistance and guidance to other regional United Nations commissions (for Asia, Latin America and Africa), as the fight against air pollution goes global.”

Clearing the Air, 30th Anniversary brochure of the LRTAP Convention, UNECE, 2009

András Koltay

TIMELINE OF ICP FORESTS

1979	Adoption of the Convention on Long-range Transboundary Air Pollution (CLRTAP) at a high-level meeting within the framework of the United Nations Economic Commission for Europe (UNECE) on the Protection of the Environment. Signing by 32 UNECE member states. At present, 51 out of the 56 UNECE member states are Parties to the Convention.
1983	Entry into force of the LRTAP Convention with the Executive Body (EB) as the governing body of the Convention, comprising representatives of the Parties to the Convention. The EB supervises the EMEP (European Monitoring and Evaluation Programme) Steering Body, the Working Group on Strategies and Review (WGSR), and the Working Group on Effects (WGE) with its later six International Co-operative Programmes (ICP Forests, ICP Integrated Monitoring, ICP Materials, ICP Modelling & Mapping, ICP Vegetation, ICP Waters), a Task Force on Health, and a Joint Expert Group on Dynamic Modelling.
1985	Launch of ICP Forests at the 1st Task Force Meeting in Freiburg, Germany. Nomination of Ernst Wermann as Chairperson of the Programme. Two Programme Co-ordinating Centres (PCC East and PCC West) are established in Prague and Hamburg, respectively. Start of the development of an ICP Forests Manual.
1986	Adoption of the Scheme on the Protection of Forests Against Atmospheric Pollution by the EU; Regulation (EEC) No 3528/86 as legal basis for the co-financing of relevant assessments. Mandatory execution of annual crown condition surveys in all EU Member States.
1986	2nd Task Force Meeting in Freiburg, Germany. Adoption of the ICP Forests Manual.
1986	1st crown condition surveys in accordance with the ICP Forests Manual in 20 participating countries.
1987	1st Forest Damage Report of ICP Forests.

TIMELINE OF ICP FORESTS

1989	1st report on the Health of Forests in the European Community 1987–1988.
1992	(EEC) 2157/92 Regulation: Extension of 3528/86, the mandatory execution of annual crown condition surveys in all EU Member States for a further 5 years.
1992	1st joint report by the EU and ICP Forests. Joint reporting continued until 2003.
1993	Council Regulation 926/93: Mandatory implementation of a soil condition survey in all EU Member States.
1994/95	1st soil survey on more than 5000 Level I plots in 31 countries.
1994	Council Regulation 836/94: Optional implementation of needle/leaf analyses in all EU Member States.
1994	Council Regulation 1091/94: Establishment of permanent intensive monitoring plots (Level II).
1994	Commissioning of the Forest Intensive Monitoring Co-ordinating Institute (FIMCI) in Heerenveen and later Wageningen, The Netherlands.
1994	1st report on the ICP Forests Needle/Leaf Interlaboratory Test 1993/94.
1995	1st foliage survey on more than 1395 Level I plots in 16 countries.
1996	1st transmission of Level II data to FIMCI.
2000	16th Task Force Meeting in Ghent. Resignation of Ernst Wermann and appointment of Thomas Haußmann as Chairperson of ICP Forests. Adoption of the strategy of the Programme for the years 2001 to 2006 by the Task Force.

TIMELINE OF ICP FORESTS

2001

Regulation (EC) 1484/2001 of the European Parliament and of the Council: Extension of 3528/86 amending Council Regulation (EEC) No 3528/86 on the protection of the Community's forests against atmospheric pollution.

2001

Transfer of responsibilities from the EC Directorate-General for Agriculture and Rural Development (DG Agri) to the EC Directorate-General for the Environment (DG Env).

2002

Regulation (EC) 804/2002 of the European Parliament and of the Council: Extension of 3528/86 for one year.

2003

Forest Focus: Regulation (EC) No 2152/2003 adopted by the European Parliament and the Council for 2003 to 2006. Monitoring of forests and environmental interactions; JRC becomes the data host for ICP Forests. FIMCI concludes its Level II activities after nine years of coordinating the intensive forest monitoring.

2005

BIOSOIL Demonstration Project under Regulation (EC) No 2152/2003 concerning the monitoring of forest and environmental interactions in the Community (Forest Focus). Field work takes place primarily in 2006 and 2007.

2005

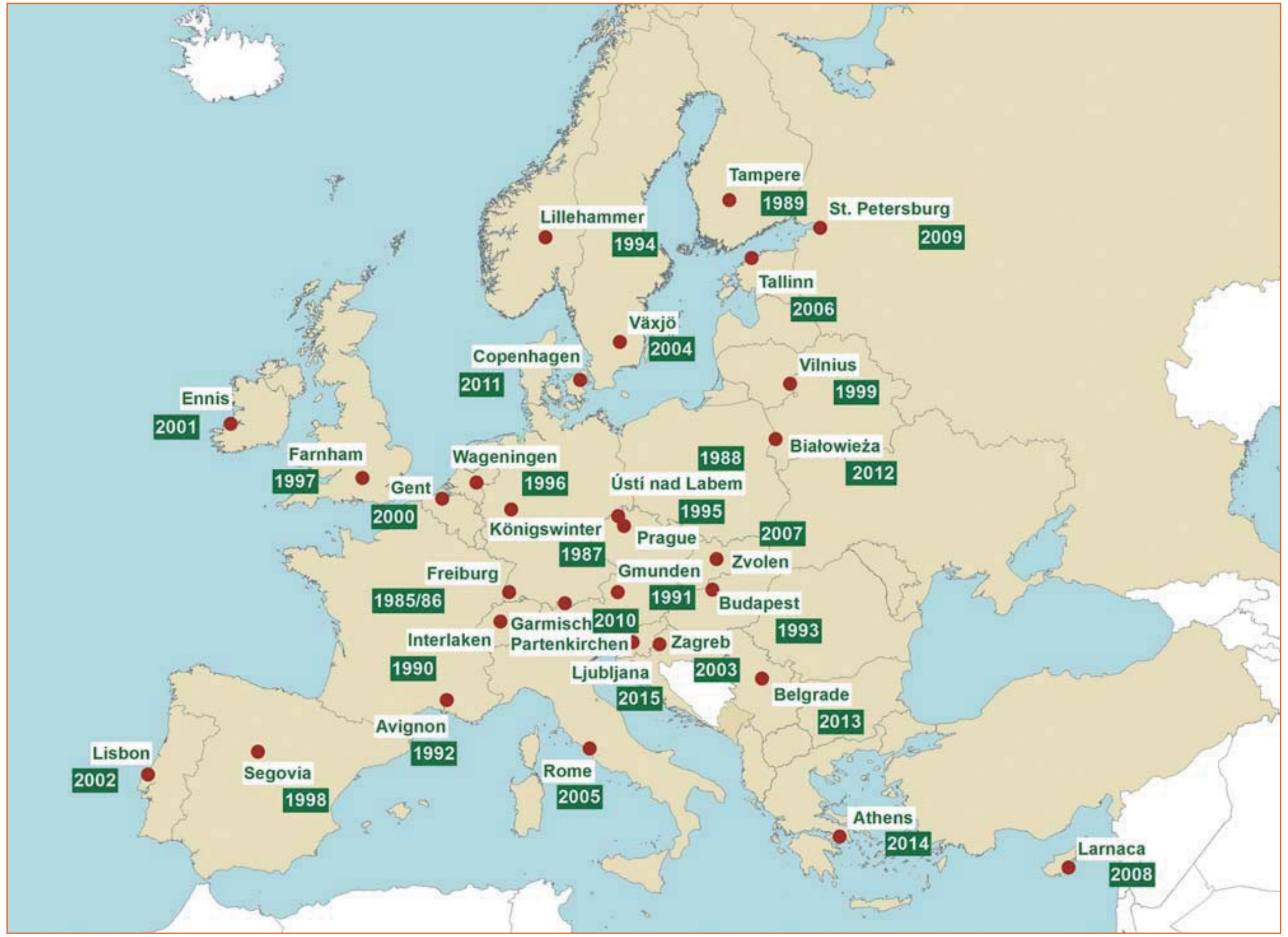
21st Task Force Meeting in Rome. Resignation of Thomas Haußmann and appointment of Michael Köhl as Chairperson of ICP Forests.

2009-2011

FutMon (Further development and implementation of an EU-level Forest Monitoring System) with co-financing under the LIFE+ Regulation (EC) No. 614/2007 of the European Parliament and of the Council.

2013

Relocation of the Programme Co-ordinating Centre (PCC) from the Thünen Institute for World Forestry in Hamburg-Bergedorf to the Thünen Institute of Forest Ecosystems in Eberswalde.



Location of Task Force meetings between 1985 and 2015.

VOICES FROM WITHIN ICP FORESTS

ICP Forests has been closely linked to forest health from the beginning. Starting as an indicator of air pollution effects, the system has evolved, showing its great potential in identifying the main harmful agents to the forests and their dynamics on a European scale. Two major milestones have been achieved in this process: the standardisation of a pan-European survey, and the provision of a coherent map of forest health each year. There are, however, many challenges still to conquer if we are to adapt to the new needs that have emerged.

Early detection of emerging forest pests and organisms requiring quarantine is the main one. Much of the future success of the ICP Forests will be based on its ability to evolve and to engage new European players who can take advantage of the fruits of their work. Only a clear and coordinated functioning at national and international level of the three pillars that support the system (rural, environmental and plant health) will allow the great potential of ICP Forests to provide the desired future results.

Gerardo Sánchez Peña
Former Spanish NFC Coordinator

ICP Forests has come a long way since its establishment 30 years ago while under the umbrella of the Convention and Working Group on Effects (WGE). It has become a very successful international forest monitoring programme with a highly dedicated ICP Forests community active in National Focal Centres, Expert Panels, and Committees. This organisational structure keeps the programme alive and flexible on the one hand and provides a sustainable working structure on the other. While co-operation within the ICP Forests community is as important as collaboration with partners from the WGE and EMEP communities, in the future there will be a strong need for closer collaboration with the scientific community outside the Convention as we face the global challenges of ongoing transboundary air pollution, climate change, and biodiversity loss. Only this will prevent isolation, and new financial options may be available within the context of larger research infrastructures on terrestrial ecosystems in general while the significant reduction of sulphur emissions and deposition in European forest ecosystems over the last few years is an example of the success of concerted activity under the LRTAP Convention. Activities of ICP Forests will continue to aim at solving the grand challenges of the future.

Walter Seidling
Head of the Programme Co-ordinating Centre of ICP Forests since 2013


Walter Seidling

View of the UNECE headquarters in Geneva, Switzerland

I have taken part in ICP Forests for 22 years, starting in 1994. Looking back, I clearly remember my first Task Force meeting in Prague in 1995. I was young and had recently finished my PhD. My colleague Inge Gillesberg and I were representing Denmark and we were the two only females in the meeting. At the early Task Force meetings, the participants (being all men) had the possibility to have their wives accompany them to the meeting, where a special Ladies Programme was arranged. When Inge and I arrived at the registration desk with our husbands, we were asked if we would like to take part in the Ladies Programme, and at the same time the registration desk had a hard time finding our husbands' names as participants on the registration lists! Needless to say, our husbands had a wonderful time in the Ladies Programme. In the Task Force meeting 2015 I believe the proportion of women and men was alike, so in 20 years this has changed towards a better gender balance.

Earlier Task Force meetings were definitely more formal than today's meetings. It was tradition that you raised your name sign in a vertical position to indicate you wanted to speak... and the speakers list was long. One of the tasks was to go through both executive and technical reports and, page by page, word by word, comment on the content and the language. Needless to say, this took time, and the meetings at that time were considerably longer than today.

In my early ICP Forests career I had a lot to learn. I had the immense luck to be guided by the late John Derome. He probably saw my despair at being a young, sole female and in a new environment, and he was a terrific mentor. His kind personality also later made it a treat to come to all ICP Forests meetings. Likewise, the late Matthias Dobbertin was a remarkable person, who made an enormous positive impact on ICP Forests. With his enthusiasm, he shone, and it was a pleasure to share both science and sociable talks about daily life with him. I am dedicated to passing on as much as I can of what they gave to me to newcomers to ICP Forests.

ICP Forests has given me a lot of new knowledge and friends in science, and I am grateful. Thanks to all friends active in ICP Forests today – see you at the next meeting.

Karin Hansen
Chair of EP Deposition


Tanja Sanders

Time series are scarce and extremely valuable in forest and environmental research, and ICP Forests takes great care in continuing the existing time series. Although ICP Forests was established for the purpose of monitoring air pollution effects, the variables are generic in the sense that they can serve other aims, and the programme is therefore well suited to demonstrate the effects of other stress factors as well. Today's potential major stress factors are climate change and the spread of pests and diseases across continents, and long time series of forest ecosystem variables can be a treasure trove for information documenting the effects of these factors.

The concept of crown condition assessments, though criticised for subjectivity, has proven useful in detecting long-term trends for several European tree species. For other species, trends in time and space may be more difficult to detect, and in periods and areas with weak or moderate stress, the noise in the data becomes relatively large in comparison to the trends. However, it is important to point out that if the forests had declined at a rapid speed, as was a widespread concern in the 1980s, then the crown assessments would have picked this up. And if a new forest decline started today from other causes, ICP Forests' assessments and long time series would be an indispensable tool in evaluating the health status of Europe's forests.

Svein Solberg
Former chair of the Expert Panel on Foliage and Litterfall and member of the Expert Panel on Crown Condition and Damage Causes


Akkin Semercis

It is my pleasure to send my greetings from our country, Albania, to you and all staff involved in ICP Forests. Thanks a lot for all your help and for your cooperation with me and all my staff at the former Forest and Pasture Research Institute! It allowed us to make a modest contribution to this very important programme for Europe and beyond as part of the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests, operating under the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP)!

Bashkim Mal Lushaj
Former Albanian NFC Coordinator


Tanja Sanders

Based on its accomplishments of the last 30 years, ICP Forests will continue to analyse the relationships between forest condition, air pollution, the carbon cycle, climate change, and biodiversity. The results will be used for modelling forest ecosystem processes. It seems necessary, however, to convince political decision makers that the funding of forest ecosystem monitoring and modelling is indispensable if the wealth of data collected by large-scale representative assessments is to be interpreted. With the required political support, ICP Forests will not only continue to assess the risks posed to forests by air pollution and climate change, but will also remain relevant for the development and assessment of indicators for sustainable forest management as well as for economic evaluations of the services provided by forest ecosystems. The results of the programme will thus continue to broaden the scientific basis not only of CLRTAP, but also of several other processes in international environmental politics.

Martin Lorenz
Head of the Programme Co-ordinating Centre of ICP Forests from 1992 to 2013

From the current perspective, we have to admire and appreciate the long-term vision of the first members of ICP Forests, who started using defoliation (a low cost and easy assessment parameter) as an indicator of forest health. Today, having the benefit of a series of sound data sets collected over a long time, it is possible to address important local and global issues with the data obtained from the Level I and Level II networks (climate change, forest dynamics, air pollution, etc.). These series show the dynamics of many existing processes in forests, allowing their analysis, interpretation and management.

Ana C. de la Cruz, Angel Fernández-Cancio, José M. Grau, Mayte Minaya
Forest Ecology and Genetics Department
Forest Research Centre (CIFOR-INIA), SPAIN


Tanja Sanders

AT THE HEART OF THE PROGRAMME – ICP FORESTS PARTICIPATING COUNTRIES AND THEIR NATIONAL FOCAL CENTRES

Austria

Austria ratified the Convention on Long Range Transboundary Air Pollution in 1982, when the commotion caused by “Waldsterben” (forest decline) was widespread across Europe. Austria contributed to Forest Damage reports from 1986. In 1988 the country set up a Level I grid as part of the transnational grid of ICP Forests. From our point of view, one of the most crucial decisions of ICP Forests was the establishment of Level II plots in 1995.

Throughout the years and despite all sorts of changes, Austria has always enjoyed a good and fruitful cooperation with the ICP Forests. However, public and political interest in forest decline has now faded in Austria, and assessment on the Level I grid was stopped in 2006. The Level II grid is hard to maintain from the financial point of view, and the cooperation with ICP Forests has therefore been reduced to some limited cooperation.

Belgium - Flanders

The Research Institute for Nature and Forest (INBO) is responsible for the forest condition monitoring in Flanders. The monitoring is carried out together with different partners, including the Flemish Agency for Nature and Forests (ANB). The Level I monitoring started in 1987 with an 8 x 8 km grid and 41 monitoring plots, including 10 plots on the international Level I grid. From 1995 onwards, the survey was performed on a denser grid with 72 regional plots, though with continuation on the international plots. The forest monitoring programme provides important information on ecological changes and is a suitable tool for investigating the effectiveness of policy measures. The results of the survey are one indicator of forest quality in Flanders.

An explorative study in the period 1983-1986 compared the chemical composition of rain water in open areas with deposition in forests, and expressed the need for a long-term monitoring programme, which was initiated in 1987 on 10 Level II sites. Thanks to the international co-operation programme, measurements have been harmonised and standardised at international level and now allow us to compare our results and put them in a wider perspective. To date, Flanders has a time series of 25 years’ worth of intensive forest monitoring data at its disposal, helping support local policies aiming to reduce the effects of atmospheric deposition on the forest ecosystems.

The Level I and Level II networks help us to describe the health status of the forests, to consider the evolution of forest condition, and to gain insight into influencing factors. The impressive monitoring period increases the value of the data, year after year.

Belgium - Wallonia

Over the last century, the forests have faced many rapid changes, such as climate change, soil degradation, air pollution, the introduction of new species, and the evolution of forestry methods. It is really important to study the effects of all these changes in the long term. Thanks to the ICP Forests initiative, scientists can rely on accurate data covering the whole of Europe. I hope this project can continue to be run for a long time to come.

Bulgaria

Forests are particularly important for Bulgaria, and the sustainability of them is a priority of national policy. In order to be sustainable, forest management needs information on the factors that influence forest condition. This is provided by the long-term, large-scale forest condition monitoring that has been carried out for 30 years in Bulgaria. The long-term observations have made it possible to determine the status of forest health and regional values (ranges) for the most important nutrients in the leaves/needles and soils. Outlook: the monitoring of forest ecosystems in Bulgaria will continue. In future, the monitoring will focus on the assessment of the state of forest ecosystems and the services they provide.

Croatia

Monitoring of forest condition in Croatia on a large, national scale began with the setting up of ICP Forests Level I plots all the way back in the year 1987, in a cooperation between the Forestry Faculty at the University of Zagreb, Croatian Forests Ltd., and the Croatian Forest Research Institute, where the NFC (National Focal Centre) is situated. Due to the war in Croatia (1991–1995) there was a two-year break in our monitoring activities, but as early as 1993, while the war was still going on, the monitoring resumed on accessible plots.

Since then, Croatia has reported on the condition of its forests regularly, with around 2000 trees assessed each year. NFC Croatia has organised several ICP Forests meetings: the 13th International Intercalibration Course for Mediterranean Countries (Crikvenica 2000), 19th ICP Forests Task Force Meeting (Zagreb 2003), and the Meeting of the Heads of Laboratories (Zadar 2013).

Recognising the importance, quality and the tradition of ICP Forests monitoring, and the obligations of the Republic of Croatia to the CLRTAP and EU Directives in the context of Croatia's accession to the European Union, the monitoring of the condition of forest ecosystems was incorporated in the country’s forestry legislation in 2005. With the funding of the monitoring programme secured by the Ministry of Agriculture, we have gradually been able to increase our activities, resulting in a higher number of Level I plots assessed each year (currently 105 plots), a higher number of parameters assessed on our seven intensive monitoring plots, and the analysis of all samples in our own laboratory. This makes our programme a reference standard for forest condition monitoring in Croatia.

Denmark

Denmark is a small country with limited forest cover compared to most other countries within ICP Forests. We have benefited considerably from the international cooperation and synergies. A large number of scientific topics have been dealt with over the last 30 years. National inventories of soil carbon stocks have been integrated into European level ICP Forests studies. Nitrogen deposition and leaching studies within Denmark have been benchmarked with similar studies at European level. The importance of summer drought, mast and defoliators for forests can be seen from the crown condition monitoring, and more recently we have also seen the impact of ash dieback. Thank you for the fruitful cooperation!

Impact of ash dieback caused by the invasive fungus Hymenoscyphus fraxineus in a forest stand in Denmark, July 2009.

Estonia

Estonia has been participating in the ICP on Assessment and Monitoring of Air Pollution Effects on Forests since 1988. The Estonian Environment Agency is responsible for the monitoring of the health and vitality of forests in Estonia. Forest monitoring activities are carried out on a permanent network of systematically positioned sample plots (Level I) using internationally standardised methods. In order to gain a better understanding of the effects of air pollution factors on forests, the Level II monitoring plots were established in typical Estonian forests. At present the primary aim of forest monitoring is to improve current methodology for monitoring the effects of climate change and air pollution on forest condition and the functioning of forest ecosystems.

Estonia has enjoyed the fruitful cooperation with all our colleagues in the ICP Forests community and we would like to express our gratitude for your contribution to the development of the monitoring programme in Estonia.

Happy anniversary, and we wish you great success in monitoring activities for the next 30 years, dear colleagues!

Finland

It has been a great pleasure to participate in the progress of the ICP Forests programme as it has become one of the world's largest biomonitoring networks. The past 30 years have taught us a great deal about European forest ecosystems and air pollutants. It has been a privilege to become a part of this community of great personalities ready to commit themselves to international cooperation and long-term forest monitoring. I would like to thank all my colleagues, both at my home institute and within the international ICP Forests community for this commitment, and hope the programme will continue to show its strength in the future, too.

Hungary

When ICP Forests was established and Hungary joined the programme, we believed that forest condition was an important issue worth discussing at international level, and that it was necessary to develop common ground to monitor and understand the processes behind the changes in ecosystems. ICP Forests proved to be an effective and successful platform for elaborating, building up and maintaining a harmonised bio-monitoring system throughout Europe, and it was also able to respond to emerging challenges. Continuous exchange of knowledge, development, the standardisation of methodologies, a unique database, and valuable evaluation and reporting are the main strengths of the cooperation. The ICP Forests monitoring system has proved to be an important component of sustainable forest management in Hungary.

Italy

Italy has participated in the activities of the ICP Forests since the beginning with the Level I monitoring plots for the assessment of crown condition, and since 1995 with the set-up of the Level II National Programme named CON.ECO.FOR. (CONtrollo ECOsistemi FORestali, i.e. Monitoring of Forest Ecosystem). This was set up by the National Forest Service (Corpo Forestale dello Stato – CFS) in collaboration with several scientific institutions and universities.

The establishment of the two forest monitoring networks – an extensive one with about 260 Level I points, and an intensive one with 31 Level II plots, representing the main Italian forest ecosystems – has allowed the recording of environmental data over a period of decades, and this is the main system of control, early warning and long-term investigation for Italy's forests.

The Italian state forestry service CFS and its partners have invested considerable financial and human resources (hundreds of operators involved, dozens of researchers), promoted skills and continuous education, dealt with international partners, developed the design, and implemented the programme. All this amazing work has allowed for great professional growth and led to the development of a vast network of relationships, also at human level, contributing to the full success of the activity.

The results of the project have always been dependent on the availability of the relevant Ministries and, at the same time, on all those public and private operators working at local and national level to provide strong support for decision makers. At this moment of celebration, our thoughts go to all those who, in any form or manner, have contributed toward the implementation of the activities of ICP Forests. All the best to ICP Forests and best wishes for another thirty years of successful forest monitoring!

Latvia

Over 30 years, great progress has been achieved in establishing and harmonising networks and monitoring methods, in the improvement of QA/QC procedures and the scientific interpretation of long-term data series. Latvia has been a member of ICP Forests since 1990, and the Latvian State Forest Research Institute Silava has been the Latvian NFC since 2012. It has been a real pleasure for us to be a part of this community and to watch it develop into one of the most important global networks, combining large-scale monitoring with in-depth scientific analyses.

We wish the programme a happy anniversary and systematic funding and lots of activities in the future!

Lado Kutnar

Norway

Norway has participated in ICP Forests from its very beginnings in 1985. We started our activities on the Level II and Level I networks in 1986 and 1989 respectively. Numerous persons – researchers as well as field personnel – have been involved and trained in the Norwegian monitoring programme in the course of the years. In cooperation with the Norwegian NFI, we have developed a sound and cost-efficient national forest monitoring system, which also delivers data to ICP Forests. The methodology from ICP Forests has successfully been applied to other monitoring programmes such as for ash dieback, as well as in research projects.

Romania

On behalf of the Romanian NFC, we extend our whole-hearted congratulations to ICP Forests for completing 30 glorious years of success. You have created a basis for outstanding cooperation in the scientific and public communities. Working together has been a real pleasure, and we value all common accomplishments that have been made over the past 30 years.

ICP Forests will have to increase its focus and identify the effects of more recent stress factors on the forests, their biodiversity and their capacity to provide goods and services, including socio-economic pressures and newly emerging damaging pollutants (fine particulate matter, dusts and solvents) along with climate change. We wish you all great success for many more years to come.

Serbia

It has been almost 13 years since we became the ICP Forests NFC in Serbia and began the job of monitoring the condition of the forests in the ICP Forests Level I and Level II programmes, joining the large ICP Forests family. During all these years, in addition to carrying out scientific and operational ICP Forests work in the country, we have developed a collegial cooperation with the Programme Co-ordinating Centre of ICP Forests and gained a large number of friends at NFCs all over Europe.

This cooperation and our continuous work will continue in future generations with the desire for a long-term continuation of the ICP Forests programme. We wish to congratulate all participants on the occasion of the 30th anniversary.

Slovakia

For participating countries and institutions, ICP Forests is primarily a unique environmental monitoring programme established to collect and evaluate data in order to fulfil the obligations resulting from international conventions. But in fact it is much more.

For participating experts, it is a platform for methodological discussions and the exchange of knowledge, cooperation, and the improvement of scientific work; a school for finding solutions; and a chance to meet open-minded, dedicated, diligent, creative and friendly people. It is an opportunity to improve the diversity and broad scope of the functions of forests across Europe.

Pip Howard

Spain

Since the beginning of ICP Forests activities in Spain (1985), it has been the Central Administration rather than a scientific body that has always assumed the role of the NFC. This has largely determined the course of activities in our country. Up to 2013, it was the responsibility of the Forest Health Unit. Thus, the monitoring of damaging agents affecting forest condition has always been very relevant, and the data resulting from the assessments have contributed to different official reports from the Ministry, as well as to several studies and evaluations. In the last two years, responsibility has been transferred to the Forest Inventory and Statistics Area, and a process of harmonisation with the NFI is taking place. Additionally, without forgetting the relevance of the monitoring of forest health and vitality, there are new requirements concerning the possible inputs of the programme in relation to the calculation of carbon stocks in forest soils, aerial biomass and litterfall.

Sweden

In the early 1980s, large parts of Europe were threatened by severe air pollution. At the same time, extensive forest damage was reported. However, the cause-effect relationships involved were quite unclear.

The monitoring programme started by ICP Forests was therefore very timely, and accurate and impressive in both its extent and its depth. Involving most of Europe's nations, the annual Task Force meetings have been excellent occasions offering the opportunity to exchange current knowledge and opinions about forest damage – as well as make friends! But the most valuable and durable effect of ICP Forests is probably the work of the Expert Panels and the resulting Manual, which now makes it possible to compare and analyse environmental data for the whole continent.

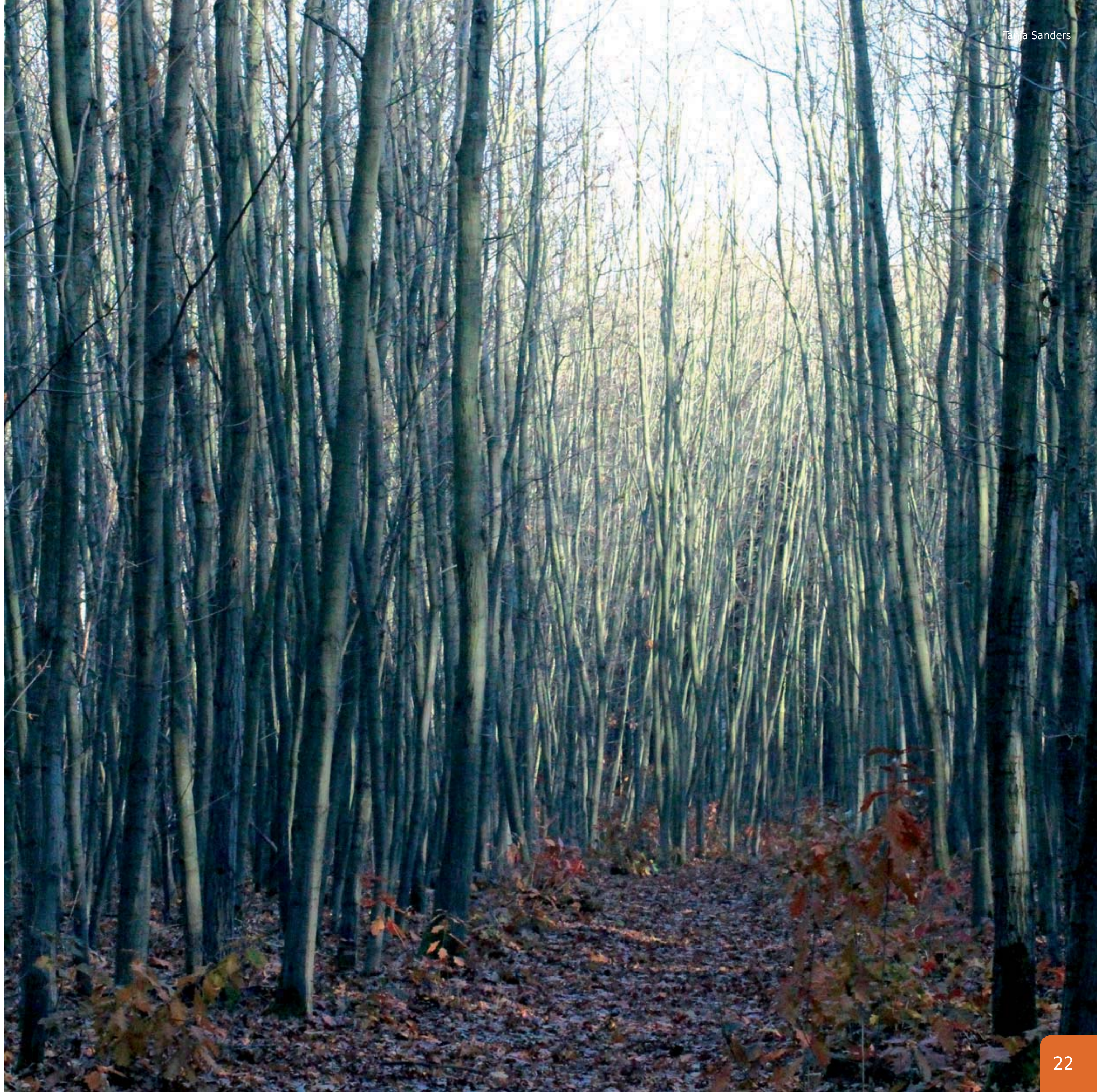

Lado Kutnar


Tanja Sanders

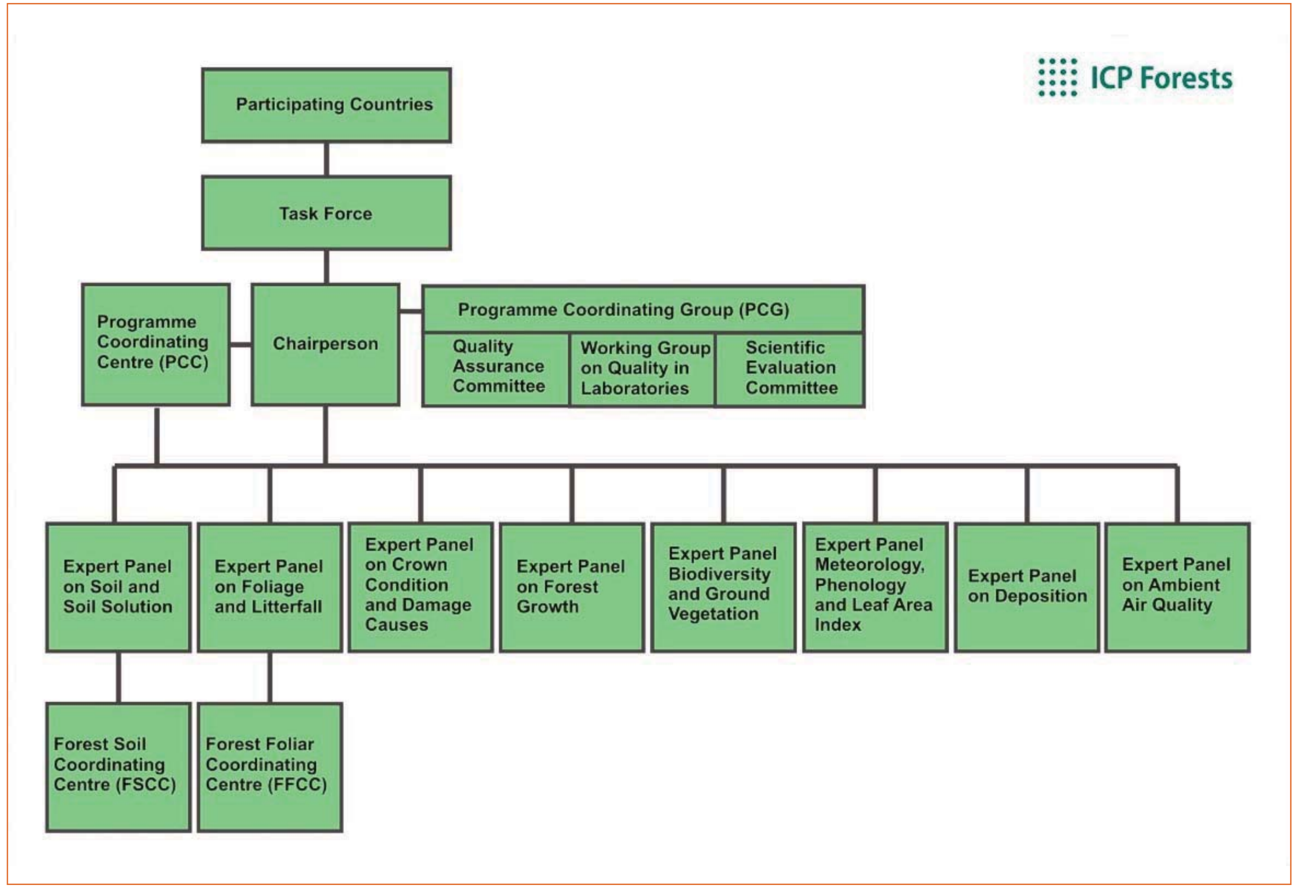
United Kingdom

The United Kingdom is very pleased to celebrate a 30 year, close relationship with ICP Forests. The partnership has been invaluable in three main ways.

Firstly, of course, it has enabled a much better understanding of the relationships between tree growth and health and atmospheric pollution, and allowed the UK to participate in pan-European science on this important subject. Secondly, by engaging significantly in Level I, and particularly Level II monitoring, the UK has taken the opportunity to increase its strengths in forest ecosystem biogeochemistry. Laboratory capabilities have also vastly improved over this time, as a result of the need to deliver high quality chemical analyses for the programme. Thirdly, and perhaps of greater significance, there has been the forging of close working partnerships with European monitoring colleagues, many of which have endured for decades and blossomed into friendships for life.


Tanja Sanders

THE ICP FORESTS EXPERT PANELS - BRINGING TOGETHER INTERNATIONAL EXPERTS TO ENSURE THE HIGH QUALITY OF THE PROGRAMME AND ADAPT IT TO FUTURE NEEDS



Organisational chart of ICP Forests. With the experience and expertise of the ICP Forests expert panels, working groups, and committees, ICP Forests works continuously to develop the monitoring methods and standards of each survey still further.

Expert Panel on Ambient Air Quality

Marcus Schaub

The measurement of air pollutants in forests is important in order to evaluate the risk for vegetation and to document spatial patterns, temporal variability, and trends in areas not covered by conventional air quality monitoring networks. Passive sampling for compounds such as ozone, sulphurdioxide, nitrogen dioxide and ammonia has been conducted by the ICP Forests Expert Panel on Ambient Air Quality since 2000 and has proved to be a valuable method in many areas. This is particularly the case for ozone; given the dense coverage of 240 forest monitoring sites from 21 countries, and that its assessment is carried out together with several other measurements on forest health, growth, nutrition, biodiversity and climate, the potential of this data set is unique.

Unlike fluoride or sulphur dioxide pollution, ozone pollution leaves no elemental residue that can be detected by analytical techniques. Since 1993, symptoms characteristic of ozone injury have been identified in a substantial number of plant species in Switzerland by John Innes et al. (1997) and John Skelly et al. (1998). A variety of other species have been identified as showing symptoms in Spain by e.g. Sanz and Millán (1999), suggesting that foliar ozone injury may be more widespread than previously believed.

Based on the above indicated state of technology, the Expert Panel on Ambient Air Quality initiated the European-wide assessment of ozone-induced symptoms in 2000 and organised international intercalibration courses in Valencia (2000), Switzerland-Italy (2001), Nice (2002), Switzerland-Italy (2003, 2004), Italy (2005), Switzerland (2006), Slovenia (2007), Italy (2008), Switzerland (2006), Hungary (2009) and Spain (2010).

I am grateful to my mentors John Innes, John Skelly and Matthias Dobbertin († 2012), who introduced me to the science and ignited my interest in forest monitoring. Thanks to the EP chair Georg H.M. Krause (1999-2004) and the EP co-chairs, Maria José Sanz (1999-2004), Vicent Calatayud (2005-2014) and Elena Gottardini (2015-present), I have always been inspired and given the support necessary to advance our work within the EP. My deepest gratitude goes to the many colleagues from 21 countries who, each year, put all their efforts into collecting scientifically sound data that permits the assessment of ozone risk across Europe.

Participants at the Intercalibration course of the Expert Panel on Ambient Air Quality in Switzerland in 2006.

Expert Panel on Biodiversity and Vegetation

Roberto Canullo

To be honest, at my first Expert Panel I was not used to the processes of formal and meticulous agreement that aimed to include any participant willing to be there. I had assumed a top-down approach based on standardisation, and my impression was that the community was supporting a "do what you want, but do it" approach…

Field work during the transnational intercomparison course merging 11 national designs for vegetation analysis in Cansiglio, Italy.

It was Brussels in 1999, and Dan Aamlid was very patient in explaining the background story to me, but – in return – he involved me as co-chairman: a hard job on top of university duties. But it was the right way to discover the scope of the programme, the inherent needs of an ambitious, long-term international project, the working environment of reciprocal consideration. I realised that it was not that easy simply to pursue some standard: the common plant species codes list was one of the first examples of stable reference on a continental scale.

The manual updates were a real training in understanding the need for harmonisation within a common set of standards, and the role of quality assurance (QA).

I would like to summarise the history of our activity with one picture. The hardest and funniest activity was the transnational intercomparison course in Cansiglio in 2009. A nightmare of coloured poles, stakes, lines and stripes, merging 11 national designs; a number of simultaneous surveys carried out by passionate colleagues eventually led to a good basis for QA recommendations and harmonisation.

A personal offshoot: at MSc level, my subject (biology) is about plant monitoring schemes; ICP Forests is the reference. Students participate in QA exercises, and, maybe, they will be the first practitioners to have it in their CV. As a consultant researcher I am not part of the bodies constituting ICP Forests, and one cannot ask me to understand the management and political background. But I feel part of a scientific, human, and strategic adventure, for which the present difficult context should be the opportunity to make a fresh start for the next 30 years.

Participants of the 1st transnational training and field inter-comparison course for the assessment of ground vegetation, Pian Cansiglio-Vallone Vallorch (Belluno-Treviso, Italy), 2009.

Expert Panel on Crown Condition and Damage Causes

Nenad Potočić, Volkmar Timmermann, Johannes Eichhorn

The annual large-scale crown condition assessment was the first monitoring activity within ICP Forests and it is still a major component today, carried out annually on more than 100 000 trees or roughly 6 000 Level I plots, and around 500 intensive monitoring (Level II) plots, with most European countries participating.

The Expert Panel on Crown Condition was established in 1996, and the first meeting was attended by 37 experts from 18 European countries. The first and longest-serving chair was Johannes Eichhorn (Germany), with Andras Szepesi (Hungary) and Marco Ferretti (Italy) as co-chairs. Later, the co-chairs were Gerardo Sanchez from Spain and Peter Roskams from Belgium. Dave Durrant from the United Kingdom also played an important role. In 2005, a new system, mainly devised by Peter Roskams, was implemented for the assessment of damage causes, giving more detailed information on symptoms, causes and extent of the damage. Gerardo Sanchez developed the concept of biotic damage from a Mediterranean point of view. The crown condition survey nowadays consists of a defoliation assessment complemented by a damage cause assessment, as this offers better explanation of annual variations in tree vitality and forest health. The work on the further integration of methods of crown condition assessment is being continued by the present chair and co-chair, Nenad Potočić (Croatia) and Volkmar Timmermann (Norway).

Besides the continuous work on the development of harmonised monitoring methods, the Expert Panel has always striven to maintain the consistency of data time series. *The Manual on the Visual Assessment of Crown Condition and Damaging Agents* still recognises some alternative definitions, especially with regard to the assessable crown, reflecting the historical fact that several countries started with organised monitoring even before ICP Forests was established; also, trees and forests do look different e.g. in northern Europe compared to Mediterranean regions. The implemented quality assurance and quality control (QA/QC) procedures in the form of international cross-comparison courses (ICCs, devised in large part by Marco Ferretti) and photo ICCs (developed by Johannes Eichhorn and Volker Mues) serve to establish quality limits, and to ensure and document the quality of the acquired data.

Participants of the excursion to Plitvice Lakes National Park, 13th International EU-ECE-ICP Forests Intercalibration Course on Crown Condition for Mediterranean Countries in Crikvenica, Croatia, in 2000.

A major challenge today is the shifting of the crown condition assessment to the National Forest Inventory (NFI) network in some countries. The disruption of data time series causes difficulties both in the annual reporting of tree health status and in the understanding of climate-tree health relationships. Although the scientific background and methodological approaches of the crown condition assessments have sometimes been questioned, the ICP Forests crown condition database remains the longest, largest, and most important record of forest condition in Europe.

Expert Panel on Deposition

Karin Hansen

It is an honour to be the chairperson of the Expert Panel on Deposition (EPD), an office that for me has lasted six years. My work rests on the work of three very dedicated former chairmen, namely Gun Lövblad from Sweden, Erwin Ulrich from France, and Nicolas Clarke from Norway. When the work of the EPD first started, it mainly consisted of describing relevant and harmonised bulk precipitation and throughfall sampling methods as well as developing solid manuals for both deposition sampling and laboratory analyses.

Participants of the Expert Panel on Deposition at the Tallinn meeting in 2011.

The goal was to have European-wide, harmonised methods. The building of this foundation was extremely important as it would allow us to compare data across Europe. Today, we appreciate the long and often difficult discussions of earlier times, and we are now harvesting the fruits of this thorough work. This is the background to the extended evaluations of scientific data and the increased volume of scientific publications produced by the EPD today.

The work is highly cooperative – we all pull together, and we are all important. I would like to express my deepest gratitude towards all the scientists who, through the years, have contributed to the development of methods and manuals, sampling, analyses and evaluations of deposition data in the EPD in both past and present. I also want to wish us all good luck with our future work in the EPD, hoping for many more fruitful discussions in the future.

Participants of the Expert Panel on Deposition in action.

Expert Panel on Foliage and Litterfall

Pasi Rautio

“Necessary is the harmonising and the improvement of analytical techniques. A high laboratory standard in all countries is indispensable for the intended elaboration of a European-wide survey of forest state.” This quotation from the introduction of the second Needle/Leaf Interlaboratory Test, dating 20 years back this year, condenses the purpose of all ICP Forests Expert Panels in that time into just a few words.

At the beginning of their work, the purpose of the Expert Panels was mainly to harmonise methods across Europe, both in the forest when taking samples, and in the lab when analysing samples, and to ensure the quality of forest monitoring.

A lot has changed since those days. From the early days of development of the ICP Forests Manual development and the establishment of interlaboratory comparison tests, the work of the Expert Panels (EP) has been directed more and more towards scientific data evaluation on a European scale. And over the past few years this work has been directed more and more into ‘multi-EP work’. In other words, we now want to bring together experts from different disciplines to have a more comprehensive outlook on the cause-effect relationships between factors affecting the condition of European forests.

One concrete example of this development was the latest combined meeting of the EPs ‘Foliage and Litterfall’, ‘Soil and Soil Solution’, ‘Deposition’, ‘Crown Condition’ and ‘Ambient Air Quality’, and the ‘Working Group on Quality Assurance and Quality Control’ in Göttingen this year, where more than 100 experts from Europe gathered together to discuss how best to combine information produced by the different EPs to allow European-wide analyses on the factors affecting our forests.

And yet even as the work of the EPs evolves, some elementary parts of their original work will remain. As an example of this work, 54 laboratories in 25 countries participated in the latest (17th) Needle/Leaf Interlaboratory Test this year. The work to ensure and control the quality of our results on the condition of forests in Europe continues.

13th Expert Panel Meeting Foliage and Litterfall in Ljubljana, Slovenia, in 2013.

Expert Panel on Forest Growth

Tom Levanič, Markus Neumann

The Expert Panel on Forest Growth was the second expert panel, formally set up in 1991. Only the Soil Expert Panel has a longer history within ICP Forests. Since that time, up to 30 experts have met at a total of 12 meetings, in more recent years often back to back with other groups. The group was initiated by John Innes from the UK, who chaired the expert panel from the very beginning; he was succeeded by Matthias Dobbertin (CH) in 1999. After the sudden and deplorable death of Matthias in October 2012, the panel was interim-chaired by Markus Neumann until 2014, when Tom Levanič was elected as chairman.

The very first meeting in Farnham in the UK in 1991 focused on considerations of how crown condition assessments could be correlated with increment to enable estimates of growth reduction to be made based on crown damage data. At this early stage, the subsequent expert panel in Sopron then took the first steps towards developing a manual for periodically repeated growth assessment on Level II plots. After the installation of intensive monitoring plots (Level II), starting in 1995, further meetings dealt with data formats, coding questions, plausible ranges, and ways of data checking and correction before storage of the information in a central database. The potential derivation of information on carbon stocks from Level II data on a European scale was very controversial at that time and the subject of much discussion.

First studies using growth data from Level II plots were presented at the meetings in 2002 and 2004. Later on, a first harmonised evaluation of data from more than 800 Level II plots became possible. This evaluation was based on the growth data from four assessment campaigns providing tree growth data for three subsequent five year periods. These results were published in the Technical Report of 2011. The years 2011 and 2012 were also dedicated to an intensive update of the manual as part of the Forest Monitoring book published in 2013. The future of the EP Growth is even more challenging. After more than 20 years of intensive work, we are finally in possession of a data set that can be used for studying trends in European forests. By analysing it, we can put trends and changes in a temporal and spatial perspective. We will continue to carry out these evaluations in the coming years.

Participants of the 7th Meeting of the Expert Panel on Forest Growth in Innsbruck, Austria, in 2005.

Expert Panel on Meteorology, Phenology and Leaf Area Index

Stephan Raspe, Stefan Fleck, Egbert Beuker, Teja Preuhsler

Since climate and weather are important factors for the vitality and the condition of forests, meteorology has been integrated into the Level II programme since 1996. In accordance with the holistic approach in the Level II programme of ICP Forests, anthropogenic (e.g. air pollution) and natural stress factors (e.g. extreme temperature or lack of precipitation) and their effects on forests should be measured directly at the same locations. A first preliminary manual was superseded by a more detailed manual on methods of meteorological measurement in forest monitoring by the Expert Panel on Meteorology under the chairmanship of Teja Preuhsler, Germany.

At the Task Force Meeting in Farnham in the UK in 1997, the new manual was accepted. During an excursion in the course of this meeting in May, a significant level of insect damage to oak trees was found. This was not discernible in the crown condition assessment carried out the following summer, illustrating that regular observation of the vegetation is of great importance to explain forest condition. This finding was the beginning of phenology within ICP Forests. At the Task Force meeting in Rome, Italy, in 2005, Teja Preuhsler passed on chairmanship of the Expert Panel to Annemarie Bastrup-Birk from Denmark, who had been very active on the Expert Panel for a long time. One year later, Annemarie transferred to the Joint Research Center (JRC) of the European Commission, and Stephan Raspe from Germany was assigned as the new chairman at the Task Force Meeting in Tallinn, Estonia.

The first ICP Forests meeting on phenology was held in September 1997 in Punkaharju, Finland. Twenty-seven experts from 15 countries discussed the possibilities of including phenology as a new parameter to be assessed on the Level II plots. It had been recognised that phenology is a strong indicator for changes in environmental factors, especially climate. A questionnaire carried out before the meeting had revealed that several countries had already started with phenological observations on their Level II plots a few years earlier. As an outcome of this meeting, an ad-hoc working group (Egbert Beuker, Teja Preuhsler, Astrid Vasella, Päivi Merilä, Koen Kramer and Marco Ferretti) was established to prepare a sub-manual for phenological observations at Level II plots and to test it in practice.

For many countries it was difficult to include phenology in their Level II network because it was not feasible to make sufficiently frequent observations on the Level II plots. The Level II network was not designed for it and most of the plots were located far from urban areas. Also, the fact that phenological observations were visual observations, giving a subjective value, not measured data, caused some opposition to the introduction of phenology into the programme. Because of this it proved impossible to have phenology included as a mandatory part of the programme.

Three years after the first meeting in Punkaharju, the ICP Forests Task Force accepted at its meeting in Gent, Belgium, in 2000, that phenological observations could be assessed on the Level II plots as an optional parameter. Phenology was added to the Expert Panel for Meteorology, which then became known as the Expert Panel on Meteorology and Phenology, under co-chair Egbert Beuker from Finland. After 11 years leading the phenology group, Egbert Beuker resigned as co-chair at the Task Force Meeting in Copenhagen in Denmark, and Urša Vilhar of Slovenia followed.

Within the Level II programme, the phenological observations also included the recording of damaging biotic and abiotic events and phenomena. This information could be used as an early warning system for damage.

Technical solutions that could provide information on the timing of annual damaging events were also accepted as possible to use. Initially the continuous measurement of girth bands and later also digital (web) cameras were included in the manual.

As for the crown condition observations, it is essential that the field staff is properly trained in carrying out the phenological observations if reliable data is to be obtained. A number of international training courses on phenology were organised in Switzerland (2006), Slovenia (2009) and Austria (2011). The latter two courses also included training in the assessment of the Leaf Area Index (LAI).

Participants of the field course on phenological autumn phases during the meeting of the Expert Panel on Meteorology and Phenology, and the LAI workshop in Vienna, Austria, in 2011.

The Leaf Area assessment is the youngest survey within ICP Forests. It started with the EU Life+ FutMon project (Further Development and Implementation of an EU-level Forest Monitoring System, 2009-2011) to develop new integrated key indicators for tree vitality, and as an input parameter for water budget models. An extended comparison of LAI measurement methods was carried out: LAI-2000, TRAC, airborne Lidar and terrestrial Lidar measurements were compared to leaf area derived from leaf litterfall, as the ultimate standard in deciduous forests. In parallel, hemispherical photographs were taken on numerous other plots.

One goal of the FutMon project was to develop a manual on LAI measurement methods for monitoring purposes. The first step in this direction (2009) was the “FutMon field protocol on radiation measurements and leaf area index (LAI)”. Further steps were the “Report on methods to assess Leaf Area Index (LAI) including LIDAR” and the "Manual for LAI assessments", which were both presented as project reports in 2011.

In October 2011, a group of scientists was invited to Vienna by the Expert Panel on Meteorology and Phenology. The goal was to combine the experience gained on LAI measurements in order to describe standard procedures for LAI measurements within the ICP Forests monitoring programme.

The group (Matjaz Cater, Stefan Fleck, Martin Greve, Christian Hertel, Stephan Raspe, Patrick Schleppi, Liisa Ukonmaanaho, Wendelin Weis) worked very efficiently and needed only one more combined session (in Freising in 2012) to come up with separate texts for each of the methods. The texts were combined and extended to form one common draft manual for LAI measurements by the beginning of May 2012.

The Task Force meeting in Białowieża (May 2012) adopted the LAI manual, which became part XVII of the ICP Forests manual. The proposition for a new LAI survey with mandatory annual measurements on core plots and optional measurements on regular Level II plots was adopted by all countries, and this forms the foundation of the current survey. The position of a co-chair for LAI measurements was established within the Expert Panel, and the Expert Panel was renamed the “Expert Panel on Meteorology, Phenology, and Leaf Area Index” under co-chair Stefan Fleck from Germany.

Summarising the history of our Expert Panel, it is obvious that it is not only the structure and names that have changed during 30 years of ICP Forests, but also its importance and objectives. Initially the Expert Panel for Meteorology considered only the effect of meteorological factors on forest vitality and condition. The inclusion of phenology and the LAI meant that effects were also added to the scope of the Expert Panel. The group of pure forest meteorologists was thereby extended to include phenologists and experts in LAI measurement. While the creation of the manuals was initially the main task of the Expert Panel, its work on data quality and data analysis has become more and more significant over the years.

The discussion on climate change effects on forest ecosystems is giving added importance to our Expert Panel. The meteorological and phenological time series in our programme are in growing demand. The water budget in particular is increasingly the focus of interest. Water budget modeling is therefore becoming a key aspect of the work within the Expert Panel, complementing soil water measurements on core plots. Thus we will also contribute to understanding the water supply of the forests in future.

András Koltay

Expert Panel on Soil and Soil Solution

Bruno De Vos, Tiina M. Nieminen, Nathalie Cools

Initiated in 1990, the Forest Soil Expert Panel (FSEP) has already convened at 19 meetings, and it will celebrate its 20th meeting in spring 2017. Generally, about 25 to 40 experts from over 20 countries have participated in the past meetings.

Belgium and Finland have always provided the EP chairs and co-chairs for both soil and soil solution. Michael Starr (Finland) was the first "Soil" chair, followed by the Belgians Franz De Coninck (1991–1996), Eric Van Ranst (1997–2006) and Bruno De Vos (2007–present), whereas John Derome (Finland), who passed away on 7th June 2010, was the chair of the ICP Forests Working Group on Soil Solution from 2001. It merged in 2008 into the EP on Soil and Soil Solution. In 2010, Tiina M. Nieminen (Finland) took over as co-chair for Soil Solution. The Forest Soil Coordinating Centre (FSCC) supported the EP from 1992 onwards, and since 2002 it has been headed by Nathalie Cools (Belgium).

Over the past 25 years the Forest Soil Expert Panel has set up a harmonised soil monitoring programme for soil solution and solid soil. It has prepared and conducted two pan-European forest soil surveys on both monitoring levels (Level I and Level II), and elaborated the results in two "Forest Soil Condition Reports". A quality control programme has been launched for the collection of samples in the field and analysis in the laboratory. Interlaboratory comparisons were initiated within the Expert Panel, and from the 7th ring test onwards in a fully harmonized way along with the other ICP Forests surveys employing laboratory analyses.

During John Derome's memorial seminar on 30 November 2010 in Rovaniemi (Finland), we remembered John's competence and enthusiastic, always open-minded spirit. He was certainly one of the driving forces in the Forest Monitoring Programme and for many among us a beloved colleague and friend. That day and during subsequent meetings we often remind ourselves that thanks to his spirit, our EP is not just a group of national soil experts, but rather a fellowship of European research comrades passionate about the forest ecosystem and its soils.

Participants of the 13th Meeting of the Expert Panel on Forest Soil in Alton, UK, in 2006.

Working Group QA/QC in Laboratories

Nils König, Anna Kowalska

After the first "Workshop of Quality Assurance and Quality Control in Laboratories Performing the Deposition Analysis" in 2001 in Ispra (Italy), the Expert Panel on Deposition (EPD), under the chairmanship of Erwin Ulrich (France) decided to develop QA/QC guidelines for the laboratory work, and to organise working ring tests to improve the quality of the ICP Forests laboratories and to ensure data comparability.

As a result of the second QA/QC workshop in Fontainebleau (France) in 2002 it was decided to set up a special QA/QC working group as an informal subgroup of the EPD within ICP Forests. At the EPD meeting in Kranj (Slovenia) in 2004, this group was formalised; Rosario Mosello (Italy) became the first chairman of the new 10-member group. Together with Erwin Ulrich, he dedicated himself to establishing better understanding of the importance of QA/QC both within individual laboratories and between all laboratories of the ICP Forests programme. The aims of the "Working Group QA/QC in Labs" (WG QA/QC) were continuous work on the QA/QC part of the ICP Forests deposition manual, the organisation of ring tests, the establishment of an assistance programme for laboratories with analytical problems, and the exchange of knowledge about analytical methods, instruments and problems.

During the next few years it very quickly became clear that the quality work on water analysis (deposition, soil solution) needed to be combined with work on soil and foliar analysis. At that time, soil and foliar ring tests were organised and evaluated by the Forest Soil Coordination Centre (FSCC) in Brussels (Belgium) and the Forest Foliar Coordination Centre (FFCC) in Vienna (Austria). The ring test organisers Bruno De Vos (soil), Nathalie Cools (soil) and Alfred Fürst (foliar) joined the WG QA/QC meeting in Brussels (Belgium) in 2007 to discuss the possibilities of forming a combined working group.

In 2007 at the Task Force meeting in Zvolen (Slovak Republic), the new combined group was formally set up as a subgroup of the Programme Coordinating Group (PCG) of ICP Forests. Nils König (Germany) took over the chairmanship of the new group. It was the beginning of a very successful collaboration, resulting in important publications on quality in laboratories, a good exchange of analytical knowledge at five regularly held meetings of the heads of the labs and many ring tests (7 water, 8 soil and 19 foliar ring tests) with continuously better results.

Participants of the 5th Meeting of the Heads of the Laboratories in Vienna, Austria, in 2015.

Ensuring the value of the monitoring and data - the Quality Assurance Committee

Marco Ferretti, Nils Koenig

Ensuring adequate data quality is vital for any monitoring programme. Despite efforts in this direction since the early stages of the ICP Forests (international training courses for the assessment of crown condition have been organised since 1987), concern about data quality and data comparability has been expressed repeatedly over time. We can now see the 1980s as a pioneering era, when the need for and basis of the future activity in the field of Quality Assurance and Quality Control in forest and ecological monitoring were made explicit.

The need for documented, high data quality was taken seriously within the ICP Forests. As the programme expanded, training and intercalibration sessions were also increased during the 1990s, and ring tests for soil, foliar and water chemistry were initiated under the co-ordination of different expert panels.

Two major changes occurred during the 2000s: firstly, all the laboratory-based ring tests were organised within the framework of the newly established Working Group on Quality in Laboratories. Secondly, a much broader range of topics was addressed – not just the quality of individual measurements. This activity resulted in a broader vision, and the setting-up of the Quality Assurance Committee, formally inaugurated at the 23rd Task Force meeting in Zvolen, Slovak Republic, in May 2007. A harmonised and co-ordinated approach to data quality was developed, covering formal expression of objectives, definitions, sampling, data quality requirements, data storage, and processing and reporting within individual investigations. This has resulted in a thorough revision of the ICP Forests Manual, implemented thanks to the support of the Life+ project "FutMon", co-financed by the European Union. It also gave rise to a book on forest monitoring methods.

Nowadays, all surveys and investigations conducted within ICP Forests are carried out within a Quality Assurance perspective, most variables have defined data quality requirements, and the manual is internally consistent in terms of structure and contents, with a clearly defined updating process. We have come a long way since the 1980s, when ICP Forests consisted of a single survey (crown condition), the data of which were much criticised. It took time, as the knowledge and practice necessary for large-scale, co-ordinated, international monitoring programmes was almost non-existent in the 1980s. However, the work that has been done, the commitment of experts, and the outstanding improvement in the quality of data that has been achieved so far are all things that permit us to look ahead with confidence in the knowledge that we can rely on what is probably the most extensive, longest-running quality-assured forest monitoring data series worldwide.

These results were made possible by dozens of experts, too numerous to be listed here individually: the National Focal Centres, who have helped with all the training, intercalibration and ring-tests over the years; the members and chairpersons of the Expert Panels, and of the Soil and Foliar Co-ordinating Centres; all past and present staff at the Programme Co-ordinating Centre; and past and present Chairmen of the ICP Forests.

Enhancing the scientific profile of the ICP Forests - the Scientific Evaluation Committee

Marco Ferretti

Think about a monitoring programme incorporating approx. 6000 Level I plots and over 30 years of data on tree health, and supplementary data on soil (including C stocks) and foliar chemistry; approx. 300-900 Level II plots active since 1992–1998 with different combinations of measurements of nutrients, air pollutants, deposition, tree health and growth, biodiversity, phenology, and meteorology; and a database that can be accessed through a designated data policy. Now think of the potential of such an infrastructure for forest scientists, decision makers, experts, and citizens: it is hardly surprising that around 90 different data retrieval applications have been submitted, and that hundreds of peer-reviewed papers based on such data have been published over the years, including papers in journals like Nature, Nature Climate Change, PNAS, and Global Change Biology (see for example http://icp-forests.net/page/scientific-publications).

The potential of the data generated by the ICP Forests is, however, still largely unexplored. Actually, the ICP Forests community concentrated for many years almost entirely on data collection, rather than data evaluation. While the first is important, it is equally important to realise that data evaluation and publication are now inescapable policy goals. The Scientific Evaluation Committee (SEC) was therefore established after the 2011 Task Force meeting held in Copenhagen, Denmark, with the mandate to promote the evaluation of the ICP Forests data, the publication of results, and — ultimately — to augment the scientific profile of the ICP Forests.

Since then, a number of initiatives have been launched, notably the organisation of four Scientific Conferences (Warsaw 2012, Belgrade 2013, Athens 2014, Ljubljana 2015) with more than 140 presentations and posters, the publication of a book in Developments of Environmental Science by Elsevier (Ferretti and Fischer, eds., 2013, Forest Monitoring, DES, Elsevier, 507 ps), and two Special Issues (Ferretti and Schaub, eds., 2014, Forest Ecology and Management; Rautio and Ferretti, eds., 2015, Annals of Forest Science). As a demonstration of the effectiveness of promoting some "evaluation attitude" within the ICP Forests community, it is worth mentioning that ICP Forests-based presentations and posters were probably the largest cluster contributing to the recent IUFRO Conference on the "Global Challenges of Air Pollution and Climate Change to Forests" held in Nice in June 2015.

The potential of the data grows year by year as the data series get longer. For this reason, besides the huge number of evaluations being undertaken (see for example http://icp-forests.net/page/project-list), new initiatives are continuously being launched, including co-operative long-term evaluations and newly devised scientific conferences.

All the above examples of progress were made possible by the contributions of many colleagues. Besides all the scientists, experts, administrators and surveyors active all year round in running the programme, I would like to thank the members of the Scientific Evaluation Committee and the Programme Co-ordinating Centre for their continuous support.

The ICP Forests PCC Collaborative Database – the backbone of ICP Forests

Walter Seidling, Till Kirchner

The collection and the consolidated storage of data have been a major concern within the ICP Forests Programme since the very beginning, when the National Focal Centres (NFCs) still sent their data to the ICP Forests Programme Co-ordinating Centre (PCC) and the Forest Intensive Monitoring Co-ordinating Institute (FIMCI, 1994-2003) on paper and later on floppy disks.

Since then, more and more formalised workflows have been developed in order to handle the growing amount of data and to ensure its overall quality. By the end of the 1990s, an advanced step-by-step system of check routines had been introduced by FIMCI to check data before submission by the NFCs.

Serina Trotzer

When the Joint Research Centre (JRC) was responsible for the management of the data as part of the Forest Focus regulation (2003–2006), a web platform was created to allow the submitting and checking of data online in real time. This guaranteed direct feedback on the data quality for the first time. After the PCC had re-assumed responsibility for the data infrastructure, the system was developed further during the EU LIFE+ FutMon project (2009–2011).

During the last two years, the data infrastructure and corresponding workflows have been advanced still further, the goal being to offer a transparent data management and documentation system to both data suppliers and user of the data.

As environmental monitoring data is quite complex, it is a continuous task to improve it in order to be able to provide data of the best quality possible to both internal and external scientists. With time series covering up to 30 years, ICP Forests stores, handles and provides a unique data set that has already been used for innumerable scientific analyses, leading to an enhanced understanding of forest ecosystems across Europe and beyond.

Belén Torres Martínez

SELECTED MONITORING RESULTS OF ICP FORESTS

FOREST HEALTH IN EUROPE

Nenad Potočić, Volkmar Timmermann

Tree defoliation and the occurrence of biotic and abiotic damage are important indicators of forest health, and they are considered within Criterion 2, "Forest health and vitality", one of the six criteria adopted by Forest Europe to provide information for sustainable forest management in Europe. They are assessed annually on ICP Forests large-scale monitoring plots (Level I) and intensive monitoring sites (Level II) according to Europe-wide, harmonised standards.

In 2014, defoliation and damage cause assessments were carried out on approx. 100,000 sample trees on more than 5,600 Level I plots in 24 European countries.

Parcours for an intercalibration course on crown condition in a pine stand in Finland in 2001.

Defoliation status, annual changes and long-term trends

Tree crown condition, assessed in terms of defoliation, discolouration and biotic and abiotic damage, is regarded as one of the most important indicators of forest health. Tree defoliation is a key variable, and provides an estimate of foliage loss in the tree crown in comparison to a fully foliated reference tree. Trees showing more than 25% defoliation are generally considered as damaged, and in 2014, 23.8% of all trees (all species) fell into this category. Deciduous tree species showed a higher mean defoliation than conifers, with deciduous temperate oak species being the most damaged trees. Scots pine (*Pinus sylvestris*) and Mediterranean lowland pines had the lowest defoliation values. It is worth noting that in some regions in central and southern Europe there were clusters of plots with high mean defoliation, especially in parts of France, northern Italy, Slovenia, Slovakia, the Czech Republic and central Germany (Fig. 2.1).

Individual tree species display different defoliation patterns over time, with relatively large annual variations. However, analyses of long-term data series for the period 1992–2014 revealed highly significant trends for defoliation in several species (Fig. 2.2): deciduous temperate oak species (*Quercus robur, Q. petraea*), evergreen oaks (*Q. coccifera, Q. ilex, Q. rotundifolia, Q. suber*), deciduous (sub-) Mediterranean oaks (*Q. cerris, Q. pubescens, Q. frainetto, Q. pyrenaica*) and Mediterranean lowland pines (*Pinus pinaster, P. halepensis, P. pinea, P. brutia*) showed the most prominent increase in defoliation, while there was a moderate increase for European beech (*Fagus sylvatica*) and only a small increase for Norway spruce (*Picea abies*). No trend was found for Scots pine.

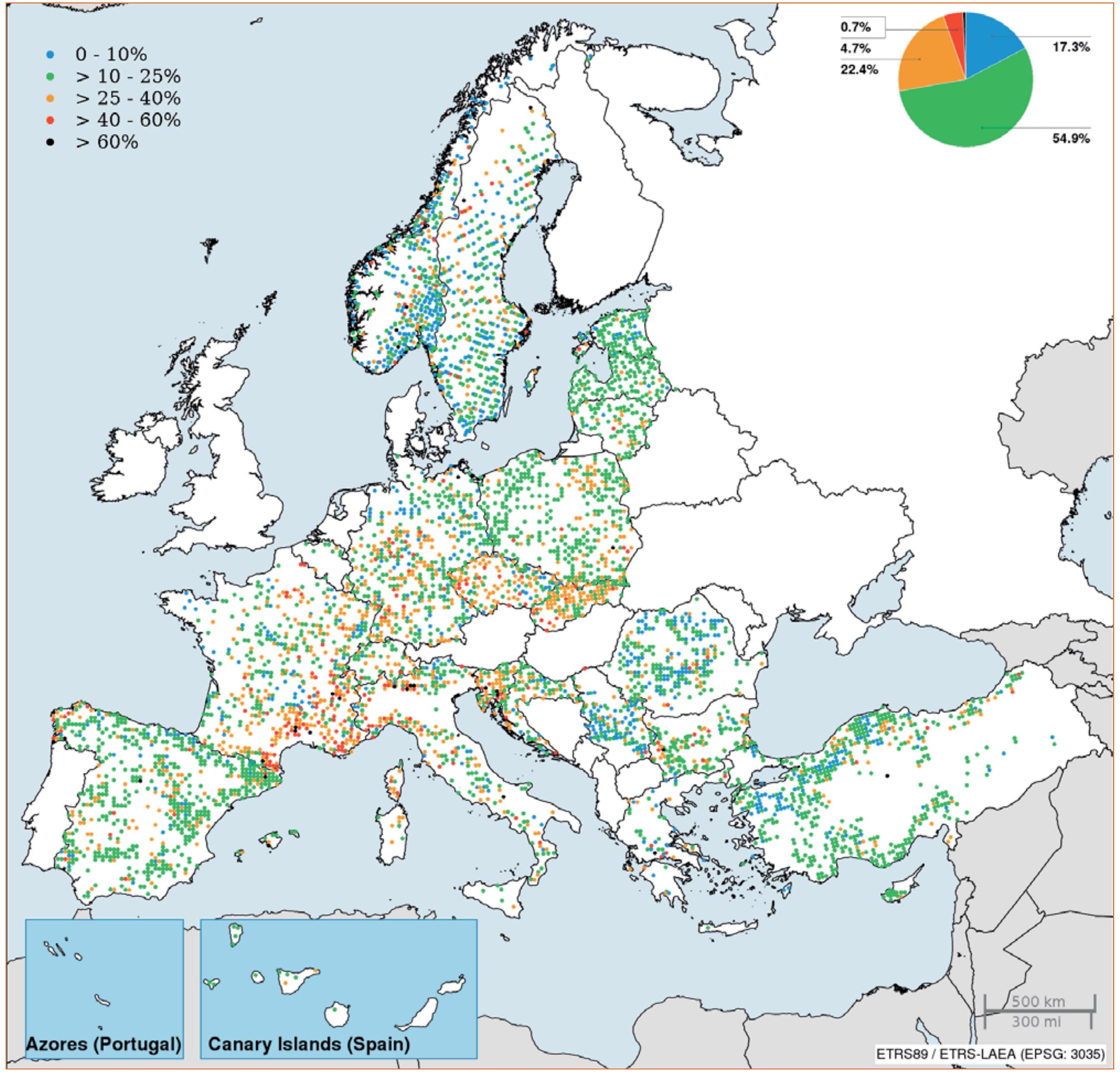


Figure 2.1. Mean plot defoliation of all species in 2014 (Seidling et al. 2015).

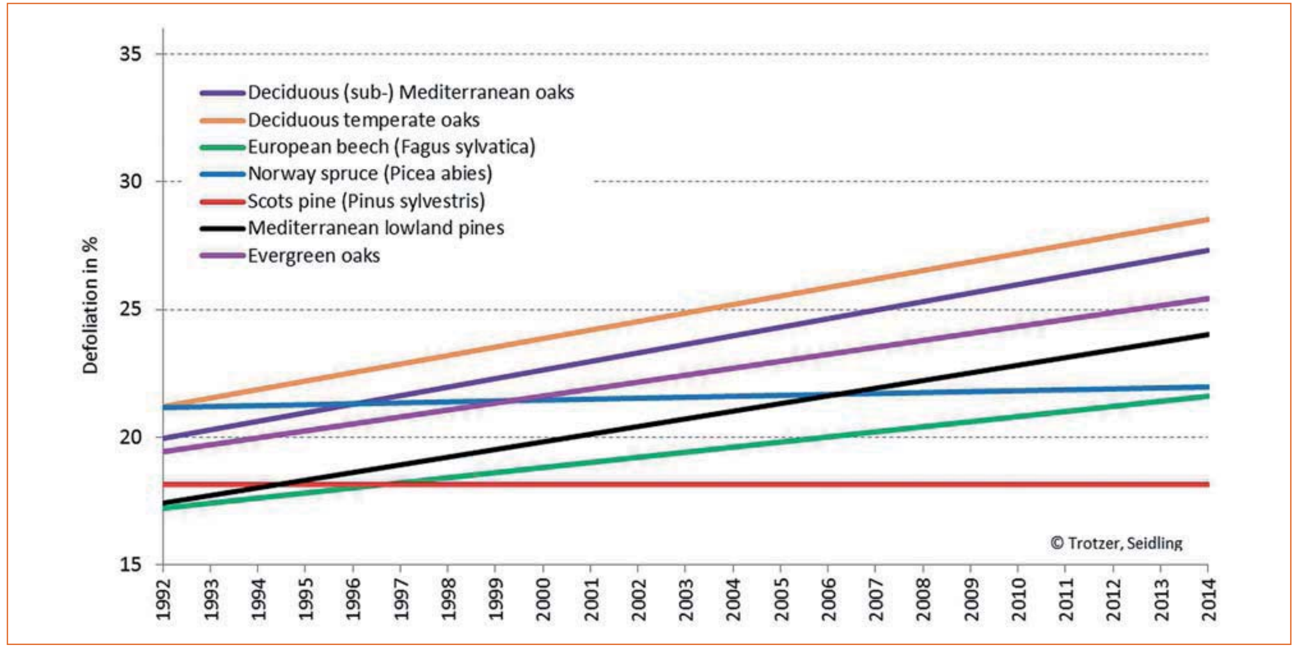


Figure 2.2. Defoliation trends of main species and species groups 1992–2014 based on plots which were assessed between 1992 and 2014 for at least 20 years.

Forest health in a changing climate

The quantification of the response of forest ecosystems to a changing environment is fundamental for the sustainability of forest ecosystem goods and services, their maintenance, enhancement and restoration. Air pollution and climate are important drivers in this context. Crown condition of European beech, for instance, is largely influenced by drought. Several studies revealed the responses of European forests to climate, with drought stress being of particular concern. In southern Europe in general, and in Spain in particular, species-specific responses to drought pressures underlying a complex geographical mosaic have been disclosed. Sensitivity of Norway spruce to variations in climate conditions has been documented in Lithuania. A study from France reported a general increase in defoliation for several species in response to precipitation deficiency, most pronounced for European beech and sessile oak (*Quercus petraea*). Also in the Turkish Level I monitoring system, drought seems to be one of the main drivers for defoliation, especially in broadleaves. A recent overview of various studies from different parts of Europe reports that climatic factors and in particular drought stress appear to be primary drivers for variations in crown condition, while the effects of air pollution seem to be more species-specific and limited in time and space.

Abiotic and biotic damaging agents and invasive species

Studies conducted on data from the ICP Forests monitoring networks pointed out the importance of both biotic and abiotic damaging factors for full understanding of the multitude of factors influencing forest health. Damage cause assessments carried out in the Level I network in 2014 showed that 40.2% of the trees were affected by one or more damaging agents, with insects being the most important agent group, followed by abiotic factors and fungi (Fig. 2.3). Defoliating insects accounted for 13% of all damage records, drought for 8%, and decay and root rot fungi for 2%. An increase in the frequency of drought episodes and other weather extremes like storms can be expected in future as a consequence of a changing climate. At the same time, damaging insect and fungal species might expand their distribution range due to more favourable climatic conditions.

One example of a non-native, invasive species is the ash dieback fungus *Hymenoscyphus fraxineus*, threatening European ash (*Fraxinus excelsior*) on a continental scale.

No direct, acute damage from air pollution was recorded (Fig. 2.3.). It is well known, however, that air pollutants often have indirect effects. This is particularly true in the case of N deposition, which can affect the nutritional status of soil and foliage, causing imbalances and potentially leading to increases in sensitivity to other damaging agents, whether biotic or abiotic. Tropospheric ozone is also considered a factor that, besides causing visible damage, may have an impact on photosynthesis, causing reduced growth and potentially having an adverse effect on forest health. Nitrogen deposition and ozone effects deserve a closer look: the evidence of their impact on forest health emerging from the ICP Forests data is given in the following chapters.

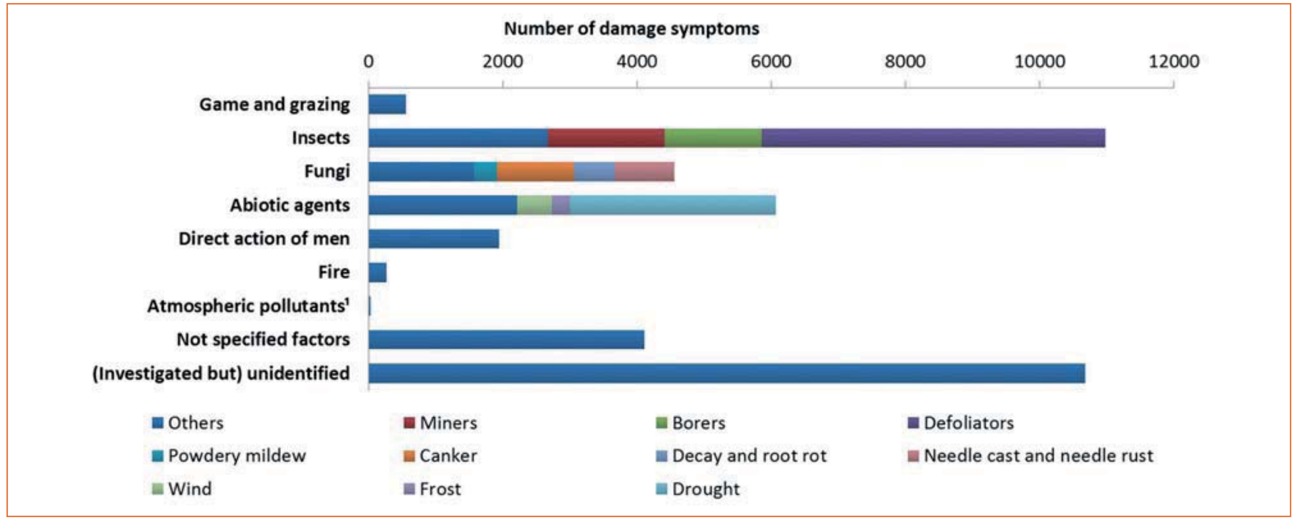


Figure 2.3. Most important damaging agents and agent groups in 2014 (Seidling et al. 2015).
[1] Visible symptoms of direct atmospheric pollution impact only.

NITROGEN DEPOSITION AND ITS IMPACT ON THE SOIL AND VEGETATION OF EUROPEAN FORESTS

Nathalie Cools, Elena Vanguelova, Karin Hansen

This chapter shows the main spatial distribution and temporal trends of nitrogen (N) deposition across European forests and presents findings of the effects of N deposition on forest soils, tree health, growth and nutrition, and forest biodiversity. The text describes the main messages communicated by these studies.

Spatial and temporal trends of N deposition

The throughfall deposition of nitrate and ammonium is highest in northern central Europe. In southern Germany, northern Italy and further west, in northern Belgium and the Netherlands, depositions of more than 20 kg N ha^{-1} yr^{-1} were recorded (Fig. 3.1).

Overall there was a decreasing trend in N deposition of about 2% per year between 2001 and 2010. This indicates a reduction in N deposition across European forests likely following reductions in N emissions. The strongest decreasing trend was observed in western and central Europe, in regions with relatively high deposition fluxes.

East of the Alpine region and in northern Europe there was no change or even a slight increase in deposition between 2005 and 2010 (Fig. 3.2). Although trends are promising, further reductions in emissions are necessary if the deposition is to be reduced to levels below critical limits, i.e. levels below which there are no significant harmful effects on the environment.

Recent regional and national studies based on intensive monitoring sites in Italy, Switzerland, Ireland, Sweden, Belgium, the Czech Republic, Germany and the UK support these differences in temporal patterns among the countries (increases as well as decreases). A significant increase in dissolved organic N in rainfall, throughfall and soil solution has been observed in a growing number of countries, such as in the UK and in northern Belgium.

Projections of future scenarios made by modelling the exceedance of the N critical loads predict that, under full implementation of existing clean air legislation, 20% of the forest sites will still be vulnerable to N deposition in 2020. Under future climate change scenarios, decreasing critical load thresholds imply an increased sensitivity of the forest towards N input.

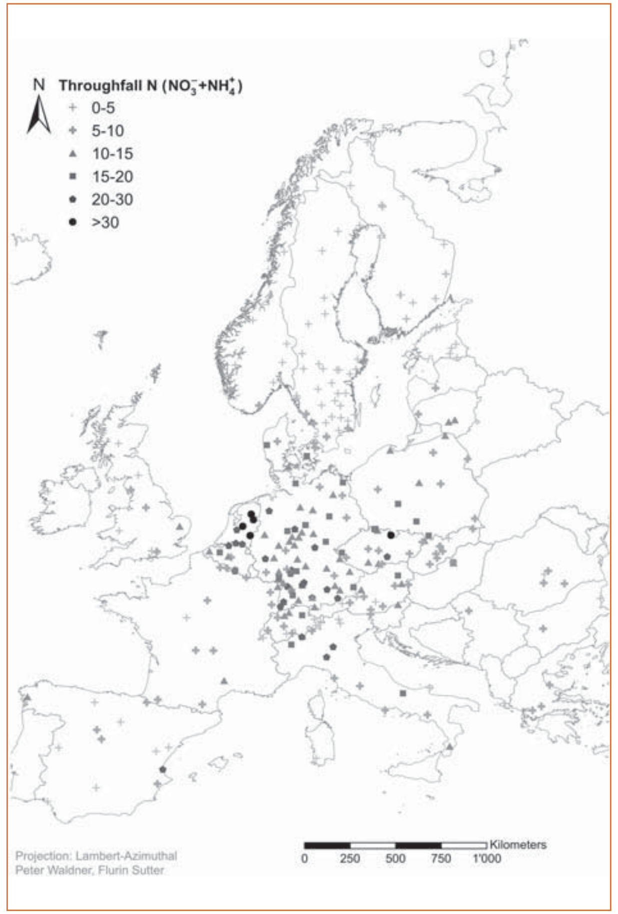


Figure 3.1. Mean annual inorganic nitrogen (NH_4^+ and NO_3^-, kg N ha^{-1} yr^{-1}) in throughfall deposition in the year 2010 (Waldner et al. 2014).

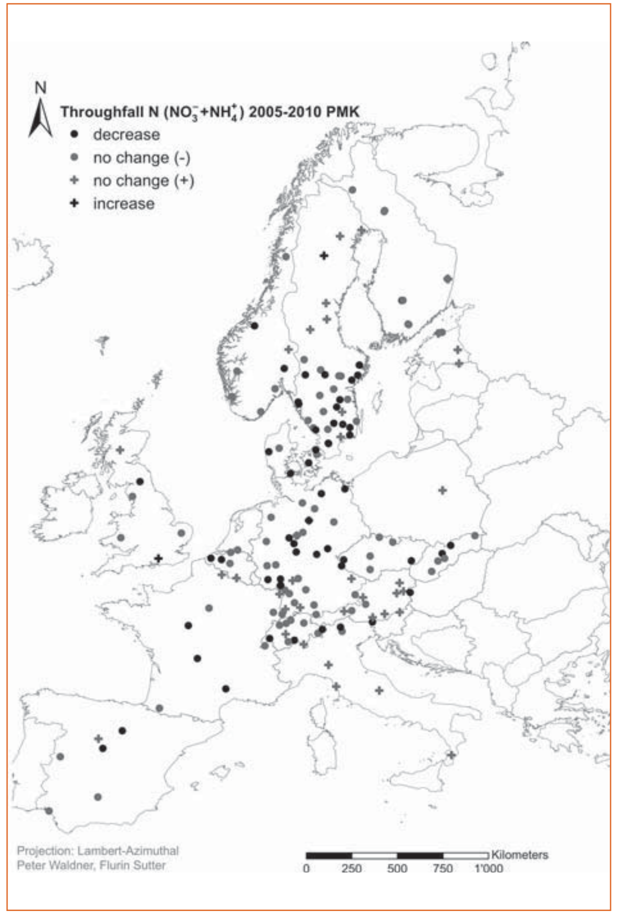


Figure 3.2. Trend of inorganic nitrogen (NH_4^+ and NO_3^-, kg N ha^{-1} yr^{-1}) throughfall deposition determined with Partial Mann-Kendall tests on plots with continuous measurements from 2005 to 2010 (Waldner et al. 2014). Non-significant positive and negative changes are indicated with 'no change (+)' and 'no change (-)', respectively.

Nutritional status in the soil

Excessive input of N accelerates eutrophication effects in soils, such as loss of nutrients by leaching, and elevated nitrate levels in percolation and runoff water. In northern Belgium, the trend of soil solution nitrate leaching fluxes mirrors the declining trends in the deposition of sulphate, ammonium and nitrate.

The capacity of the soil solution to neutralise acids increased, but remained negative, indicating that soil acidification is ongoing. The start of recovery from acidification was delayed by a simultaneous decrease over time in the deposition of base cations and short-term soil buffering processes. Despite substantial reductions, current N deposition levels in some parts of Europe still exceed the critical load for safeguarding sensitive lichen species by 4–8 times, and they are still 22–69% above the critical load for maintaining ground vegetation diversity.

In Ireland, it has not yet been possible to discern significant effects related to decreased N deposition. In the UK, a decline in nitrate in the soil solution was detected, but only at sites receiving declining high N deposition. The soil weathering process contributes significantly to the provision of base cations and is therefore essential for the sustainability of site productivity e.g. in boreal catchments receiving low deposition loads. In Italy, topsoil exchangeable base cations and pH decreased with increasing N deposition.

A number of studies concentrated on the relation between dissolved organic carbon (DOC) and dissolved organic N (DON). In northern Belgium, the soil solution DOC has increased over the past 11 years. In surface waters an increasing trend in DOC concentration has been related to a decreased deposition of sulphate and chloride. In Norway, evidence is appearing to suggest that DOC concentrations in the soil solution are related to non-marine sulphate and chloride, while the most important variable explaining DOC leaching from the soil is the ammonium content in the soil solution. Across Europe, a positive relationship was established between DOC trends and mean nitrate (NO_3^-) deposition and a negative correlation with mean sulphate (SO_4^{2-}) deposition, depending on N deposition loading at the sites. In the UK, the DON in soil solution has increased significantly in many forests, which is likely to be due in part to increased DON input by rainfall.

Although C:N ratios on forest floors and in mineral topsoils across Europe are mainly driven by tree species, N deposition partially explains the ratio. Further analysis for eight main tree species shows that the influence of environmental variables on the C:N ratios is dependent on the tree species.

Permanent soil sampling plot and installation of a soil moisture sensor (tensiometer) in Freising, Germany.

Tree growth

Nitrogen deposition may alter the growth of nutrient limited forests and lead, in combination with increased carbon dioxide (CO_2) content in the atmosphere, to increased tree growth and C sequestration at least in the short-term. In Finland, where deposition is relatively low compared to the rest of Europe, the N enrichment of the forest ecosystem has a positive effect on tree growth and the sustainable yield at harvest. In boreal coniferous forests, N deposition accumulating during a rotation period is able to compensate for the export of N caused by conventional stem-only-harvesting in final felling operations. If more intense whole-tree harvesting regimes are practised, the sustainability of site productivity will be challenged, especially in Norway spruce stands.

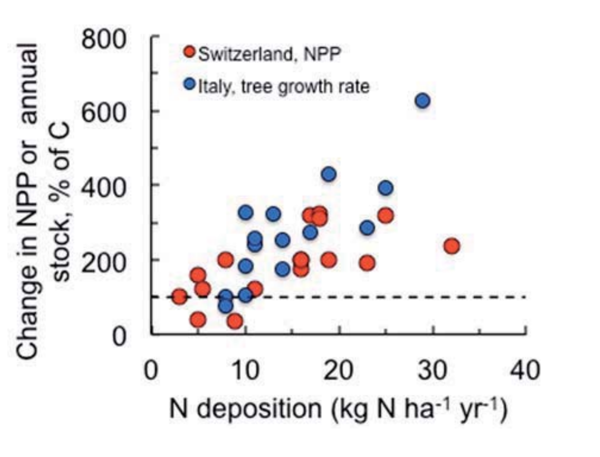


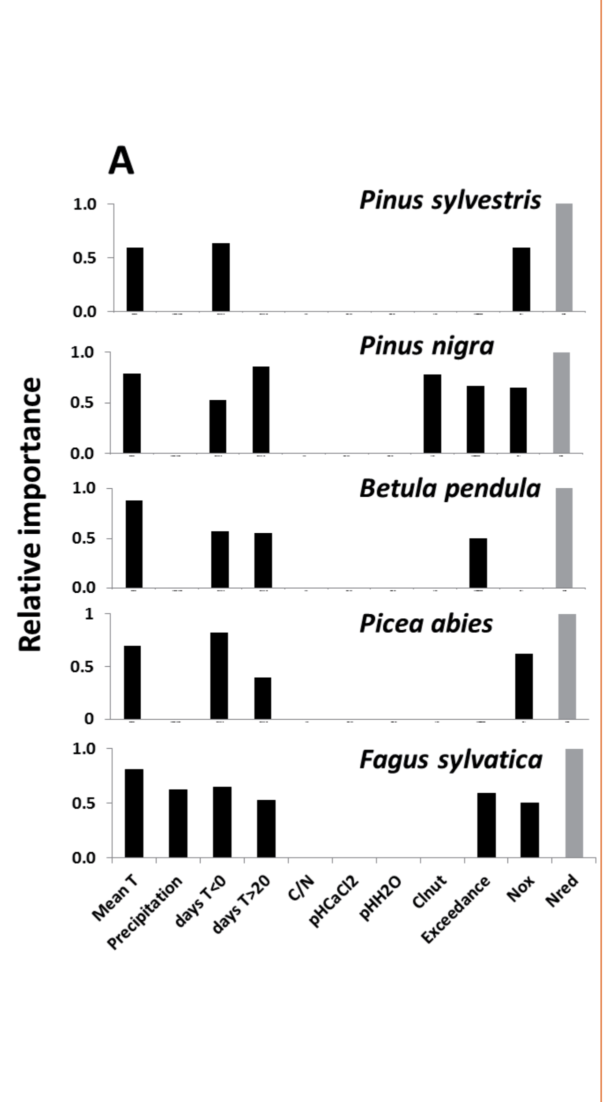
Figure 3.3. Change of Net Primary Productivity (Switzerland) or relative increment (Italy) in terms of carbon and in relation to N deposition. NPP and growth rate are assumed to be 100 (dotted line) for the lowest N deposition rate of each data set (re-calculated and re-drawn in accordance with Etzold et al. 2014 and Ferretti et al. 2014)

Forest stem growth in Swiss forests is enhanced by N deposition up to a level of 20-25 kg N ha^{-1} yr^{1}, with no further increase beyond that threshold (Fig. 3.3). In Italy, a positive growth response occurs even beyond such a threshold at sites where there are signs of possible, perhaps recent N saturation (Fig. 3.3).

Despite the high levels of N deposition in Austria, the increase in forest stand density and productivity has increased demand for N. Soils retain N efficiently, and nitrate leaching into the groundwater is currently not a large-scale problem.

Nutrient balance of trees

European forests seem to be shifting from N limiting growth to phosphorus (P) limiting growth. Phosphorus, sulphur, and potassium have decreased as a proportion of foliar nutrition in comparison to N nutrition over the past 20 years. In Italy for example, foliar nutrient N ratios (especially N:P and N:K) increase with increased N deposition. The decrease in P nutrition is more pronounced in forests with an already low P status. This suggests that high nutrient demands due to increased tree productivity cannot always be met and/or that a high N status impairs P uptake. Nitrogen deposition above 20 kg ha^{-1} yr^{1} has an impact on tree physiology by stimulating the tree flowering and fruiting of both conifer and broadleaved species in the UK.



Development of mycorrhiza

Increased N availability reduces fine root biomass and has a negative effect on the development of mycorrhizae. Increased N reduces fungal diversity and causes shifts in mycorrhizal community composition in pine stands along an N gradient in the UK and Germany and in spruce stands in Denmark. Along the climatic and N deposition gradient in sub-arctic-boreal to temperate regions in Europe, N deposition can be used to predict about 80% of the total variability of the ectomycorrhizal root tip biomass in relation to tree basal area in Norway spruce. The most rapid decline in the ectomycorrhizal biomass occurs when N deposition at forest stands increases from 1 to 4 kg N ha^{-1} yr^{1}.

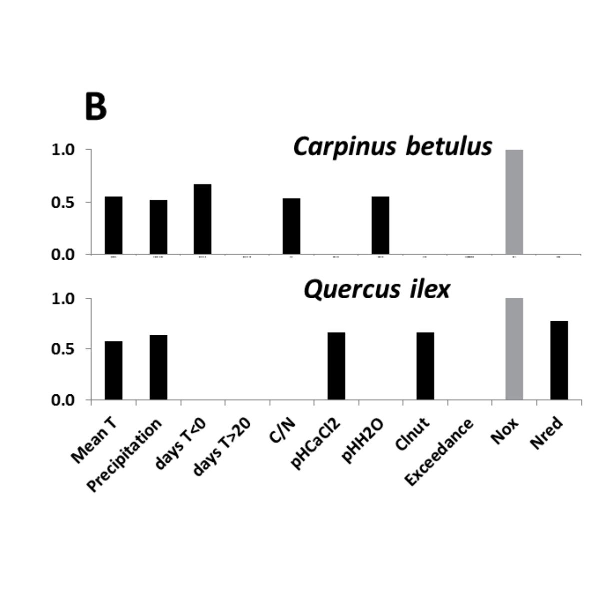


Figure 3.4. Predictor importance derived from Random Forests Analysis (RFA). A: Tree species with NHy-nitrogen deposition (N_{red}) as the most important predictor of defoliation. B: Tree species with NO_X-nitrogen deposition (N_{OX}) as the most important predictor (re-drawn in accordance with De Marco et al. 2014).

Tree health and crown condition

Research based on a large set of soil, foliar and defoliation data from the ICP Forests Level I network in combination with modelled climate and deposition data has shown the N deposition and climatic parameters to be important predictors of defoliation in several tree species (Fig. 3.4). Defoliation and discolouration were also related to the foliar N:P ratio. Nitrogen deposition was found to influence the foliar N:P ratio, supporting the idea of increased defoliation (or discoloration) with N deposition above a certain threshold.

ICP Forests intensive monitoring plots (Level II) permit more direct comparisons of crown condition with measured deposition data at the same sites, and recently published data shows that throughfall N deposition correlated positively with the proportion of European beech and Norway spruce trees displaying more than 25% defoliation, while the opposite was true for Scots pine. Furthermore, the share of trees showing more than 25% defoliation rose with increasing ratios of foliar N to other nutrients for all tree species considered, indicating nutrient imbalances.

Biodiversity

The composition of ground vegetation is largely determined by soil, climate and tree species, while a small, statistically significant effect is attributed to deposition. The effects of N deposition include a slight shift towards nitrophylous species at high levels of N deposition and possibly towards a homogenisation of the forest floor vegetation.

The replacement of oligotrophic species by eutrophic species in forest ground vegetation on a European scale is a gradual process, and no immediate response to exceedance of critical loads of N is discernible in terms of species richness or homogeneity. In the Czech Republic, a higher abundance of nitrophylous species was observed at sites with higher N concentrations in the upper mineral soil and the humus layer. An inventory of lichens on a large subset of Level II sites across Europe shows that the percentage of macro-lichens is largely explained by N deposition.

Walter Seidling

Marcus Schaub

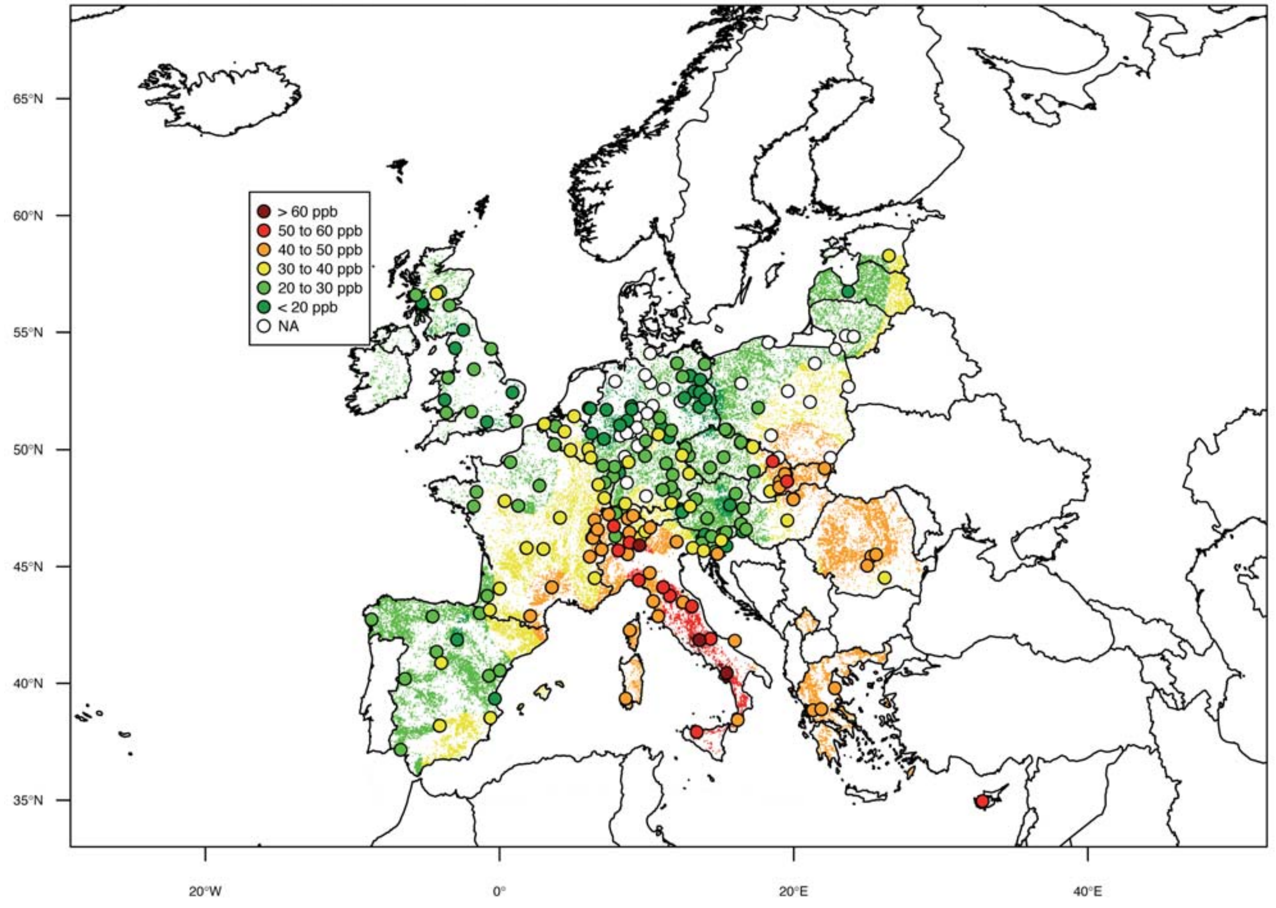


Figure 4.1. Spatial distribution of April - September mean ozone concentrations (ppb) measured using passive samplers in 20 countries from 2000 to 2013.

GROUND LEVEL OZONE AND ITS IMPACT ON EUROPEAN FORESTS

Marcus Schaub, Matthias Haeni, Marco Ferretti, Elena Gottardini, Vicent Calatayud

Tropospheric ozone (O_3) is a gaseous air pollutant that can impact forest vegetation, causing effects ranging from visible injury to reduced carbon sink strength of forest trees, and it is thus a priority for the UNECE Convention on Long-range Transboundary Air Pollution. Emissions associated with the burning of fossil fuel and biomass have approximately doubled the mean global tropospheric ozone concentrations, and further increases are expected over the course of the twenty-first century.

Ozone concentrations, exposure and trends

Most recent results from measurements made using passive samplers located on ICP Forests Level II sites across Europe reveal that seasonal mean ozone concentrations recorded in April-September from 2000 to 2013 ranged from 19 to 64 ppb, with an apparent north-south gradient (Fig. 4.1).

AOT40 ozone exposure (Accumulated concentrations Over a Threshold of 40 ppb, the regulatory air quality standard used in Europe to estimate the potential risk posed to vegetation) was assessed. Mean values of AOT40 for 2000-2013 ranged from 2 to 67 ppm h. The AOT40 threshold of 5 ppm h set to protect forests from adverse effects was exceeded in almost all countries (Fig. 4.2).

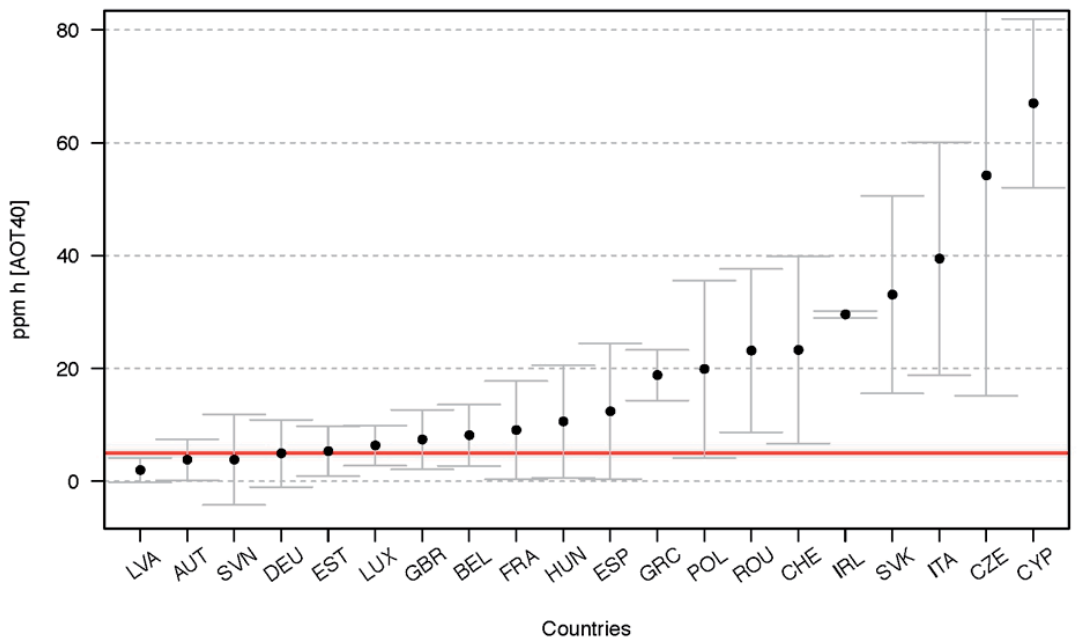


Figure 4.2. Mean AOT40 (ppm h) for 20 countries based on April - September passive ozone concentration values from 2000 to 2013. The red line identifies the Critical Level of 5 ppm h set to protect forest trees.

The overall decreasing trend of 0.35 ppb per year during the time period 2000 to 2013 (Fig. 4.3 and 4.4) matches the latest findings of the European Monitoring and Evaluation Programme (EMEP), which indicates that modelled maximum values decreased by 0.1 to 0.5 ppb per year for the April-September period in most of Europe during 2000 to 2012. This is also consistent with a number of studies reporting a flattening or even reduction in the ozone levels, most pronounced in summer. However, there are also European reports showing that there are no downwards trends in ground-level ozone concentrations.

The differing outputs from various trend reports demonstrate the difficulty of modelling concentration trends. This underlines the great value of long-term air pollution measurements made at the very forest site as a means of ensuring the greatest possible accuracy and in situ model validation.

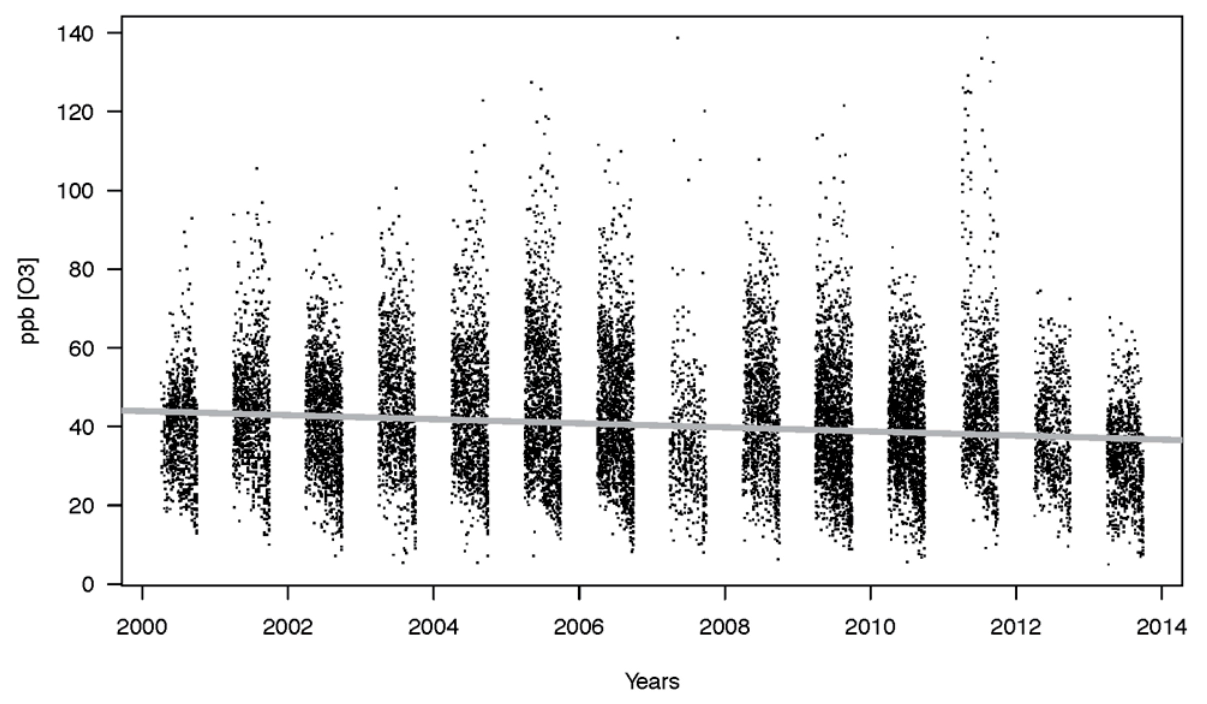


Figure 4.3. Scatter plot for ozone concentration (ppb) from passive samplers exposed in 20 countries from 2000 to 2013, showing a faint but significant decrease of 0.35 ppb per year (n = 29 356; p = 0.000).

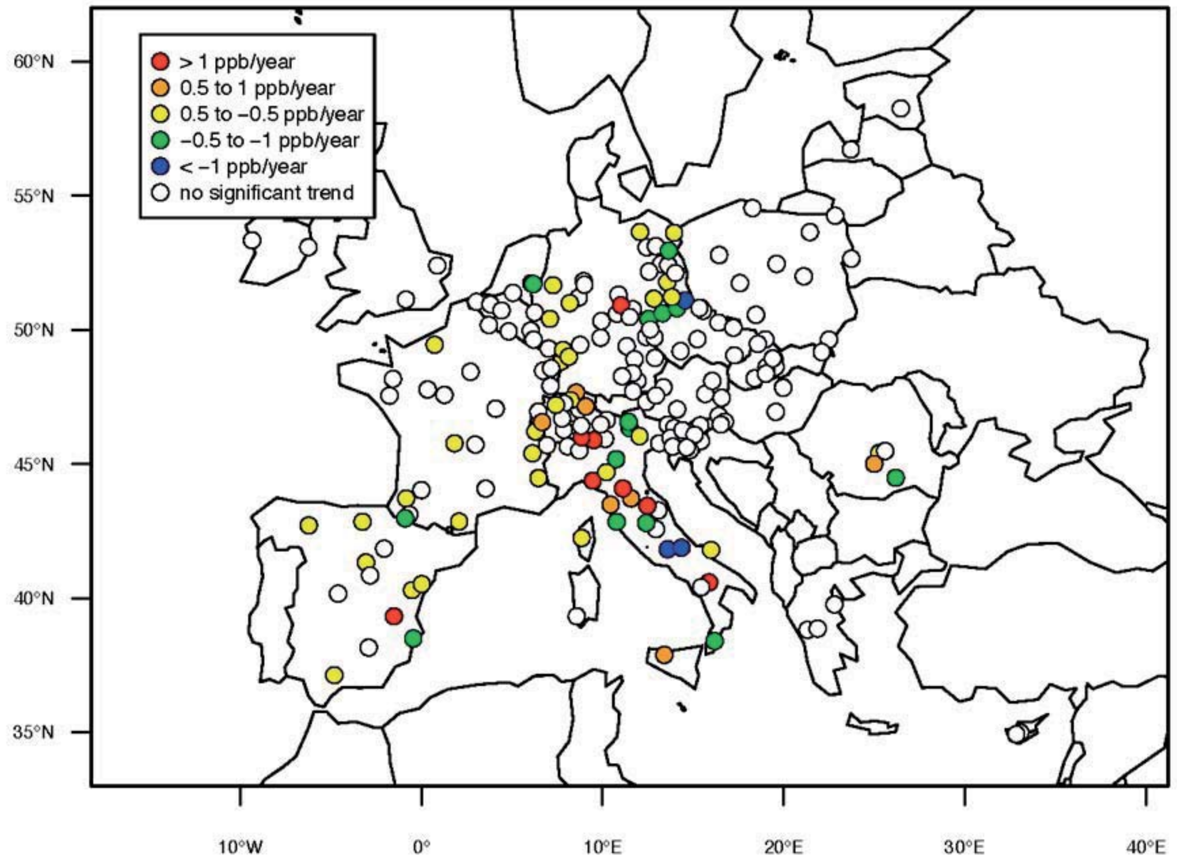


Figure 4.4. Spatial distribution of significant trends in weighted mean concentrations (ppb) on 214 sites with at least 6 years and 120 days per season data coverage between 2000 and 2013. Empty circles identify those plots for which trends could not be calculated (< 6 years of validated data).

Risk assessment at remote forest sites

Risk assessment at remote sites is often constrained by the limited availability of in situ data to estimate ozone exposure. Conventional monitoring of ground-level ozone is possible and/or affordable only on a very limited number of sites, and conventional monitors located in urban areas cannot be readily used to infer risk to forests. ICP Forests data offers a unique opportunity in this respect. There have been several attempts to estimate risk to European forests using ICP Forests data.

In a former European study with passive samplers placed on 81 Level II plots, concentrations during 2000–2004 ranged from 30–45 ppb at most of the stations. The highest ozone concentrations occurred in southern Europe, especially in northern Italy, southern Switzerland, and Spain. From 2000 to 2002, the AOT40 threshold of 5 ppm h to protect forests was exceeded at 77—100% of the same forest sites across France, Italy, Spain and Switzerland.

More recently, in the mountainous environment of Trentino in Italy, geo-statistical modelling and mapping has been applied on the basis of ozone concentration data collected from 2007 to 2011 by means of passive sampling on ICP Forests Level I plots over an area of 6207 km^2. Mean (May–July) concentrations ranged from 29.5-86.1 ppb, and the AOT40 risk threshold of 5 ppm h was exceeded on 90% of the study area. Considerable variability was found between AOT40 values at individual sites, even within the same EMEP grid cell.

Another study conducted in the Jizerské hory mountains in the Czech Republic in 2006 and 2007 recorded seasonal averages of 41.1 ppb in 2006 and 36.0 ppb in 2007. The AOT40 threshold of 5 ppm h was exceeded over the entire area — by up to 12 times in the upper portions of the mountains. Direct measurement of air pollutants at the intensive monitoring sites is therefore important in order to evaluate the risk for vegetation and to document spatial patterns, temporal variability, and trends in areas not covered by conventional air quality monitoring networks. It is also useful for providing a better understanding and quantification of processes of immission into European forest ecosystems.

The impact of ozone on forest vegetation

As a strong oxidant, ozone causes several types of visible symptom, including chlorosis and necrosis. It also decreases photosynthesis, leading to reduced plant growth and impairment to water-use efficiency and other functions. It has been estimated that enhanced ozone levels have led to a 7% decrease in forest biomass growth in the northern hemisphere. Plants weakened by ozone may also be more susceptible to pests, disease, and drought. Experimental studies show a high variability of different tree growth parameters in response to elevated ozone exposure. Despite the high variability in the reactions of different tree species, the overall impact seen in the experimental results shows a clear decline in growth in response to elevated ozone exposure. A reduced annual increment in Norway spruce and also a delay of growth activity for European beech exposed to double ambient levels were reported.

While the results of experimental studies conducted under controlled conditions make valuable contributions to our understanding of the mechanisms of ozone effects on forest trees, observational field studies on adult trees are also important, albeit more difficult to interpret. Although monitoring results at both national and European level show some statistical relationship between defoliation and ozone exposure, the effects generally appear limited, and they are not always consistent. For example, results from a study in the Czech Republic support the evidence that the current concentration of ground level ozone has a significant impact on the crown condition of Norway spruce, but not on that of beech, and yet the radial increments of beech were affected. A recent review of correlative studies based on monitoring data does not confirm the hypothesis that ambient ozone is generally a key factor explaining spatial and temporal changes in tree defoliation and forest growth in Europe.

Figure 4.5. Typical ozone-induced symptoms on Viburnum lantana.

Visible foliar symptoms are usually the first sign of the presence of phytotoxic ozone levels, and their measurement is a method of monitoring the potential impact of ozone on vegetation. From 2000 to 2002, a total of 65 species representing 52 genera were seen to be manifesting symptoms of ozone damage in Spain, Italy and Switzerland. Species showing symptoms were found on 47% of the common monitoring plots in 2001, and on 38% in 2002. However, the complex set of interactions (ozone levels, factors controlling the uptake, and defensive mechanisms) sometimes makes it difficult to establish a clear dose-response relationship between ozone and plant response under real conditions in the field.

For example, although critical levels were reported to have been exceeded by large amounts (AOT40 exposure index ranged from 12.7–28.5 ppm h ppb from 2005 to 2008) in the Jizerské hory mountains in the Czech Republic, foliar symptoms were observed only on *Rubus idaeus* and *Fagus sylvatica*, two species for which the role of confounding factors such as heat and high radiation can also be important.

One way of disentangling the complex interactions between species-specific sensitivity and environmental factors in order to assess the actual "net impact" of ambient ozone on plants growing on site in the forest may be the use of single species in situ bio-indicators. Studies conducted in Trentino, a mountainous region in northern Italy, used *Viburnum lantana* as an in situ bio-indicator to assess the frequency and temporal development of visible symptoms (Fig. 4.5) at sites subjected to different levels of ozone and the spatial distribution of symptoms in relation to ozone exposure.

Results showed that the temporal development of symptoms was consistent with the temporal development of AOT40, and that the number of plants displaying symptoms and symptomatic leaves per plant was significantly more frequent at sites with higher exposure, especially at elevations over 700m a.s.l. However, differences between the levels of symptoms displayed at the different sites were not always proportional to the differences in exposure.

THE FUTURE OF ICP FORESTS - OUR VISION, MISSION AND VALUES FOR THE YEARS TO COME

Michael Köhl, Chair of ICP Forests,
and the Programme Co-ordinating Group of ICP Forests

ICP Forests has become a very successful forest monitoring programme over the last 30 years. It has provided the bodies of the LRTAP Convention, political stakeholders, the scientific community, and the public with relevant information on the status of forest ecosystems and on processes within them with respect to transboundary air pollution and climate change, thereby improving the dialogue between the scientific and policy-making communities, and making scientific knowledge more accessible to policy makers and the public. As a result of the work of ICP Forests and other programmes under the LRTAP Convention, eight protocols containing legally binding targets for emission reductions and the prevention of air pollution in the UNECE region have successfully been adopted over time by the Parties to the Convention.

Our vision of the future of ICP Forests continues to be that of a pan-European forest monitoring infrastructure that integrates multiple levels and provides high quality, transparent, robust and open access data on

(i) the status and trends of forest health, vitality, productivity and biodiversity;

(ii) the risks of forests being exposed to anthropogenic and natural stressors (separately and in combination), and

(iii) progress in achieving the relevant policy goals to diminish risks.

In the years to come, ICP Forests will specifically focus on the following objectives and actions as specified in its new strategy for 2016-2023 which has been developed by the ICP Forests Programme Co-ordinating Group:

- **To intensify co-ordination** of national monitoring activities by offering a standardised infrastructure and facilities to potential users, including forest authorities, environmental agencies, and research institutions, enabling them to carry out additional research activities that complement the central purpose and data, thereby leading to improvements and/or extensions to the programme, such as additional long-term experimental monitoring sites.

- **To broaden the scope of monitoring activities** for the unique long-term data series of traits and processes in forest ecosystems by considering topics such as the effects of climate change, ecosystem services, biodiversity, and large-scale scientific investigations.

- **To follow-up on relevant international policy issues** and offer collaborative support by providing information and the scientific background for forest related policies and by giving advice to national and European policy-makers.

- **To strive for long-term financing** of activities, particularly the maintenance of the existing infrastructure and required staff and the exploring of further mechanisms for sustainable funding.

- **To increase the visibility** of the programme to improve acknowledgement and funding opportunities by organising scientific conferences and workshops (partly in co-operation with other ICPs and forestry organisations), by publishing peer-reviewed scientific articles in highly ranked journals, policy briefs, fact sheets, information bulletins, and in social media (internet blogs, ResearchGate, Facebook, etc.).

- **To foster a high quality and transparent database** and work towards open access to researchers and stakeholders.

- **To strive to maintain the used field measurement methods** at the latest state of technology in order to guarantee the high quality of data. A review of the Manual every five years and Expert Panel meetings will continuously promote awareness of the latest methodologies and instrumentation and discussion on them. The concept of core plots with more in depth investigations is to be further explored.

- **To explore new tools and technologies** (e.g. satellites, remote sensors, proximal sensing, new analytical instruments, modelling tools, information technology) and strive to incorporate them into the programme.

- **To use monitoring data to test** cause-effect relationships, long-term trend analyses, and modelling (calibration, parameterization, and validation), and to evaluate the effects of forest management and environmental policy stratgies.

- **To enhance co-operation with other ICPs** to promote integrated and cross-sectorial evaluations and reporting as well as unified measurement protocols e.g. through mutual funding and scientific conferences.

- **To stress the global importance of air pollution monitoring** and increase motivation for common activities by collaborating more closely with monitoring networks outside Europe, such as NADP (USA) and EANET (East Asia), and by inviting members from SEE and EECCA countries to join the ICP Forests network.

- **To encourage and increase future collaboration** on other research activities and with other monitoring platforms by promoting joint use of research infrastructures, open data access, data harmonisation, federated databases and large-scale scientific evaluations, hereby expanding the possibilities for an even more comprehensive terrestrial monitoring re search programme.

- **To supply information to other bodies and programmes** such as the FAO Forest Resources Assessment (FRA 2015 and its long-term strategy), the Ministerial Conference for Protection of Forests in Europe (Forest Europe), the UN Convention on Biological Diversity (CBD), the Framework Convention on Climate Change (UNFCCC), and other appropriate bodies, e.g. of the European Commission (EC).

For more information on the programme, please visit the ICP Forests website at http://icp-forests.net.

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