LRTAP
Long-range Transboundary Air Pollution

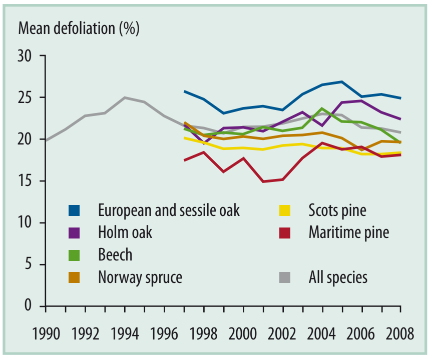
The Condition of Forests in Europe

2009 Executive Report

Institute for World Forestry

Main Points of Interest

Close cooperation between the European Commission and ICP Forests has led to standardised monitoring methods and field protocols being taught and applied within European countries. Together with the harmonisation of existing monitoring programmes through the FutMon project, this will strengthen and widen the scope of forest monitoring in Europe and so help meet the need for better information on topics such as climate change and biodiversity.

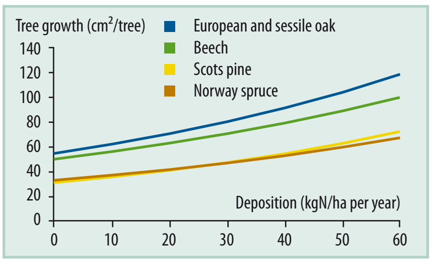


After a peak in defoliation during 2004 and 2005, crown condition in the most frequent European tree species has improved. Around 21 % of the trees assessed in 2008 were classed as damaged. European oak and sessile oak have consistently shown the highest levels of defoliation. Crown condition is better in most evergreen species than deciduous species.

... but trends vary by species and region

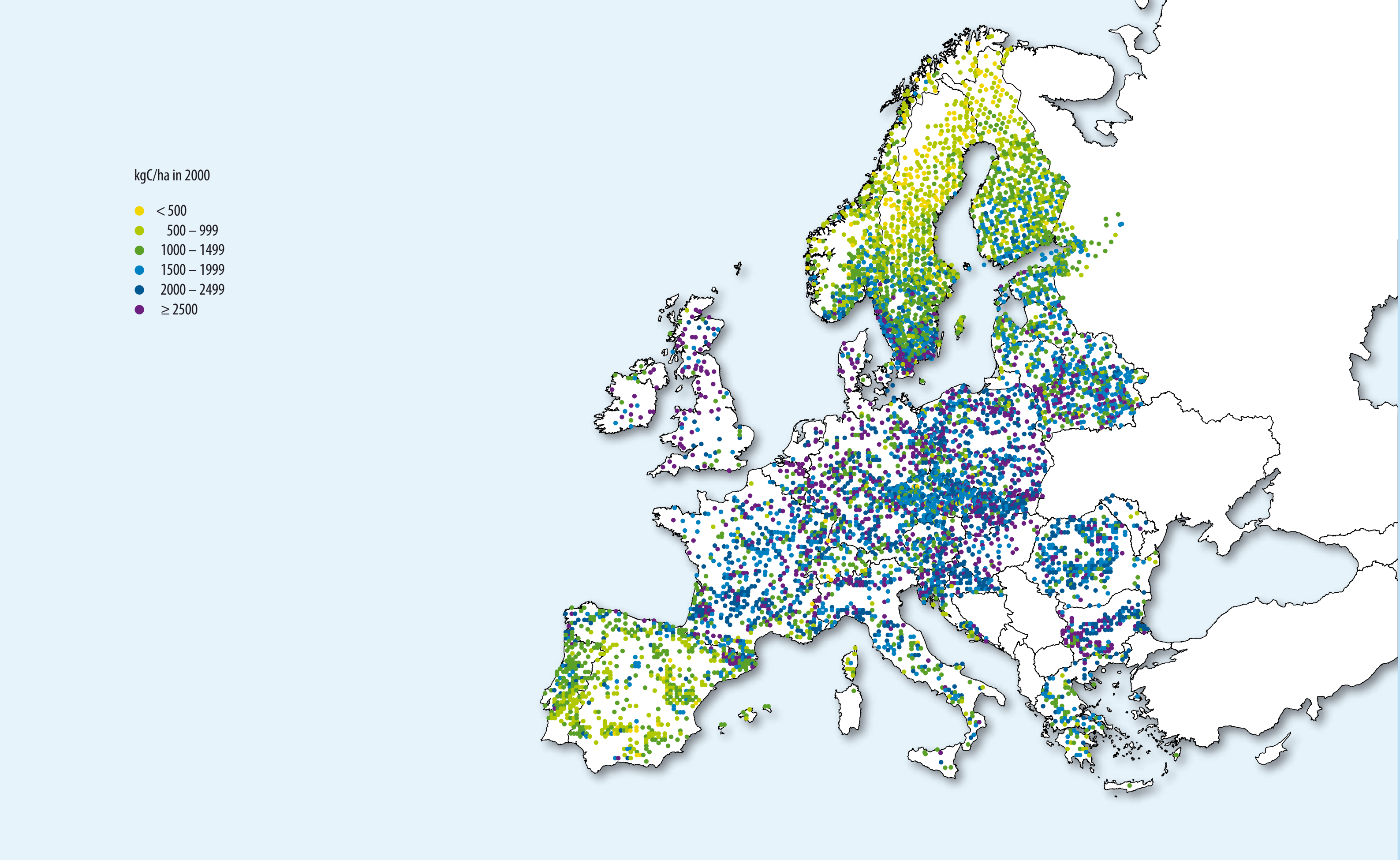
Assessments based on harmonised data demonstrate wide-ranging differences in forest health for the different European forest types.

Efforts to reduce the emission of contaminants known to affect the functioning of forest ecosystems have been very successful in the case of sulphur. Over three-quarters of monitoring plots now receive below the critical load for acidity. In contrast, the deposition of nitrogen has shown little change and critical loads are exceeded on two-thirds of the monitoring plots.

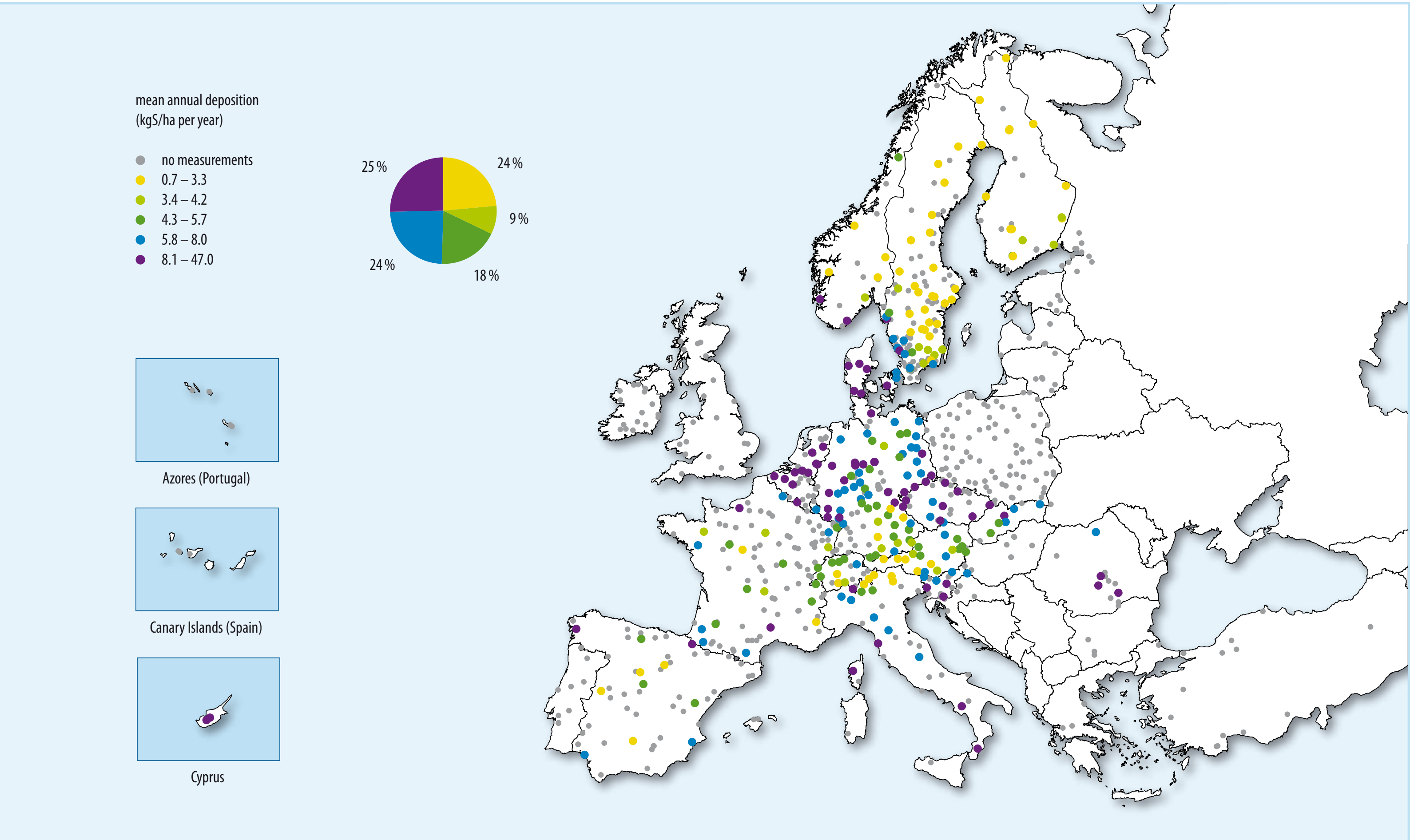


Climate change is affecting forest ecosystems but forests are helping to mitigate the effects of climate change by acting as carbon sinks. Trees extract carbon dioxide from the air and store the carbon in woody biomass. Although nitrogen deposition and higher temperatures are accelerating tree growth, carbon uptake by European forests corresponds to only 10 % of CO_2 emissions in Europe. Emissions reductions for CO_2 are still urgently required.

Managed forests are increasingly diverse and biodiversity indicators reveal encouraging trends. But, demands on forests are increasing and biodiversity must compete with other services. Biodiversity monitoring is increasing in importance as this underlies a balanced use of the forests. The effects of climate change on forest biodiversity are still uncertain.



Calculated net carbon sequestration (kgC/ha) in trees at 6000 Level I plots for the year 2000. Plots of the EU/ICP Forests offer a unique basis for modelling climate change effects and mitigation for European forests.



Mean sulphate (SO_4-S) deposition on Level II plots for 2004-2006. Measurements of air pollution are a core activity of the programme.

Two decades of forest monitoring form the basis for sustainable forest management, now and in the future

How will forests respond to a changing climate? How will changes in air pollution affect forests? Will forest damage affect biodiversity and sustainable forest development? And can sustainable forest management and carbon sequestration help mitigate the effects of climate change? These questions are being posed by scientists, politicians, and the public alike. Long-term systematic and intensive forest monitoring provides a solid basis for answering such questions and for taking political action. This report presents the latest the results of forest monitoring in Europe in the context of findings obtained over the past 20 years.

At the European-scale, forest condition over the past two decades has deteriorated far less severely than was feared back in the early 1980s (see page 5). In fact, since the mid-1990s the health status of Scots pine in central and north-eastern Europe has even improved. Most of the defoliation which gave rise to concern about the future of the European forests is now known to have been due to natural factors such as tree age, extreme weather conditions, pests and diseases. It is hard to establish the contribution of anthropogenic impacts like air pollution, but several forest areas have experienced a severe decline that cannot be explained by natural factors alone. The quantities of nitrogen and acidity deposited from the air exceed the threshold for the beginning of ecological damage (the so-called 'critical loads') in a large number of the forest monitoring plots. Nevertheless, declining trends in deposition illustrate the success of the internationally agreed 'clean air' policies (see page 8). Models project that the current level of air pollution abatement will lead to a recovery of forest soils, although soil acidity on most plots will not have reached pre-industrial levels even by 2050.

Air pollution has led to a number of negative effects of forest ecosystems. Critical load exceedance for acidification is partly linked to defoliation. Nitrogen deposited from the air is leached from forest soils; nitrate concentrations in soil water can exceed the groundwater quality criteria for human health. The low aluminium to base cation ratio in soil increases the risk of root damage.

Air pollution is closely related to a loss of biodiversity. Nitrogen and sulphur deposition influence the species composition of ground vegetation and the abundance of epiphytic lichens (see page 11). Nitrogen deposition enhances tree growth (see page 10) and, on the basis of model results, accounts for 5% of carbon uptake by forests over the last 40 years in Europe. The annual carbon sequestration in trees is currently about five to seven times higher than in forest soils. But, the carbon pools in forest soils are much bigger than in forest trees.

The unusual heat and drought of summer 2003 caused a severe reduction in water availability and transpiration in the forest trees of central Europe. This led to a peak in defoliation for several tree species as well as to reduced tree growth. High levels of insolation in 2003 increased ozone concentrations. Critical ozone concentrations for sensitive forest vegetation were frequently exceeded. Under the changing climate, the frequency of extreme events is predicted to increase.

Long-term forest monitoring provides the basis for assessing the impact of changing environmental conditions on the status and health of European forests as well as for developing strategies for future sustainable forest management.

Litterfall and deposition sampler on an intensive monitoring plot in the Slovak Republic

The Condition of Forests in Europe

2009 Executive Report

United Nations Economic Commission for Europe,
Convention on Long-range Transboundary Air Pollution,
International Co-operative Programme on Assessment and
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LIFE Unit

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Photo references

D. Aamlid (p. 2/3 – landscape, 4, 5, 11, 12), A. Bobrinsky (p. 6 – left), L. Croise (p. 6 – right), European Commission (p. 3), Federal Agency of Forestry, Russia (p. 2), R. Fischer (p. 7, 8), M. Rütze (p. 10).

Preface

Alexey Savinov

It is my pleasure to introduce and present the 2009 Executive Report of the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) on behalf of the 41 countries currently participating in the programme. ICP Forests is among the largest bio-monitoring programmes in the world. It was established by the United Nations Economic Commission for Europe (UNECE) in 1985 under the Convention on Long-range Transboundary Air Pollution (CLRTAP). To date, the CLRTAP Convention has been signed by 51 parties, including the Soviet Union in 1979. At that time, forest decline in Europe was mainly attributed to the adverse effects of air pollution. However, we are now aware that the assessment of air pollution effects on forests must also take into account other disturbance factors, such as fires, cuttings, and insect pests. Furthermore, air pollution can also interact with climate change, and either enhance or mitigate the effects of climate warming.

Today, the ICP Forests monitoring programme is of considerable relevance for many policy processes related to clean air, climate change, biodiversity, and sustainable forest management. ICP Forests provides reliable, scientifically sound information on the spatial and temporal variation of forest condition to policy makers, scientists and the public.

As the legal successor to the Soviet Union, the Russian Federation has taken over the liabilities arising from the CLRTAP Convention. While acknowledging the global ecological significance of the Russian forests, and thereby undertaking to safeguard biodiversity and the vital functioning of forest ecosystems and, at the same time, aiming for the successful development of multi-functional forestry, the Ministry of Natural Resources of the Russian Federation and the Federal Agency of Forestry made the decision to co-operate with other European countries in the field of forest monitoring within the framework of ICP Forests. As a result, ICP Forests monitoring is currently carried out in the Leningrad, Pskov, Novgorod, Kaliningrad and Murmansk oblasts, and the Republic of Karelia, in the 500 km-wide zone along Russia's western borders. So far, 569 monitoring plots have been established in this zone, and the first results on defoliation, discolouration of trees, their damages, biodiversity, carbon cycle, and nutritional status of soil and plants have recently been presented.

I hope that continued fruitful international cooperation within the framework of ICP Forests will allow us to obtain harmonized data on the state of European forests for use in decision making aimed at their sustainable management.

Alexey Savinov,
Head of Federal Agency of Forestry,
Russia

Preface

Around one third of the European Union's land surface is covered by forests. Throughout Europe, forests provide goods and services that are not only valuable economically, but also play a significant role in the development of rural areas, and for recreational purposes. Forests also play a major role in nature conservation and environmental protection and are extremely relevant in the context of climate change mitigation.

For these reasons the European Commission has been supporting forest-related activities in cooperation with the EU-Member States for many years. The European Commission's engagement in forest monitoring is an important part of this support. The LIFE+ Regulation, adopted in 2007, provides a financial basis for assessing policy relevant information on forests, specifically in relation to climate change, biodiversity, forest condition and the protective functions of forests.

Against this background, the European Commission agreed to co-finance the FutMon (Further Development and Implementation of an EU-level Forest Monitoring System) project. The FutMon project builds on and further develops existing forest monitoring activities. It is the continuation of 20 years of fruitful cooperation between the European Commission and ICP Forests. The new FutMon project started in January 2009. This will provide information on the health status of forests and aims to provide insight into threats arising from air pollution, soil acidification and nitrate leaching. In cooperation with national forest inventories it further develops a systematic grid of forest plots as the basis for regular monitoring of many parameters, including ground vegetation and deadwood. In addition, we expect detailed answers as to how increasing temperatures and more frequently occurring extreme events like storms or insect infestations affect forest ecosystems. The project assembles 38 partner institutions in 24 European countries and relies on the knowledge and expertise of more than 300 experts. Close collaboration between the various scientists, institutions and networks will enable the creation of a multifunctional information base serving the information needs of policy, as well as research and forest management.

Good communication and a well-informed general public is a particular focus of the LIFE+ Regulation. I thus welcome the timely preparation of the first layman's report of the FutMon project. It clearly shows that the sustainable management and protection of our forests is in the interest and responsibility of the whole European community. I acknowledge the motivated engagement of the experts involved and wish the FutMon project every success.

Joaquim Capitão,
Acting Head of LIFE Unit
Directorate General Environment
European Commission

Joaquim Capitão

International excursion to a monitoring plot in Russia. Harmonized methods form the basis for assessments.

The European forest monitoring programme

Close cooperation forms the basis for successful forest monitoring

Forest monitoring dates back to the early 1980s when a severe decline in tree crown condition occurred across large parts of Europe. Concern that the decline was triggered by air pollution led to the *International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests* (ICP Forests) in 1985. Close cooperation between the European Commission and ICP Forests over the next 20 years led to the project *Further Development and Implementation of an EU-level Forest Monitoring System* (FutMon) in 2007. ICP Forests and FutMon are coordinated by the Institute for World Forestry at the Johann Heinrich von Thünen-Institute in Hamburg, Germany.

Survey	Plot numbers
Crown condition	822/662
Foliar chemistry	795/150
Soil chemistry	742/0
Tree growth	781/77
Ground vegetation	757/119
Deadwood	90/0
Epiphytic lichens	90/0
Soil solution chemistry	262/241
Atmospheric deposition	558/437
Ambient air quality	121/121
Meteorology	235/235
Phenology	152/152
Litterfall	145/145
Remote sensing	National data/0

ICP Forests ensures continuous and harmonized forest monitoring

ICP Forests is the only field-based monitoring system providing continuous and trans-nationally harmonized data on forests for most countries in Europe. Monitoring occurs at two levels of intensity: 'Level I' (~ 6000 systematically selected plots in 38 participating countries) and the more intensive 'Level II' (~ 800 plots located in some of the most important forest ecosystems in 29 participating countries). ICP Forests is one of the largest and longest running forest monitoring programmes in the world, covering over 200 million hectares.

FutMon widens the scope of forest monitoring across Europe

The new FutMon project further develops forest monitoring in the EU-Member States. It builds on and supports the existing set of monitoring plots. It creates a pan-European system that will provide information on a range of different topics, including forest health, biodiversity and climate change. The number of Level II plots monitored will fall to 300 within EU countries (plus 90 in non-EU countries). In turn, new and more intensive surveys are developed and tested within so-called 'demonstration projects'. At the large scale, FutMon supports the integration of National Forest Inventories with ICP Forests Level I plots in a number of countries.

Level II monitoring. The number of plots for each survey ranges from 90 (deadwood, epiphytic lichens) to 822 (crown condition). Variations in the number of plots for which data were submitted in 2006 (the second number) reflects differences in sampling frequency; not all surveys are carried out each year.

Healthy cedar forest in Cyprus. Tree health is indicated by the extent of needle or leaf loss in tree crowns; fully foliated trees are considered healthy.

Forest health and vitality remained stable in 2008 …

Long-term monitoring underlies sustainable forest management

Forest condition has been assessed over long periods in many European countries. Defoliation has been the main parameter monitored. Changes in forest condition are used to assess the response of forest ecosystems to environmental change. They also provide the basis of sustainable forest management. The Ministerial Conference on the Protection of Forests in Europe uses defoliation as one of four indicators of forest health and vitality.

One fifth of trees are considered 'damaged'

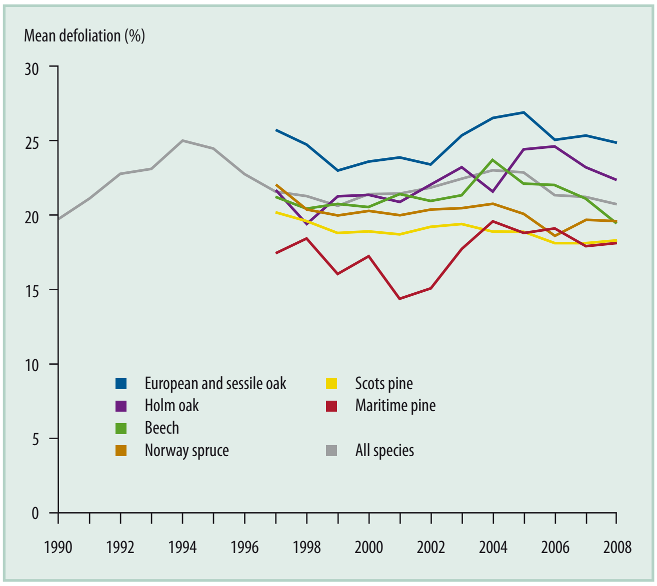
After a peak in defoliation during 2004 and 2005, crown condition in the most frequent European tree species improved. Crown condition on 5000 plots in 25 countries, led to 21 % of the trees assessed in 2008 being classed as damaged. Of the species monitored, European oak and sessile oak have consistently shown the highest levels of defoliation. Beech has reacted strongly to the extreme heat and drought that occurred in central Europe in 2003 but has recuperated in subsequent years. There have been slight overall improvements in the condition of Scots pine and Norway spruce since the late 1990s.

Insect pests, fungi, drought, snow, and storms are among the most frequent causes of direct damage to trees. Their impacts can be exacerbated by air pollution and changes in climate.

Crown condition in the most frequent tree species (as indicated by the extent of needle or leaf loss) appears to have improved over the past two years. Crown condition is better in evergreen species than deciduous species. Data from 1990 onwards are based on a smaller number of countries.

Harmonising national forest inventories

National forest inventories – used by many European countries to assess their national forests – produce datasets that are rarely comparable between countries. Although shorter and less comprehensive, datasets generated by the harmonised Level I monitoring are comparable across national boundaries. Through FutMon, the trans-national Level I monitoring grid (16 × 16 km throughout Europe) is being restructured and national forest inventories are partly merged with it. The Level I grid can thus serve as a reference grid for the further harmonisation of national forest inventories.



Bark beetle infestation in the Arkhangelsk region, Russia.

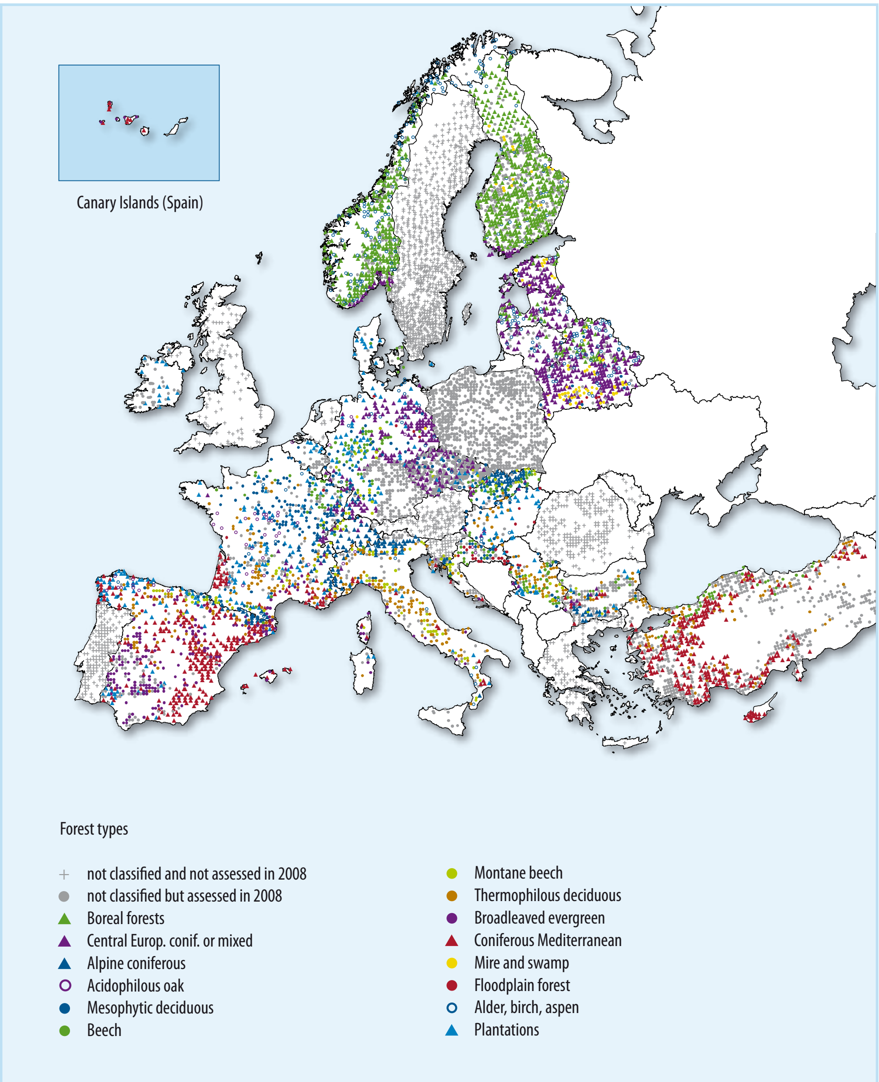
Oak leaf, damaged by drought.

… BUT TRENDS VARY BY SPECIES AND REGION

Adverse effects on boreal forests in Russia

Boreal forests cover large areas of northern Europe: across Scandinavia, the Baltic states, Belarus and Russia. The cool climate and harsh winters favour the dominance of Norway spruce and Scots pine, partially mixed with birch.

Russia is currently developing a forest monitoring system. Although this is not yet in place, a number of forest damage events have been reported. One began in the hot dry summer of 1997, with the widespread defoliation and discolouration of spruce. The weakened trees went on to suffer from windthrow and massive bark beetle infestations; over 600 km² were eventually affected. Huge clear cuttings over recent years have exacerbated the problem by altering drainage and light regimes. Forest ecosystems across vast areas of the Murmansk region and northern Europe have been affected by pollutants emitted over the past 60 years from the two non-ferrous metal smelters (Pechenganikel and



Level I plots classified according to forest types of the European Environment Agency. Forest types form the basis for assessing trends in European forest ecosystems.

Holm oak is an important broadleaved evergreen species in Spain. Overgrazing often constitutes a major pressure.

Severonikel) on the Kola Peninsula. The critical load for sulphur (3kg/ha/y) has been exceeded over more than 90 000 km². Signs of visible damage occur over 39 000 km², and forest ecosystems have been completely destroyed over more than 1000 km².

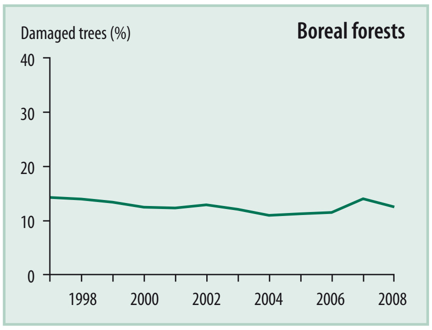
In contrast, low levels of defoliation in the Baltic countries, Finland and Norway indicate good overall health. However, there have been regional outbreaks of fungal diseases, such as Scleroderris canker in Sweden and Finland in 2001. Large areas were affected by windthrow in 2005 and bark-beetle infestations resulted in 700 000 m³ of timber in Sweden in 2008.

Extreme drought in Central European mixed deciduous forests

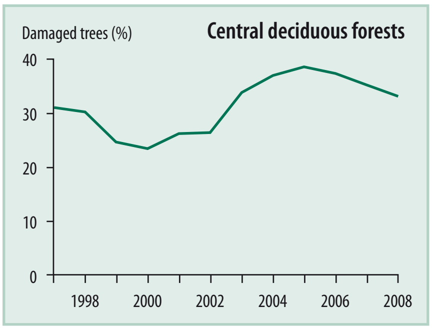
Mesophytic deciduous forests in central Europe typically comprise mixed forests on soils with a good nutrient supply. The main species are sessile oak, European oak, ash, maple and lime. Oak has been the most severely damaged tree species in Europe for many years. Oak forests were badly affected by the extremely dry and warm summer of 2003 and took until 2006 to begin recovering. A similar pattern occurred in beech forests. The increase in extreme climatic events predicted under most climate change scenarios is likely to have strong adverse effects on most forest types.

Remnants of natural broadleaved evergreen forests now protected

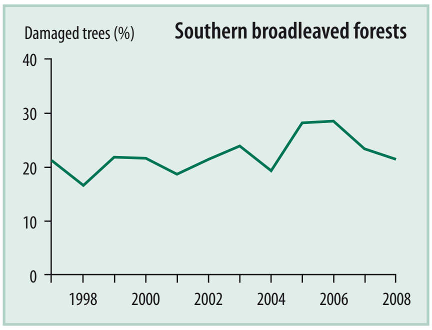
Broadleaved evergreen forests are one of the most common natural forest types in southern Europe. Holm oak is the dominant species. Today, large areas have been transformed into low density agro-silvicultural systems. In Spain, these have suffered from 'seca' syndrome, triggered by a series of dry years, although insects, fungal infestations and overexploitation were also important. Wetter summers have helped recovery since 2006. Forest fires are a constant threat. Dense, natural forests with close canopy are less at risk than open woodlands.



The low proportion of damaged trees within the boreal forests of the Baltic states, Finland and Norway, indicates good overall health.



Mixed deciduous forests, occurring mostly in central Europe, reacted strongly to the extreme drought of 2003. The forests are now recovering.



Drought and insect and fungal diseases in evergreen broadleaved forests across southern Europe led to higher levels of defoliation in 2005 and 2006.

Partial success for 'clean air' policies

Air pollution affects ecosystem stability

Atmospheric deposition of contaminants can affect the functioning of forest ecosystems. Fluxes of nutrients, contaminants and other elements within forest ecosystems are important indicators of ecosystem functioning and stability. Important fluxes include uptake by plants, fluxes associated with soil processes, and leaching into surface waters and ground waters. Data on soil, soil water, forest growth and foliage chemistry are important for assessing the impact of atmospheric deposition. These data are obtained at Level II plots and used for establishing the maximum levels of deposition that the ecosystem can tolerate – the so-called 'critical loads'.

Lower sulphur deposition but no change for nitrogen

Sulphur emissions in Europe have been reduced by 70 % since 1981. This reflects the success of clean air policies adopted under the UN Economic Commission for Europe and the EC. Based on measurements conducted under the forest canopy on around 200 monitoring plots, mean annual sulphur inputs fell by 20 % between 2001 and 2006. Sulphur deposition was generally higher on plots in central Europe than in northern and southern Europe.

There has been little change in nitrogen deposition since 2001. Ammonium and nitrate are the main nitrogen compounds deposited from the air. Measurements at the same 200 plots show mean annual inputs of about 5 kg per hectare. Inputs across Europe vary widely, however, with the highest levels measured in central Europe. Inputs range from just above zero to 36 kg ammonium per

Deposition samples are collected weekly, fortnightly or monthly and are analyzed by national experts. Data are validated before submission to the Programme Coordination Centre for evaluation.

Dynamic soil chemistry models rely on historical deposition data from the literature, on present measurements and on future deposition scenarios. They model key processes such as element fluxes in deposition, nutrient uptake by trees, nutrient cycling including mineralization, weathering processes for base cations and aluminium, and leaching to groundwater.

Critical loads define thresholds for the effects of air pollution. They are derived by comparing inputs on the one hand and the removal, acceptable storage and outputs of pollutants on the other. Critical loads are not exceeded as long as inputs do not exceed outputs. Any additional input of pollutants may cause harmful effects.

hectare and 16 kg nitrate per hectare. The main sources of nitrogen emissions are fossil fuel combustion and intensive animal husbandry.

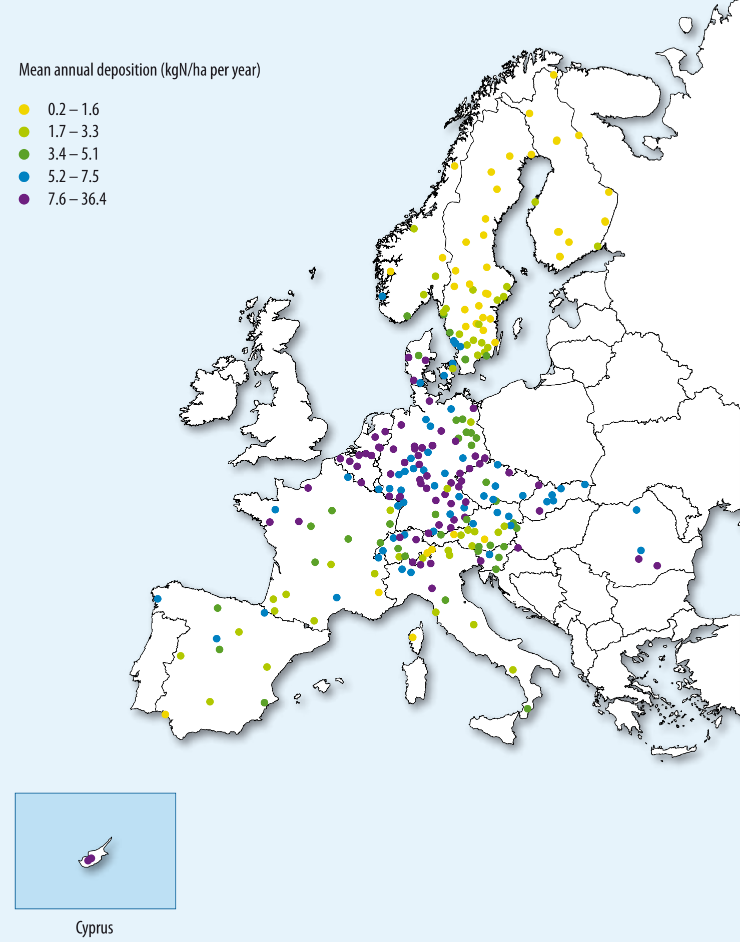
Forest ecosystems are still affected

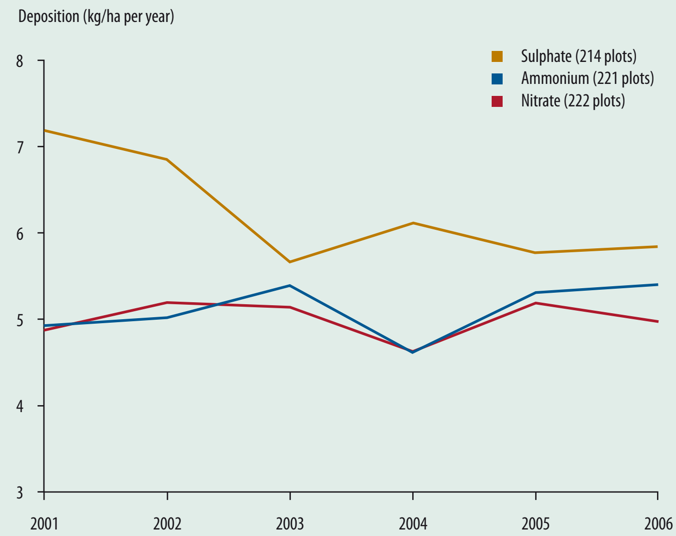
Nitrogen enrichment in the soil can accelerate forest tree growth. However, it can also affect the composition of the vegetation and the amount of nitrate leaching into groundwater. Over the past few decades, deposition from the air has led to increasing storage of nitrogen in plants and soil. On forest floors that are already nitrogen-enriched the soil and the plants can retain little extra nitrogen and so it passes relatively quickly through to the groundwater.

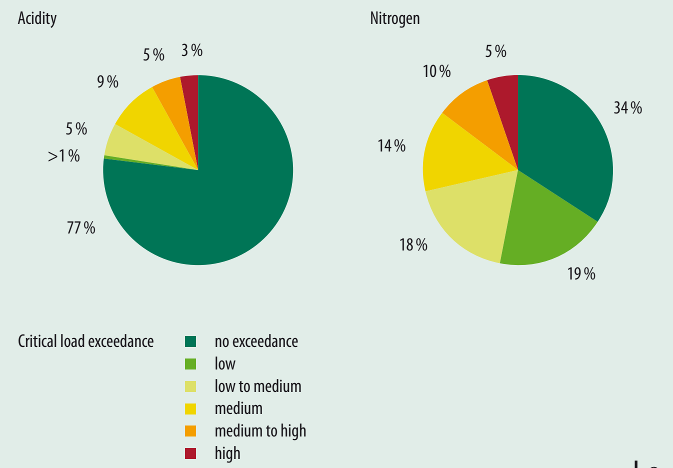
Atmospheric deposition is the main factor underlying widespread soil acidification in Europe. Acidified soils affect the rooting systems of trees, can impair balanced nutrition of plants and reduce soil biodiversity. Soil acidification is confirmed using direct measurements and dynamic soil models. Models suggest that soil acidification increased until 1990. They also predict a slight recovery up to 2030. Observed reductions in soil acidification reflect the success of emission reductions policies. Nevertheless, soil acidity levels assumed for 1900 will not be regained on many plots for many decades.

Critical loads are exceeded on two-thirds of plots

Information on deposition alone is not enough for predicting the possible effects of air pollution on forest ecosystems. This is achieved by comparing measured inputs against ‘critical loads’. Critical loads are thresholds derived from ecosystem models below which environmental damage is not expected to occur. Ecosystem stability is maintained as long as inputs are below the critical loads. Success in lowering sulphur emissions has reduced the area with critical load exceedance for acidity: over 75 % of plots now receive below the critical load for acidity. In contrast, over 65 % of nearly 200 ICP Forests and EU plots show critical load exceedance for nitrogen, especially in central Europe.







Left: Deposition sampler in Greek mountain forests. ICP Forests began measuring deposition on Level II plots in the 1990s. The field protocols require 20 to 40 samplers for each plot depending on the structure of the forest canopy.

Top right: Mean ammonium (NH_4-N) deposition below the forest canopy for 2004-2006. Atmospheric inputs are comparatively high in central Europe.

Middle right: Mean annual atmospheric deposition of sulphur (in sulphate) and nitrogen (in ammonium and nitrate) on the European forest monitoring plots. There is a clear fall in sulphur inputs but little change in nitrogen inputs.

Bottom right: Exceedance of critical loads for acidity and nitrogen deposition for 1999 to 2004. The critical load for nitrogen was exceeded on around two thirds of the plots.

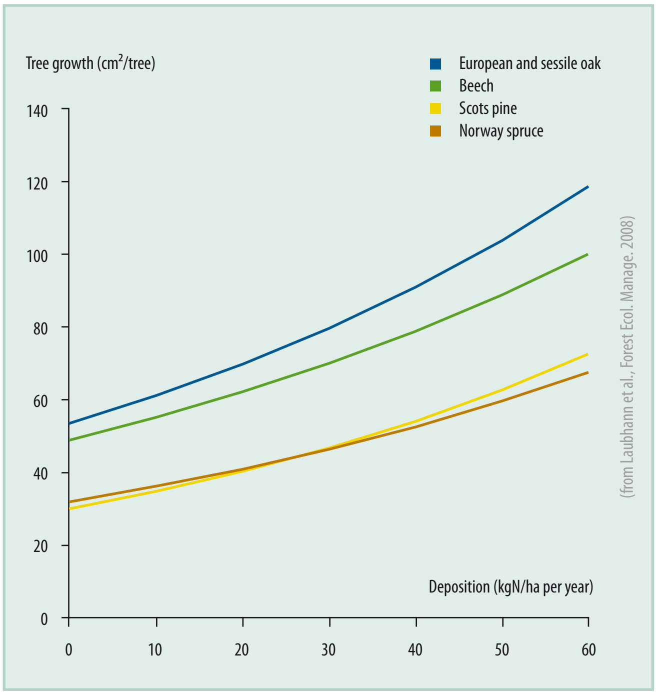
Woody biomass is about 50 % carbon. Forest growth extracts large amounts of carbon dioxide from the air and so helps mitigate climate change.

European forests in a changing climate

Nitrogen deposition and higher temperatures accelerate tree growth

Changes in temperature and precipitation, as well as more frequent extreme events, can affect ecosystem functioning in European forests. In a study co-financed by the European Commission, data were assessed from 382 plots across Europe.

Nitrogen deposition increased tree growth in the four species studied. The effect was smallest on soils that were already well supplied with nitrogen. An annual nitrogen deposition of 1 kg/ha corresponds to an average increased tree growth of ~1 %, which corresponds to an average carbon fixation in tree stems of about 20 kg/ha per year. Sulphur and acid deposition did not cause negative effects on tree growth, possibly because any negative effects were outweighed by the positive effect of nitrogen deposition. Above-average temperatures during the growing season increased tree stem growth in common beech and Norway spruce.



Forests take up and store vast quantities of carbon. But emissions reductions are still urgently required

Forests can help mitigate the effects of climate change by acting as carbon sinks. Trees extract carbon dioxide (an extremely important greenhouse gas) from the air and store the carbon in woody biomass. In areas that were previously overexploited or which have an otherwise low nitrogen status, human-derived nitrogen deposition increases tree growth which in turn increases carbon uptake. Continued nitrogen deposition, however, may eventually lead to nutrient imbalances and in the long term to a destabilisation of forest stands.

In terms of the total CO_2 emissions in Europe the mitigating effects of forests are small: forest uptake is thought to represent only 10 % of emissions. This may even decrease in future because forest growth cannot be endlessly accelerated and forest carbon pools that are generally increased by nitrogen deposition will come to a new equilibrium.

Higher levels of nitrogen deposition lead to higher levels of tree growth which results in higher levels of carbon storage.

Cranberries and deadwood. Ground vegetation and deadwood are important indicators of biodiversity.

Biodiversity indicators receiving much attention

Forests among the most natural ecosystems in Europe

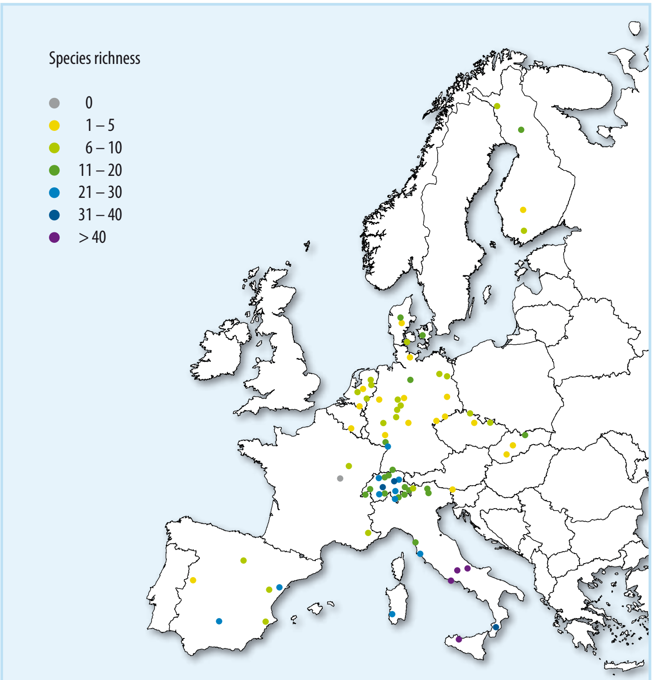
Forest biodiversity indicators reveal encouraging trends. Total forest area and standing wood volumes have both increased over the past decades. And more forests are being allowed to grow into older development stages, which has a positive effect on forest biodiversity. Managed forests are increasingly diverse, often with a mixture of coniferous and broadleaved tree species. However, forest fragmentation is often a problem for viable populations. Demands on forests are increasing and biodiversity is competing with other services. The effects of climate change on forest biodiversity are not yet fully understood. Forest ecosystems were disturbed in 2004 and 2007 across central and southern Europe after intense heat waves and drought.

Biodiversity monitoring is increasing in importance

Trans-national harmonisation of monitoring methodology is a focus for the European forest monitoring programme. With co-financing from the European Commission, a biodiversity project was completed on 96 Level II plots in 2006 (ForestBIOTA), with a related project (BioSoil) on ~4000 Level I plots completed in 2007. Methods were developed for monitoring forest stand structure, deadwood, epiphytic lichens and ground vegetation; a first implementation of these methods has been successful; the existing plots proved to be suitable for biodiversity assessments; and new projects involving a larger number of plots are underway.

Monitoring data underlie a balanced use of forests

Biodiversity reflects the variety of all living organisms. It is thus impossible to monitor comprehensively. Under the lead of the European Environment Agency, a pan-European initiative, SEBI2010, was launched in 2004 to develop a European set of biodiversity indicators. These include a 'Forest Status Indicator' which relies on the data of the forest monitoring programme. Further large-scale implementation of the related monitoring is a priority. The data provided will form the basis for balancing demands for ecological services, timber, and cultural services.



Epiphytic lichen species monitored on Level II plots within the ForestBIOTA project; a pilot project, preparing assessments on larger numbers of plots in Europe.

Conclusions and outlook

In its present form, forest monitoring in Europe meets the information needs of the relevant international bodies. For example, the Convention on Long-range Transboundary Air Pollution (CLRTAP) and the Ministerial Conference on the Protection of Forests in Europe (MCPFE). Data are also submitted to the Global Forest Resources Assessment (FRA) and the Convention on Biological Diversity (CBD). But, information needs and reporting obligations are increasing. Plus, large-scale forest survey systems exist in parallel in many countries. Together, these call for a further integration of existing large-scale programmes, namely ICP Forests and the national forest inventories (NFIs).

Complex interplay between climate change, forests and deposition

Continued recovery of crown condition from the very warm and dry summer of 2003 occurred across large parts of central Europe. The new forest type classification developed by the European Environment Agency has proved suitable for assessing large-scale crown condition data. In general, boreal forests show lower levels of defoliation, while forest condition in southern Europe reflects the impacts of a range of stress factors. These include overexploitation, fire, drought, and higher ozone levels, and many interact with insect infestations and fungi.

Lower levels of sulphur deposition are a direct result of the clean air policies adopted under the UNECE and the EC. This is not the case for nitrogen, where little or no fall in deposition and the continued exceedance of critical loads across large parts of Europe indicate a risk to ecosystem stability. Nutrient enrichment remains a threat to plant diversity, and to the quality of surface waters and groundwater. One effect of nitrogen deposition is accelerated forest growth and thus increased carbon uptake and storage – at least in the short term. This can help mitigate the effects of climate change attributed to increasing concentrations of carbon dioxide and other greenhouse gases, but will only compensate for a small proportion of anthropogenic carbon dioxide emissions.

FutMon is on its way to meeting increased information needs

The multidisciplinary monitoring approach implemented by ICP Forests in cooperation with the EC constitutes a solid basis for the further development of forest monitoring in Europe, especially in relation to meeting the increasing needs for information on biodiversity, climate change and carbon uptake and storage. These issues must be studied in conjunction with air pollution, owing to the complex interrelationships between the two. FutMon began the work on integrating the large-scale monitoring approaches (Level I and NFIs) and consolidating the intensive monitoring plots (Level II). FutMon will provide policy relevant information on forests in Europe by the end of 2010.

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