United Nations Economic Commission for Europe

Europe's Forests in a Changing Environment

Twenty years of Monitoring Forest Condition by ICP Forests

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Europe's Forests in a Changing Environment

Twenty years of Monitoring Forest Condition by ICP Forests

United Nations Economic Commission for Europe

Convention on Long-range Transboundary Air Pollution

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

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WWW.ICP-FORESTS.ORG

Task Force Meeting 1999, Lithuania.

1. Introduction

Forests and their sustainable management are high on the agenda of many international and national policies. In order to be sustainable, forest management needs information on the factors influencing forest condition. This is provided by the long-term, large scale and intensive monitoring of forest condition that has been carried out for 20 years jointly by ICP Forests under the Convention on Long-range Transboundary Air Pollution (CLRTAP) and the European Union.

In times of short-term political interests and limited funds, 20 years of continuous and harmonised forest monitoring on the European-wide scale is a considerable success per se. But ICP Forests is even expanding. In the past few years, Cyprus, Serbia and Montenegro, Andorra and Moldova have joined the programme, which now involves 41 countries. Also, contacts to programmes outside the Convention, notably to the Acid Deposition Monitoring Network in East Asia and to programmes in the United States of America and Canada, underline that forest condition is a matter of concern for many governments. An important partner of ICP Forests remains the European Commission. With its Forest Focus programme, the legal basis of forest monitoring in 25 European Union countries has been created. The backbone of the programme is formed by the people involved in the work. More than 200 scientists at national and international level contribute directly or indirectly to its success.

The basic idea is that the data assessed are of direct relevance not only at the European level but also for national and regional policies. This brochure therefore aims to document the political, scientific and organisational background of the national programmes, to compile the main national results obtained over such a long period and finally to elucidate the future plans of the national governments. In addition, it includes information on the Expert Panels and Working Groups of ICP Forests as well as on its three Coordinating Centres.

In order to give a complete picture, the most relevant results of the transnational evaluations of ICP Forests are also added in brief. For more detailed information it is recommended to consult the annual Forest Condition Reports (see also www.icp-forests.org).

2. From forest decline monitoring to a multifunctional network – a short history of the programme

International Co-operative Programme

on

Assessment and Monitoring of Air Pollution
Effects on Forests in the ECE Region

MINUTES OF THE FIRST MEETING OF THE PROGRAMME TASK FORCE
4 October 1985, Freiburg, Federal Republic of Germany

Prepared by the ECE Secretariat in consultation
with the Chairman

1. The first meeting of the Programme Task Force for the International Co-operative Programme on the assessment and monitoring of air pollution effects on forests in the ECE region was convened in Freiburg-im-Breisgau (Federal Republic of Germany) on 4 October 1985 by the Federal Republic of Germany, lead country of the Programme Task Force.

2. The meeting was attended by experts from the following Parties to the Convention: Austria; Canada; Czechoslovakia; Denmark; Finland; Germany, Federal Republic of; Hungary; Netherlands; Sweden; Switzerland; United Kingdom; United States of America; and the European Economic Community (EEC). Representatives of the United Nations Environment Programme (UNEP) and the Food and Agricultural Organisation (FAO) were also present.

Minutes of the first ICP Forests Task Force Meeting, 1985.

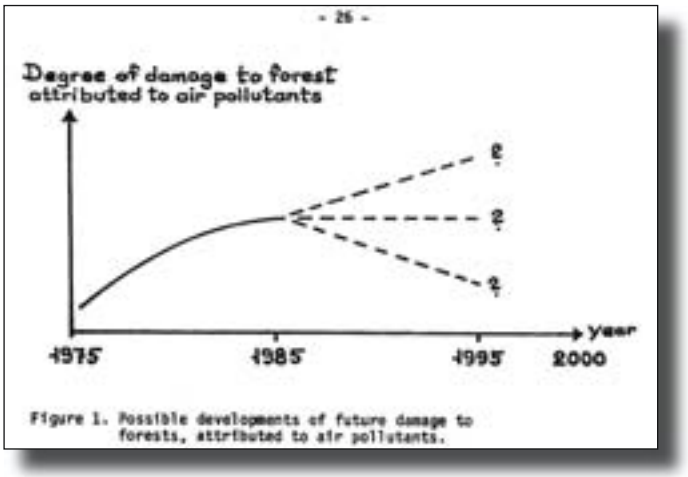
Forest damage of previously unknown extent and intensity was observed on silver fir (*Abies alba*) in the 1970s, and later on also on other coniferous tree species in Central Europe. This was the starting point for international efforts aiming at the setting up of a harmonised forest monitoring system in order to provide policy makers with reliable figures on forest condition in Europe. The political framework for this engagement was set with the signature of the Convention on Long-range Transboundary Air Pollution (CLRTAP) in 1979 and with its entering into force on 16 March 1983.

Major inputs for the development of harmonised methods were given by a Working Group of the European Forestry Commission of the Food and Agriculture Organisation (FAO) at a workshop held in Geneva in April 1983. This Working Group stated that "serious concern exists in most countries of Europe and Northern America over the impact of air pollution on forests". A number of concrete measures were suggested.

The basis for today's ICP Forests Manual on Methods for Harmonised Monitoring of Forest Condition was laid at an ad hoc working group meeting of the European Forestry Commission in Freiburg (Germany) in June 1984. Following an agreement by the Executive Body of the CLRTAP in December 1984, ICP Forests was born with its first Task Force Meeting held on 4 October 1985 in Freiburg. Since then, it has been operating under the Working Group on Effects under the Geneva Convention. Soon after, on 23 December 1985, contracts for the coordination of the programme were signed by the Executive Secretary of the ECE, Mr. Brian Duke, and the directors of two Programme Coordinating Centres in Hamburg (Mr. Noack) and Prague (Mr. Chrast). The first major task of the Coordinating Centres was the elaboration of the Manual, which was adopted at the 2nd Task Force meeting, again in Freiburg, in May 1986. Also in this year, the European Union adopted Regulation No. 3528/86, which was the legal basis for its scheme on the Protection of Forests against Atmospheric Pollution.

The first Forest Condition Report was adopted in 1987 at the third Task Force Meeting of ICP Forests in Usti nad Labem (Czech Republic). The report mainly focussed on results of the large-scale crown condition assessments. The European Commission also produced a report on the results for the EU Member States. It was not before 1992 that the first joint EU/ICP Forests report on forest condition in Europe was published. After 12 joint reports, the European Commission decided in 2004 that the Forest Condition Report

Mr. Ernst Wermann, first Chairman of ICP Forests from 1985 to 2000 giving a television interview at the Task Force Meeting 1989 in Finland, together with Mr. Kai Panzer, Head of the Programme Coordinating Centre in Hamburg from 1985 to 1992 (left) and Mr. Pekka Kauppi (centre), delegate of the host country.



How would the damage develop? Graph from the UNECE document "Implications of Air Pollution Damage to Forests for Roundwood Supply and Forest Products Markets: Study on the Extent of Damage" (TIM/R. 124/Add.1), 1986.

should be again only published as an ICP Forests report.

The annual large-scale crown condition assessment was the first monitoring activity within ICP Forests and is still a major component today. Important progress was made with the first European forest soil condition survey, which was coordinated by the Forest Soil Coordinating Centre in Gent (Belgium). The Soil Condition Report was published in 1997 and was received with great attention. On a large number of Level I plots, the chemical content of the foliage was analysed. This survey was organised by the Forest Foliar Coordinating Centre in Vienna (Austria) under its chairman Mr. Klaus Stefan.

Another important milestone for the programme was the adoption of Resolution Nr. 1 of the Ministerial Conference for the Protection of Forests in Europe (MCPFE) in Strasbourg in December 1990. This gave the political impetus to implement the so-called Level II Intensive Monitoring Programme. It took another four years before the European Commission, with Regulation No. 1091/1994, adopted the legal basis for the Level II programme. Step by step, 860 intensive monitoring plots were established in 28 countries. The Forest Intensive Monitoring Coordinating Institute (FIMCI) was a Dutch consortium established by Alterra Green World (Mr. de Vries) and Oranjewoud (Mr. Vel), and was responsible for the coordination and data management of the Level II programme from 1995 until 2002. Scientific steering was ensured by the Scientific Advisory Group led by Mr. Guy Landmann, which also ended its work in 2002 with the termination of EU Regulation No. 3528/86. On the EU level, Regulation No. 2152/2003 (Forest Focus) has ensured the continuation of the monitoring program since 2003.

Today, 41 countries including the United States of America and Canada are active within ICP Forests and a close cooperation has been established with the Acid Deposition Monitoring Network in East Asia (EANET). The main pillars of ICP Forests are 9 Expert Panels and Working Groups in which experts of the participating countries are developing and updating methods. They are also responsible for the steering of common projects and for the integrated set-up of the programme. The broad participation of the countries and the engagement of its experts will guarantee the success of the programme also in the future.

3. Monitoring Plots and Infrastructure

The structure of ICP Forests is based on three main pillars. These are (i) the large scale Level I monitoring net, (ii) the Intensive Monitoring Programme and (iii) a strong institutional infrastructure for scientists, experts and delegates of the participating countries.

A large-scale overview of forest condition

The first objective of the programme is *"to provide a periodic overview on the spatial and temporal variation in forest condition in relation to anthropogenic and natural stress factors in an European and national large-scale systematic network (Level I)".*

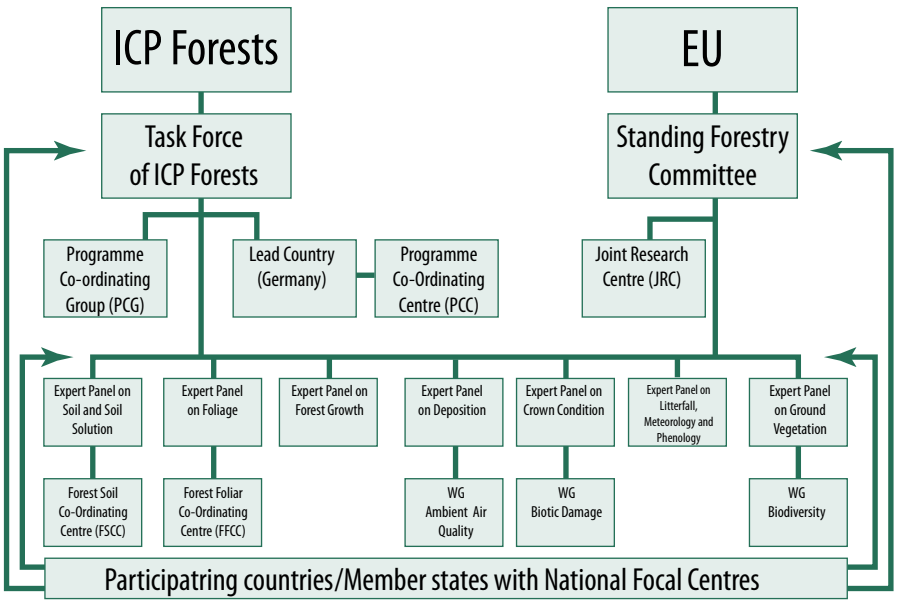
Following this objective, the Level I monitoring gridnet has been implemented since the 1980s and today comprises more than 6,000 permanent observation points arranged in a 16x16 km grid in 33 countries throughout Europe. At each plot, the crown condition of a fixed number of trees is assessed annually in terms of defoliation. This parameter estimates the lack of needles or leaves in comparison with an undamaged tree. Defoliation is an unspecific parameter that responds to many factors and is comparatively easy to assess on a large number of trees. At Level I plots, soil chemical parameters have also been assessed, and in some countries chemical foliage analyses have also been conducted. A repetition of the soil survey is presently under preparation.

Relationships between forest condition and influencing stress factors

The second objective of the programme is *"to contribute to a better understanding of the relationships between the condition of forest ecosystems and stress factors, in particular air pollution, through intensive monitoring in a number of selected permanent observation plots spread across Europe (Level II)".*

Starting at the beginning of the 1990s, so-called Level II intensive monitoring plots have been installed in the most important forest ecosystems of 28 participating countries. The plots are equipped with a larger number of measurement installations, which enable surveys of atmospheric deposition, ambient air quality, soil and soil solution, meteorology, forest growth, and litterfall. Ground vegetation and crown condition are also assessed at Level II and foliar analyses are conducted. On an optional basis, phenology is assessed. The set-up enables correlative studies in order to find out about the influence of various stress factors and the forest ecosystems' reactions.

Additional objectives of the programme aim at the calculation of critical loads, at collaboration with other environmental programmes, at contributions in the fields of biodiversity and climate change monitoring, and at informing policy makers and the public.

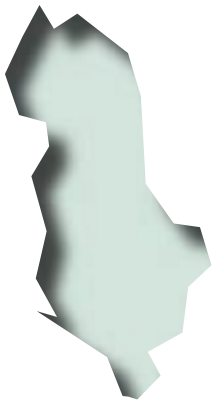


Present programme structure of ICP Forests and its cooperation with the EU.

Participating countries and national experts are the knowledge base of the programme

The Task Force is the programme's highest body. It is composed of delegates of all participating countries and is chaired by Germany as Lead Country. The European Commission is also represented. The scientific backbone of ICP Forests is its Expert Panels and Working Groups. Here, the national experts and leaders of the surveys meet regularly in order to ensure the continuous harmonisation and development of monitoring methods. The monitoring methodology is documented in a Manual, which is elaborated by the Expert Panels and adopted by the Task Force. With a growing database, the integrated evaluation and steering of common projects are also on the agenda of the Expert Panels. The close collaboration with the EU is documented in the fact that the European Commission with its Standing Forestry Committee also relies on the scientific support of these panels.

4. Country reports



ALBANIA

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Pinus heldreichii **trees in the south-east of Albania.**

Background information

Forest condition monitoring started in Albania in 1998 with the financial support of a World Bank Forestry Project. Since 2002, the monitoring has been financially supported by the Ministry of the Environment. A summary of the monitoring results is published on the web site of the Ministry of the Environment each year.

Main results

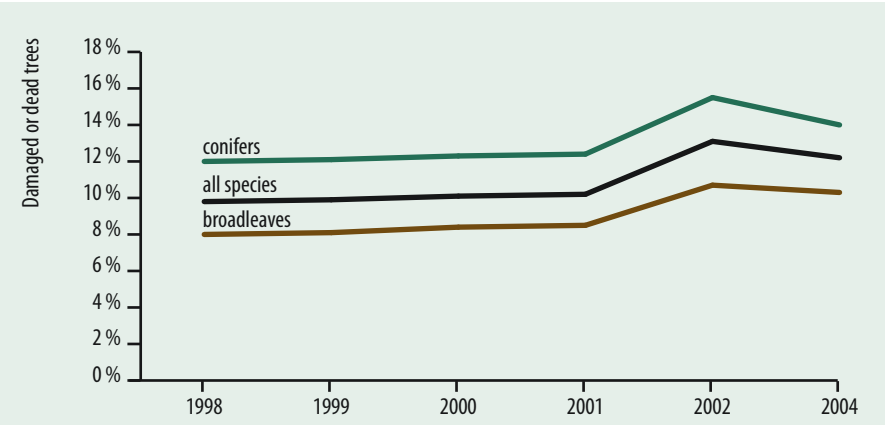
Due to limited funds, only Level I plots have been set up in Albania. Currently, there are 299 plots in a 10x10 km grid in the country.

The main species assessed include Austrian black pine, beech, and European oak, as well as poplar and fir species. The condition of the Albanian forests in general is evaluated based on the defoliation and discolouration of the forest trees. Results indicate that the condition of conifers is more problematic than that of broadleaves. Among the coniferous and broadleaved species, black pine and European oak show the highest percentages of discolouration and defoliation.

Outlook

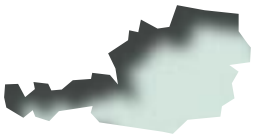
Albania will continue the Level I monitoring with the objective of also setting up Level II plots in the near future. It will be of high priority as well to make the results of the forest monitoring available to the public.

Albanian sustainable forest management will aim to combine the monitoring activities with the "ecosystem approach", which is nowadays widely promoted by the Ministerial Conference on the Protection of Forests in Europe (MCPFE) and the Convention on Biological Diversity (CBD).



Defoliation of conifers and broadleaves in Albania

AUSTRIA



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Inner Alpine valley (Zillertal).

Background information

Faced with forest dieback reports in Austria, a large-scale crown condition survey on a 4x4 km grid was started in 1984 on about 2,200 sample plots. As there was no important change through time, neither in the extent nor in the regional pattern of damage symptoms, the grid density was reduced to 534 plots in 1989. The range of assessments was, however, extended in order to obtain more information on the influence of air pollution, pathogens, insects and abiotic stresses on forest ecosystems. In 2003, it was decided to reduce the large-scale crown condition survey to the transnational 16x16 km grid with about 130 sample plots. Since 1986, Austria has participated in ICP Forests. In 1990, Austria joined the EU forest health survey under Regulation No. 3528/86. The Level II monitoring programme was established with 20 plots in 1995.

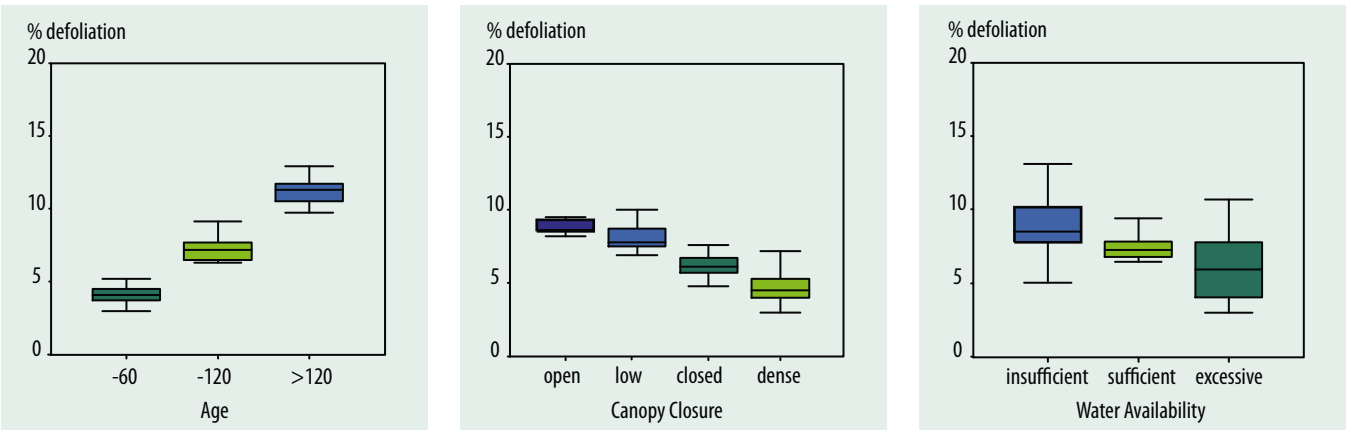
Main results

Crown condition did not change remarkably during the 20 year survey period. Overall, up to the year 2000 there seemed to be a slight recovery, but since then a slight deterioration has been observed. The latter might be influenced by adverse weather conditions, i.e. lack of precipitation. Out of all observed species, oak showed the highest degree of defoliation, followed by silver fir. More detailed investigations on the relationship between stand and site criteria and crown condition were carried out for Norway spruce as the most frequent tree species, covering 70% of Austria's forests. Higher defoliation was found in stands with higher age, stands with low density and stands with insufficient or irregular water supply (see Figure).

Since 1996, sampling of wet deposition has been performed on all 20 Level II plots. Mean pH values were below the "natural pH" of 5.6 at all plots. Overall concentrations and deposition rates were low, although critical loads for nitrogen were exceeded in some cases at single plots. The mean deposition at all 20 plots during the monitoring period was about 5 kg sulphur and 6.9 kg nitrogen per hectare and year. The overall trend of sulphur and nitrogen deposition rates was decreasing.

Outlook

The condition of forests is determined by numerous environmental influences. The effects of these factors vary greatly over space and time. In order to understand the complexity of causal relationships within forest ecosystems, the measurements need to be continued or even intensified. However, the need for intensified research is often not acknowledged with an increase in resources. Therefore, the existing programme has to be evaluated periodically to assure effective forest monitoring in the future.



Mean defoliation by stand and site criteria (common sample trees of Norway spruce).

BELARUS

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Background information

The forest condition monitoring grid net installed according to the ICP Forests methods is the only representative one in Belarus. Today it is based on 1,212 Level I plots. Moreover, there are small local monitoring grids around industrial centres. There are also 80 Level II monitoring plots, but their surveys are limited to crown condition, biotic and abiotic damage factors, tree growth and ground vegetation assessments. Soils are studied on all plots. In the far south–west of the country, which is most exposed to transboundary air pollution, and in the Berezina biosphere reserve in the north-east, Level II plots coincide with stations of the complex background monitoring of the EMEP programme.

Main results of 14 years' monitoring

Mean annual sulphur inputs vary from 8 kg per hectare and year in the south–west to 5kg in the north-east of the country, which amounts to 30%-40% of the deposition levels of the 1980s. Total nitrogen deposition in 2003 varied from 8 kg/ha to 4 kg/ha. Most of the forest ecosystems grow on sandy soils and thus have a low tolerance towards acid atmospheric inputs. 70% of mineral soils in the forests belong to the textural classes "sand" and "loamy sand". Only 1% of the plots have calcareous soils and 5% of the plots have weakly acid soils with pH above 4.6.

Crown condition has been proven to be a valuable indicator to reflect the effect of different stressors on most of the tree species. In Belarus, the most important stressors are weather extremes. Frequent droughts in combination with insect calamities are linked to high defoliation and lower wood increment even in the most productive stands of Norway spruce. Frost events at the beginning of the vegetation period and, possibly, severe winters are stress factors for European oak and for ash in the northern part of Belarus. During the past 12 years the tree mortality at the observed plots was 4 times higher for spruce and 3 times higher for ash and oak compared to Scots pine.

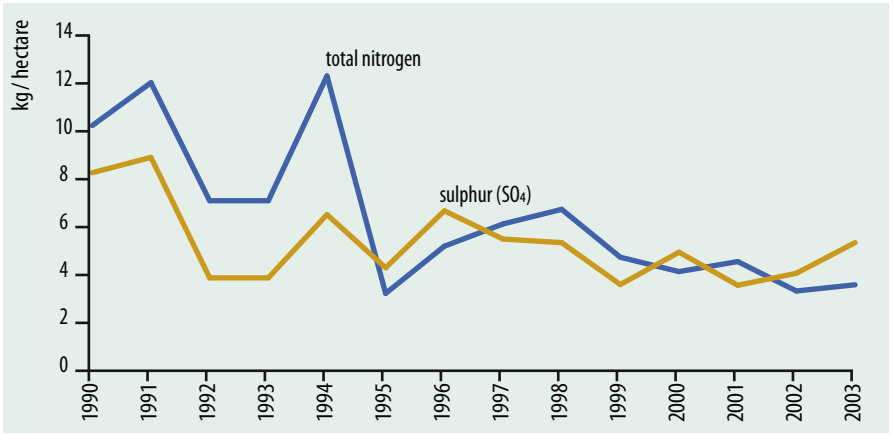
Outlook

Belarus will continue the policy of changing from oil to natural gas. This also covers the petrol and diesel sectors. Therefore, an increase in the low levels of acid deposition is not expected.

Forest policy will also in the future promote sustainable forest management in order to overcome adverse natural influences and past unsuitable practices in the field of forestry.

The forest monitoring programme has to reflect processes in the forests and the effectiveness of forest policy measures. Pollution by heavy metals will also be studied, particularly in zones that are contaminated by radioactivity. The plots will also be the basis for the monitoring of biodiversity and for the integrated monitoring of forest ecosystems.

Monitoring plot in north-eastern Belarus.



Deposition trends at the Berensina intensive monitoring plot.

BELGIUM Flemish Region

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Forest condition monitoring in Belgium – Flanders started in 1987.

Background information

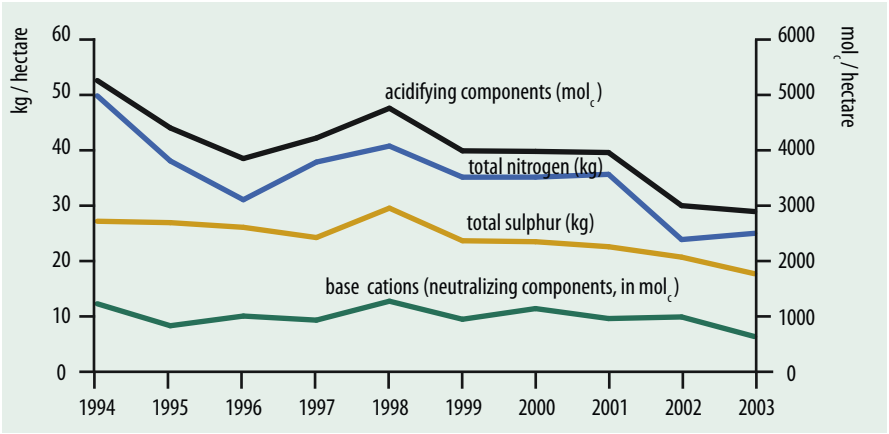
Forest condition monitoring in Belgium Flemish Region started in 1987 in order to describe the condition and the evolution of Flemish forests and to gain insight in influencing factors. Today, the monitoring programme is based on 72 Level I plots in a regional 4x4 km grid, 11 Level II plots and a measuring tower for gaseous pollutants and forest meteorology. Links to other research groups have been established. The results of the monitoring programme are published annually.

Main results

- In the early 1990s, nitrogen was the prevailing parameter in atmospheric deposition in Flanders. The dominance of nitrogen was due to the high ammonium level. The total sulphur deposition in this period averaged 27 kg sulphur per hectare and year. By 2003, there had been a 35% reduction in sulphur deposition, while total nitrogen deposition had, remarkably, been reduced by 50%.
- Monitoring of gaseous air pollutants also revealed a decreasing trend for sulphur dioxide. Ozone levels, however, showed a steady increase. For nitrogen oxides no clear trend could be discerned.
- In forests exposed to a high nitrogen load, nitrate leaching has been observed, and nitrate losses were related to atmospheric inputs. Despite the decreasing trends in deposition, critical loads of nitrogen and sulphur are still exceeded in many forest areas.
- Crown condition is affected by a number of factors, like weather conditions, insect infestations and fungal diseases. Mean defoliation increased during the first 10 years of the survey. From 1997 on, crown condition has remained more or less stable with a share of damaged trees between 20 and 25%.

Outlook

The forest monitoring programme provides important information on ecological changes and is a suitable tool for investigating the effectiveness of policy measures. The programme will, therefore, be continued. The focus for the near future will be on the development of target loads and the second soil survey on the Level I grid.



Trends for mean total deposition at 5 Level II plots in Belgium-Flanders (1994-2003).

BELGIUM Walloon Region

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Background information

The condition of 478,000 ha of forest stands is monitored in Wallonia under ICP Forests on an 8x8 km grid, with more than 60 plots and 1,500 trees. Nine plots are under intensive monitoring in beech, spruce and oak stands.

Main results

Thanks to sulphur dioxide and nitrogen emission reductions, sulphur deposition in forests has decreased by 50% compared to 20 years ago. Since 1997, it is around 9 kg per hectare and year. For nitrogen oxides and ammonium, deposition has stabilized at 4.9 kg/ha/yr and 6.8 kg/ha/yr of nitrogen, respectively. These inputs change the nutrient situation of forest trees and ecosystems. They imply risks of nutrient deficiencies and are related to nutrient leaching from poor soils. Soil analyses at intensive monitoring plots and within the regional forest inventory show that about 70% of soils are too acid and half of the analysed soils show deficiencies for calcium and magnesium.

These conditions, combined with climatic events or pests and diseases, explain the average levels of defoliation and discoloration, and the year-to-year variations observed since 1989 (see Figure).

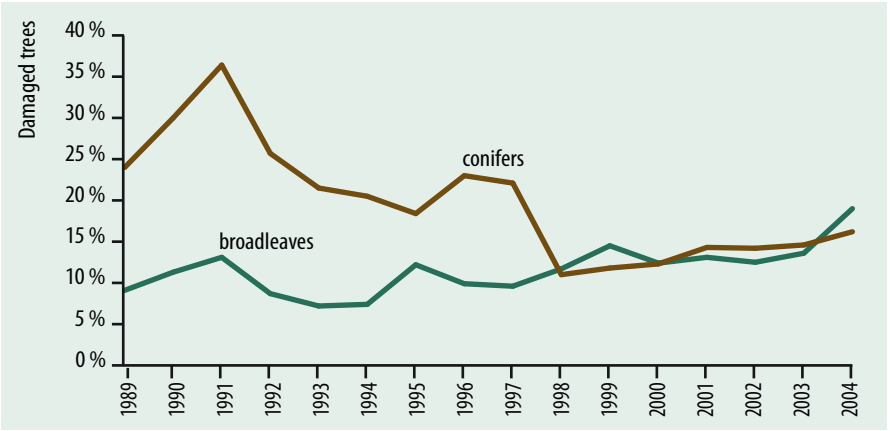
The percentage of damaged trees decreased for conifers until 1998 but has been increasing again since then. For broadleaved tree species, a rather steady increase has been observed since the beginning of the 1990s. Identifiable damage causes occur annually on less than 10% of the trees. Nevertheless, insects and, sometimes, fungi and abiotic agents like weather extremes, can partly explain the annual changes of defoliation. The high level for conifers in the early 1990s was due to storm damage, followed by bark beetle attacks. High caterpillar populations on oaks as well as the drought in 2003 are related to the increasing share of damaged broadleaves. Beech stands have suffered under harsh frost that was also followed by beetle (*Xyloterus* spp) and fungal attacks in the years 2000 to 2002.

Outlook

Forest condition monitoring will continue. A special emphasis will be laid on the analysis of forest soils in the regional forest inventory with a planned repetition on part of the plots every 10 years.

Additional measures planned comprise (i) the further reduction of air pollution by means of a regional 'Plan Air' which has already been adopted, (ii) the adaptation of forest practices in sensitive ecosystems, including an improved tree species choice and mixture, stronger thinnings and lower densities, and in some cases the stop of economically oriented forestry, and (iii) the liming under strict conditions of soils and stands with an unbalanced nutrient situation, avoiding adverse effects on water quality and biodiversity.

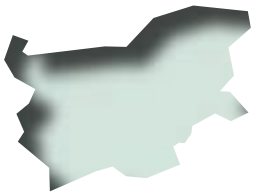
Cleaning deposition samplers in the Walloon region.



Percentage of trees in defoliation classes 2 to 4.

Open field station of an Intensive Monitoring Plot with automatic equipment for dry deposition and wet only sampling.

BULGARIA



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Background information

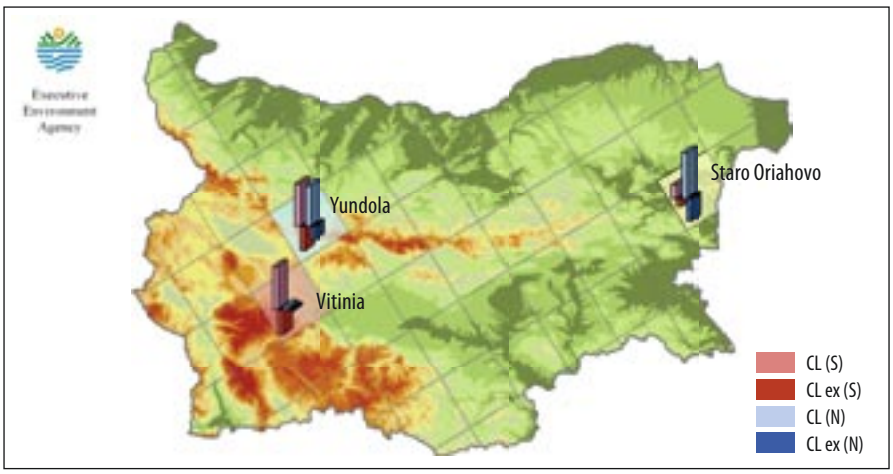
In Bulgaria, forest condition monitoring started 18 years ago on 256 Level I plots. Since 2003, intensive monitoring has been carried out on 5 plots. The results are included in annual bulletins and reports on the state of the environment in Bulgaria. An efficient collaboration between the responsible Bulgarian governmental institutions and the national forest research community has been established.

Main results

The crown condition data for the period 1994-2004 showed negative statistical trends for 51% of the observed trees. The regions with improvements, worsening and no changes in forest condition were mapped. Soils, in general, have not been affected by acid deposition. In most catchments, the measured pH in the forest soils was between 6.5 and 7.5. However, critical loads for heavy metals like lead and cadmium have been exceeded even at remote plots. Ozone concentrations were frequently beyond critical levels. This shows the risk for negative impacts. Critical loads for sulfur and nitrogen were not exceeded at any of the three evaluated Level II plots.

Outlook

The monitoring of forest ecosystems in Bulgaria will continue. So far, the programme has provided regular information about forest condition in relation to environmental stress factors. In the future too, knowledge about damage mechanisms will help responsible forest and governmental institutions to make strategic decisions and to manage Bulgarian forests sustainably.



Station	CL (S)	CL ex (S)	CL (N)	CL ex (N)
Yundola	3110	-1832	233	-163
Vitinia	1126	-644	1075	-361
Staro Oriahovo	1134	-602	3685	-1789

Critical loads (CL) and their exceedances (CL ex) for nitrogen (N)and sulphur (S) at forest monitoring plots in Bulgaria.

CANADA

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Background information

The Acid Rain Early Warning System (ARNEWS) was established in 1984 by the Canadian Forest Service (CFS) to detect signs of damage to Canadian forests and to monitor changes in forest vegetation and soils. In 1988, the North American Maple Project (NAMP) was established, in cooperation with the United States, to monitor the condition of sugar maple (*Acer saccharum* Marsh.) across north-eastern North America. Both ARNEWS and NAMP ceased as monitoring networks in 1997. CFS plans to integrate forest health monitoring with the new National Forest Inventory, which is being implemented in cooperation with the provinces and territories. This plot-based inventory allows measurement, nationally, of ecological change over time. This ability to measure change over time was not possible with previous inventory and monitoring systems.

Environment Canada, through the Canadian Air Precipitation Monitoring Network (CAPMON) measures the occurrence and distribution of air pollutants such as nitrates and sulphates. Both Québec and Ontario have monitoring networks looking at impacts of acid rain. Canada has published national Acid Rain Assessment Reports in 1990 and 1997, and the most recent assessment was released in early 2005.

Main results

- By 2000, there had been a 48% reduction in sulphur dioxide emissions compared to 1980. Nitrogen oxide emissions have been relatively constant since 1990.
- Net losses of basic cations from forested catchments in eastern Canada are widespread, particularly for calcium. Recent studies support the relationship between loss of basic cations from acidified soils and reduced growth rates and health of trees.
- In most eastern Canadian forested catchments, the release of sulphate into surface waters exceeds the amount of sulphate received via acid deposition. Likely sources of this "extra" sulphate are desorption of sulphate bound to soil and/or release of sulphate during the decomposition of organic matter.
- Nitrogen saturation does not appear to be a problem at most eastern Canadian sites; however, the long-term impact of chronic nitrogen inputs is uncertain and remains a major concern.
- There is a clear correlation between loss of tree productivity and exceedances of critical loads of sulphate and nitrate.
- Cumulative threats from ozone and acid rain are of increasing concern.

Field technicians taking a soil sample and assessing crown condition at a forest health plot in eastern Canada.

Outlook

Research will continue into the development of critical loads for sensitive forest ecosystems incorporating harvest scenarios into the calculations. Joint efforts with the US on impacts of elevated levels of ground-level ozone on sensitive forest ecosystems will continue. The new National Forest Inventory will increasingly provide data to monitor and track changes in the health of Canadian Forest ecosystems.

CROATIA

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Silver fir dieback in Gorski kotar, western Croatia.

Background information

For silver fir, reports on forest dieback in Croatia date back to the year 1900. There have been repeated reports until today. However, the first systematic monitoring started when Croatia joined ICP Forests in 1987. The monitoring programme is carried out in cooperation with the Forestry Faculty of the University of Zagreb and Croatian Forests Ltd. The monitoring is conducted on 87 Level I plots and 7 intensive monitoring plots. Silver fir and common oak (along with common beech) are the most widely distributed and the most important tree species in Croatia from an ecological and economic point of view. Therefore, their high defoliation is a matter of great concern.

Main results

Crown condition in Croatia is heavily influenced by environmental stress. Statistically it is related to the groundwater level (*common oak*), drought (silver fir), age (oaks), exposition (black pine and sessile oak) and height above sea level (common oak, silver fir, common beech and narrow-leaved ash).

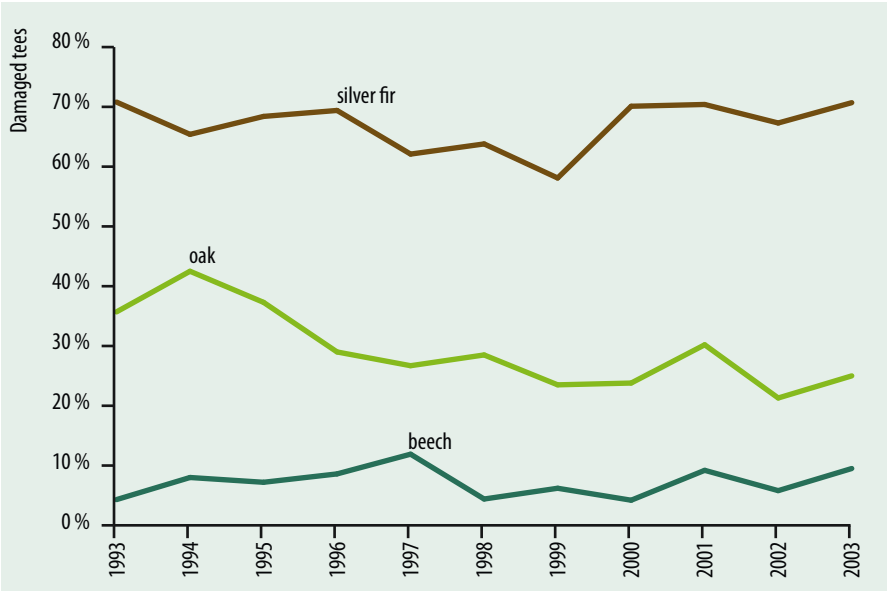
The foliage is sampled annually on Level II plots. The results of foliar analysis show a clear link between foliar chemistry and the crown condition of silver fir.

The importance of long-range transport of industrial pollutants into otherwise unpolluted forests was revealed through deposition monitoring. Elevated sulphur deposition was e.g. found in a non-industrial area of beech and fir forests in Gorski kotar (western Croatia).

Outlook

Although the crown condition of some important tree species is poor, the practice of sustainable, close-to-nature forest management, as well as the enforcement of environmental laws, helps to protect the stability of the forest ecosystems in Croatia.

A challenge for the condition of Croatian forests is the opening of new motorways and the expected increase in traffic-related pollution.



Percentage of moderately to severely damaged trees (defoliation classes 2 and 3).

CYPRUS

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Background information

The forest condition monitoring programme was started in Cyprus in 2001 and is today based on 15 Level I and 4 Level II plots, covering the main forest ecosystems of the island. A close link has been developed with the National Forest Inventory, with the National Meteorological Service and with various research groups.

The Forest Department was designated as the National Focal Point and is responsible for the implementation of the programme and for the evaluation and storage of the data. The data collected until today refer to the years 2001-2004 for the Level I plots, and 2003-2004 for the Level II plots.

Main Results

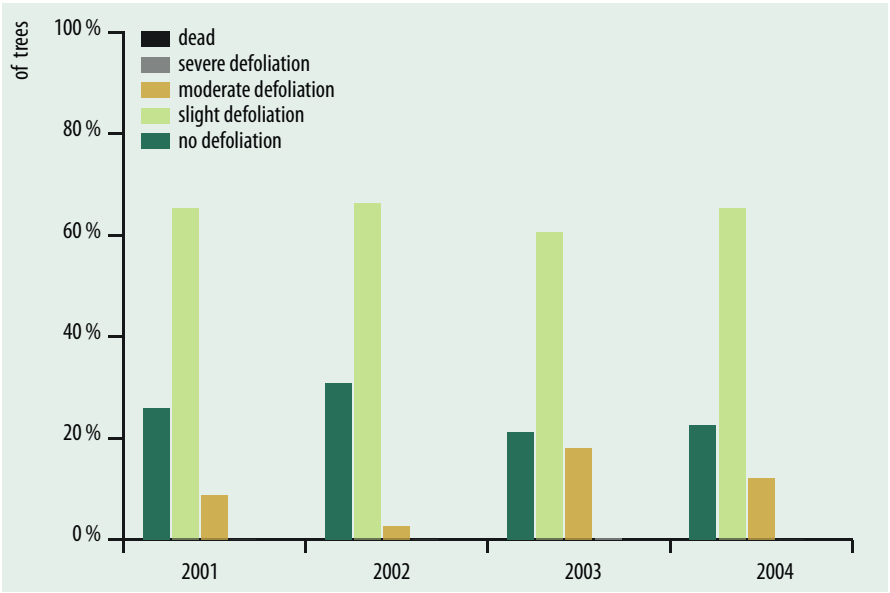
The results of the four years of the forest condition monitoring programme are indicative of the condition of the forests of Cyprus.

- Crown condition is rather stable, and the main factors causing defoliation are drought stress and insects.
- Ozone is found at high concentrations and visible injuries have been detected on some species.
- Results for deposition show a stable situation with values not indicating high levels of pollution in the forests.
- An additional threat is forest fire.

Outlook

Forest policy in Cyprus aims at the promotion of sustainable forest management in order to ensure ecological, social and economic benefits, even under changing environmental conditions.

The four years of the forest monitoring programme have provided large amounts of valuable data. Cyprus will continue the programme as an important tool in providing essential information on the prevailing conditions and changes in the forest ecosystems. This information is important for sustainable management and for the evaluation of the effectiveness of the policy measures taken as well. Forest monitoring will be further developed to include surveys of forest soils, biodiversity, carbon stocks and plant phenology. Special focus will be put on the impacts of elevated levels of ground-level ozone on forest ecosystems.



Crown defoliation trends at the 15 Level I plots in Cyprus (2001-2004).

Monitoring plot in Cyprus.

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Background information

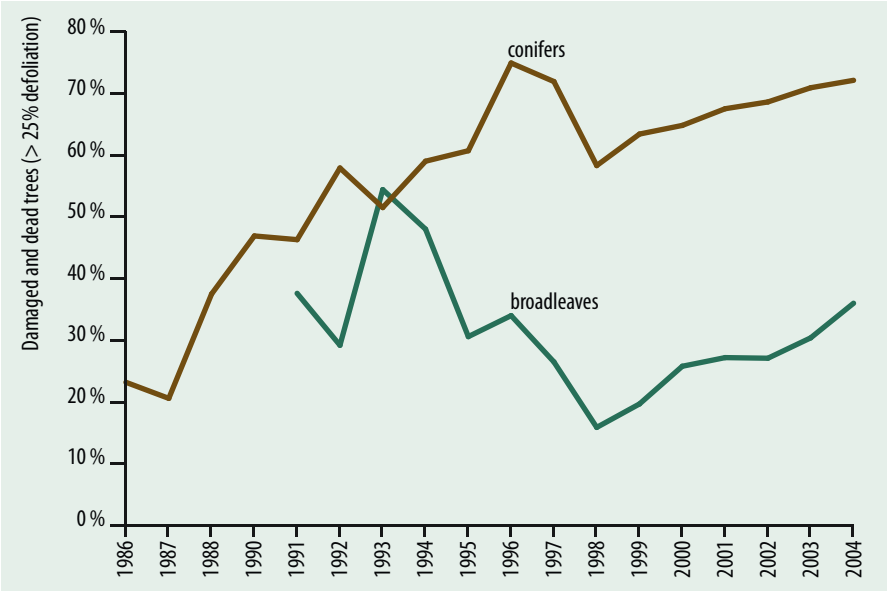
Under the impact of extremely heavy air pollution damage, mainly in the so-called "Black Triangle" region in the border regions with Germany and Poland, the Czech Republic joined the trans-national forest condition monitoring programme in 1986. Today, observations are ongoing on 306 plots of a systematic network. 146 plots are part of the international Level I network in a 16x16 km grid. Research at Level II intensive monitoring sites was initiated in 1996. Presently, 16 plots are regularly monitored. The results are presented in annual reports.

Main results

- Sulphur dioxide emissions have been reduced by 92% since the 1980s. The last case of large-scale direct air pollution damage to forests was observed in the Ore Mountain region in 1996.
- Nitrogen and sulphur deposition, however, are still quite high in some regions and affect tree growth and ground vegetation.
- Soil acidification is very severe and causes problems in tree nutrition. In some regions, magnesium and calcium deficiency have resulted in needle yellowing and tree decline.
- Ozone is also a matter of concern. Visible ozone damage is assessed using the list of sensitive plant species that has been produced by the programme. In the recent dry and hot summers, ozone injuries became visible at a number of plots.
- Crown condition gives information on the general state of health of the trees. After an improvement in the early 1990s, a slight deterioration has been observed in recent years. Nowadays, defoliation has stabilised at a mean defoliation level of around 30%.
- Additional stress is connected to weather extremes and sharp meteorological changes. The drought in 2003 and 2004 was especially important.

Outlook

In recent years, the Intensive Monitoring Programme has also concentrated on changes in biodiversity and on global climate change. It contributes to the definition and monitoring of criteria and indicators of sustainable forest management. Carbon sequestration, the evaluation of ecosystem health, forest production, the species variability of the ground vegetation and protective forest functions are on the agenda. The data are used for policy making and to inform the general public as well. In the future, a closer co-operation of research institutions, universities, environmental agencies and private consultants will be supported.



Development of defoliation in stands older 60 years.

Ozone sampler.

Intensive monitoring in an oak stand.

DENMARK

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Background

A nation-wide systematic survey was set up in 1985 to detect signs of changing forest condition expressed as defoliation and discoloration. Furthermore, intensive monitoring plots were selected that were typical for Danish forests, growth conditions and management. These case studies are designed to provide data to determine baseline or current conditions of forest ecosystems, and to detect changes and trends over time.

Main results

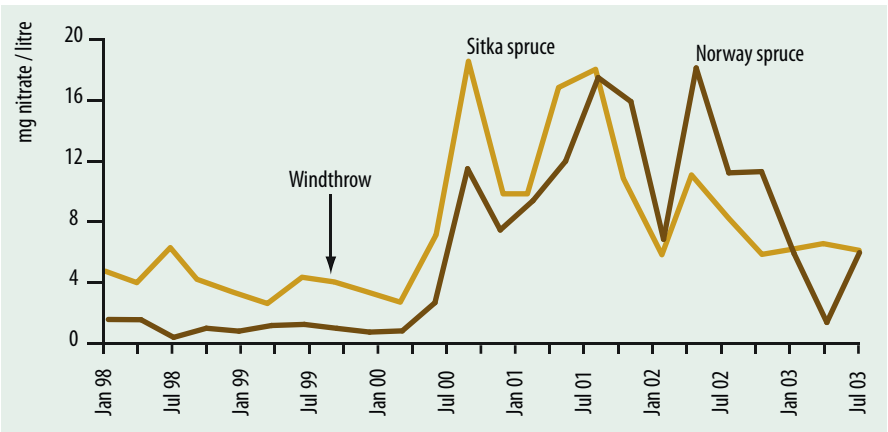
Defoliation results from 1989 to 2004 have shown that deterioration of forest health can usually be explained by specific events, such as drought, wind, deposition of salt, insects, fungi, fruiting or frost. Forest health was poor in the mid-nineties, but has since improved considerably. The time series constitute a baseline to compare forest health against in the future, which was lacking in the 1980s when the discussion of forest decline began.

The reduced emissions of sulphur dioxide in Europe resulted in a 50% decrease in the atmospheric deposition of sulphur compounds and strong acids at all plots. No evident change in the deposition of nitrogen was apparent over the years. The dry deposition of ammonia from intensive agriculture was shown to make up over half of the total deposition of nitrogen to the forests. The deposition of nitrogen was on average 12-33 kg N per hectare and year. It was highest in areas where agriculture was most intensive.

In general, leaching of nitrate on these locations was insignificant. Younger forest stands on nutrient-poor sites can take up and accumulate large amounts of nitrogen deposited from the atmosphere. When the stands mature and growth rates decline the risk of nitrate leaching will increase, in particular in areas with high inputs of nitrogen or after extreme events (see Figure).

The risk of nutrient depletion as a result of acidification is less than expected in the early 80s after the international debate on "forest decline". The western part of Jutland receives calcium, magnesium, and potassium from the nearby sea, and this input of nutrients mitigates the need for obtaining them from other sources. Concentrations of nutrients measured in foliage thus show that the nutrient status is satisfactory.

Concentrations of ozone during the growing season exceeded the critical level of 40 ppb, but no direct damage on the trees has been observed.

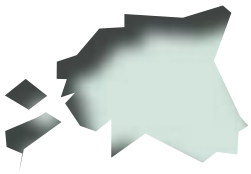


Nitrogen leaching at a plot with untouched windthrow.

Outlook

Knowledge about original and normal ranges is important to objectively evaluate whether or not the forest is in an unhealthy condition. Forest health and ecosystem monitoring will continue to be relevant with increasing concerns about the sustainability of forests in a changing environment. Monitoring the health of forest ecosystems requires an integrated approach at multiple scales and is now combined with the Forest Inventory. The future strategy is to build the monitoring on a variety of tools from satellites and aircraft to ground-based measurements and surveys.

ESTONIA



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Snow and rain water collectors on an Estonian Level II plot.

Background information

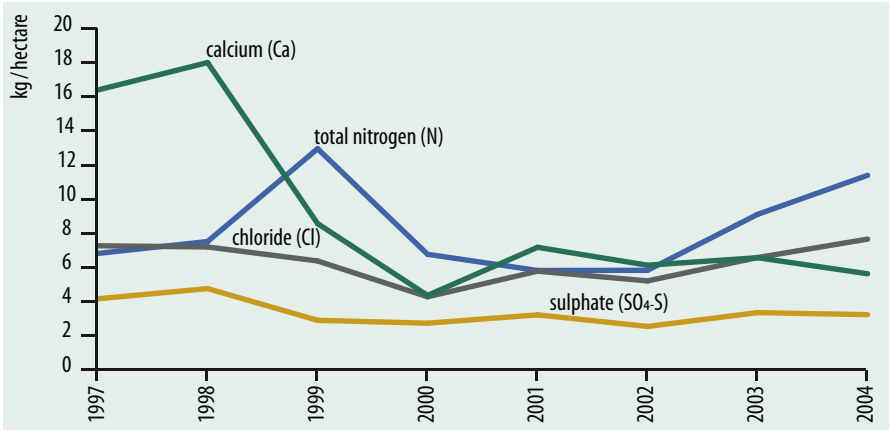
In order to observe the development of forest damage, forest condition monitoring was started in many European countries during the 1980s. In Estonia, a network of Level I sampling points for the assessment of the health state of forests according to the ICP on Assessment and Monitoring of Air Pollution Effects on Forests was established in 1988. In 1997, the assessment of different environmental parameters was started on Level II plots. Presently, forest condition monitoring is based on 96 Level I plots and on 7 Level II intensive monitoring plots.

Main results

- During the years 1988–2004 the condition of forests was comparatively normal and stable. The crown defoliation of conifers decreased a little. The defoliation of deciduous tree species was clearly lower than the defoliation of conifers.
- The threat of acid rain to the forests is very low. Ca, Mg, NO_3, Na and SO_4 deposition were reduced in the period 1997–2004. Leaching of NO_3, SO_4, Na, Cl and K was observed on all the Level II plots. Leaching of K was especially high from Norway spruce monitoring plots.
- In addition to atmospheric pollution, some biotic and abiotic factors have had a serious influence on the crown condition of forests. As to specific biotic stresses, needle and shoot diseases have been found to be most important. Abiotic threats include extreme weather conditions such as storm events and droughts.

Outlook

Forest condition assessments will continue on all Level I and Level II plots with a particular emphasis on quality control and quality assurance of the research data. A new Level II sample plot will be installed focusing especially on meteorological parameters. The public interest in various aspects of forest condition information will also be followed in the future.



Trends of mean deposition on Level II plots.

Monitoring in a Finnish pine stand.

FINLAND

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Background information

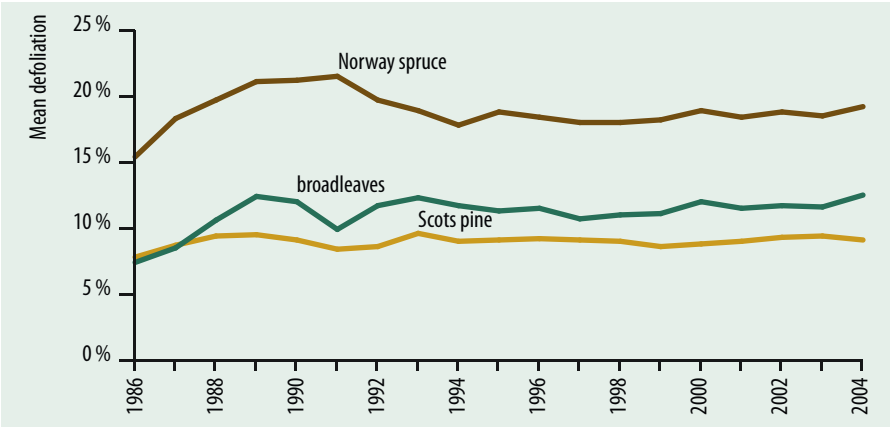
Finland first started monitoring the effects of air pollution on its forests in the middle of the 1980s and, over the years, has continued these activities within the framework of a number of regional and national monitoring programmes. Finland's participation in the ICP Forests programme has, during the past 20 years, considerably increased the capacity of its scientists to monitor and investigate the effects of both local and regional air pollution on the forests in Finland, as well as strengthened contacts with other scientists and organizations working on these extremely important topics in other countries.

Main results

- As in most other countries in Europe, there has been a strong decrease in sulphur deposition, as well as to some extent in nitrogen deposition, during the past two decades in Finland. However, the deposition of acidifying compounds in Finland has, throughout the period, remained much lower than that in many other countries.
- The main threats to the health and condition of Finland's forests are primarily abiotic factors, such as storms, drought, and extreme winter conditions, as well as associated biotic factors such as insect pests and fungal pathogens.
- Needle and leaf loss has, despite a slight increase at the start of the monitoring period, remained constant at a relatively low level. No clear correlation has been found between the defoliation pattern of conifers or broadleaves and the modelled sulphur or nitrogen deposition at the national level.
- Foliar sulphur concentrations have decreased sharply from the levels reported in the late 1980s because of the major decrease in sulphur emissions and deposition. Foliar nitrogen concentrations have varied without showing any clear trends.
- The acidity status of the forest soils was surveyed during the late 1980s and early 1990s. No signs of elevated acidity attributable to the deposition of acidifying compounds were found.

Outlook

Finland considers that monitoring and research on climate change, forest biodiversity, and the criteria and indicators of sustainable forestry, will play an ever-increasing role in the ICP Forests programme. However, co-operation should be intensified between the biodiversity surveys carried out within the ICP Forests programme and the National Forest Inventory. The ICP Forests monitoring programme has already provided a sound basis, and will continue to do so, for future emission-abatement legislation by specifying which emission restrictions give the greatest benefit in each region.



Average leaf and needle loss on mineral soil sites during 1986 - 2004 in Finland.

Crown condition assessment.

FRANCE

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Background information

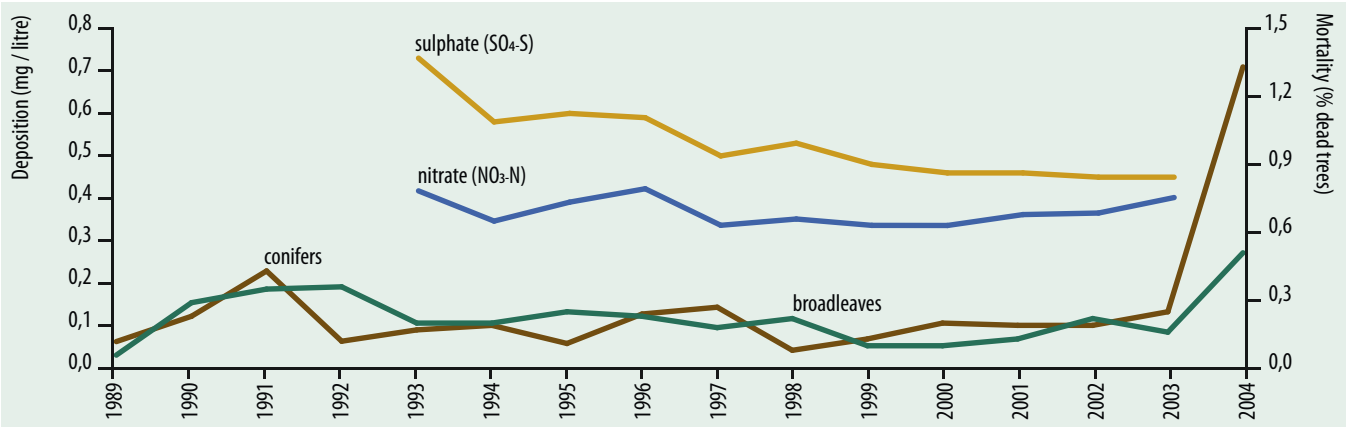
The Level I network was set up in 1989 and has been managed by the Forest Health Department (DSF) since 1994. It includes 558 potential plots, with 512 plots actually monitored in 2004. The Level II network, called RENECOFOR, was set up in 1992 and is managed by the National Forest Agency (ONF). It includes 100 plots. Crown condition is assessed on both networks by DSF observers. Their unfailing forest health knowledge enables them to identify precisely factors responsible for the observed damage.

Main results

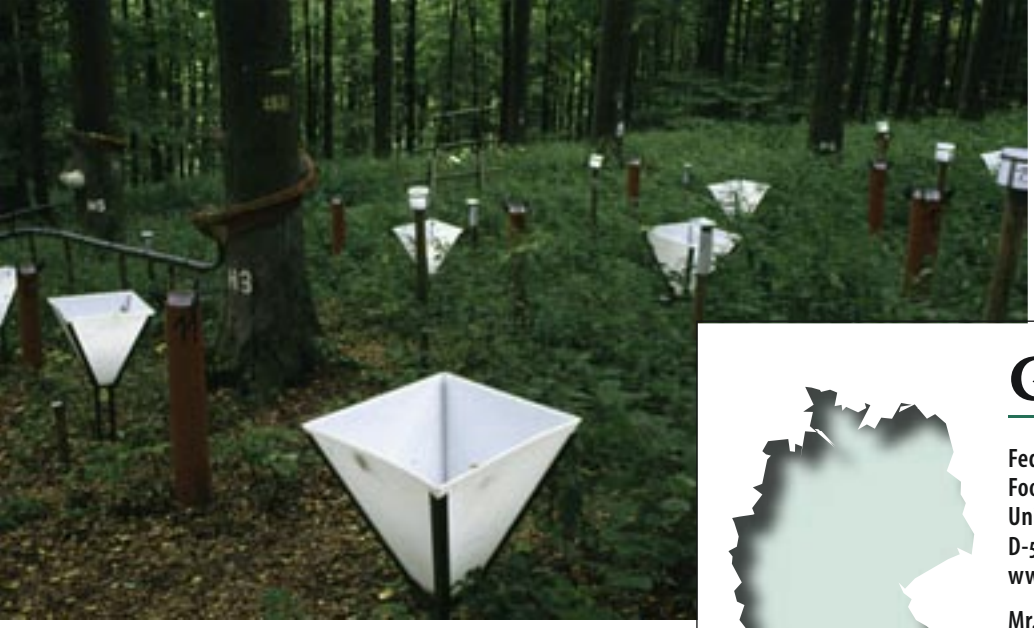
- In spite of serious fears in the early 1980s about forest dieback, there has been no overall forest decline in France. Temporal variation of crown condition depends on tree species, local environmental conditions, weather extremes such as drought, heat, and late frost, and biotic agents such as leaf-eating caterpillars and fungi.
- Observation protocols have been considerably improved, particularly from 1994 to 1997. Periodic training and randomly planned controls today ensure a consistent monitoring methodology across all plots.
- Twelve years' Level II monitoring has given numerous results in the fields of atmospheric deposition, ozone and ammonia air concentrations, soil characteristics, mineral nutrition of forest stands, phenology, tree health, and forest growth. Synthetic indicators are currently being developed, in order to inform scientists and the general public on forest development. A model dealing with tree phenology and climatic data will provide information on the effects of global warming on forests in the near future.

Outlook

The Level I and II networks constitute an essential tool, complementary to the general monitoring of French forests by DSF observers. From 2005 onwards, new protocols will reinforce the assessment of damage causes by both networks. For the second time, the Level I and II plots will be specifically evaluated as regards their ecological characteristics. This will help us to understand how forest ecosystems may evolve in response to global changes.



Mean sulphate and nitrate concentrations in open field measurements at 25 Level II plots and mortality rates for broadleaves and conifers at Level I.



Intensive monitoring plot with litterfall (white), throughfall (orange) and stemflow samplers.

GERMANY

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Background information

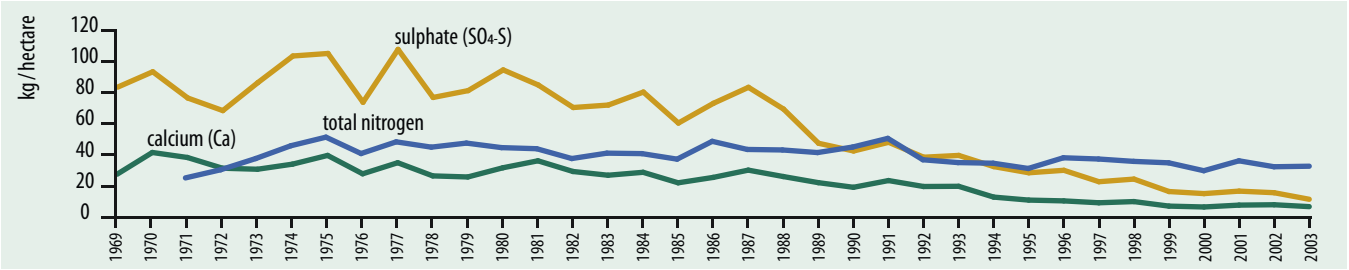
As a reaction to widespread damage observed on the main tree species, forest condition monitoring was started in Germany already at the beginning of the 1980s and is today based on 450 Level I and 89 Level II plots. A few plots offer time series dating back to the 1960s. In addition, different *Länder* have installed denser grid nets and additional monitoring plots in order to obtain regional results. A close link has been established to the National Forest Inventory and to various research groups at universities, environmental agencies and private consultants. The results are published annually at federal and regional level.

Main results

- As in other European regions, sulphur deposition was reduced greatly by 89% in the period 1980 - 2000. Trees have been shown to react to this with reduced sulphur contents in needles and leaves. However, total nitrogen deposition, although reduced for ammonium by 28%, is still too high in many regions. Mean nitrogen inputs of 20 kg nitrogen per year and hectare result in increased tree growth and in a shift of ground vegetation composition. Nowadays more nitrophilic plants can be found on many plots. Nitrate is leached in significant quantities from every third intensive monitoring plot. The present nitrogen deposition loads and the sulphur deposition of the former decades are today the main driving forces for acidification in forest soils.
- Ozone is also a matter of concern, with ozone injuries mainly detected on beech trees.
- Soils are acidified at most of the plots and thus also indicate changes in the ecosystems. The water filtering function of many of these forest soils is endangered. Only 9% of the plots have calcareous soils and are thus not affected by acid deposition.
- Crown condition has been proven to be a valuable indicator to reflect these stressors. Mainly oak, but also beech, is affected with nearly every fourth tree classified as damaged.
- Additional threats include weather extremes such as long lasting droughts and storm events

Outlook

Germany will continue its clean air policy. Forest policy will also in the future promote sustainable forest management in order to ensure ecological, economic and social benefits also under changing environmental conditions. The forest monitoring programme has provided essential information on the effectiveness of the policy measures. In addition there is a continuing high public interest in forest related information and forest health issues, and a strong demand for actual risk assessments and information. Therefore the forest monitoring programme will be continued. A special focus will be the preparation of the second forest soil survey at Level I.



Deposition trends of the Solling Level II plot 1969 - 2003.

GREECE

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Forest vegetation in Greece grows in a Mediterranean climate and is thus exposed to a number of weather hazards. It is also exposed to local and long-range transported air pollutants. For these reasons, forest monitoring started in 1988 with 100 Level I plots covering all forest types. In 1996, four Level II plots were established. The latter represent the maquis, oak, beech and fir ecosystems. The results are analyzed and published annually.

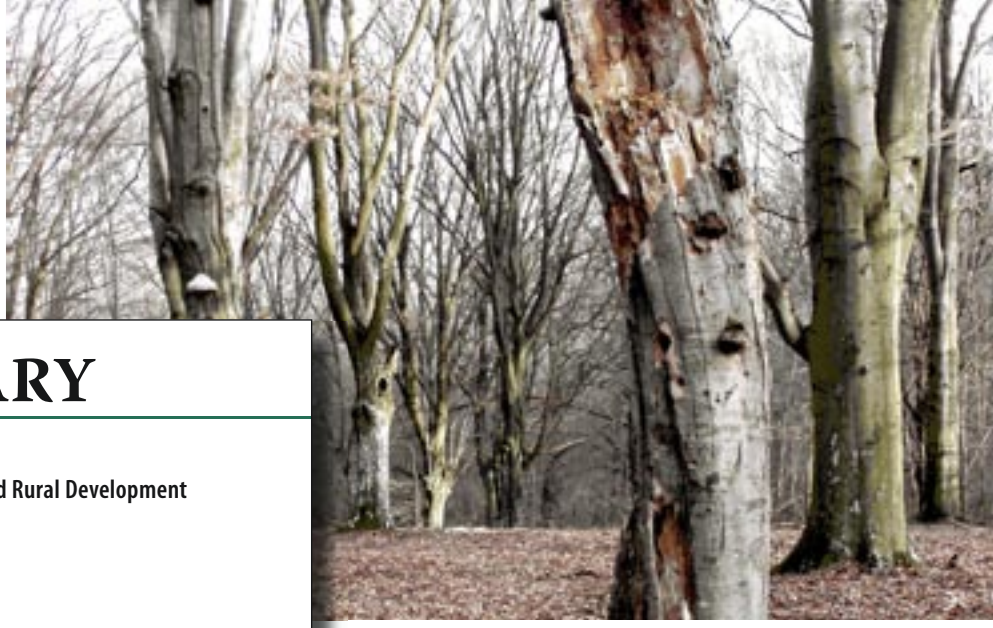
Main results

- Crown defoliation of forest trees is mainly attributed to biotic and abiotic factors, like high temperatures, droughts, frost, and insects. High percentages of defoliation, due to drought, were reported in 1988, 1993-1995 and 2001-2002. Intensive attacks by the insect *Thaumetopoea pityocampa* on Aleppo pine trees were observed in 1993. Fir trees were intensively attacked by the insect *Horistoneura murinama* in the period 1994-2001. Forest fires also destroy extensive forested areas and are thus a high risk for forest ecosystems.
- Elemental fluxes: At the beech and oak stands, average bulk fluxes for sulphate and inorganic nitrogen were 18 and 14.7 kg per hectare and year respectively for the period 1997-2003. At the same plots, low pH values in bulk deposition were significantly correlated with high sulphate and nitrate concentrations. The nitrate concentration in lysimeter water, extracted from the rooting zone at the beech plot, was significantly higher than that of ammonium, although the nitrate concentration in stream water was very low. It is very likely that the beech and oak plots, located in central-eastern Greece, receive atmospheric pollutants from northern areas of Greece or abroad. The acidity of rainwater at all plots has decreased since 1997.
- Foliar analysis showed that the nitrogen concentrations in plant tissues had the lowest variability since 1995. However, values for phosphorus fluctuated by up to 20%. The N/P ratio has to be monitored in the future in order to detect possible nutrient imbalances. So far, no significant trends have been observed in time with respect to this ratio.
- Soil properties: The nitrogen pools were highest in the soil of the fir plot, intermediate at the maquis and beech plots, and lowest at the oak plot. The C/N ratio in the H horizons at all plots was less than 16.5 (oak), and the lowest value was observed at the fir plot (11.8). It is concluded that the fir plot might be predisposed to nitrogen saturation. For this reason, the monitoring of the nitrogen status should continue in the future.
- Litterfall quantities in the beech and fir plots were not always constant. The most influential factor was the amount of rain.
- Ozone concentrations are usually high during July and August. Mean monthly concentrations ranged from 95 to 118 μg/m³. The main forest tree species affected are beech, ash and pine species.

Outlook

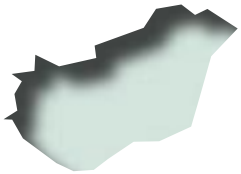
The monitoring of chemical parameters in water, foliage, litterfall and soils should continue in the future to disclose trends and correlations. Phenology is another important aspect related to litterfall and therefore to nutrient cycling. Also, measurements of ozone concentrations will continue. Statistical models should be applied to predict nutrient uptake and leaching. In this way, forest management can profit from the data because its practices affect the plant nutrient status.

Intensive monitoring plot in Greece.



Forest monitoring is an advanced tool to protect nature and its resources.

HUNGARY



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Background information

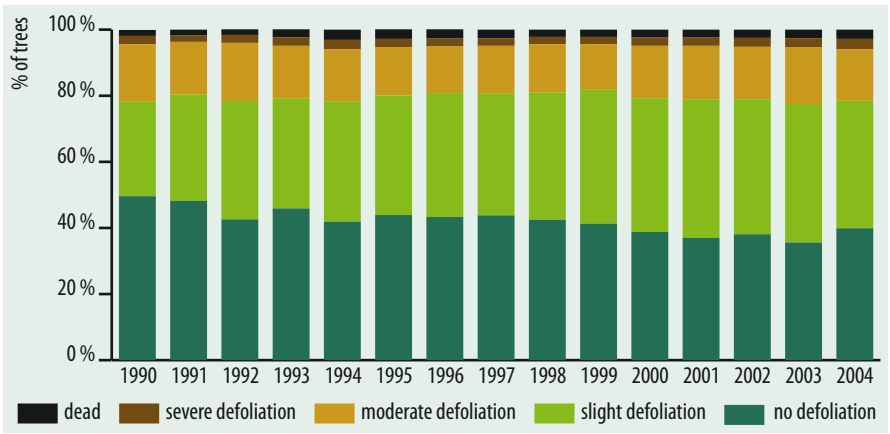
Hungarian forestry has a long tradition of observing forest health condition. The annual reports of forest owners, the light trap network covering the whole country and the management planning have been the traditional sources of information since the 1960s. After joining ICP Forests, the network of Level I plots was established (4x4 km grid) in 1988. In addition, 14 Level II plots were set up in 1995 to monitor causes and effects in the main forest ecosystems. All information sources mentioned were integrated into the National Forest Condition Monitoring System by the Forest Act in 1996, forming a comprehensive tool for the protection of national forests. Based on the interpretation of monitoring and research results, the present system successfully supports local foresters, forest managers, the authorities and decision makers.

Main results

- During the last 20 years, sulphur dioxide emissions were reduced by 73% and nitrogen oxide emissions by 32%. Deposition levels also decreased but at a less impressive rate. However, the presently measured sulphur and especially nitrogen deposition may still affect forest ecosystems.
- Due to the lime content or the high buffer capacity in the majority of forest soils, acid deposition measured in the 1980s is unlikely to cause significant acidification on the sites observed. Long-lasting effects of deposition on soils have to be monitored, especially on sensitive sites, and further elucidation is necessary by resampling the soils periodically.
- Different environmental effects caused slight deterioration of the crown condition since 1990. Air pollution can be a contributing factor; however, large-scale forest dieback in relation to air pollution has not been observed in the country.
- Since 1988, the monitoring system has revealed the weakening of forests and tree dieback in some areas and has supported the forestry sector in responding appropriately and in time. Among the related abiotic and biotic impacts, drought plays an important role as a predisposing or damaging factor.
- Ozone concentrations have increased moderately in the last 15 years, though they are not considered high compared to overall European levels. Ozone symptoms were observed on specific sites, mainly on beech and oak, and the impact of ozone has therefore to be clarified in the future.

Outlook

The continuation of monitoring and research is necessary for the protection of forest resources. Air pollution still has to be considered in the future. The existing infrastructure is the basis for an early warning system, for periodic monitoring and for cause-effect research in forestry.



Defoliation of all tree species on the Level I plots.

Mixed woodland in the west of Ireland.

IRELAND

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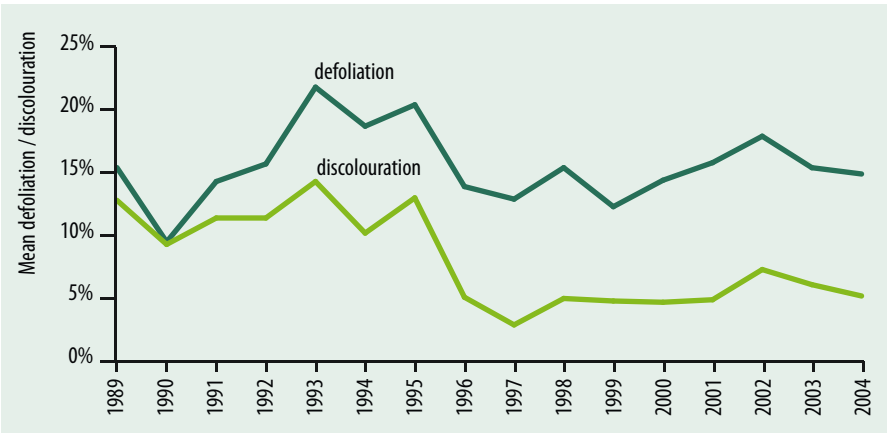
Background information

Ireland has been monitoring forest health and vitality since 1987 at twenty two permanently marked plots incorporated into the pan-European Level I network. Intensive monitoring of forest ecosystems has been ongoing since 1990, and in 1994 twelve Level II plots were included into the current scheme. An expansion of the Irish network of plots is underway to reflect recent trends in afforestation.

Main results

Air pollution effects on forests, which were so pervasive across Europe, have been demonstrated to be absent from Irish forests, with the main stressor on forest condition being identified as climatic rather than anthropogenic. There is no evidence of long-term trends of defoliation of the main tree species of the survey, Sitka spruce, but long term monitoring has allowed observation and understanding of trends in forest condition over time and detection of short-term defoliating agents such as the green spruce aphid, *Elatobium abietinum*.

Chemical analysis of the nutrient contents of the needles and leaves demonstrated no significant nutrient deficiencies among the sample trees. Results from the deposition survey have demonstrated that although nitrogen deposition is considered low in Ireland, locally high rates of deposition occur and may have implications for sustainable forest management. Results from one Level II plot show clear evidence of nitrogen saturation of the ecosystem.



Defoliation and discolouration of sample trees from 1989 to 2004.

Outlook

Both the Irish Level I and Level II plots have provided valuable information on forest condition and ecosystem processes both nationally and in the European context. Results collected from the intensively monitored plots have been used to construct nutrient input/output budgets for forest ecosystems. While the impact of air pollution on forests in a changing deposition environment continues to evolve, the plots have proven and are proving an invaluable source of hard data to address other aspects of forest policy such as carbon sequestration and biodiversity in forests. After twenty years, forest monitoring is only beginning.

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Background information

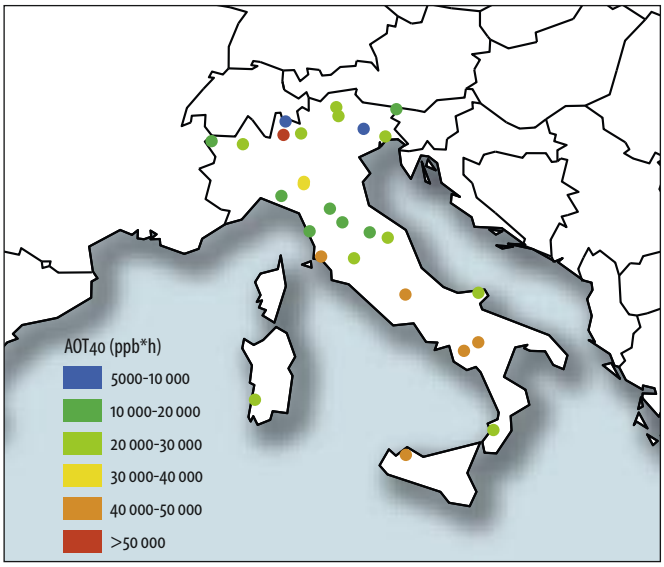
Forest condition monitoring at a national scale has been promoted in Italy since 1987 under the co-ordination of the National Forest Service. The programme named CONECOFOR (Forest Ecosystems Monitoring) since 1995 involves investigations on 265 Level I and 31 Level II monitoring plots. On Level I, crown condition assessments are carried out on an annual basis. The 31 Level II CONECOFOR permanent plots are designed to study the ecological interactions between the structural and functional components of forest ecosystems and stress factors, such as air pollution and climate change. Of these plots, 11 are classified as "biomonitoring sites" in the framework of the ICP Integrated Monitoring of Ecosystems. Recently, a process for including some of the Level II sites in the I-LTER Network was launched, which will be completed in 2005.

Main results

- The combined and integrated data evaluation showed the particular risk of high acid and nitrogen deposition for sensitive soils and for the biodiversity status of the forest sites. Critical acidity loads were exceeded in the most sensitive forest ecosystems in Italy and total nitrogen deposition is high on many plots.
- On average, estimated ozone concentrations in terms of the AOT40 indicator exceed the critical level of 5,000 ppb*h at all monitoring sites, with annual peak values at 83,000 ppb*h. A number of plant species with ozone-like damage symptoms were found. Ozone also reduces the vitality of sensitive species. It affects crown transparency and is related to carbon sequestration through its effects on tree growth. These data confirm that ozone represents a potential risk factor for Italian forests.

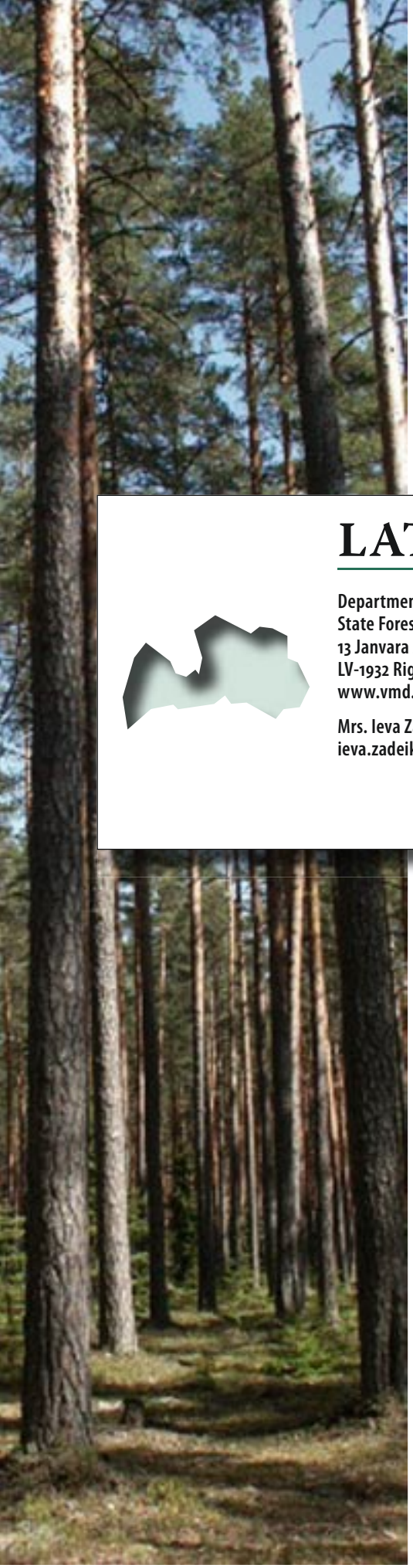
Outlook

While air pollution remains of concern, the programme has been re-oriented to new tasks and projects. In the field of biodiversity, CONECOFOR participates in international initiatives like ALTER-Net, ForestBIOTA and IEBI2010. Climate change effects are tackled within CLIMECO and the pilot project BioRefugia. The pilot project CarbonFlux is oriented towards questions of carbon sequestration. Specific ozone and biodiversity campaigns for the public and policy makers have been implemented in 2003 and 2004 or are planned for 2005 and 2006. They also tackle questions of contamination by genetically modified organisms. Finally, a synthesis of the intensive monitoring programme with the Natura2000 and Life programmes is planned to be implemented in 2007.



Estimated ozone mean concentrations (AOT 40) for CONECOFOR Level II plots (Jun – Sept 2000-2002).

CONECOFOR Plot with meteorological station for continuous microclimate measurements.



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Background information

Latvia joined the ICP Forests programme in 1990 with 398 Level I observation plots in the national grid of 8x8 km. Nowadays, about 360 Level I plots are assessed every year. They include 95 plots of the transnational grid. Level II intensive monitoring was launched in 1995 with two plots. Unfortunately, the observations ceased for some years, but resumed in 2004 including one new monitoring plot.

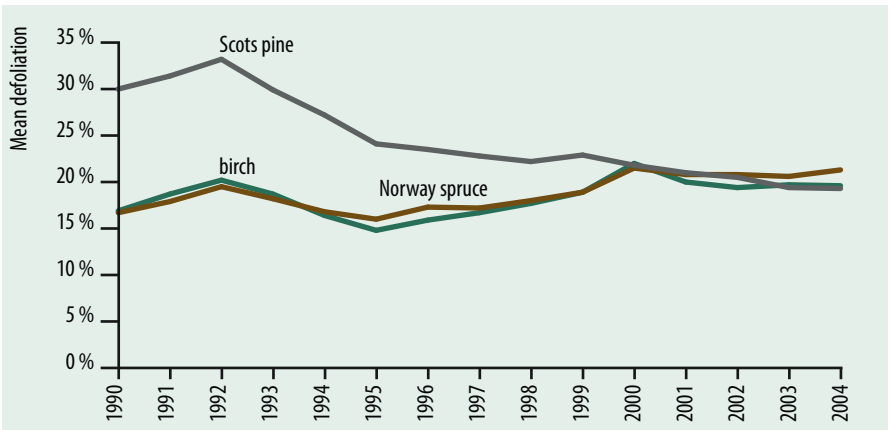
To describe atmospheric pollution, the data of the Latvian Hydrometeorological Agency are used because the data from the Level II observations have become available only recently.

Main results

- In Latvia, the level of air pollution is, in general, considerably lower than in Central Europe. During recent years, background stations have revealed annual nitrogen loads of about 6-8 kg per hectare and year. Sulphur inputs are around 5-6 kg/ha/yr. The total deposition of nitrogen and sulphur compounds, in particular, has shown decreasing trends since 1986. The pH of rainwater has remained quite stable during this period.
- A set of crown condition data has been obtained since 1990, demonstrating temporal and spatial variations in tree health over this period. A considerable decrease in mean defoliation has been observed for Scots pine (from 33% in 1992 to 19 % in 2004). The improvement of the condition of pine crowns is explained by a considerable reduction in the deposition of sulphur compounds, although there have been unfavourable weather conditions and outbreaks of different insects in the early 1990s.
- Norway spruce and common birch show periodic fluctuations in the level of defoliation with a slight increasing trend. Tree crown condition in Latvia is affected primarily by biotic and abiotic factors such as insects, diseases, adverse site conditions, and weather conditions. Air pollution is regarded as one of the factors weakening the resistance of forest ecosystems.

Outlook

The assessment of crown condition gives a general insight into forest health condition and it is important to ensure continuity of the survey. Specific attention in the future will be paid to quality assurance. Level II measurements will be developed in the near future and the emphasis will be on the evaluation of the collected data. The coming soil survey at Level I will be of great value for Latvia.



Scots pine stand in Latvia.

Changes in mean defoliation for the main tree species, 1990-2004.

Intensive monitoring plot with deposition samplers.

LITHUANIA

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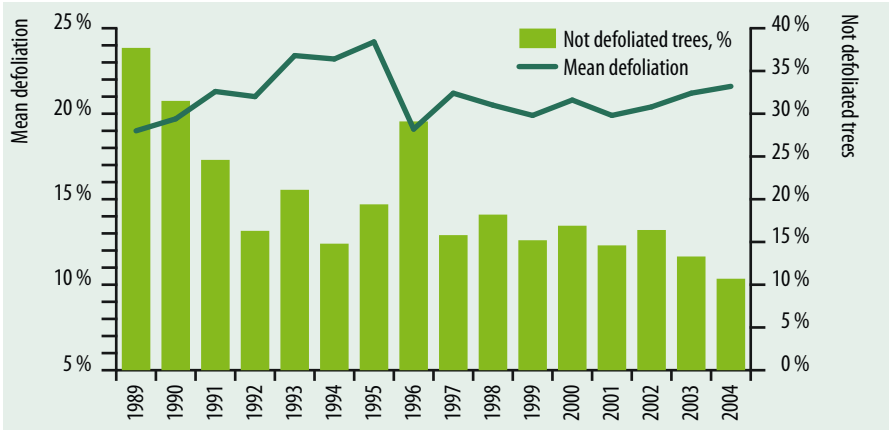
Background information

Forest ecosystem research including elements of forest monitoring in Lithuania was initiated over 20 years ago. The present national forest condition monitoring network covers the total forest area of Lithuania and was created in 1987/88. Today it is based on 963 Level I plots in a 4x4 km grid. Out of these, 74 permanent observation plots were assigned to the transnational 16x16 km grid in 1991. The condition of forest soils was assessed in 1992-1993. Nine intensive monitoring (Level II) plots were installed in 1995. Today, the monitoring activities are coordinated by the State Forest Survey Service. The Lithuanian Forest Research Institute carries out the intensive forest monitoring on the Level II plots.

Main results

- The air quality in Lithuania is largely determined by long-range transboundary pollution. In the 1990s, the mean annual deposition decreased to about 24 kg sulphur and 10 kg nitrogen per hectare and year. This decrease is mainly due to emission reductions in Europe. In the period from 1981 to 1999 ozone concentrations increased to a current annual mean of 0.93 µg/m³.
- During 1989-1995, the condition of forests was declining. This was caused by the summer droughts of 1992 and 1994, and hurricanes during the winter of 1993, along with the insect and fungal calamities in 1992-1994. A stabilization of forest condition was observed during 1996-2001. Starting from 2002, a slight decline of forest condition has been observed. Air pollution is regarded as one factor related to forest condition.
- At least 50% of forest soils (mostly sandy Arenosols and Podzols) are sensitive to acidic air pollution. The concentrations of heavy metals are in the range of natural levels. No relationship was found between the condition of forest soils and tree crown defoliation.



Changes of mean crown defoliation and number of not defoliated trees in Lithuania.

Outlook

Lithuania supports the clean air policy of EU and UNECE. The future priorities of the Lithuanian forest condition monitoring activities are: (i) to participate in the estimation, interpretation and comparison of forest condition monitoring data throughout Europe; (ii) to provide society and policy makers with information on the current state of forest ecosystems; and (iii) to further pursue the investigations of forest ecosystems.

Knowledge about forest condition is a prerequisite to protect forests and to mitigate economic and ecological losses. Political and economic means will be applied to ensure the protection of forests. The monitoring programme in Lithuania will be continued.

Throughfall and stemflow samplers on an intensive monitoring plot.

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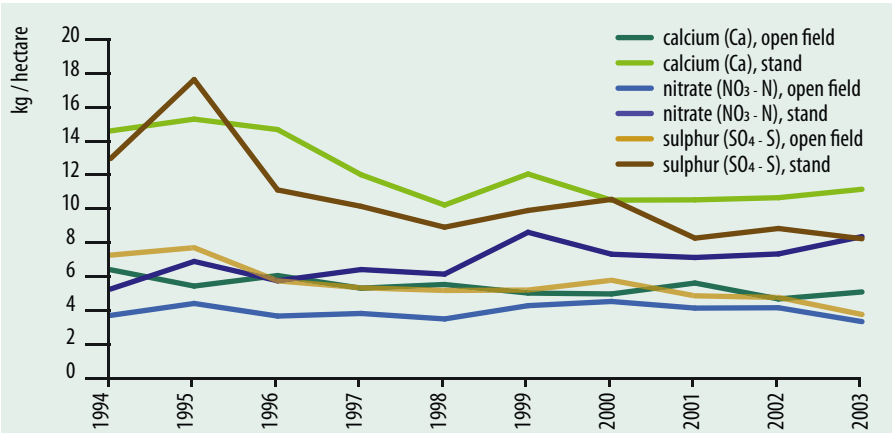
Background information

In the context of an increase of transboundary forest damage and air pollution, the Grand Duchy of Luxembourg established in the year 1987 four plots fitting into the European Level I network. The survey of these 96 sampling trees contributes to a widespread monitoring of the forest condition in Europe. In 1994, for a more intensive investigation of key factors and processes on the ecosystem scale, two Level II plots were installed in characteristic beech forests of Luxembourg as a part of the French RENECOFOR network. A national forest condition survey, based on 51 plots, has been carried out since 1984.

Main results

In Luxembourg, atmospheric deposition is sampled on one Level II plot located in a beech forest of the Gruenewald located next to the capital city of Luxembourg.



Deposition trends of the Gruenewald Level II plot.

- At present, the deposition of sulphate (SO_4-S) in the open field is relatively low with 3 to 4 kg per hectare and year, while in the forest stands, about 10 kg per hectare and year are measured. The sulphate deposition decreased by 52% over a period of 10 years, which helped to reduce the acidification of soils. This trend has to be seen as a result of the effort to lower emissions in this region.
- The deposition of nitrate (NO_3-N) shows a relatively constant trend in the open field (about 3 to 5 kg N per hectare and year). In the forest stands, the deposition increased by 40% in the past 10 years to reach 5 to 8 kg per hectare and year. The total input of mineral nitrogen is estimated at 15-20 kg per hectare and year. As the direct link between nitrogen deposition and eutrophication of the ecosystems is well known, these deposition rates are rather worrying.
- In the beech forest, calcium deposition decreased by 33% and potassium deposition by 44% in 10 years.

Outlook

In the light of the latest climatic variations and severe atmospheric pollution, there is an increasing importance in observing the effects of a changing environment on forests in the future. Therefore, the Grand Duchy of Luxembourg will continue to monitor forest condition on the basis of the Level I and Level II networks.

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Intensive monitoring plot with throughfall and soil solution (yellow circles)measurement equipment.

Background information

As a reaction to widespread damage observed on the main tree species, forest condition monitoring started in The Netherlands in 1984 and was carried out yearly up to 1994 on a subset of 3,000 plots in a systematic 1x1 km grid square. Besides a number of large surveys including crown condition, ground vegetation and chemical condition of foliage, soil and soil solution measurements were executed in 1990 on 150 plots and in 1995 and 2000 on 200 plots, representing the new national monitoring network to measure forest health. A subset of 13 of these 200 plots are measured yearly as part of the Level II intensive monitoring network. Furthermore, 11 plots are established as Level I monitoring plots.

Main results

- As in other European regions, sulphur deposition has been reduced by approximately 80% in the period 1980 - 2000. Trees have reacted to this with reduced sulphur contents in needles and leaves. However, the total nitrogen deposition has been reduced by only approximately 25% in this period and is still too high in nearly the whole of the Netherlands. Present mean nitrogen inputs of approximately 30 kg nitrogen per year and hectare lead to elevated nitrate leaching to the groundwater, increased sensibility to stress factors like drought, frost and diseases and to a disturbance of the nutrient balance.
- Nearly all investigated forest plots are non-calcareous sandy soils (covering more than 80% of the Dutch forests) and are affected by acid deposition, but the reduced inputs of sulphur and nitrogen did cause an improvement. This is reflected in a strong reduction in sulphate and toxic aluminium (by more than 60%) and an increase in pH of 0.1 in soil solution in the last ten years. Although less significant, there has also been a clear reduction in dissolved nitrate concentration (near 25%) and in soil nitrogen content in this period.
- Crown condition was related to stand characteristics and external factors. Multiple linear regression analyses for 150 plots showed that tree species and age were the main factors explaining defoliation. Additional explaining factors were the nitrogen content in needles and leaves and the pH of the soil solution. This confirms the roles of nitrogen and acidification in the decline of crown condition.
- Multivariate statistical analyses also showed that there is a strong relationship between the composition of the ground vegetation and tree species, the chemical composition of the soil (mainly the availability of base cations), deposition and groundwater. However, no significant relationship was found between vegetation composition and the deposition of total nitrogen. Relationships to nitrogen deposition are likely to be detected when a repetition of the ground vegetation survey is carried out.

Outlook

In the Netherlands, interest in air pollution/acid deposition and related forest monitoring has strongly decreased since 1995. The monitoring network to measure forest health on the 200 plots has therefore been stopped since 2000. However, there is still a lot of policy interest in ammonia emissions and related nitrogen deposition with its impacts on biodiversity and carbon sequestration by forest growth. Apart from monitoring nitrogen deposition and its impacts on a reduced number of 5 Level II plots, the monitoring of forest growth and forest diversity aspects is continued in a network called “Meetnet Functie vervulling”.

Sampling of needles from Scots pine on the Level II plot at Kårvatn.

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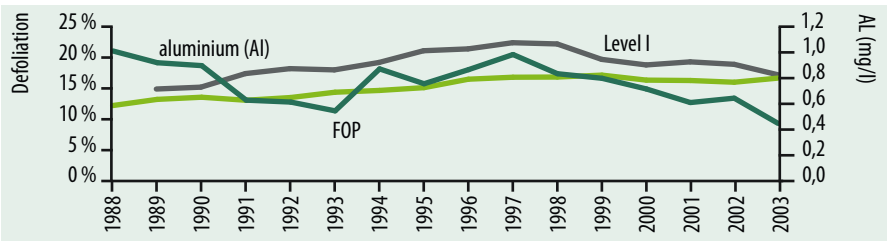
Background information

The Norwegian Monitoring Programme for Forest Damage has been running since 1986. The aim is to monitor the vitality of Norwegian forests and evaluate the influence of long-range transboundary air pollutants. Monitoring comprises two extensive nation-wide sets of plots, national representative plots, which are part of the ICP Forests Level I net, and the Forest Officers' plots. In addition, there are eight intensive monitoring plots, where monitoring at Level II is carried out, and a national network of air pollution monitoring plots.

Main results

Since 1980, the concentration of sulphate in precipitation has decreased by 62-76%. Reductions in airborne concentrations were between 82-93% and 64-73% for sulphur dioxide and sulphate, respectively. There are no clear trends for the concentrations of the different nitrogen compounds, except for nitrogen dioxide that has decreased significantly in the last 10 years.

Crown condition has been stable for the last five years following a slight improvement in tree vitality in the late 1990s. The variation in the last years has mainly been caused by fungal and insect attacks that were largely due to a combination of climatic stress to trees and a favourable climatic environment for the fungi and insects. Effects of air pollutants may come in addition to or interaction with these biotic and climatic factors. They are, however, hard to estimate, as they appear to have been small compared with the effects of other factors. There are no indications at present that long-range transboundary pollutants have directly or indirectly damaged the Norwegian forest. The concentrations of air pollutants and of potentially toxic aluminium in soil water have normally been lower than the threshold values for damage. Increased growth in southern Norway is consistent with the hypothesis that this may be an effect of nitrogen deposition. Results from the intensive monitoring plots suggest that there are fluctuations from year to year in some measurements, probably within the normal variation for boreal coniferous forests.



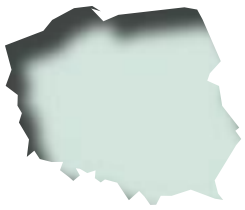
Mean defoliation of Norway spruce on Level I and Forest Officers' (FOP) plots, and volume-weighted mean aluminium concentrations in soil water from 15 cm depth on the Level II plots.

Outlook

The forest ecosystem seems at present to be quite stable. Air pollutants appear to have had little effect compared with other factors. In the future, the effects of climate change, including indirect effects such as pathogen attacks, may be important. In order to detect any changes that might occur, it is important that the monitoring programme be continued.

Ground vegetation survey at a beech plot in the Baltic Region.

POLAND



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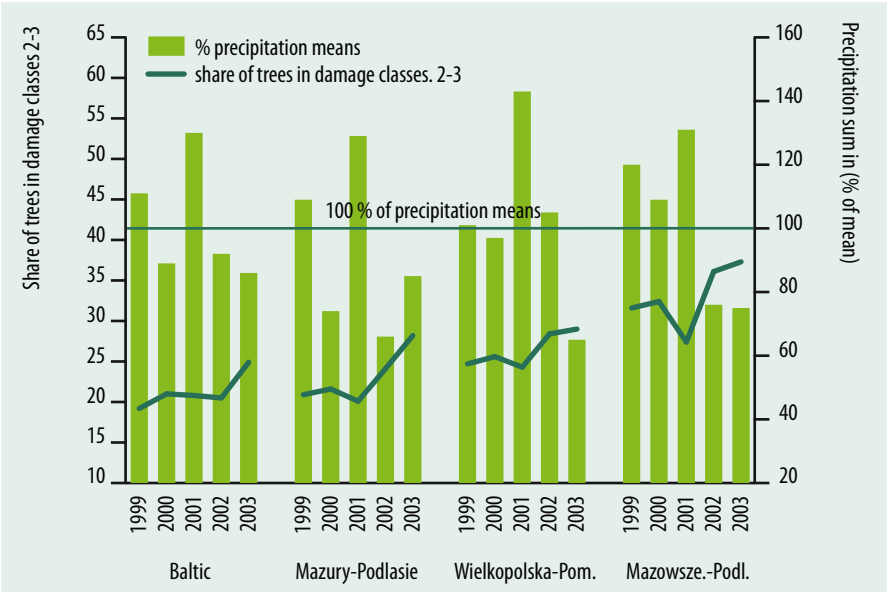
Background information

Forests cover one third of Poland and have a considerable economic, social and environmental importance for the country. The natural environment presently undergoes quick changes attributable to climate change and a decreasing level of anthropogenic stress. This makes the monitoring of forest ecosystems an essential tool for putting into practice the principles of sustainable forest management. In 1989, forest monitoring was started on the basis of permanent observation plots. There are 433 permanent Level I observation plots distributed in a 16x16 km grid and 86 Level II plots representing the most common forest types in Poland.

Main results

- The poorest health condition was found in fir and oak stands, whereas beech and birch stands proved to be the healthiest.
- Precipitation deficit during the growing period was the environmental factor that most affected forest health.
- Air pollution has been significantly reduced. The comparison of element contents in pine needles in 1997 and 2001 indicated a significant increase in the concentrations of nitrogen (N), phosphorus (P), and magnesium (Mg), and a decrease in the concentration of potassium (K).
- Species richness of vascular herbaceous plants in the fresh pine forest habitats (Leucobryo-Pinetum and Peucedano-Pinetum taken together) increases steadily from western to eastern Poland. This is indicated by a correlation coefficient of 0.439.



Damage to stands and precipitation sum in the growing season in the period 1999-2003 for selected forest regions.

Outlook

Decreasing stress from atmospheric pollutants will enable the introduction of new components into the forest monitoring programme. These will aim at studying the relationships between forest management, the environment and nature protection, including the assessment of carbon retention in forest ecosystems (as related to the Kyoto Protocol), the monitoring of biodiversity in forests (as related to the Convention on Biodiversity) and the monitoring of protected areas (as related to Natura 2000). In the nearest future, the integration of 300 Level I plots into the national large-scale forest inventory is foreseen, in order to obtain comprehensive and reliable information on the state of the forests.

Background information

In 1987, Portugal launched an annual forest vitality inventory based on a Level I systematic grid net. At national level, 137 plots on the mainland and 4 plots in the Azores were monitored in 2004. Monitoring at Level II was launched in 1993 and 1994. This network consists of 12 plots (8 on the mainland and 4 in the Azores), representing the most common forest ecosystems. At all the Level II mainland plots, crown condition, foliar condition, increment change and ground vegetation are assessed. Continuous assessment of atmospheric deposition, meteorology and soil solution is carried out at one of them. At all the Level II plots in the Azores, crown condition, foliar condition and increment changes are assessed. Continuous assessment of atmospheric deposition and meteorology is carried out at one of them.

PORTUGAL

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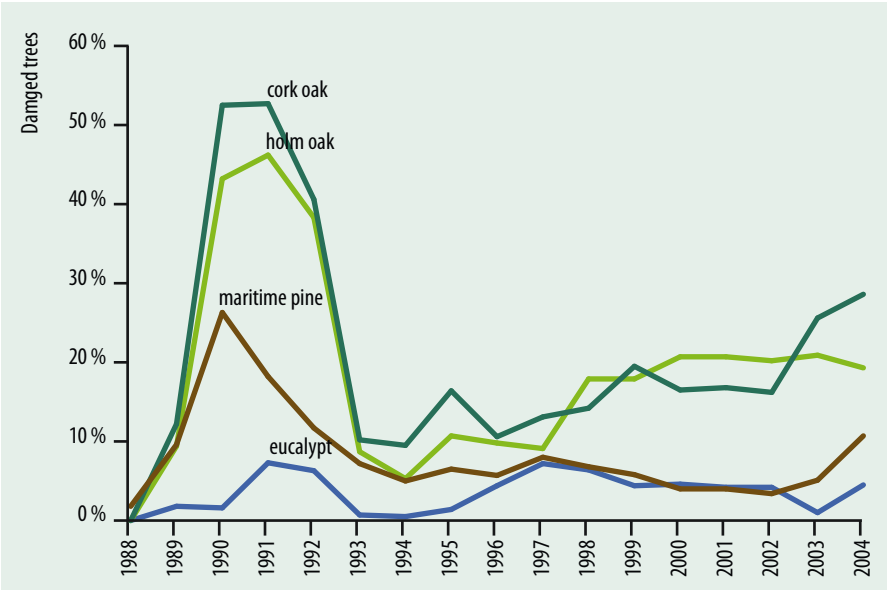
Main results

- At the Level I mainland plots, the proportion of both broadleaves and conifers with symptoms of damage showed a clear peak in 1990, and then decreased until 2002. However, in 2003 a slight increase was again observed. The poor crown condition of several tree species in the years 1990 and 1991, and recently in 2003 and 2004, was caused by fungi and insect attacks as well as by forest fires, triggered by drought periods. In fact, 2003 was the worst year since the beginning of systematic registrations with respect to forest fires: 423,276 ha were burned, 283,063 ha (67%) of which were forest stands, representing 8% of the total Portuguese forest. Maritime pine was the most affected (109,567 ha, i.e. 39%), followed by eucalypt (58,343 ha, i.e. 21%) and cork oak (43,613 ha, i.e. 15%).
- In the Azores, salty sea winds are the most significant cause for defoliation and discoloration. In some plots, isolated trees are worse than the average due to attacks of *Armillaria* sp.
- Atmospheric deposition seems to have only a small influence as a stress factor, except in the Azores where the normal sea winds carry a lot of salts and winds from Africa increase the levels of Ca, Mg, Na, K and sulphate.

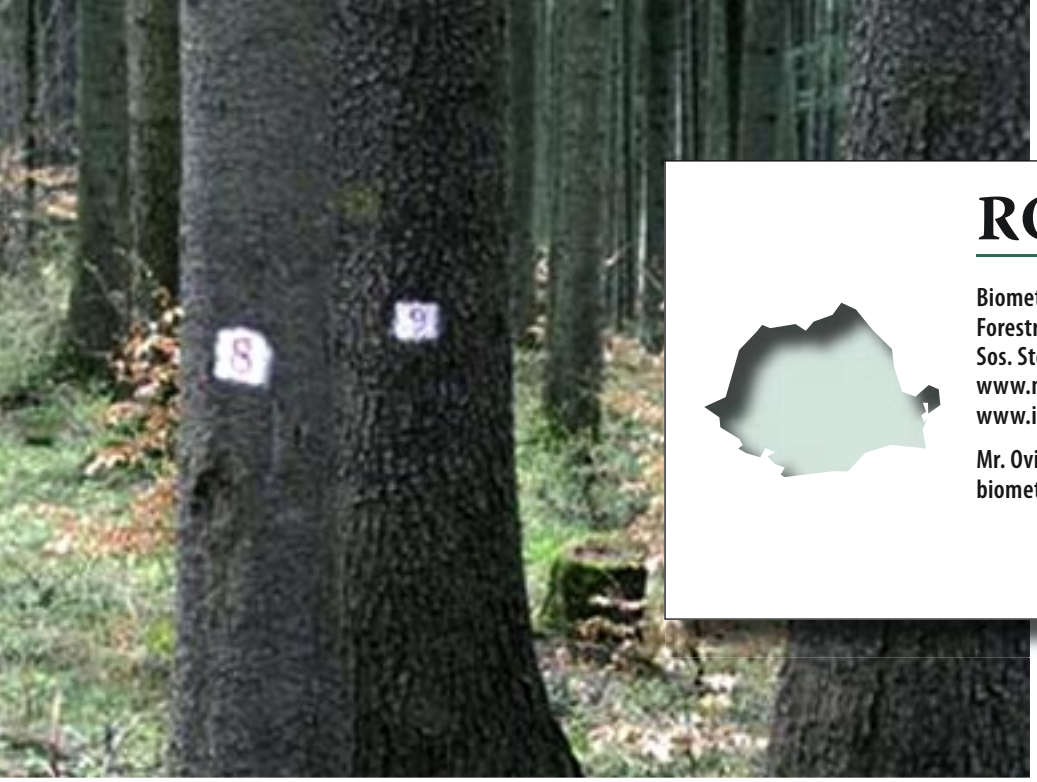
Outlook

The forest monitoring programme has provided essential information on the Portuguese forest health condition. Therefore the monitoring program will be continued. The programme will amend its objectives in the next years, in order to satisfy new needs. In this sense, a second forest soil assessment at a national level will start in 2005, as part of the BioSoil project.



Shares of damaged trees (defoliation classes 2-4).

Monitoring installations in Portugal.



ROMANIA

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Intensive monitoring plot with increment, soil, foliar and ground vegetation assessments.

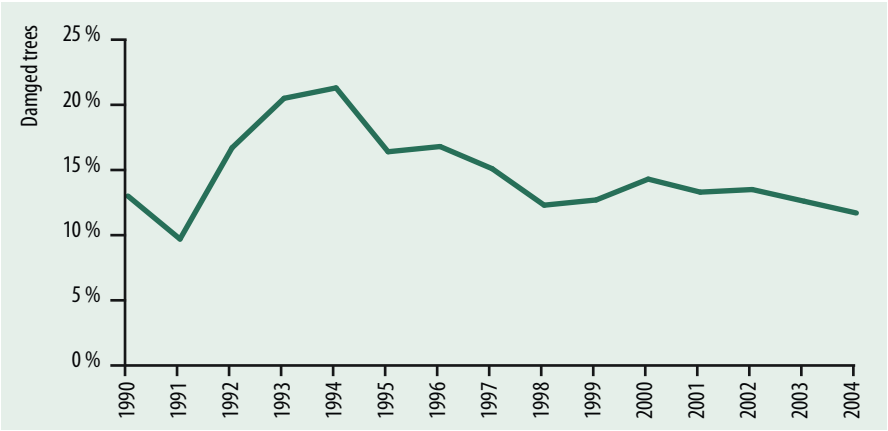
Background information

In Romania, forest decline with increased abnormal tree death occurred for oak species already in the periods 1937-1943, 1947-1949, and 1955-1958. For other important tree species such as silver fir, Norway spruce, pines, beech, and black locust, it was mainly recorded in the periods 1970-1978 and 1984-1990.

Forest crown condition assessments started in 1990 and are presently based on approximately 4,500 permanent plots in the national monitoring network (4x4 km). Around 230 permanent plots are part of the transnational Level I network (16x16 km). There are 12 permanent intensive monitoring plots (Level II) in the most important forest ecosystems, which are not systematically located.

Main results

- Crown condition is a meaningful indicator for the additive effects of air pollution and frequent drought in the south and south-east of the country. Oak species are the most affected, with the highest share (20-35%) of damaged trees. An overall improved situation in the last years is attributed to an increase in rainfall. The increment of trees has been found to be reduced at plots with higher defoliation.
- In the majority of the analyzed forest soils, the critical values for sulphur and nitrogen content were exceeded. Soil pH was below the critical value of 3.0 on most plots in the western region of the country, and in some conifer stands of the north-east and south of the Carpathian Mountains area.
- In Romania, more than half of Europe's potential natural vegetation types occur. Aspects of biodiversity have been assessed at the intensive monitoring plots. A remarkable abundance of plant species has been substantiated and biodiversity indicators have varied widely.
- In the last 10 years, atmospheric deposition has been reduced in the north of the country, whereas an increase has been observed in the south. Atmospheric inputs are in the range of 4-18 kg per hectare and year for sulphate and vary from 3-33 kg/ha/yr for total nitrogen.



Shares of damaged trees (defoliation classes 2-4, 4x4 km grid), all tree species.

Outlook

Romania will continue its air pollution reduction policy and will foster sustainable forest management in order to provide future ecological, social and economic benefits.

The National Soil-vegetation Monitoring Programme for Silviculture in Romania was started under Law No. 444/2002 and will offer also for the future essential information on forest condition. In 2005, this information will be complemented with the data of the National Forest Inventory.

Pine forest with spruce regeneration in the Leningrad region.

RUSSIA

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Background information

In 1988-89, the first 70 sample plots were installed in the Kaliningrad and Murmansk regions with support from specialists of the Lithuanian Forest Research Institute. The Biological Research Institute of Saint Petersburg State University added another 144 Level I sample plots in 1990-1992 in the Leningrad, Novgorod and Pskov regions, and installed 12 Level II plots in 1994-1995. In 1995, this Research Institute was appointed as the Russian National Focal Centre of ICP Forests. The Scientific Research Centre of Ecological Safety of the Russian Academy of Science (Saint Petersburg) actively participated in the work in north-western Russia. The Forestry Institute in Moscow was engaged in ICP Forests work in the central part of European Russia (Moscow region). The more than 450 Level I plots in the north-west of Russia have been used for education, for air pollution monitoring, for bioindication, for growth models, for the investigation of plant biodiversity, and for soil studies by many institutions. Special attention is given to the calibration of methods according to the standards of ICP Forests.

Main results

In Russia, sulphur deposition has been reduced by 70% since 1990. As in other European countries, this has improved the air quality in large areas. Zones with sub-lethal and lethal damage to epiphytic lichens on pine trees have been reduced considerably. The recovery of crown condition took place more slowly. However, the collapse of parts of the industry had a positive influence on the forests and is reflected in a decrease of total defoliation of pine and spruce trees. Nowadays, industrial development is resuming, which can have negative influences on the environment. Higher volumes of traffic and the expansion of recreation activities increased the damage to pine and spruce forests in the neighborhood of densely populated areas.

Outlook

The forest monitoring programme of ICP Forests has provided a very effective methodology for the evaluation of the ecological situation and the effectiveness of forest management with respect to forest health. Its long-term continuation will be important. Today, the measurement of forest growth and the prediction of its economic potential are important topics as well. It seems that in the near future, Russian society and government will pay increased attention to environmental issues, and it is hoped that this will also result in financial and political support for the monitoring programme. In the past, the instability of quickly changing Russian local authorities and central ministries were the main constraints for the activities. The database now holds data for almost 20 years and will become more and more relevant as a basis for political decisions.

SERBIA AND MONTENEGRO

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Background information

The first assessment of forest condition in Serbia, within the framework of Level I monitoring according to the ICP Forests methods, was performed in 1988 on more than 150 plots.

The development of ICP Forests monitoring has stagnated in the last decade due to lack of resources in Serbia. Systematic monitoring continued again in 2003. In the region of Serbia, 103 sampling plots are established on a 16x16 km grid and 27 new plots have been added on a 4x4 km grid, making a total of 130 Level I plots (not including the Kosovo and Metohija regions). Results are published on the national and regional levels.

Main results

- In total, 103 earlier established plots on a 16x16 km grid were re-established in 2003.
- 27 additional plots on a 4x4 km grid fitting into the existing 16x16 km grid were established in 2004.
- Crown condition assessments were carried out on 103 plots in 2003, and on 130 plots in 2004.
- Chemical properties of the soil in both the organic and mineral layers were surveyed on 103 plots in 2003 and on 27 plots in 2004, covering all main soil types of Serbian forest ecosystems.
- Based on the soil analyses, the nutrient supply of the forest trees was evaluated on 103 plots.

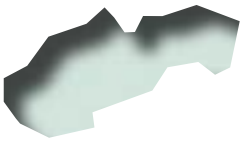
Outlook

Serbia will continue its environmentally oriented and clean air policies in the years to come. A system of intensive monitoring on Level II is planned to become active from 2006 onwards. ICP Forests monitoring in Serbia will provide deeper insight into the interactions between the various components of forest ecosystems. Close cooperation with ICP Forests will contribute to the calculation of critical levels/loads and their exceedances in forests and include other environmental monitoring programs in the future.

Re-established plot in Serbia.

Deposition samplers on the tower of the intensive monitoring plot Polana.

SLOVAKIA



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Background information

In the 1980s, the forests of Slovakia as a central European country were rather strongly affected by high levels of different types of air pollution and a widespread forest decline was observed. Forest condition assessments started on permanent monitoring plots on a 16x16 km grid in 1987. In 1995, the first three intensive monitoring plots were established under the pan-European programme. At present, the monitoring activities are being executed on 112 monitoring plots and 7 intensive monitoring plots. Results are published annually within the Environmental Information System of the Slovak Republic.

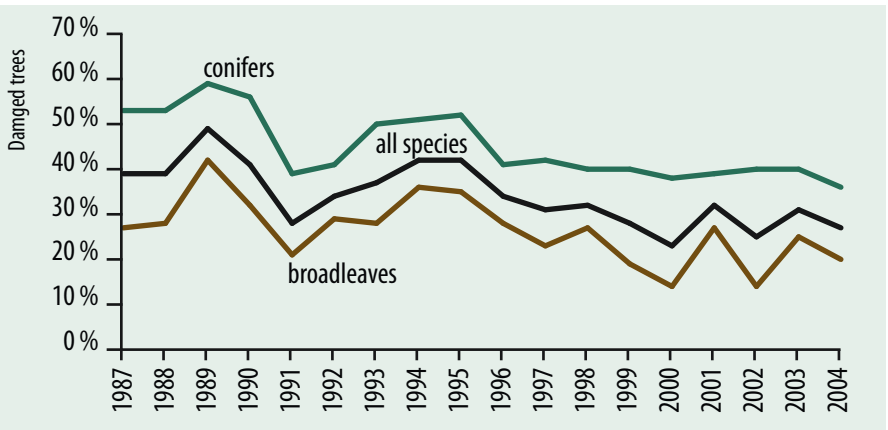
Main results

- From 1987, when the monitoring activities began, until 1996, a slight decrease in defoliation and visible forest damage was observed. Since 1996, the proportion of damaged trees (25-32%) and the average defoliation (22-25%) has remained relatively unchanged. The recorded fluctuation of defoliation depends mostly on meteorological conditions.
- The radial increment of trees is also strongly influenced by meteorological conditions. The long lasting droughts in the years 1993, 2000 and 2003 led to remarkable growth reductions.
- The mean sulphate concentration in atmospheric deposition has decreased during the observation period. Today, the effects of nitrate and ammonium deposition are dominant.
- The soil data show the acidification of more sensitive soils. A rather strong accumulation of potentially toxic elements has been observed in regions with long lasting heavy metal air pollution in the past.

Outlook

Forest monitoring plays an important role for the understanding of processes in forest ecosystems. In the context of sustainable forest management the main tasks for the future are:

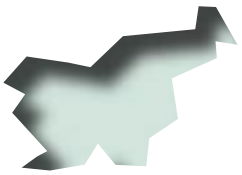
- to continue the periodic extensive and intensive monitoring of forest ecosystems;
- to extend the activities to additional fields like biodiversity, the protective functions of forests, climate change, and carbon sequestration;
- to supply the public with information about forests and thus to enhance awareness of the importance and the multifunctional role of forests.



Shares of damaged trees (defoliation classes 2-4).

Beech forest in Slovenia.

SLOVENIA



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Background information

The beginning of the systematic monitoring of forest condition in Slovenia dates back to 1985, when the country for the first time launched an inventory system largely based on the ICP Forests methodology. Since then, the monitoring framework has been continuously improved. At present it consists of 42 large-scale systematic monitoring plots on a 16x16 km grid and 11 intensive monitoring plots. The latter were installed in 2004. In addition to the monitoring on the 16x16 km grid, the country occasionally carries out an inventory on a 4x4 km grid. Its main goal is to obtain trustworthy data on growing stock volume and its increment, biodiversity, and forest health: information that is needed for answering questions on sustainability in the forests.

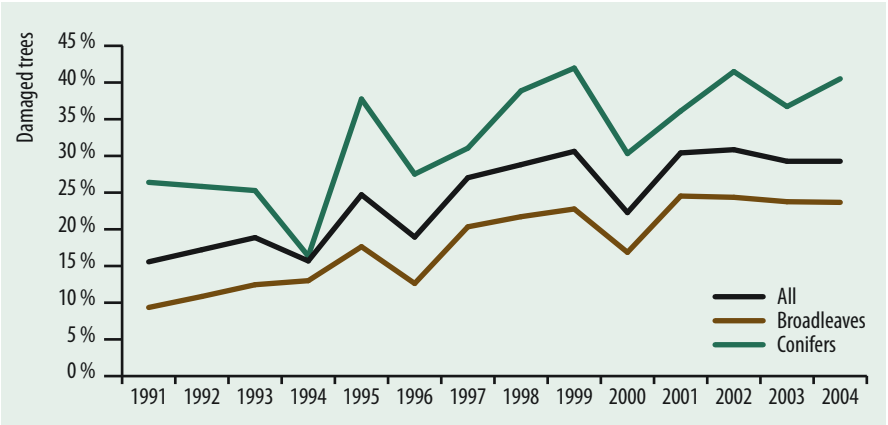
Main results

The analysis of defoliation changes over time reveals that the condition of Slovenia's forests is to a considerable extent stable. Although an increase in mean defoliation and in the proportion of damaged trees has been recorded, forests did not decline with the intensity that was predicted in the early 1980s. Moreover, results from additional permanent sample plots suggest that forest condition is even better than shown in the Figure.

Despite this rather convenient forest health trend, Slovenia's forests are far from being safe. Although sulphur concentrations, the main threat to forests about two decades ago, declined significantly, new stress factors have been evolving. Among them, ozone and extreme climatic events seem to be the most important.

Outlook

About 30 years ago, Slovenia adopted a rather modern concept of forest management that was grounded on the principles of sustainability, multifunctionality and close-to-nature management. To implement such a forest policy in day-to-day practice, there has always been a need for reliable data. This is perhaps the most important reason why the forest monitoring programme has lately become an essential part of Slovenia's forestry activities. In turn, it is also expected that the implementation of the monitoring programme as a whole will strengthen the position of forest science and practice in the country.



Shares of damaged trees (defoliation classes 2-4).

Stone pine (*Pinus pinea*) intensive monitoring plot in southern Spain (Huelva).

SPAIN

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Background information

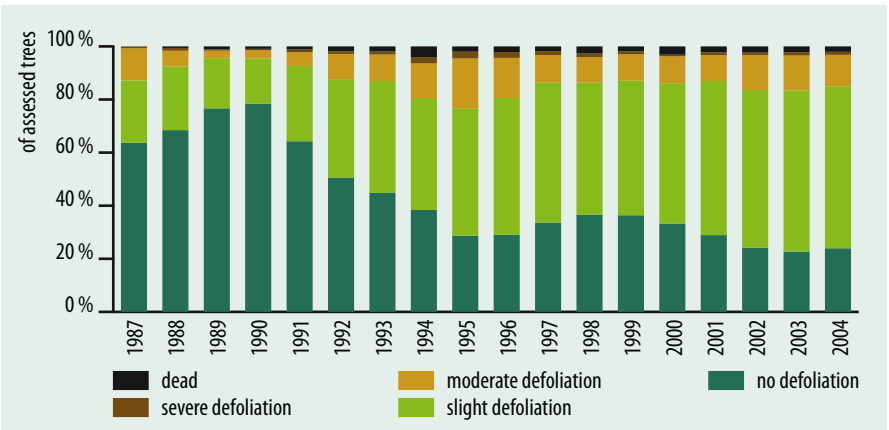
Spain has been participating in the ICP Forests programme since 1985. In 1987, the Level I grid was established at national level, now comprising 620 plots with a total of 14,880 sample trees. The setting up of Level II plots took place from 1993 to 1994. Today, 54 permanent intensive plots represent the most common Spanish forest ecosystems, with the aim of deriving in-depth knowledge about the impact of a changing environment on forests. 13 Level II plots are instrumented in order to carry out periodic measurements of deposition, meteorology, phenology and air quality, among others.

Main results

The main Level I results, derived from the so-called Forest Damages Inventory (IDF), revealed effects of a severe drought between 1991 and 1995 and allowed quantifying of the *Seca* syndrome that affects Mediterranean oak stands. Among the biotic damaging factors, the pine nematode specifically played an important role.

Level II shows levels of and trends in environmental conditions in the forests through the analysis of key factors, such as:

- Atmospheric deposition: At 13 Level II plots located all over the country total nitrogen deposition has been around 7 kg per hectare and year since 1997. Whereas the total nitrogen deposition has decreased slightly by 3%, the share of NH_4 has decreased remarkably in relation to NO_3. The average sulphur deposition has fluctuated around 6 kg/ha/yr with no clear trend.
- Ozone: Air quality has been monitored with passive samplers since 2001. Extreme ozone peaks of up to 76.46 ppb were reached in 2001. The European Reference Centre for Ozone Damage Assessments in Forest Ecosystems (Fundación CEAM, Valencia) provides a European reference web page for ozone damage (www.gva.es/ceam/ICP-forests) and offers a central laboratory for checking ozone like damage at the European level. Also, the first photoguide on ozone damage to Mediterranean forest species has been elaborated.
- Forest soil condition: Almost half of the Spanish soils contain carbonates, which originate from the geological parent material and have a pH above 6.



Evolution of defoliation levels 1987 – 2004: Percentage of assessed trees in different defoliation classes.

Outlook

Still taking into account the main goals of the two networks, the programme has broadened its objectives in order to satisfy new information needs in the fields of forest biodiversity and forest carbon sinks. The monitoring plots will also serve as an early warning system for climate change impacts. A new forest soil inventory at national level and the measurement of forest biodiversity will start in 2005. New parameters are tested in order to improve usefulness for the monitoring of pests, diseases and changes in the dynamics of Spanish forests.

Calibration exercises are carried out annually in order to maintain the quality of the visual damage assessments.

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Background information

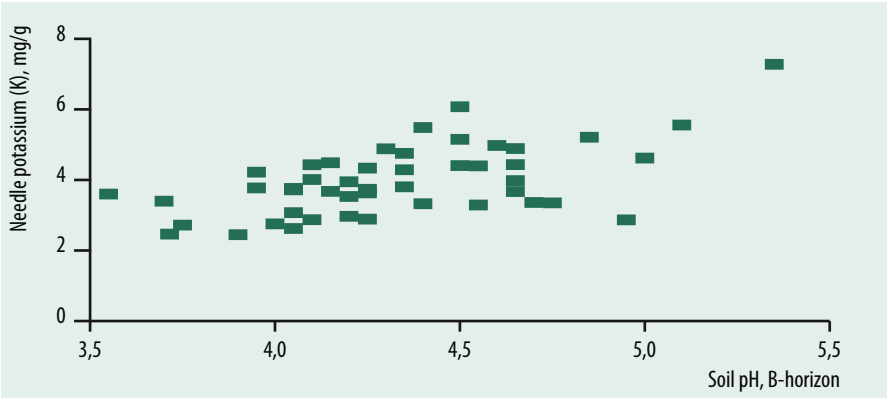
Assessments of tree defoliation were introduced in the National Forest Inventory in 1984. At that time damage symptoms were observed in south Sweden similar to those of the *"waldsterben"* areas of central Europe. In the same year, permanent observation plots were established in order to more closely follow the development of damage, which later on became the Level II plots. In connection with EU membership a major revision of the Swedish monitoring system was carried out in 1995. A new set of 100 Level II plots was established with a clear aim to elucidate any correlative relationships between air pollution and forest health. The Level I programme became based on 770 permanent plots of the National Forest Inventory.

Main results

The defoliation of conifers increased during the late 1980s until about 1992, but since then no clear tendency can be seen. Scots pines suffered from extensive infections by the fungus *Gremmeniella abietina* in 2001 and 2002, while storm events are probably the most important single damage factor for Norway spruce stands notably in 1999 and 2005. A more general climatic stress appears in forests closer to the alpine mountain range. Sweden also experienced a widespread oak decline in the late 1990s, as did many other areas of Europe. There is no strong evidence that air pollution or soil acidification has affected tree condition. More obvious are the effects of acid deposition on epiphytic lichens and mosses, fungi and vascular plants in the forests, not to forget the disastrous impact on the aquatic ecosystems.

Outlook

Forest monitoring of today covers many aspects from the genetic level to the landscape level. The information requirement shifts with new issues like climate change and biodiversity. It is therefore a challenge to update and coordinate the monitoring activities without losing continuity both in a national and an international context.



Example of correlation between soil pH and potassium (K) content of spruce needles from the Swedish Level II plots.

Challenging monitoring conditions at the Swiss Level II site of Beatenberg.

SWITZERLAND

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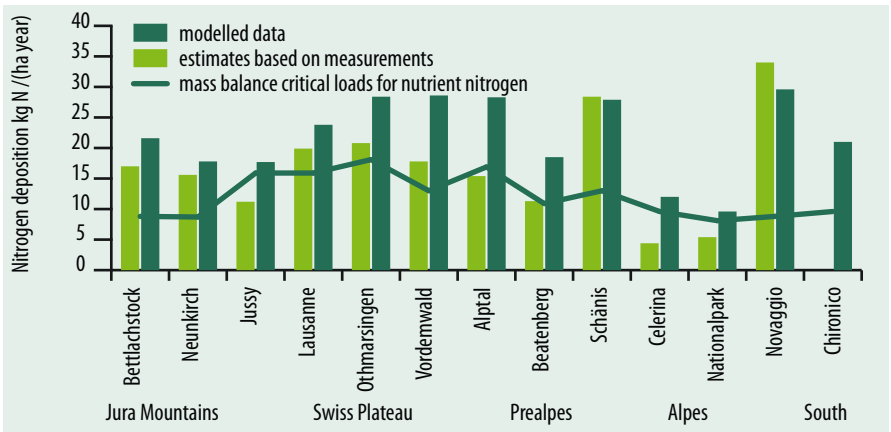
Background information

As a response to the fear of a widespread forest decline, annual tree crown condition assessments began in 1985 on a subset of the Swiss National Forest Inventory plots. The survey was first conducted on a 4x4 km grid. Later it was carried out on an 8x8 km and a 16x16 km grid (Level I). Between 1994 and 1997, 17 long-term forest research plots (Level II) were established in either the most common forest types or presumed sensitive forests, covering the five main regions of Switzerland. In general, the plots are 2 ha in size, with two 0.25 ha subplots for crown condition assessments and a 40x40 m soil chemistry, throughfall and vegetation subplot. Each plot is equipped with a below-canopy and an open-field meteorological station. All trees are numbered and geo-referenced, and selected trees in a buffer zone outside the plots are cored for past tree growth and sampled for foliar analysis.

Main results

Crown defoliation increased until the mid 1990s and has stabilized since on a high level with varying annual fluctuations. On the other hand, results from Level I show that annual mortality rates have remained almost constant. Tree growth, crown defoliation and subsequent tree mortality correlated on both Level I and Level II plots. Acidifying deposition was clearly below the calculated critical loads on most Level II plots. However, nitrogen deposition in the southern part of Switzerland, the Swiss Plateau and parts of the Pre-Alps and the Jura mountains exceeded mass balance critical loads of nutrient nitrogen. Only the inner Alps showed low nitrogen deposition levels.



Nitrogen deposition and critical loads for nutrient nitrogen on Swiss Level II (LWF) plots.

Tree stem growth during the 2003 heatwave summer was reduced in comparison to the wet summer of 2002 on plots with computed high drought stress at low altitudes and increased on sites without drought stress at high altitudes. The Open Top Chambers in Lattecaldo, Ticino, have become an international training centre for ozone injury assessment.

Outlook

In the future, more integrated analysis is foreseen, focussing on the relationships between the various forest condition variables, such as tree defoliation, mortality, growth, foliar nutrient content, and ground vegetation, on the one hand, and, on the other hand, short-term stress factors such as drought stress or episodes of high ozone concentration and long-term stresses such as deposition loads or nutrient availability.

Soil pit in a beech forest.

TURKEY

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Background information

Level I monitoring plots have been established and studies conducted for almost 5 years in the western part of Turkey. The Poplar and Fast Growing Forest Tree Research Institute in Izmit and the Soil Laboratory in Eskisehir are the institutions under the Ministry of the Environment and Forestry that are in charge of the projects at Level I.

The first project, which is conducted by the Poplar and Fast Growing Forest Tree Research Institute, started in July 2000. It is based on 25 stationary monitoring sites located in the forests of the provinces of Istanbul, Kocaeli, Bursa, Sakarya, and Duzce. The final project report is expected to be completed in 2005.

The second project is conducted by the Eskisehir Soil Laboratory. It started in 2002 and is expected to finish in 2007. The monitoring area is located just to the south of the first project, covering the Eskisehir, Bilecik, Bolu and Adapazarý provinces.

With the execution of the two above-mentioned projects, the Level I part of the ICP Forests Programme will be implemented in the north-western part of Turkey. The analyses and monitoring activities are performed according to the ICP Forests procedures on a 16x16 km grid.

Main Results

Preliminary results show that local pollution sources as well as long-range air pollution originating from Balkan countries and carried over the Black Sea might be responsible for some forest damage in the Kocaeli province. Kocaeli receives air masses from the north and northwest, especially in the winter months, which deposit amounts of pollutants that are above critical limits. In the Istanbul province, the effects are found to be less severe, which is attributed to a deposition mechanism that exports and reduces polluted air masses.

Outlook

The sulphur concentrations in leaf samples are regarded as a good indicator for air pollution. However, the separation of damage caused by anthropogenic and natural effects is still the main problem. Further studies are needed in this respect. Also, the network needs to be extended by permanent plots. It is planned to finalize the above-mentioned projects and to start the implementation of Level II as a next step.

Forest landscape in the Ukraine.

UKRAINE

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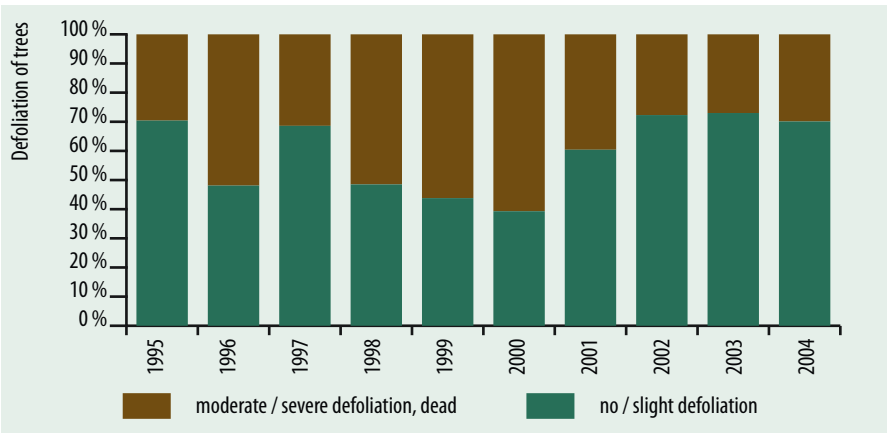
Background information

In the Ukraine, forest monitoring under the framework of ICP Forests has been carried out since 1989, when the Ukrainian Research Institute of Forestry and Forest Melioration (URIFFM) began to establish Level I monitoring plots. Under the leadership of URIFFM, scientists from regional research institutes established additional forest monitoring plots in regions with high atmospheric pollution. In 2000, the State Forest Inventory Service (VO "Ukrderzhlisproekt") was entrusted with the National Forest Monitoring Network, which today is a joint project of scientists and forest managers. In 2001, the ICP Forests Manual was translated into Russian, which improved the application of the methods of ICP Forests tremendously. At the 4th Ministerial Conference on the Protection of Forests in Europe (MCPFE, Vienna, 2003), the Ukraine signed the Strasbourg resolution S1, which refers to the monitoring system of ICP Forests. During the last years, the National Forest Monitoring Plot network has been constantly enlarged, covering nearly one half of Ukrainian territory in 2004. Forest monitoring results are annually used for the preparation of national reports.

Main results

ICP Forests Level I monitoring plots are mainly located in the regions with highest levels of air pollution. The average air pollution level in the Ukraine decreased by more than half compared to 1990. The total sum of ions in precipitation decreased by almost 40%. The acidity of rainwater decreased from a mean pH of 6.2 to 6.5 in 1997. After 2000, precipitation acidity again increased to pH values between 6.2 and 6.3.

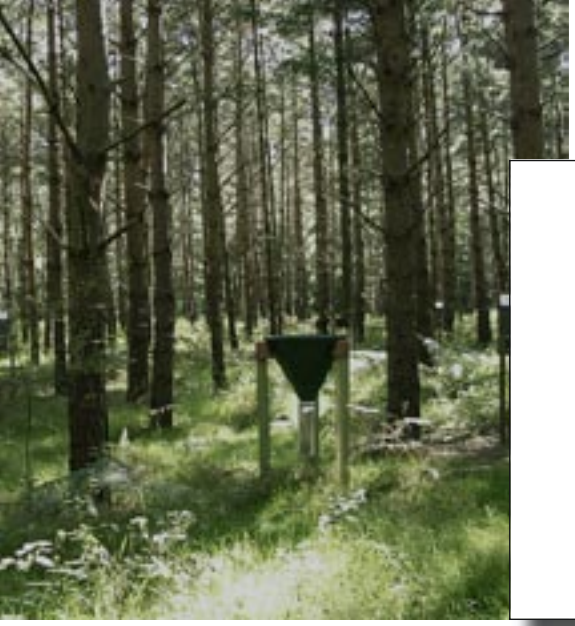
Tree crown defoliation increased on the Level I plots after 1997. Whereas in 1997 only one third of all investigated trees were rated as damaged, this proportion amounted to over 50% in 1998 and 1999 and exceeded 60% in 2000. Since then, crown condition on the observation plots has improved. Once again in the past three years, only 30% of the trees were recorded as damaged. Not only air pollution, but also harmful insects, diseases and weather extremes such as spring frosts, long summer droughts and high temperatures strongly influenced tree condition.



Defoliation of all species.

Outlook

Following national legislation and international commitments, forest monitoring activities in the Ukraine will be continued. The national network of Level I forest monitoring plots will be optimized and expanded into all administrative regions of the country. The number of investigations will be enlarged. In the future, the forest monitoring activities will be integrated with the forest inventory into a joint programme.



Thetford site: Litterfall and deposition collectors in a Scots pine stand.

UNITED KINGDOM

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Background information

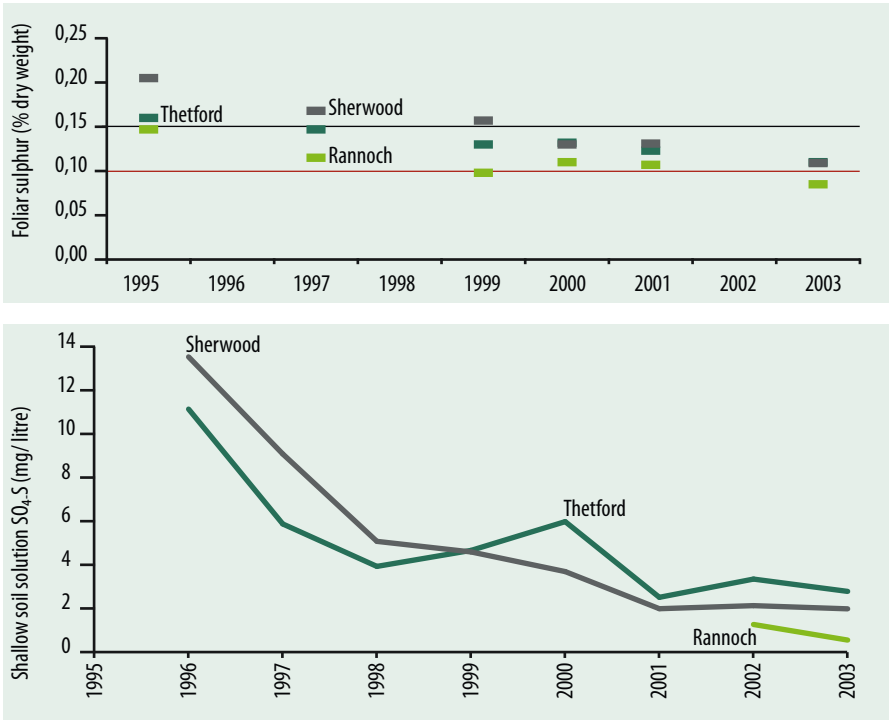
The first national survey of tree health (Forest Condition Survey) was carried out in the UK in 1984. This annual survey involved annual assessments of crown condition and, in 1987, was incorporated into the pan-European Level I Network. The Forest Condition Survey includes 350 permanent plots of which around 85 are Level I plots. In 2002, the Level I plots included managed forest of Sitka and Norway spruce, Scots pine, oak and beech. These same species are currently also monitored intensively within the Level II network of twenty permanent plots. Ten Level II plots were established in 1995 and ten in 2001.

Main results of more than 10 years of monitoring

- Like in other regions of Europe, there is a general downward trend in foliar sulphur concentrations at most UK Level II sites, corresponding to a reduction in soil solution sulphate concentrations. At some Level II sites foliar concentrations suggest that sulphur nutrient deficiency is beginning to occur (Figure 1).
- A reduction in foliar aluminium concentrations is evident at most sites, which may reflect the early stages of recovery from the effects of acid deposition.
- Visible ozone injury at the monitoring sites has been reported for Pinus strobus in 2001 and for two shrub species (*Salix caprea* and *Viburnum lantana*) in 2003. These observations demonstrate that the effects of ozone pollution are not limited to southern and central Europe.
- Nitrate concentrations in soil solution have shown a distinct increase over time in peat soils under Picea sitchensis. Nitrogen deposition is correlated with insect damage and needle retention in Scots pine.
- There is no evidence of a long-term trend (1987-2004) in the crown density of beech, Sitka spruce and Scots pine. There has, however, been a small but significant deterioration in the crown density of both Norway spruce and oak. No causal relationship between crown density and air pollution has been established on the basis of results from the Level I network.

Outlook

The UK Level I and Level II networks have been invaluable sources of information, providing details of the condition of national forests and their interaction with the wider environment. They have facilitated national and international reporting, and evaluation of sustainable forest management principles and how they apply in the UK. Data from the networks will continue to be used in national critical load evaluations.



Trends in foliar (top) and soil solution (bottom) chemistry at three Scots pine Level II plots. Deficient concentrations fall below the red line and optimal levels above the black line.

USA

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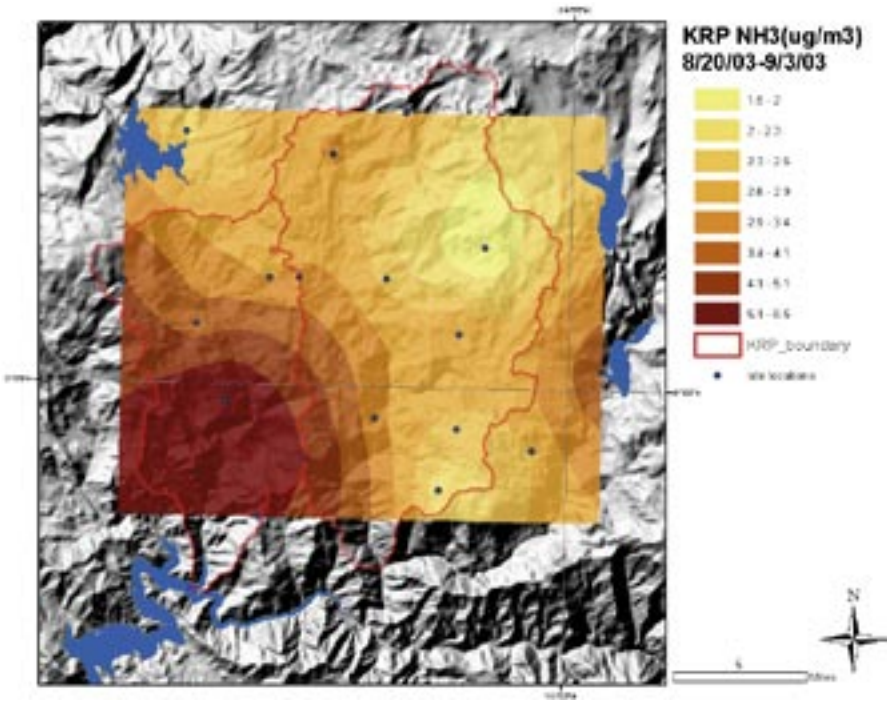
Passive sampler monitoring site in the mixed conifer forest in the Kings River Project, Sierra Nevada, California.

Background information

Since 2002, the USDA Forest Service scientists and managers together with their European and Canadian colleagues have been discussing a need for testing the ICP Forests methodologies. As a result, nine demonstration sites representing diverse US forest ecosystems have been selected in which methodologies used in Europe, Canada, and New England are tested.

Main results

In summer 2004, monitoring of parameters needed for the calculation of critical loads for nitrogen and sulphur deposition according to the ICP Forests protocols, took place in two demonstration sites, Otter Creek in West Virginia and Kings River in California. Based on these measurements the calculation of critical loads is currently being conducted by scientists of the Forest Service Northeastern Research Station. Progress in these monitoring and modeling activities was presented at the meeting in Riverside, CA, in February 2005. In the Kings River demonstration site special attention is placed on the spatial distribution of ozone and nitrogenous pollutants. In semi-arid forests of Sierra Nevada, a large portion of nitrogen is deposited as ammonia (NH_3) or nitric acid (HNO_3) in dry summer seasons. These pollutants are generated by mobile sources (automobiles), agricultural and industrial activities in California Central Valley and San Francisco Bay Area, and move eastwards into the Sierra Nevada. Information on distribution of these pollutants is obtained from a network of passive samplers and is needed for calculating dry nitrogen deposition to the Sierra Nevada ecosystems (see Figure).



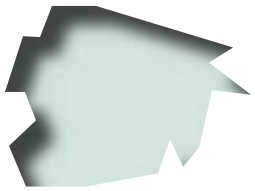
Distribution of ammonia (NH_3) in the Kings River Project, Sierra Nevada.

Outlook

The described activities will be expanded in 2005 into all of the demonstration sites. Active collaboration with specialists from US universities and other US governmental agencies, as well as the Canadian and European colleagues, will assure that state-of-science approaches to evaluation of critical loads are used. Future activities will be closely linked to the Forest Service national network of Forest Health Monitoring plots. Various factors affecting nitrogen and sulphur deposition effects, such as tropospheric ozone and climate variability, will be monitored and tested. Weakened forest trees are predisposed to drought and thus to fire calamities. The proposed activities will help with implementation of the recent presidential initiative "Restoration of Healthy Forests".

5. Additional Countries

ANDORRA



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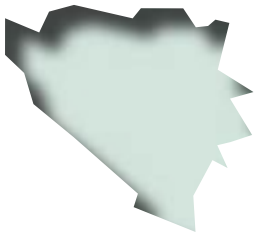
BOSNIA AND HERZEGOVINA



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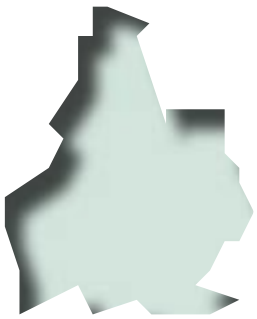
LIECHTENSTEIN



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MOLDOVA

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6. Coordinating Centres, Expert Panels and Working Groups

PROGRAMME COORDINATING CENTRE (PCC)

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Background information

Since the beginning of the programme in 1985, Germany has been chairing the ICP Forests as Lead Country and has established a Programme Coordinating Centre (PCC) at the Federal Research Centre for Forestry and Forest Products in Hamburg.

Main results

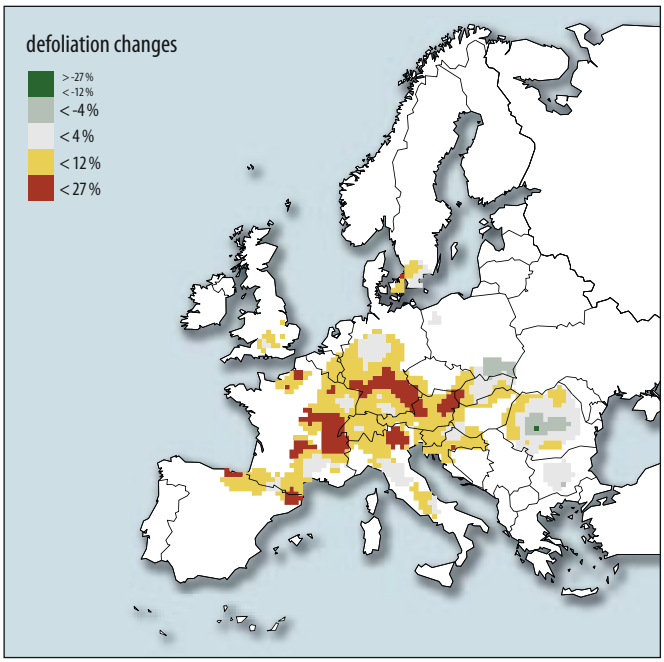
PCC is entrusted with a broad range of tasks in the fields of programme management, data processing, evaluations and reporting. It serves as information platform for the participating countries and assists the Task Force in the administration and further development of the programme. The main results that were published in previous years' reports show that:

- Weather extremes, insects and fungal diseases are linked to forest vitality as assessed by the parameter of crown defoliation. Air pollution and tree age also play an important role. Crown condition and the relevance of the influencing factors show a strong variation in different regions of Europe.
- There are relationships between atmospheric deposition, soil condition, foliar chemistry and tree growth. The programme has confirmed the decrease in sulphur depositions and has revealed resulting positive effects in forest soils. However, deposition of acidity and nitrogen were shown to exceed critical loads at a large number of forest sites.

PCC is an interface to the Convention on Long-range Transboundary Air Pollution in Geneva, which relies on the programme's results as a basis for its clean air policies.

Outlook

In the near future, specific emphasis will be laid on the development of a Level II database including an internet interface for participating countries and users. In addition, the development of the system of cross-calibration courses for crown condition assessments and of test-wise biodiversity assessments at the plots will be major activities. Also, dynamic models will be applied to the programme's data. All these activities will be carried out in cooperation with Expert Panels and participating countries.



Mean plot defoliation of common beech in 2004 in comparison to the average defoliation from 1997 to 2003. Kriging interpolation based on 564 plots continuously assessed from 1997 to 2004. After the extreme drought in 2003, the Level I monitoring net has again been a valuable early warning system.

The programme's webpage under www.icp-forests.org is a management tool of increasing importance. It is maintained by the Programme Coordinating Centre.

EXPERT PANEL ON SOIL AND FOREST SOIL CO-ORDINATING CENTRE (FSCC)

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Background information

At the Programme Task Force meeting in 1989, it was decided to monitor the impact of acid deposition on forest soils. The Forest Soil Expert Panel was charged with the inventory of the condition of forest soils in Europe. In 1993, the Forest Soil Co-ordinating Centre (FSCC) was established to co-ordinate the large-scale national soil inventories and to store and study the data and report the results. Presently, data from 5289 plots in 28 countries are stored.

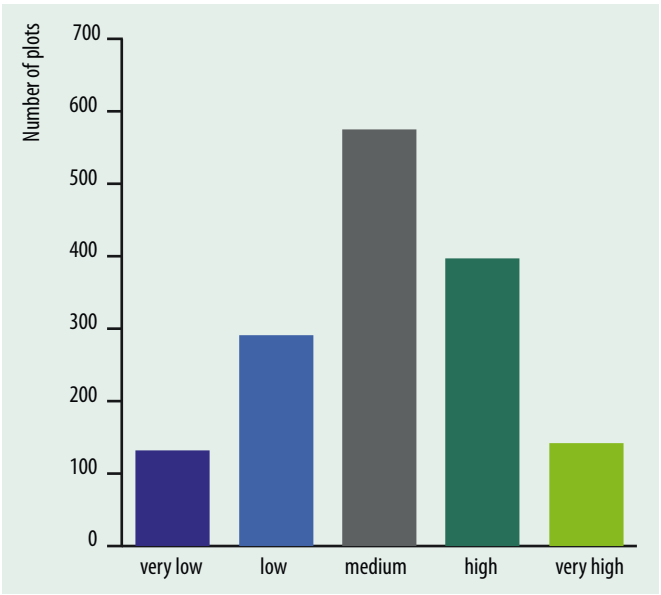
Main results

- The results of the large-scale soil survey, published in the Report on the Forest Soil Condition in Europe in 1997, documented a wide range of chemical soil conditions. Results showed a correlation between solid soil chemistry and atmospheric deposition of nitrogen, acidity and heavy metals. The intensive monitoring studies (Level II) as evaluated by the Forest Intensive Monitoring Coordinating Institute (FIMCI) showed that the concentrations of major ions in the soil solution were also to a large extent related to atmospheric deposition.
- Nitrogen pools in the organic layer of forest soils varied mostly between 100 and 250 kg per hectare. It is estimated that the present atmospheric nitrogen inputs will lead to significant changes in the soil nitrogen pools at approximately 25% of the plots within a time interval of 10 years.
- On average, the estimated carbon pools in soils are approximately twice as large as in trees, but carbon pool changes in tree stem wood are generally 5-10 times as high as in soil.

Outlook

A second soil survey is foreseen in the near future and will complete the database with relevant soil parameters and soil layers not considered in the first survey. It will also improve the overall data quality and enable a first monitoring of possible changes in the soils after a period of 10 to 15 years. An overlay between the Forest Soil Condition database and the Crown Condition database will allow for integrated analyses.

Forest soil on loess parent material in western Europe.



Sensitivity to soil acidification based on data from 1537 Level I plots in 1997.

EXPERT PANEL ON FOLIAGE AND FOREST FOLIAR COORDINATING CENTRE (FFCC)

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Background information

The nutritional state of trees can be a key indicator for forest ecosystems. Inadequate nutrient supply may cause low tree vitality or increase adverse effects of air pollution. High concentrations of certain elements in foliar tissues are often the effect of intoxication or of high air pollution levels.

The Expert Panel on Foliage has been established to develop and monitor methods of foliar analysis and to supervise laboratories in applying these methods. It collaborates closely with the Forest Foliar Coordinating Centre which was set up in 1994. The main activities of FFCC are the storage, quality control, evaluation, presentation, and publication of foliar Level I data, and the definition of general classification values.

Main results

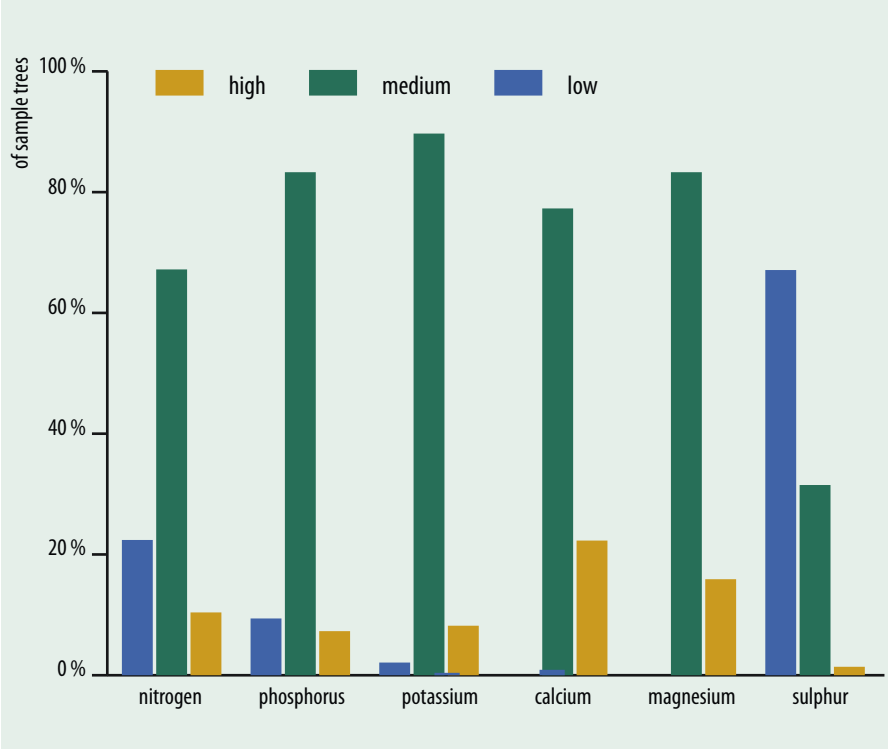
- Foliar sulphur concentrations have decreased drastically from the levels detected in late 1980 due to the decreased sulphur emissions, but no clear trend in foliar nitrogen levels can be seen. Most plots have an adequate status regarding nutrient concentrations (see Figure). At a relatively large number of plots in Germany, Slovakia and the United Kingdom, high levels of nitrogen and sulphur were found.
- The Expert Panel on Foliage has developed the foliar analysis part of the ICP Forests manual.
- Participating countries have used the methods of the manual to follow the trends in foliar element concentrations.
- Annual interlaboratory comparison tests have been implemented to ensure data quality. Results showed good quality for most of the participating laboratories.

Outlook

The main tasks for the future are:

- to continue the annual interlaboratory comparison tests and to develop indicators for data quality;
- to strengthen the exchange of information between participating countries and laboratories about analytical methods, measures of quality control and new possibilities for data evaluation.

Needle sampling by tree climber.



Classification of the content of major elements in the foliage of Level I sample trees in 1995 on 905 plots.

EXPERT PANEL ON DEPOSITION

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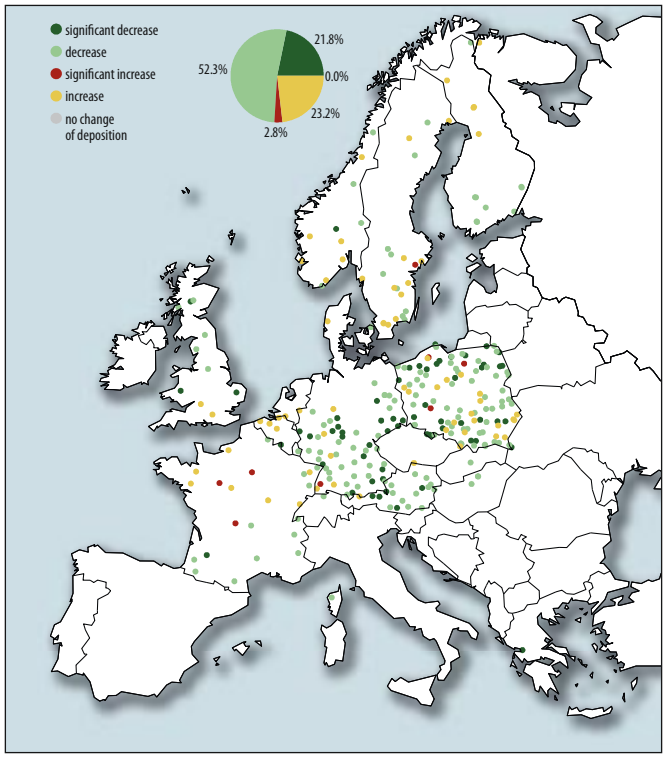
Background information and results

Within the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests, the Expert Panel on Deposition was created in 1993, contributing also actively to Regulation 3128/86 (Protection of Forests against Atmospheric Pollution) and now the Forest Focus Regulation (n°2152/2003) of the European Union. It has since then fulfilled many tasks, by:

- contributing to the aims of the Convention by providing regularly raw and aggregated data on the deposition and ozone situations in Europe;
- bringing regularly together all actors carrying out deposition and ambient air quality monitoring in their countries. This was one of the most important tasks at the beginning, because most of the national actors had to learn to know each other in order to profit from the experience of neighbouring countries in an atmosphere based on trust.
- harmonising field and analytical methods for deposition monitoring but also for ozone symptom detection in order to minimize differences between countries to acceptable error ranges. Part of the work is a continuous improvement of the European manual on deposition measurements. In 2004, a Working Group on Quality Assurance and Quality Control was convened, aiming to assist countries and to organise regular Working Ring Tests. These tests help all participating countries to check the evolution of their analytical performance.
- stimulating the evaluation of deposition and ozone measurements, the information flow between countries and the production of national and European indicators of use for a larger public, in order to inform them on trends in e.g. acidity or nitrogen;
- participating in scientific or demonstration projects, like the sampling method inter-comparison 1999/2000 in the Speulder Forest and the future HARMONDEPO project (co-financed by the EU under the Forest Focus Regulation);
- creating a platform for new research projects and for the development of equipment.

A major task in the future will be to gather early information on possible new problems, like heavy metals or organic pollution.



Trends in bulk sulphate deposition (SO4-S) from 1996 to 2001 at Level II plots.

Wet only deposition sampler. In order to distinguish wet from dry deposition, these samplers open only when rain, snow or extreme fog are occurring.

WORKING GROUP ON AMBIENT AIR QUALITY

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Background information

Ozone measurements suggest that surface ozone concentrations in central and southern Europe have more than doubled during the past century. In nearly all regions of Europe, ozone concentrations during spring and summer are high enough to be of potential risk to sensitive plants. Until recently, much of the ozone data were gathered in urban/sub-urban areas. A comprehensive dataset from forest sites was needed in order to provide for a better understanding of ozone levels and their potential risk to forest ecosystems in remote areas. Besides the obvious connections with the potential effects on forests, ozone data are also relevant in relation to tropospheric chemistry changes and regional ozone formation.

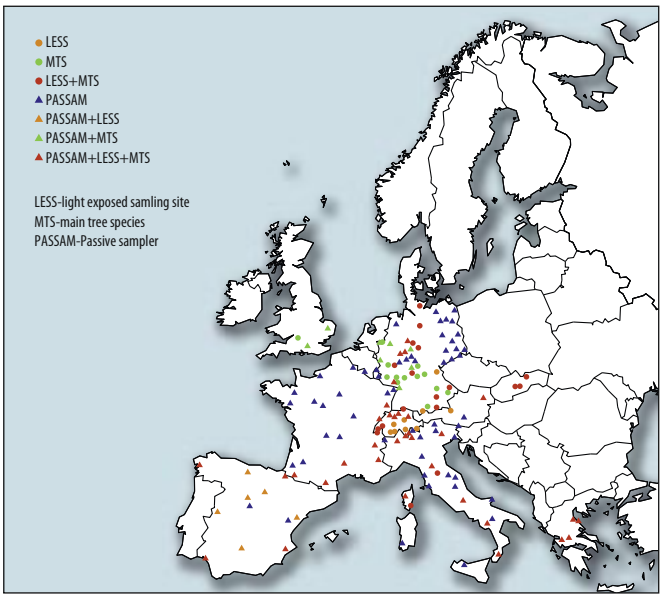
Main results

In a test phase that started in 2001, passive samplers were installed at around 100 Intensive Monitoring Plots. They proved to be a cost effective and reliable method for determining ozone concentrations in rural areas in Europe. The main results indicated that ozone concentrations and induced visible injuries are higher in the south of Europe. Among the 23 tree species screened, 6 showed validated ozone injuries. In total, the number of plots with ozone injury symptoms was 18 out of 72 (25%). Herb vegetation was screened at so-called Light Exposed Sampling Sites (LESS) at nearby forest edges. At 37 out of 67 LESS sites, ozone symptoms were observed, whereas at 30 LESS sites no ozone injury was found. Many of the species registered with ozone symptoms were not known to be ozone sensitive before (18 out of 61).

Substantial efforts have been made for training in the recognition of visible ozone injuries across Europe.

Outlook

The assessment of ozone injury on main tree species as well as ground vegetation at the LESS sites has to be considered as the first and unique effects monitoring system on a European scale based on real field observations. The test phase ends in 2005 with a refined manual for the assessment of visible injury that can be applied by all countries and with an increased expertise across countries in recognizing visible ozone injury. Linking of the two information systems ambient air quality and ozone effects assessment in a geographic information system (GIS) will be an important task for the near future. It will allow analysing coinciding hot spots in both information layers.



Test phase plots in 2001.

Visble ozone injury on leaves of ash (top) and common beech (bottom).

EXPERT PANEL ON FOREST GROWTH

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Background information

In the 1980s the concern for a large-scale forest decline due to air pollution in Europe instigated studies to quantify the assumed effect of air pollution on forest growth. The comparison between trees judged as 'healthy' or 'damaged' suggested decreasing tree growth. However, since the early 1990s several studies have reported higher forest growth in comparison with previously derived yield table estimates. The exact causes for these growth trends could not be determined. In order to define common methods for growth assessments, the Expert Panel was convened in 1991. Since plot installation in 1994/95, tree growth parameters, such as stem diameter at breast height (dbh), have been measured three times.

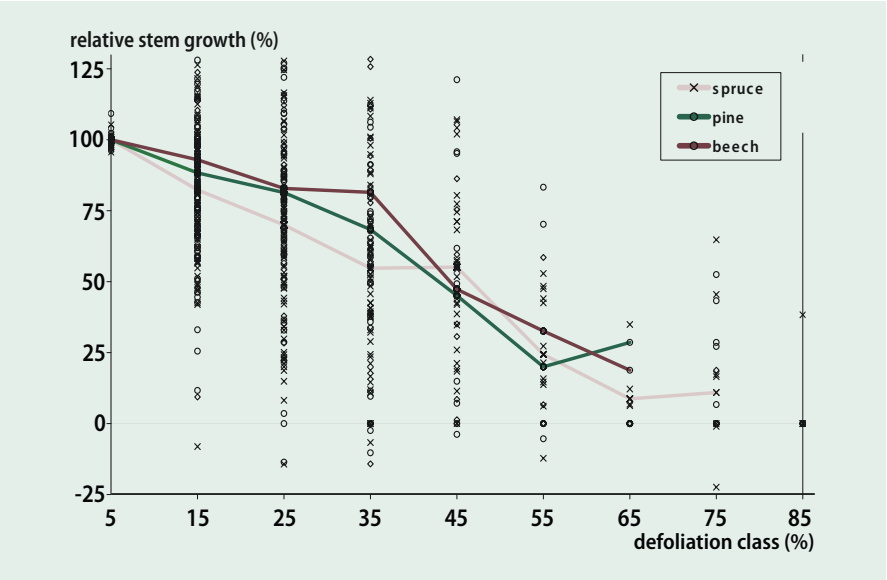
Main results

- Two studies (DEFOGRO, PrognEU) showed that basal area growth and defoliation correlated negatively for all species examined (see Figure). In other words, trees with fewer needles or leaves had reduced basal area growth. This relationship had previously been found in some studies for spruce and pine, but for beech no such clear results had been established.
- Another study (RECOGNITION) found that, for the period 1960-2000, annual height growth of younger trees for the three species Norway spruce, common beech and Scots pine was more than 20% larger than the height growth of older trees when they were of the same age. The finding that trees currently grow faster than in the past due to changes in site productivity confirmed several prior studies.
- While forest growth has been enhanced across Europe, defoliation and growth of single trees within the stands are correlated. This means that, in general, both healthy and defoliated trees have currently increased increment. The absolute growth level of the defoliated trees is, however, lower.

Outlook

The evaluation of the second 5-year growth period will be carried out after 2004/05. Special attention will be paid to possible causes for growth changes, such as drought stress or anomalies in temperature. Data from permanent increment measurements will be of specific interest. It is further foreseen to use growth measurements to calibrate, test and implement explanatory growth models. In the long run, growth data from Level II plots will increase in importance for proving whether or not the current growth trend continues and to test hypotheses for its causes.

Tree with breast height mark and manual and electronic girth bands.



Tree growth in relation to defoliation (DEFOGRO).

EXPERT PANEL ON CROWN CONDITION ASSESSMENTS

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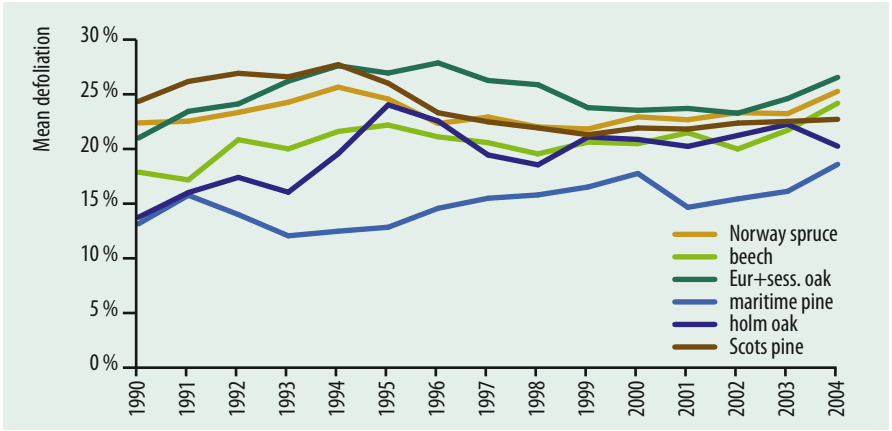
Background information

Since the early 1980s, when a severe deterioration of forest condition was observed in large areas of Europe, tree vitality has been monitored. In line with the objectives of ICP Forests and the EU, defoliation assessments have been implemented. On the one hand, they fulfil the requirement of an annual, low cost overview of tree vitality, and on the other hand they can serve as a target variable for statistical analyses aiming at explanations of causes and effects. This parameter has been selected by the Ministerial Conference for the Protection of Forests in Europe as one indicator for sustainable forest management. Today, long defoliation time series are one of the most valuable results and outputs of the programme, and added value lies in integrated evaluations in cooperation with the Expert Panels on Litterfall, Phenology, Foliar Analyses, Ambient Air Quality and Deposition.

Crowns of undefoliated, severely defoliated and dead Scots pines.



Mean defoliation of European main tree species.

Main results

- On average, crown condition of most European main tree species deteriorated until the mid 1990s. After a recuperation and fluctuation in the subsequent years, a new deterioration has been observed since 2002, which seems at least partly to be related to the hot and dry summer in 2003. Crown condition developments differ, however, between tree species and regions of Europe.
- Crown condition reacts to a multitude of environmental factors including insects, fungi, weather conditions and air pollution.
- The Expert Panel has been the main body for the development of the methodology and for assuring the quality of the assessments. Regular Intercalibration Courses with participants from all participating countries assure the consistency of the time series. Modern techniques like digital photography and image processing have become important parts of these activities. In recent years a specific methodology has been elaborated in order to better describe biotic damage symptoms.
- Scientific evaluations have shown a close relationship of defoliation to tree growth, tree crown morphology, tree mortality and fructification. This underlines the value of crown condition as an overall integrating parameter for tree vitality. The extreme drought in central Europe in 2003 also had significant effects on defoliation.

Outlook

The main tasks for the future will be the continuation of the time series, the further development of quality control and assurance tools, and the initiation of integrated evaluations, which might also lead to the development of an even more integrated vitality indicator.

EXPERT PANEL ON METEOROLOGY, PHENOLOGY AND LITTERFALL

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Meteorology

Meteorological phenomena are among the most important factors influencing forest condition and growth. Meteorology has been part of the monitoring programme since 1996 with measurement stations installed on a limited number of the intensive monitoring plots (Level II). The objective is to provide local information on basic driving and influencing factors from inside the forest ecosystems and nearby open fields.

The basic meteorological parameters measured in the programme are air temperature, relative humidity, precipitation, wind speed, wind direction, and solar radiation. The recording of these parameters is essential for the calculation of transport and deposition of air pollutants to forest stands, and water and element cycles. Temperature and precipitation may have severe effects on the trees like frost during bud burst or drought during the growing season. Meteorology may also indirectly contribute to favourable breeding conditions for insects.

Phenology

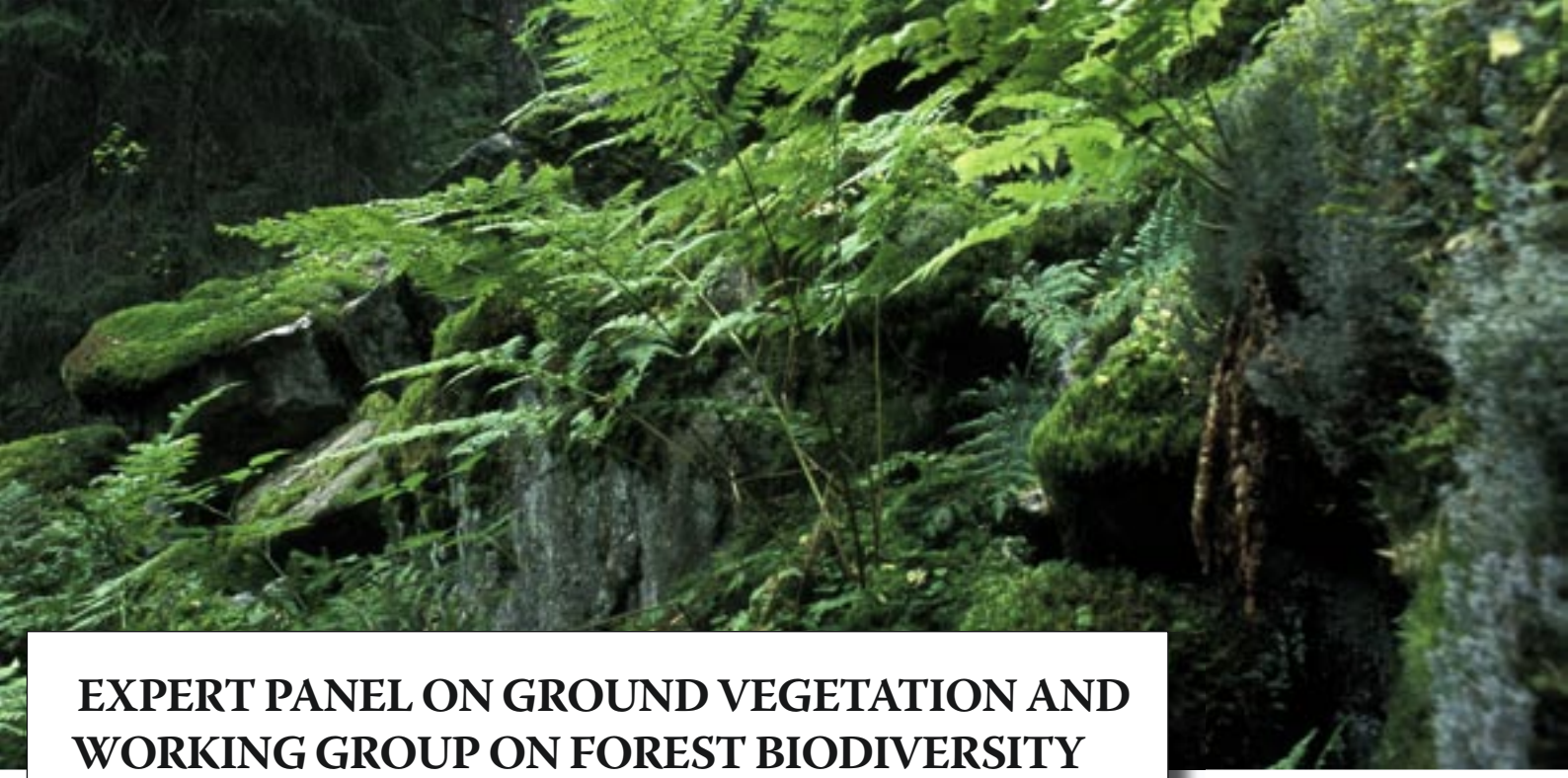
Within the aims of the Intensive Monitoring Programme, forest phenology is defined as the systematic observation and recording of the biotic and abiotic (e.g. damaging) events and phenomena and of the yearly development stages of forest trees. The main objective of phenological observations at the Level II plots is to provide information on the status and development of forest tree condition during the year. Phenology is a simple but effective tool to study the effect of fluctuations in climate and weather on trees. The timing of spring flushing, flowering, autumn coloration and leaf fall are highly correlated with temperature. Thus, long-term assessments, in combination with meteorology, will give an indication of changes in the duration of the growing season and consequently in tree growth as a result of climate change. Changes in phenology may also affect the occurrence of pests and diseases, water availability during summer and the uptake of nutrients and/or air pollutants. This may have a direct effect on forest condition. Litterfall can be used to quantify the phenological parameters flowering (fruiting) and leaf fall.

Monitoring of phenology started in 2000 on a few plots. Because of the growing importance of climate change, also within the ICP Forests programme, the importance of phenology will increase, and as a result also the number of plots with phenological assessments.

Litterfall

Litterfall is one of the most significant element fluxes in the forest ecosystem, playing a fundamental role in the nutrient turnover and in the transfer of energy between the trees and the soil. The primary net productivity of forest vegetation is subject to environmental factors such as climate and soil and to inherent factors such as age and tree cover. The amount of litterfall is related to these climate-soil factors, as the total mass of shed litter is directly proportional to the fertility of the soil. Thus, litterfall is closely related to both meteorology and phenology. Through its effects on ground vegetation, litterfall is also closely related to biodiversity issues. A new litterfall manual was adopted by the ICP Forests Task Force in 2004 and is now a part of the Intensive Monitoring Programme. According to a survey carried out in 2001, litterfall has, however, been collected for several years on about 65% of the intensive monitoring plots in Europe.

Meteorological measurement equipment in the open field, Denmark.



EXPERT PANEL ON GROUND VEGETATION AND WORKING GROUP ON FOREST BIODIVERSITY

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Vegetation surveys include the recording of ferns and mosses on the forest floor.

Background information

The assessment of ground vegetation has been part of the ICP Forests programme since 1995, and was formally adopted as one of the main parts of the programme at the Task Force Meeting in 1997 in Farnham (United Kingdom) where the EP on Ground Vegetation Assessment was formally convened. Ground vegetation assessments are mandatory on all Level II plots. The Expert Panel assembles the national experts responsible for these assessments. The Expert Panel collaborates closely with the ICP Forests Working Group on Forest Biodiversity, established in 2001 in line with the amended mandate of ICP Forests.

Ground vegetation is a major component of forest ecosystems. Vegetation layers contain a large part of total forest biological diversity. They play a direct role in water and nutrient cycling, and strongly interact with other biotic components like insects and game. Vegetation is a good bioindicator of environmental changes and certain species are known to react to atmospheric deposition. The current knowledge of the ecological niche of numerous plant species allows changes in underlying environmental factors to be deduced from vegetation changes. Thus, the long-term study of vegetation dynamics at selected locations will provide information on changes in other forest ecosystem variables, such as soil and microclimate.

Main results

The main results from the Expert Panel and Working Group are the development and harmonization of field methodologies, including harmonisation of field work and non-destructive sampling procedures. Much effort is put on the enhancement of a list of species codes to be used at the European scale. The Expert Panel on Ground Vegetation maintains a web page where users can find up-dated information on topics that are related to the main issues of the Expert Panel.

The Working Group on Forest Biodiversity has been mainly focusing on the development of simple and practical methods of monitoring forest biodiversity components within the ICP Forests network. A project known as ForestBIOTA, which aims to test methods in the field at Level II plots, is scheduled to begin in spring 2005, while the Working Group is currently elaborating methods for use in the BioSoil project which aims at monitoring forest biodiversity at Level I from spring 2006 onwards.

Outlook

Main activities in the future are:

- to enhance quality control of the assessments mainly through international inter-calibration courses
- to further develop the harmonised methods as laid down in the Manual
- to strengthen the exchange of information between the participating countries on ground vegetation questions
- joint evaluation of ground vegetation data
- joint evaluation of the field methodology for forest biodiversity monitoring
- joint evaluation of gathered data on different biodiversity indices.

Lysimeters extract water from the soil (soil solution).

WORKING GROUP ON SOIL SOLUTION

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Background

Monitoring the chemical composition of the soil solution is an extremely important tool when investigating the interactions between the input of nutrients and other elements from microbial decomposition and weathering in the soil, nutrient uptake by the trees and other vegetation, and the input of ions into the ecosystem from deposition. The techniques of soil lysimetry are also well suited for monitoring long-term changes in site fertility and the effects of acidifying deposition on forest ecosystems. Although the monitoring of soil solution quality has a relatively long history in a number of countries, the first steps in establishing a European soil solution monitoring network did not take place until 1994, when the ICP Forests Level II network was set up. Since then, soil solution monitoring has formed an integral part of the Level II activities.

Main activities

- The first sub-manual covering the collection, analysis and reporting of soil solution data was completed in 1996 by the soil solution experts working within the Expert Panel on Soils.
- During 1998-2000 an evaluation project was carried out by Finland and Denmark on the lysimeter techniques employed in monitoring soil solution quality in the European Level II intensive plot network, and assessment of the future comparability of the soil solution data.
- An Ad Hoc Soil Solution Expert Panel was set up to modify and develop the sub-manual in accordance with the findings of the evaluation project.
- The Ad Hoc Expert Panel is currently concentrating on improving the quality of the soil solution data, in co-operation with the Expert Panel on Deposition, by participating in Working Ring Tests and joint workshops.

Outlook

In the future it is expected that soil solution monitoring will play an important role in research on the effects of climate change on forest ecosystems. The flux of carbon in the soil solution is an important and relatively sensitive indicator of changes taking place, for instance, in the rate of decomposition of organic matter on the forest floor.

7. Acid Deposition Monitoring Network in East Asia (EANET)

NETWORK CENTER FOR EANET

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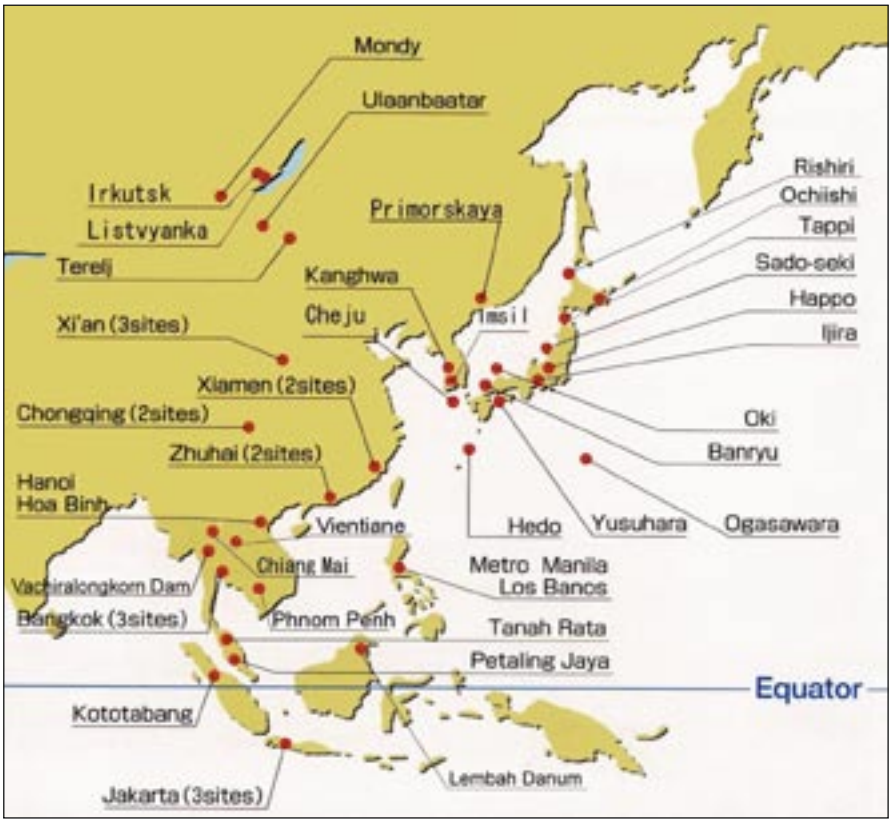
Wet and dry deposition monitoring site in Terelj, Mongolia.

Background information

ICP Forests closely cooperates with the Acid Deposition Monitoring Network in East Asia (EANET). This network started its preparatory phase activities in April 1998 with ten participating countries, namely, China, Indonesia, Japan, Malaysia, Mongolia, the Philippines, the Republic of Korea, Russia, Thailand and Viet Nam. After a successful completion of the preparatory phase it was decided to start the EANET activities on a regular basis from January 2001 onwards. Cambodia and the Lao P.D.R. joined the network in 2001 and 2002 respectively. In EANET, wet and dry deposition monitoring, soil and vegetation monitoring, and monitoring of the inland aquatic environment are carried out according to the Technical Documents adopted by the participating countries. Major achievements in the regular phase activities:

- The number of monitoring sites is increasing year by year. As of January 2005, monitoring is carried out at 47 sites for wet deposition, at 34 sites for dry deposition (air concentrations), at 29 forest sites for soil and vegetation, and at 12 lakes/rivers for the inland aquatic environment. No obvious relationship between air pollution and tree decline has been reported yet.
- The Data Report on the Acid Deposition in the East Asian Region has been issued annually by the Network Center since 2001. Presently, the latest Data Report available is for 2003.
- Inter-laboratory comparison projects on wet deposition (rainwater), soil, and the inland aquatic environment (lake water) are annually carried out among the analytical laboratories of EANET in order to improve the analytical precision and accuracy in the respective laboratories.



Wet deposition monitoring sites of EANET.

Outlook

The first periodic report of EANET based on the data of the regular phase activities is under peparation. A submanual on forest monitoring is under development for the further elaboration of the methodologies in cooperation with ICP Forests, and will be finalized in 2006.

8. Summary of multinational results

Over its twenty years of existence, the active participation of a large number of countries has underpinned ICP Forests. This participation has not been confined to monitoring and data submission, but has also comprised a wealth of national evaluations, as shown in Chapter 4. However, the success of the programme is based as well on its numerous evaluations of multinational data assessed by means of harmonized methods across Europe. The results of these multinational evaluations have been published in a series of Technical and Executive Reports. The main findings from twenty years of multinational evaluations of forest condition in Europe are highlighted in the present chapter.

Concern about forest condition at the European-wide scale resulted from the alarming deterioration of tree crowns in many forest areas in Europe in the early 1980s. This gave rise to the continuous monitoring of crown condition. Crown condition reflects tree vitality, is useful as a fast reacting indicator for numerous environmental factors and can be assessed with reasonable effort at the European-wide scale. Nineteen years of annual monitoring of crown condition have revealed high spatial and temporal variation in defoliation. Forest damage has developed far less dramatically than predicted by some scientists two decades ago, but defoliation has increased in general for most main tree species. However, in some regions of central and eastern Europe a transient recuperation of Scots pine was observed from the mid 1990s on. The variation in defoliation is mainly explained by tree age, weather extremes and biotic factors. The recent response of crown condition to the summer heat and drought of the year 2003 in large areas of central Europe proves the value of the monitoring programme as an early warning system. Air pollution was also found to be correlated with defoliation, but less highly than the above-mentioned natural factors. More pronounced effects of air pollution on forest ecosystems, in particular on soil condition, foliage chemistry and tree growth, were shown by multinational evaluations including the numerous further parameters assessed besides defoliation.

Sulphate deposition, both in the open field (bulk deposition) and especially under the canopy (throughfall), decreased clearly on most of the intensive monitoring plots in northern, central and western Europe over an evaluation period from 1996 to 2001. Soil solution shows the first signs of a recovery from sulphur impact on many of the plots. However, in certain regions sulphate deposition is still high. Ammonium and nitrate deposition has decreased as well on a number of plots but is still fluctuating at too high levels at other sites. Despite some decrease, deposition of nitrogen and acidity still exceeds critical loads at a large number of forest sites. The concentrations of ground level ozone exceed critical levels on the majority of plots in southwestern Europe. Scenario analyses show that the emission reductions expected from clean air policies under CLRTAP will on average result in a recovery of soil solution. The reactions of the soil solid phase and especially of fauna and flora will be considerably slower and take decades.

High nitrogen deposition, reduced sulphur deposition, enhanced temperatures and concentrations of carbon dioxide, and improvements in silviculture have probably all contributed to a clear increase in forest growth. The monitoring results confirm a general increase in growth by up to 25% compared to earlier decades. However, trees with high defoliation show reduced increment in comparison to trees with no or little defoliation. The growth and soil analyses of the programme help to estimate to which degree carbon sequestration in forests can decrease atmospheric carbon dioxide concentrations. To a small extent, nitrogen deposition has been shown to enhance carbon sequestration by means of a stimulation of forest growth. Atmospheric deposition was also found to have an impact on ground vegetation. Plant diversity was found to be lower on acid forest soils.

9. Conclusions and outlook

More than two decades ago, Europe was alarmed by evil tidings of air pollution causing catastrophic forest death. The situation has changed in the meantime. Forest condition has deteriorated far less dramatically at the European-wide scale than was feared in the early 1980s and forests are growing faster than before. But how great is the extent of forest damage in Europe actually, how is it developing and what are its causes? How is air pollution involved and does clean air policy pay? For twenty years, ICP Forests has been working on these questions under the Convention on Long-range Transboundary Air Pollution (CLRTAP) under the United Nations Economic Commission for Europe (UNECE) and in close cooperation with the European Commission. Twenty years of ICP Forests stand for the development and international harmonization of methods and standards, for the implementation of data management and data quality control as well as for scientific evaluations of the monitoring data and for continuous reporting of results. With 41 participating countries, a systematic grid of more than 6,000 sample plots and some 860 intensive monitoring plots, the programme constitutes one of the world's largest biomonitoring networks.

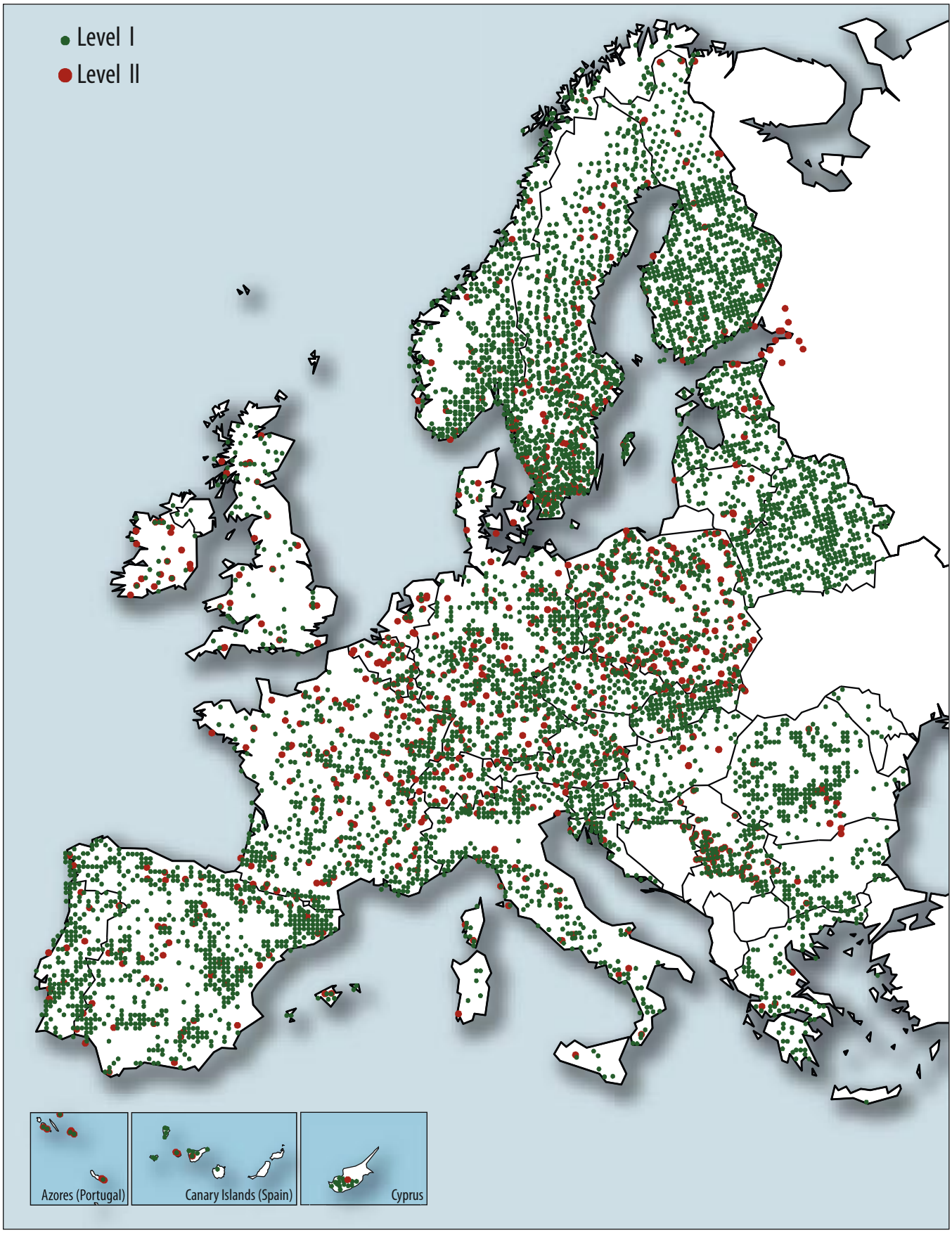
The results published by ICP Forests in the last two decades provide a realistic picture of the extent and development of forest damage and contribute to the elucidation of the complex causes and effects involved. They constitute a part of the scientific basis of the legally binding protocols on air pollution abatement of the countries of UNECE under CLRTAP. The considerable reduction of sulphur emissions in particular, and the resulting notable improvement of air quality in Europe testify to the success of the work of ICP Forests and all other ICPs under CLRTAP.

In the future, the provision of relevant scientific information to CLRTAP will remain of highest priority for ICP Forests. This will comprise the verification of the efficiency of air pollution abatement policies. A positive response of forest ecosystems to emission control can be verified already now, and further positive effects are predicted by scenario analyses. Nevertheless, in-depth assessments of air pollution effects on forests will remain of the utmost importance, given the enduring exceedance of critical loads, especially of acidity and nitrogen, the exceedance of critical levels of ozone, particularly in many forest areas of south western Europe, and the continuing accumulation of heavy metals in forest soils.

Besides fulfilling its obligations under CLRTAP, ICP Forests will use its well-established infrastructure, its multidisciplinary monitoring approach and its comprehensive database to also contribute to other international environmental policy processes. The programme pursues the objectives of Resolutions S1, H1 and L2 and already provides information on several of the indicators for sustainable forest management of the Ministerial Conference on the Protection of Forests in Europe. Moreover, it will contribute urgently needed information on species diversity and carbon sequestration to the United Nations Framework Conventions on Climate Change and Biological Diversity. The close cooperation of ICP Forests with the scientific community will continue to be of mutual benefit: the programme profits from advice provided by scientists regarding the continuous improvement of methods and data quality, and scientists are increasingly benefiting from ICP Forests' multinational data. The manifold results of evaluations of national data give evidence of the relevance of the programme for each individual country too.

Programme homepage:
www.icp-forests.org

Field excercise at the ICP Forests Crown Condition Intercalibration Course 2002, Spain.



Map of Level I and Level II plots, 2004.

Forests and their sustainable management are high on the agenda of many international and national policies. In order to be sustainable, forest management needs information on the factors influencing forest condition.

Long-term, large scale and intensive monitoring of forest condition has been carried out for 20 years jointly by ICP Forests under the Convention on Long-range Transboundary Air Pollution and the European Union.

With 41 participating countries, a systematic grid of more than 6,000 sample plots and some 860 intensive monitoring plots, the programme constitutes one of the world's largest biomonitoring networks.

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