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for Europe

The Condition of Forests in Europe

2004 Executive Report

Federal Research Centre
for Forestry and
Forest Products (BFH)

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The Condition of Forests in Europe

2004 Executive Report

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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Economic Commission for Europe

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Contents and Main Findings

Preface

Under the framework of the United Nations Economic Commission for Europe, the Programme Co-ordinating Centre of ICP Forests and the National Focal Centres have provided again a full set of relevant information on the status of the forest resources in Europe. After a number of years of relatively unvarying situation, the latest observations show an increase in defoliation that is likely a consequence of extreme climatic conditions during the summer 2003. The report also emphasises the linkages between air pollution, defoliation and increment of the trees.

Over the years, ICP Forests has developed a network which primarily aims at dealing with questions related to air pollution. This monitoring network is one of the first initiatives demonstrating the benefits of pooling national resources in order to achieve not only national but European-wide results. Common methods in measuring and analysing the data in participating countries have made it possible to validate often weak signals of changes in the ecosystems.

ICP Forests has parallel goals in the field of forest monitoring as the European Forest Institute has in facilitating networking in forest research. Especially for this reason it is a pleasure for me to introduce the reader to the topic and bring up some relevant issues related to European forest monitoring today.

The political aspects and issues related to forests and forestry were discussed in the fourth Ministerial Conference on the Protection of Forests in Europe last year. In the Vienna Declaration, the Signatory States and the European Community committed themselves to make the forest-related decisions based on science and to take measures that support and strengthen existing research and increase interdisciplinary approaches. The ICP Forests has contributed to the process by providing a number of sustainability indicators for reporting. Before the next Conference in Warsaw in 2007, the scientific community aims at facilitating an inter-disciplinary dialogue and at identifying ways for research to serve the political decision-making better. The work by ICP Forests on developing the indicators of sustainability further to be more valid and reliable and to cover more issues of political relevance will be of high value. The 2004 report indicates the future directions of ICP Forests to be within the topics of climate change and forest biodiversity, both of which are highly prioritised by the Pan-European Process.

The lessons learnt during almost two decades of forest health monitoring, utilising forest measurements at various levels of details demonstrate the complexity in the reactions of ecosystems to pollution and other environmental changes. Increasing defoliation leading to the decrease in the increment of trees, and, at the same time, forest inventory results signalling increased growth of the forests have represented a paradox that can be settled in future research.

To serve the political needs we need to assess new forest parameters and in order to understand the complex causal connections of the ecosystem we need to extend the measurements to the micro-level in functions of the trees. However, the requests for more information are not always followed by an increase of resources for monitoring and research. To avoid the negative consequences of this unfortunate reality we need to consider how to use the existing resources for forest monitoring at the national and international levels.

At the national level, the main collaborator for the ICP Forests is usually the National Forest Inventory. The role of activities related to ICP Forests monitoring network, and the ones carried out in National Forest Inventories or various long-term monitoring experiments depend heavily on the capacities of the countries to carry out their national inventories.

In the countries with strong inventory tradition and continuous update of national forest resource statistics, the additional value of European monitoring lies in further resources and harmonisation which helps to transfer the methodologies and research results from country to country. In cases where the resources of a National Forest Inventory are insufficient, the Commission funding has a more crucial role in maintaining forest monitoring activities.

The National Forest Inventories have also their own programmes to harmonise the data collection and reporting methods. A new COST Action 'Harmonisation of National Forest Inventories in Europe: Techniques for Common Reporting' has recently been approved by the European Commission and will start in 2004. The work addresses particularly the questions of how National Forest Inventories can produce comparable and harmonised information over large areas and how to estimate forest carbon pools and forests biodiversity.

It will be of uttermost importance that the ICP Forests monitoring programme and the future directions of National Forest Inventories support each other as efficiently as possible.

It is my great pleasure, the 2004 Executive Report in my hand, to congratulate the ICP Forests and the European Commission for their long-term contribution to the European cooperation in forest monitoring. In this context, I would like to express the willingness of the European Forest Institute and its network of 140 member organisations to collaborate in improving the cost-effectiveness of forest monitoring and research activities in Europe within the newly-established Forest Focus Programme.

Prof. Dr. Risto Paivinen
Director
European Forest Institute (EFI)

Meteorological measurement station located in the timber line, Norway.

Environmental Stress Factors and European Forests

Latest Results in the context of 18 Years of Forest Condition Monitoring

Environmental changes are affecting forest condition. In order to be sustainable, forest management needs information on these influences. Also, abatement strategies and the evaluation of the effects of international environmental policies need a sound scientific basis. This scientific basis is provided by long-term, large-scale and intensive monitoring of forest condition. Forest condition in Europe has been monitored over 18 years jointly by the United Nations Economic Commission for Europe (UNECE) and the European Union (EU).

The monitoring system

This pan European programme relies upon one of the world's largest biomonitoring networks. On 6 000 plots systematically spread across 39 countries in Europe the variation of forest condition over space and time is assessed in relation to natural and anthropogenic factors. This large-scale monitoring approach is designated as "Level I". An intensive monitoring approach referred to as "Level II" aims at causal relationships and is pursued on another 860 intensive monitoring plots covering the most important forest ecosystems in Europe. Both monitoring intensity levels are complementary to each other.

Crown condition

The vitality of a tree is reflected largely in the condition of its crown. Therefore crown condition has been assessed annually since the programme's origin. In the mid 1990s several main tree species recovered from their originally raised defoliation. After subsequent years of a steady state, defoliation increased again in 2003, this time consistently for all main tree species. Clearly more than one fifth of the 130 000 sample trees assessed in 2003 were classified as moderately or severely damaged. Plausible causes are the extraordinary heat and drought having prevailed in Europe in summer 2003. Weather extremes have proved to be explanatory variables of the high spatial and temporal variation of crown condition in earlier studies of the programme, along with air pollution, biotic factors and tree age. The occurrence and impacts of several environmental factors are highlighted in the present report.

Forest growth

Forest growth is another important indicator of forest condition. Latest monitoring results confirm a generally increased tree growth of up to 25% compared to earlier decades. This might be due to a combination of improved silviculture, increased temperature and carbon dioxide concentrations as well as increased nitrogen depositions or reduced sulphur deposition. While forest growth has been enhanced across Europe, defoliation and growth of single trees within the stands are correlated. This means that today in general both, healthy and defoliated trees, show increased increment. The absolute growth level of the defoliated trees is however lower.

Biodiversity

Environmental changes can also affect biological diversity of forests in Europe. ICP Forests contributes to the monitoring of these aspects with its existing data such as on stand structure and ground vegetation. In 2003, 14 countries of the ICP Forests launched a test phase for additional contributions in the field of forest biodiversity monitoring (ForestBIOTA project). First experiences show the feasibility of the newly established and transnationally harmonized methods on the test plots. In mountainous regions, epiphytic lichen species composition was related to the share of conifers and the altitude of the plots.

Air pollution

Air pollution is the main focus of the programme because of its mandate. The programme has detected relationships between atmospheric deposition, soil condition, foliage chemistry, tree growth and crown condition. Moreover, it has confirmed the decrease in sulphur depositions and has revealed resulting positive effects in forest soils. These results show the success of the drastic reductions of sulphur emissions in Europe under the Convention on Long-range Transboundary Air Pollution (CLRTAP) of UNECE and the related EU regulations. However, deposition of acidity, nitrogen and heavy metals were shown to exceed critical loads at a large number of forest sites. The concentrations of ground level ozone exceeded critical levels on the majority of the plots in south western Europe.

Other environmental influences

Crown condition and tree growth as well as tree mortality are affected by annual weather conditions. Results show that the unusual heat and drought in summer 2003 caused a severe reduction of water availability and transpiration on several Level II plots in central Europe. This led to growth reductions on these plots. Heat and drought also fostered bark beetle attacks in larger areas. Other insects as well as fungi were of rather local importance. Forest fires had particular importance in south western Europe. The storm damage observed during the past decade was now shown to have occurred preferably on acid soils and in coniferous stands.

Future directions

The programme will continue its regular overviews on forest condition in Europe. It will further produce policy relevant key information on stress factors such as air pollution and in this context will also contribute urgently needed information on climate change and forest biodiversity. Thus, the monitoring activities will provide a sound basis for clean air and environmental policy as well as for sustainable forest management.

Further information:
http://www.icp-forests.org

Waldgrenze in Norwegen

Umweltbelastungen und Wälder in Europa

Die neuesten Ergebnisse und der Wissenstand nach 18 Jahren Waldzustandsüberwachung

Umweltveränderungen beeinträchtigen den Waldzustand. Für eine nachhaltige Waldbewirtschaftung werden Informationen über diese Einflüsse benötigt. Außerdem ist für Gegenmaßnahmen und für die Erfolgskontrolle von internationaler Umweltpolitik eine verlässliche wissenschaftliche Grundlage unabdingbar. Einen Grundpfeiler dieser wissenschaftlichen Basis bildet die langfristige, großräumige und intensive Waldzustandsüberwachung. Seit 18 Jahren wird der Waldzustand in Europa in einem gemeinsamen Programm der Wirtschaftskommission der Vereinten Nationen für Europa (UNECE) und der Europäischen Union (EU) überwacht.

Monitoringsystem

Dieses gesamteuropäische Programm basiert auf einem der weltweit größten Biomonitoring-Netzwerke. In 39 europäischen Staaten wird auf 6000 systematisch verteilten Probeflächen die räumliche und zeitliche Veränderung des Waldes aufgrund von natürlichen und menschlich bedingten Faktoren erfasst. Diese großflächige Überwachung wird als „Level I" bezeichnet. Darüber hinaus wird im Rahmen des „Level II" Monitoring eine Intensivbeobachtung durchgeführt. Diese stützt sich auf 860 Dauerbeobachtungsflächen in allen wichtigen Waldökosystemen Europas und befasst sich mit Ursache-Wirkungs-Beziehungen. Beide Monitoringstufen ergänzen sich untereinander.

Kronenzustand

Die Vitalität eines Baumes lässt sich weitgehend am Zustand seiner Krone ablesen. Seit Beginn des Programms wird daher jährlich der Kronenzustand erfasst. Mitte der 90er Jahre erholten sich einige Hauptbaumarten von ihrem bis dahin erhöhten Nadel-/Blattverlust. Nachdem der Zustand in den darauf folgenden Jahren weitgehend unverändert blieb, wurde 2003 wiederum eine Zunahme des Nadel-/Blattverlustes festgestellt, und zwar diesmal bei allen Hauptbaumarten. Mehr als ein Fünftel aller 130 000 erfassten Probebäume wurde als geschädigt oder deutlich geschädigt eingestuft. Die in weiten Teilen Europas extrem trockene und heiße Witterung des Sommers 2003 ist eine plausible Erklärung für diese Beobachtung. Bereits in früheren Untersuchungen des Programms zeigten Wetterextreme zusammen mit Luftverunreinigung, biotischen Faktoren und Baumalter deutliche statistische Zusammenhänge zu den räumlichen und zeitlichen Veränderungen des Kronenzustandes. Einige wesentliche Umweltfaktoren werden im vorliegenden Bericht speziell beleuchtet.

Waldwachstum

Das Waldwachstum ist ebenfalls ein wichtiger Indikator für den Zustand des Waldes. Neueste Beobachtungsergebnisse bestätigen eine generelle Zunahme des Baumwachstums um bis zu 25% verglichen mit früheren Jahrzehnten. Dies kann auf ein Zusammenwirken von verbesserter Waldbewirtschaftung, ansteigenden Temperaturen und Kohlendioxidkonzentrationen als auch auf zunehmende Stickstoffeinträge oder verringerte Schwefeldepositionen zurückzuführen sein. Außer einem erhöhten Waldwachstum wurden deutliche Zusammenhänge zwischen Nadel-/Blattverlust und dem Wachstum der einzelnen Bäume nachgewiesen. Somit weisen sowohl gesunde als auch geschädigte Bäume ein erhöhtes Wachstum auf. Allerdings ist der absolute Zuwachs der geschädigten Bäume niedriger.

Biodiversität

Umweltveränderungen können auch die biologische Vielfalt in den Wäldern Europas beeinflussen. Die Datenbank des ICP Forests beinhaltet unter anderem Informationen zur Bestandesstruktur und Bodenvegetation. Damit leistet dieses Programm bereits einen wertvollen Beitrag zur Erfassung dieser Umwelteinflüsse. 2003 wurde in 14 Ländern eine zusätzliche Testphase begonnen (ForestBIOTA Projekt). Erste Erfahrungen auf den Testflächen zeigen, dass die neuen länderübergreifend harmonisierten Methoden für die geplanten Aufnahmen im Bereich Biodiversität geeignet sind. In Gebirgsregionen konnten Zusammenhänge zwischen der Artzusammensetzung von epiphytischen Flechten einerseits und dem Anteil von Nadelbäumen sowie der Höhenlage der Probeflächen andererseits gezeigt werden.

Luftverunreinigung

Gemäß seinem Auftrag befasst sich das Programm insbesondere mit Luftverunreinigung. ICP Forests hat Zusammenhänge zwischen Luftschadstoffeinträgen, Bodenzustand, Nadel-/Blattchemie, Baumwachstum und Kronenzustand aufgezeigt. Weiterhin wurde die Abnahme von Schwefeleinträgen bestätigt und die hieraus resultierenden positiven Auswirkungen auf den Waldboden nachgewiesen. Diese Ergebnisse zeigen den Erfolg der verringerten Schwefelemissionen, die in Europa im Rahmen des Übereinkommens über weiträumige grenzüberschreitende Luftverunreinigung der UNECE (Genfer Luftreinhaltekonvention) und den entsprechenden Richtlinien der Europäischen Kommission umgesetzt wurden. Jedoch werden auf vielen Waldflächen die Grenzwerte für Gesamtsäure-, Stickstoff- und Schwermetalleinträge nach wie vor überschritten. Auf den meisten untersuchten Flächen in Südwesteuropa lagen die Ozonkonzentrationen deutlich über den Grenzwerten.

Weitere Umwelteinflüsse

Die Witterung hat Auswirkungen auf den Kronenzustand, auf das Baumwachstum und auch auf das Absterben von Bäumen. Auf mehreren Level II Probeflächen in Mitteleuropa zeigte sich, dass die extreme Hitze und Trockenheit im Sommer 2003 zu einer erheblich verringerten Wasserverfügbarkeit und Verdunstung durch die Bäume führten, was wiederum Wachstumshemmungen nach sich zog. Hitze und Trockenheit verstärkten auf größeren Flächen auch Borkenkäferbefall. Schädigungen durch andere Insekten und Pilze wurden eher lokal registriert. In Südwesteuropa waren Waldbrände von großer Bedeutung. Auswertungen der Stürme Ende der 90er Jahre zeigten, dass Schäden überwiegend auf sauren Böden und in Nadelwaldbeständen auftraten.

Ausblick

Das ICP Forests wird die regelmäßige Waldzustandsüberwachung in Europa fortführen. Als Grundlage für politische Entscheidungen wird es die benötigten Informationen über Stressfaktoren wie Luftverunreinigung zur Verfügung stellen. Es kann darüber hinaus auch dringend benötigte Daten zum Klimawandel und zur biologischen Vielfalt in Wäldern liefern. Das Monitoring ist somit eine solide Basis für die Europa weite Luftreinhaltepolitik, Umweltpolitik und für eine nachhaltige Waldbewirtschaftung.

Weitere Informationen:
http://www.icp-forests.org

Station météorologique située à la limite supèrieure de la forêt, Norvège.

Les facteurs environnementaux de stress dans les forêts européennes

Derniers résultats après 18 ans de suivi de l'état des forêts

Les changements environnementaux ont un impact sur l'état des forêts qu'il est nécessaire de connaître dans le cadre de la gestion durable des forêts. La mise en place de stratégies visant à réduire cet impact et l'évaluation de l'efficacité des politiques environnementales décidées au niveau international nécessitent un solide fonds de connaissances scientifiques. Celui-ci est acquis grâce au suivi à long terme des dommages forestiers, sous forme d'un suivi à grande échelle et d'un suivi intensif. En Europe, ce suivi est effectué depuis 18 ans par la Commission Economique pour l'Europe des Nations Unies (UNECE) et par l'Union Européenne (UE).

Réseau de suivi

Ce programme pan-européen s'appuie sur un des plus grands réseaux mondiaux de suivi biologique. Les variations spatiales et temporelles de l'état des forêts sont évaluées sur 6 000 placettes réparties selon un maillage systématique dans 39 pays européens, et sont mises en relation avec des facteurs naturels et anthropiques. Le suivi réalisé à grande échelle est qualifié de « Niveau I ». Un suivi plus intensif, qualifié de « Niveau II », est effectué sur 860 placettes supplémentaires représentatives des principaux écosystèmes des forêts européennes, afin de pouvoir établir des relations de cause à effet. Ces deux niveaux de suivi sont complémentaires.

Etat des houppiers

La vitalité d'un arbre se reflétant fortement au niveau de sa cime, l'état des houppiers des arbres est évalué chaque année depuis le début du programme. Plusieurs essences importantes qui avaient vu croître leur niveau de déficit foliaire ont récupéré au milieu des années 1990. Après plusieurs années de stabilité, les déficits foliaires ont augmenté à nouveau en 2003, et de façon simultanée pour toutes les essences importantes. Plus de 20% des 130 000 arbres échantillonnés en 2003 sont classés dans la catégorie « modérément à sévèrement endommagé ». La canicule exceptionnelle et la sécheresse qui ont prévalu en Europe pendant l'été 2003 pourraient expliquer ce phénomène. Lors d'études antérieures réalisées dans le cadre de ce programme, il a en effet été démontré que les facteurs climatiques extrêmes étaient des variables explicatives des fortes variations spatiales et temporelles de l'état des houppiers, de même que la pollution atmosphérique, les facteurs biotiques et l'âge des arbres. L'occurrence et l'impact de plusieurs facteurs environnementaux sont soulignés dans ce rapport.

Croissance des arbres

La croissance des arbres est un indicateur important de l'état de santé des forêts. Les derniers résultats du suivi confirment une augmentation généralisée de cette croissance, qui peut dépasser de 25% les valeurs enregistrées au cours des précédentes décennies. Ceci pourrait résulter des effets combinés de l'intensification de la sylviculture, de la hausse des températures, de l'élévation de la concentration en dioxyde de carbone dans l'atmosphère, ainsi que de l'augmentation des dépôts d'azote et de la réduction des dépôts de soufre. La croissance forestière augmente dans l'Europe entière, alors que croissance et défoliation individuelles des arbres apparaissent négativement corrélées à l'intérieur d'un peuplement. Cela correspond à une situation actuelle où le taux de croissance augmente à la fois pour les arbres en bonne santé et pour les arbres défoliés, avec toutefois une augmentation de croissance des arbres défoliés inférieure en valeur absolue à celle des arbres en bonne santé.

Biodiversité

Les changements environnementaux peuvent également affecter la diversité biologique des forêts européennes. Le PIC Forêts contribue au suivi de ces impacts notamment grâce aux données recueillies sur la structure des peuplements et sur la végétation arbustive et herbacée. En 2003, 14 pays participant au PIC Forêts se sont engagés dans une démarche pilote d'observations supplémentaires, dans le domaine du suivi de la biodiversité forestière (projet ForestBIOTA). Les premières expériences sur des placettes test ont établi la faisabilité de méthodes d'observation nouvellement mises au point et harmonisées entre les différents pays. Dans les régions montagneuses, la composition spécifique des lichens épiphytes a été mise en relation avec la proportion de conifères dans le peuplement et avec l'altitude de la placette.

Pollution atmosphérique

La pollution atmosphérique est le principal objet d'étude du programme, ce qui a permis de mettre en évidence des relations entre dépôts atmosphériques, état des sols, composition chimique du feuillage, croissance des arbres et état des houppiers. La réduction des dépôts de soufre a bien été confirmée, et son effet positif sur l'état des sols a été mis en évidence. Ces résultats montrent le succès des politiques de réduction drastique des émissions de soufre mises en place dans le cadre de la Convention sur la pollution atmosphérique transfrontalière à longue distance de l'UNECE (convention CLRTAP) et des réglementations correspondantes de l'UE. Cependant, les dépôts acides, d'azote ou de métaux lourds dépassent les charges critiques sur de nombreux sites forestiers. Les concentrations en ozone au niveau du sol dépassent également les seuils critiques sur la plus grande partie des placettes du sud-ouest de l'Europe.

Autres facteurs environnementaux

L'état des cimes, la croissance et le taux de mortalité des arbres sont affectés par les conditions climatiques annuelles. Les suivis montrent que la canicule et la sécheresse exceptionnelles de l'été 2003 ont provoqué une forte réduction de la disponibilité en eau et de la transpiration sur plusieurs placettes de niveau II en Europe centrale, d'où une diminution de la croissance sur ces placettes. Par ailleurs, la canicule et la sécheresse ont favorisé les attaques de scolytes sous-corticaux sur de vastes zones. D'autres ravageurs et des pathogènes ont été à l'origine d'attaques localement importantes. Les incendies de forêts ont concerné des surfaces particulièrement élevées dans le sud-ouest de l'Europe. Enfin, il a été démontré que les dégâts consécutifs aux tempêtes observés durant la dernière décennie ont majoritairement concerné des sols acides et des peuplements résineux.

Objectifs futurs

Le programme va poursuivre régulièrement les observations de l'état des forêts en Europe. Il fournira des informations clés relatives aux facteurs de stress tels que la pollution atmosphérique, et contribuera à l'acquisition des données dont nous avons un besoin urgent dans les domaines du changement climatique et de la biodiversité forestière. Ainsi, ce suivi permettra de disposer d'une base scientifique claire indispensable aux politiques en matière de qualité de l'air et d'environnement ainsi qu'à la gestion durable des forêts.

Pour de plus amples informations, consulter le site : http://www.icp-forests.org

Norway spruce forest, Sweden.

1. A pan European monitoring system

Forests have an important multifunctional role for society. Apart from the economic benefit of wood production and their significant role in the development of rural areas, forests have a major value for nature conservation and play an important role in preserving the environment. They are significant carbon sinks and thus relevant in the context of climate change. Forests also represent a controlling factor of the water cycle.

In 1985 the International Co-operative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) was established under the UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP). In 1986 the European Union (EU) adopted the Scheme on the Protection of Forests against Atmospheric Pollution and with the Council Regulation (EEC) No. 3528/86 the legal basis for the co-financing of the assessments was provided.

In 2003, this regulation was prolonged and modified through the "Forest Focus" regulation (EC No 2152/2003). ICP Forests and EU have been closely co-operating in monitoring the effects of air pollution and other stress factors on forests. Today 40 countries participate in the monitoring programme which contributes to the implementation of clean air policies at European and national level.

Programme objectives

The objectives of the monitoring programme are:

- to provide a periodic overview on the spatial and temporal variation in forest condition in relation to anthropogenic and natural stress factors in a European and national large-scale systematic network (Level I);

- 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);
- to contribute to the calculation of critical levels, critical loads and their exceedances in forests;
- to collaborate with other environmental monitoring programmes in order to provide information on other important issues, such as climate change and biodiversity in forests and thus contribute to the sustainable management of European forests;
- to compile information on forest ecosystem processes and to provide policy makers and the public with relevant information.

Monitoring design and reporting

A systematic large scale monitoring network (Level I) and an Intensive Forest Monitoring Programme (Level II) are managed to meet these objectives (see Tab. 1).

The strength of the Level I network is the vast extent of its approximately 6000 permanent plots, arranged on a 16 x 16 km grid, in 33 countries throughout Europe. Annual crown condition assessments are carried out at Level I plots. In addition, soil and/or foliage surveys were conducted on most of the plots. A repetition of the soil survey is under discussion also in context with the EU soil strategy.

For intensive monitoring more than 860 Level II plots have been selected in the most important forest ecosystems of 28 participating countries. A larger number of key factors is assessed on these plots. The collected data are not representative at the European scale. They enable case studies and correlative studies for the key factors and various combinations of site conditions and species to be made. Some projects and evaluations are carried out under the initiative of selected countries. Related results are thus not based on the complete set of all pan European plots.

Surveys conducted	Level I		Level II	
Crown condition	annually	all plots	at least annually	all plots
Foliar chemistry	once until now	1497 plots	every 2 years	all plots
Soil chemistry	once until now	5289 plots	every 10 years	all plots
Soil solution chemistry			continuously	part of the plots
Tree growth			every 5 years	all plots
Ground vegetation			every 5 years	all plots
Atmospheric deposition			continuously	part of the plots
Ambient air quality			continuously	part of the plots
Meteorology			continuously	part of the plots
Phenology			several times per year	optional
Litterfall			continuously	part of the plots
Remote sensing			preferably at plot installation	optional

Table 1: Main surveys carried out at Level I and Level II.

Scots pine stand, Estonia.

2. The state of forests in Europe

Since the early 1980s when a severe deterioration of forest condition was observed in large areas of Europe, the situation and health status of European forests have been under close observation, and with the increasing length of the monitoring time series a differentiated view has become possible. Monitoring is today based on traditional indicators, like crown condition and forest growth (see Chapt. 2.1 and 2.2). In recent times, also the biological state of forests has received increased attention and the monitoring programme has reacted to related information needs (see Chapt. 2.3).

2.1 Defoliation in 2003 and its trends

Summary

- *More than 20% of around 130 000 trees assessed in 2003 were classified as damaged. Trees in countries that have been monitored since the start of the survey show a peak of high defoliation in the mid 1990s. In the last year again a consistent worsening occurred for all main tree species. Plausible explanations are the extreme drought and heat during summer 2003.*
- *Time trends for the main tree species show that there is no uniform trend of defoliation throughout Europe. Rather, they reveal changing conditions in different regions.*

Introduction

The annual large scale forest condition assessment of the programme is based on a systematic 16 x 16 km grid net and gives a good overview on the health status of the forest ecosystems. In 2003, 131 503 trees were assessed in 30 countries. Defoliation is the main parameter within this survey. It is a single tree estimate for the lack of foliage, responds to many stress factors and is easily assessable over large areas. This makes defoliation a valuable overall indicator for forest condition.

Large scale status

22.7% of all trees assessed in 2003 were classified as moderately or severely defoliated or dead. Crown condition in the EU-15 Member States was slightly better than in Europe as a whole. Of the four tree species most frequently occurring on the plots, European and sessile oak were the most severely defoliated species (see Fig. 2).

Temporal development

Mean defoliation has increased during the last year for all main tree species except for Norway spruce which remained on the same defoliation level (see Fig. 3). Mean defoliation was mostly still lower than in the mid

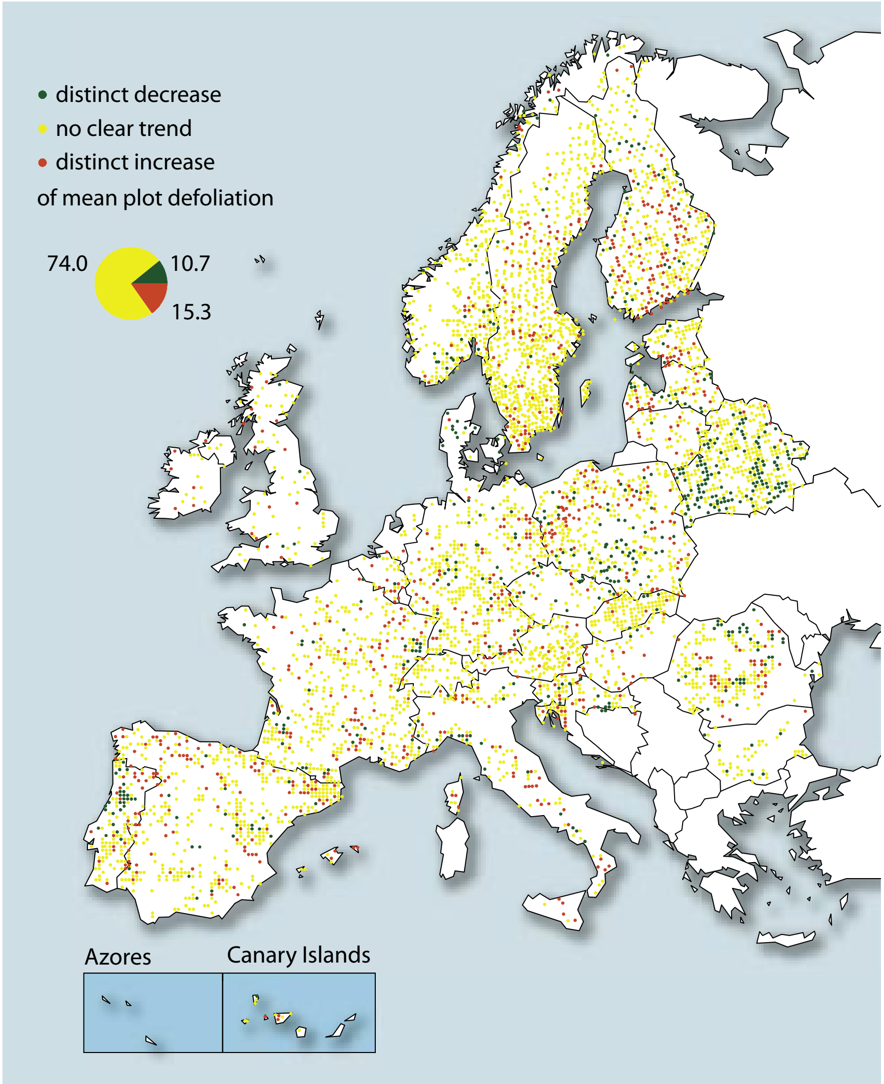


Figure 1: Plot-wise development of defoliation for all tree species, 1997-2003.

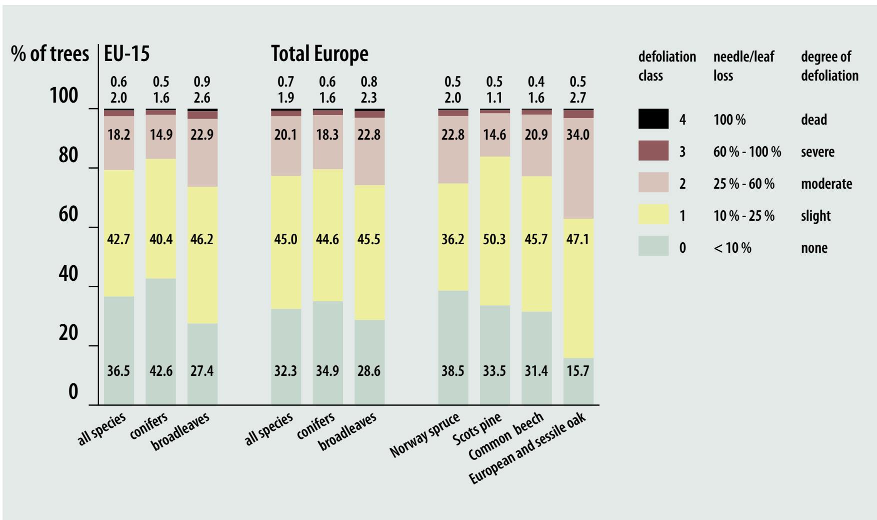


Figure 2: Percentage of trees in different defoliation classes. Total Europe and EU, 2003.

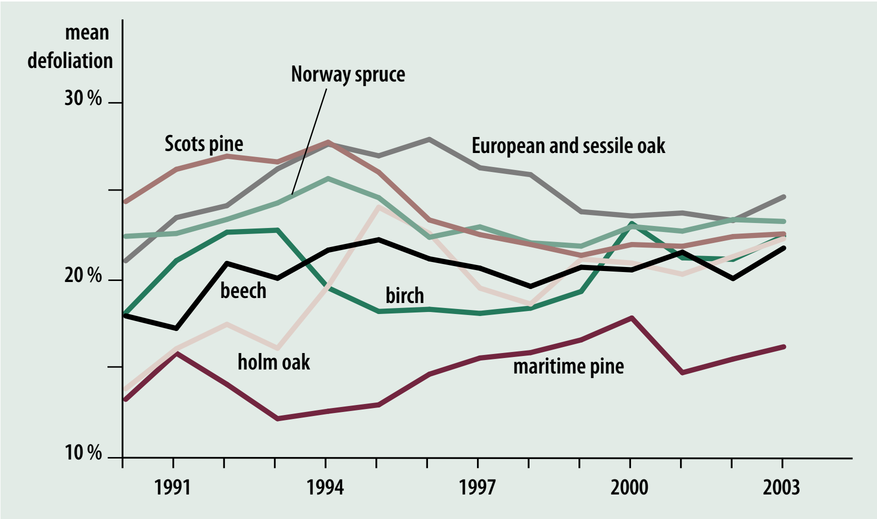


Figure 3: Mean defoliation of European main tree species. Sample sizes vary between 2 600 and 11 924 trees per depicted species. Results are based on data from 21 countries.

90s when most tree species showed a maximum defoliation. Beech reached the level of its previous maximum in 1995. An overall worsening is also documented in the share of plots that show a significant increase in defoliation since 1997 (see Fig. 1). With 15.3% this proportion is bigger than the percentage of plots showing a decrease (10.7%). The temporal development at single plots shows a belt with prevailing deterioration along the eastern edge of the Baltic Sea reaching from southern Finland to eastern Germany. Improvements were mainly registered in Belarus and southern Poland. Influences on crown condition are many and diverse; they are in more detail described in Chapter 3. The extreme heat and drought in large parts of Europe during late summer 2003 are however suspected to be explanations for the increased defoliation. It is even expected that these weather extremes will have a sustained effect on the health status of the forests in 2004 (see Chapt. 3.1).

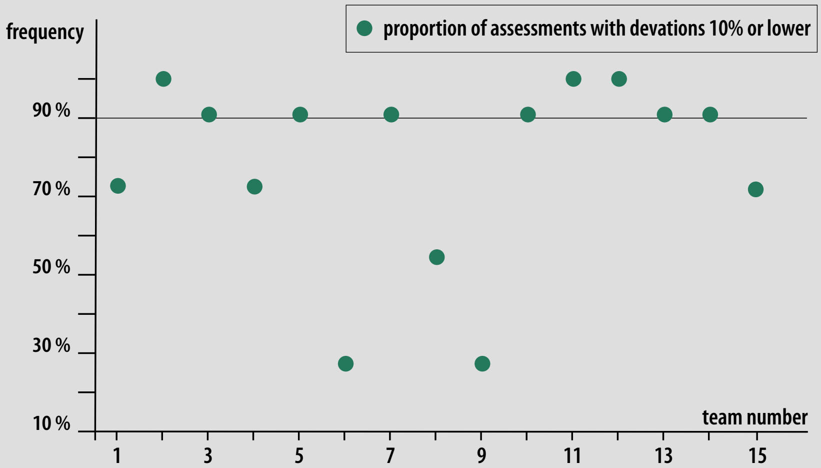
The development of main tree species (see Figs. 4 to 7) shows that crown condition of common beech fluctuated across large areas of Europe. Distinct worsening was registered in southern Sweden, Romania and Belgium. Here, it was due to the combined influence of adverse weather conditions, bark beetle attacks and fungal infections. In southern Germany the beech trees on the plots recuperated after a worsening at the end 1990s. The deciduous oak species deteriorated in this period mainly in southern Sweden, eastern Austria and central France. The latter region deserves particular attention as the situation has remained unchanged for years. The worsening of the conifers in Scandinavia was ascribed to root rot and needle rust fungi. Improving trends have been observed in Belarus in particular.

Further information:

Lorenz, M., Becher, G., Mues, V., Fischer, R., Ulrich, E., Dobbertin, M., Stofer, S. 2004. Forest Condition in Europe. 2004 Technical Report. UNECE 2004, Geneva.

Quality Control

Quality control plays an important role within the monitoring programme. In 2003, International Cross-Calibration Courses were held in Germany and Estonia. Here, defoliation of a larger number of trees was assessed by experts from different countries in order to document the level of their scores and possible differences in the assessment methodology. In general, results were convincing, as most trees were assessed with similar scores by all participants. Since recently, photo assessments are included in these courses. Photos can be re-interpreted after years and thus enable to check the time consistency of the assessments. If the photo interpretation proves reliable, it may partly replace costly field exercises in the future. A first evaluation of the photo assessments during the courses in 2002 and 2003 was encouraging. Photo and field assessments were highly correlated in most cases. Results will still be improved when more experience is collected over the years (see Fig.).



Correspondance between photo and field assessments for different teams. For most teams, deviations larger than 10% occurred rather seldomly.

Many holm oak stands in Spain and other southern European countries showed a decline in recent years, caused by a complex of different stress factors including drought, insects and fungal diseases.

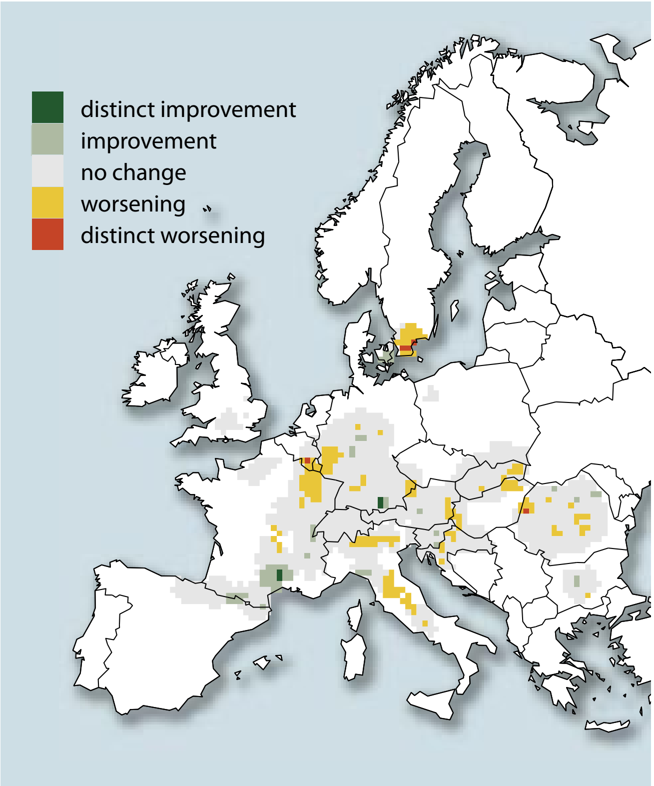


Figure 4: Temporal development of mean plot defoliation for common beech; interpolation based on 564 plots continuously assessed from 1997 to 2003.

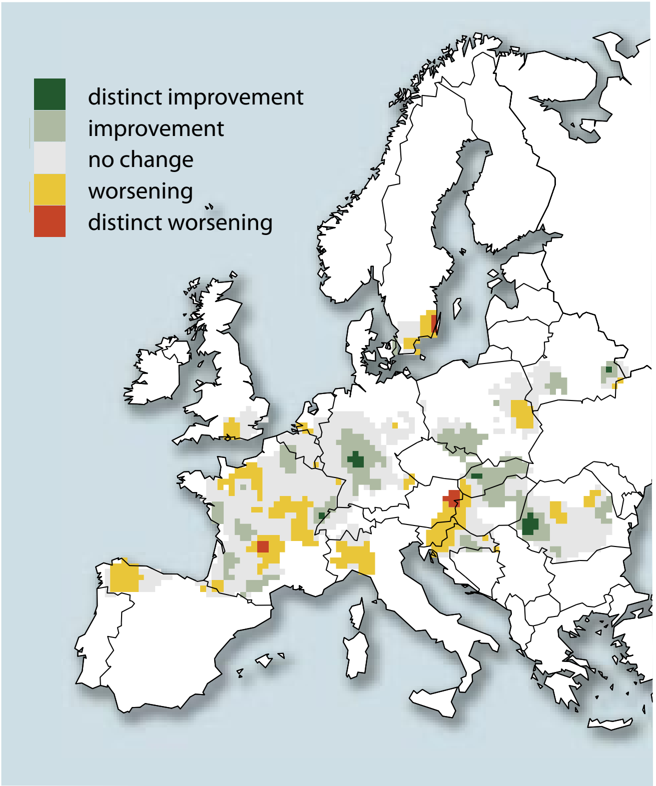


Figure 5: Temporal development of mean plot defoliation for European and sessile oak; interpolation based on 507 plots continuously assessed from 1997 to 2003.

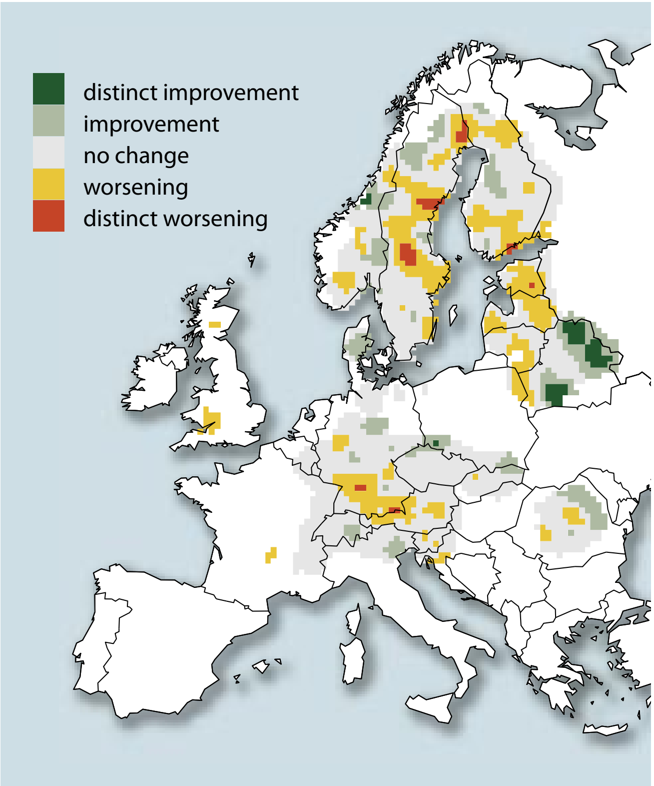


Figure 6: Temporal development of mean plot defoliation for Norway spruce; interpolation based on 1463 plots continuously assessed from 1997 to 2003.

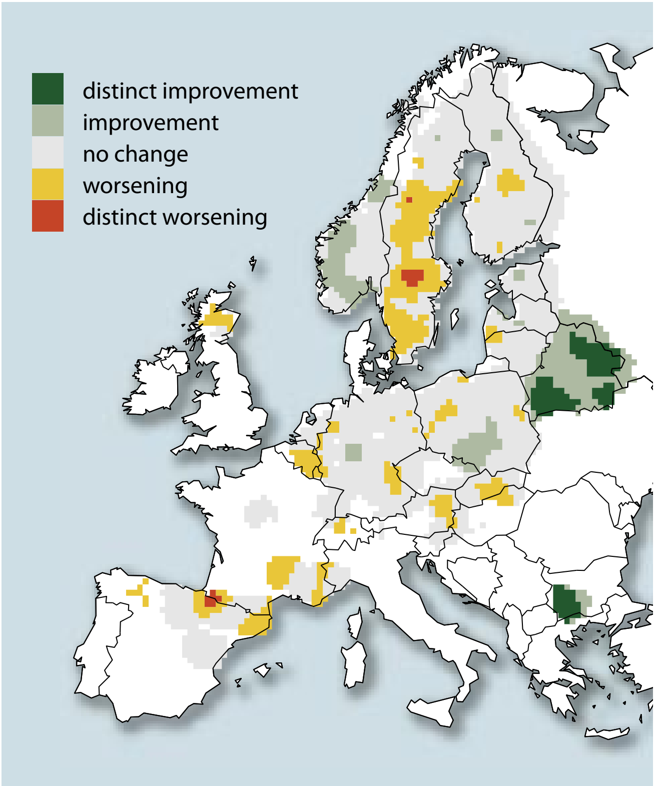


Figure 7: Temporal development of mean plot defoliation for Scots pine; interpolation based on 1953 plots continuously assessed from 1997 to 2003.

Leaves and catkins of birch (*Betula pubescens*).

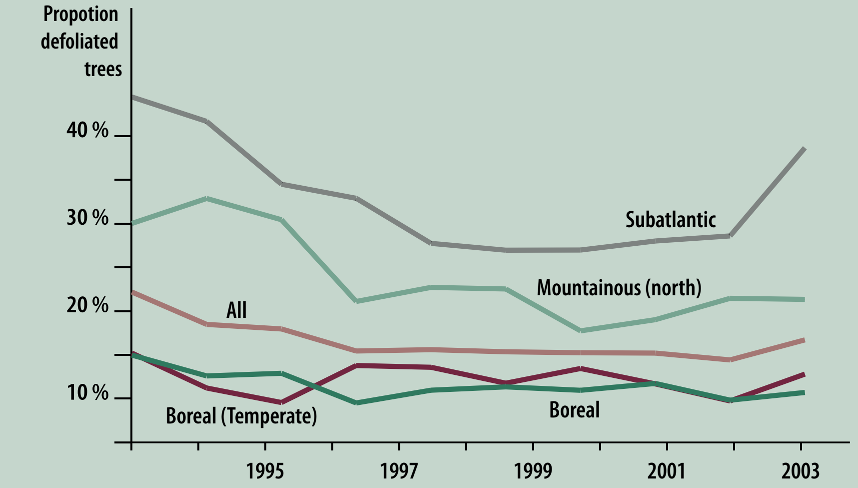
The condition of birch

Summary

- *Birch is spread over almost all Europe with higher proportions in northern forests. This tree species is mostly found in mixed stands. Presence of birch in a forest stand improves both, the chemical and physical soil status and often decreases the spreading of root rot in spruce stands.*
- *More than 7 500 birch trees are assessed annually in the ICP Forests Level I monitoring programme. Results from the inventory show a variation in defoliation and discolouration between single years and regions. To a large extent this variation is probably due to normal forest ecological processes like weather and biotic factors.*
- *Young birch forests may be subjected to severe damage caused by grazing from moose and deer or by eating by voles. Attacks of birch rust fungi can be abundant, but severe damage is restricted to young birch plants. Insect damage on birch normally has a minor importance, except for autumnal moth that may cause substantial damage in the mountain regions of northern Europe.*

Introduction

Two species of birch, *Betula pendula* and *Betula pubescens*, are naturally growing in Europe. The two birch species are found all over Europe, except in the most south-eastern and south-western parts. It is not always easy to separate them as they can hybridize, which is more common further north. A subspecies, *Betula pubescens subsp. czerepanovii* covers huge areas as tree or bush stands in the mountain regions of northern Europe. Although birch is widespread over Europe its overall share is low compared to the other main



Proportion of defoliated birch trees (defoliation >25%) in different regions of the Level I grid 1994 - 2003.

tree species. Birch is mostly found in mixed stands, but pure stands are more common in the north and north-eastern parts of Europe. Birches are pioneer tree species and establish quickly after forest fires or clear cuttings. *B. pendula* has modest demands on nutrient and water supply, but is sensitive to flooding and drought and is easily competed by other species such as Norway spruce. *B. pubescens* is more often found on wet and moist sites and at higher altitudes in the northern parts of Europe. Presence of birch in a stand will improve the soil status by the chemical content of the litter and by giving a less compact humus layer. Due to the translucent birch crowns, herbs and grasses will also be favoured. In spruce stands seriously affected by root rot (*Heterobasidion annosum*) the occurrence of birch will obstruct the extension of this fungus.

Gall mites (*Eriophyes longisetosus*) colonize single birch leaves.

Monitoring results

At present more than 7 500 birch trees are assessed annually in the transnational monitoring programme. In the Level I database more than 1 000 birch trees originate from each of the countries Belarus, Norway, Finland and Sweden. The highest proportions of defoliated birches (defoliation >25%) are observed in the mountainous – north and subatlantic regions (see Fig.). In all regions a slight decrease in defoliation has been observed since 1994 with an increase in 2003. However, the proportion of damaged and discoloured trees varies largely in the different regions and between single years. To a large extend this is assumed to be due to direct or indirect weather effects. Excessive outbreaks of fungi and heavy flowering, which strongly affects the damage rate, largely depend on propitious weather conditions. When a strong flowering occurs a larger part of the birch crown produces leaves with a reduced size. In the following year also dead twigs will appear as a consequence of the flowering. In Sweden and Finland, intensive flowering occurred in 1998 and 2002 and partly in 2003. In 2000, also an intense flowering on *B. pendula* was noticed in southern Sweden.

Biotic stress factors

Birch is often exposed to grazing by game as moose and deer or damaged by voles. Planting birch without any mechanical protection to grazing can be hazardous in areas with large game populations. Among insects only a few species appear as defoliators, for instance the winter moth (*Operophtera brumata*) and northern winter moth (*O. fagata*). In younger stands feeding by adult beetles of the genus *Phyllobius* may occur, but no insect except autumnal moth (*Epirrita autumnata*) normally initiates any substantial damage. In summer 2003 large areas of *B. pubescens subsp. czerepanovii* in the northern mountain region were defoliated by this moth. Wood living beetles, as *Scolytus ratzeburgi*, *Trypodendron spp.* and *Hylecoetus dermestoides*, only attack and colonize dead or weakened trees and occur as secondary pests.

Decay fungi, as *Fomes fomentarius* or *Piptoperus betulinus*, normally only appear in old and weakened trees. Inonotus obliquus however may generate decay damage also to healthy birch trees.The rust fungus *Melampsoridium betulinum* can appear in large outbreaks when the weather is favourable for the fungus. The last larger outbreak in Sweden occurred in 2000 in the eastern parts of the country. In 2002 it caused massive defoliation in late summer in Norway. The effects of such outbreaks are mostly restricted to growth reduction, but in nurseries it can turn out to be a larger problem. Witches' brooms sporadically occur on birch, caused by the fungus *Taphrina betulina*. Fungi like *Marssonina betulae* and *Pyrenopeziza betulicola* can cause leaf spots and discolouration of the leaves. *Pleomassaria siparia* can cause defoliation of birch by killing the branches prematurely.

2.2 Forest growth

Summary

- *Stand growth (tree height and wood volume) has increased in most European forests during the last 40 years. This was also confirmed on the investigated Level II plots.*
- *Individual tree growth is correlated with defoliation at all site productivity levels.*
- *Both, growth and defoliation, are valuable indicators of forest condition.*
- *Besides nitrogen deposition, also increasing temperature and carbon dioxide (CO_2) concentrations can have an effect on tree growth. This issue will be further investigated.*

Introduction

Growth of trees is a key indicator for the condition and vitality of forests, just like defoliation (see Chapt. 2.1). Tree measurements have been carried out on Level II plots in the years 1994/95 and 1999/2000. Forest growth and the knowledge of forest structure are also prerequisites for the analysis of many other parameters assessed on Level II plots, including the diversity of species groups (see Chapt. 2.3).

Recently three studies were carried out using growth data from Level II plots in a larger number of countries. Two studies were co-financed within the EU regulation 3528/86 (DEFOGRO and PROGNEU), while the third study was conducted as a part of the EU-Project RECOGNITION.

Individual tree growth as indicator of forest condition

The relation between tree growth and defoliation was evaluated for the main tree species Norway spruce, Scots pine and beech on plots of 15 countries. Although growth was highly variable, it significantly correlated with defoliation for all three species (see Fig. 8). In other words, defoliated trees had reduced growth compared to undefoliated trees. The

Old growth oak and young beech, Germany.

relative growth reduction was higher for spruce than for pine and beech.

The results were very similar, when comparing the ratio of measured growth and modelled growth with tree defoliation scores. This confirms earlier studies for conifers based on a lower number of trees and is new for common beech. For a given defoliation, a wide variability of tree growth was observed, indicating other important influences, such as tree competition and tree size as well as differences in site conditions or defoliation assessments. While duly considering all these and other influences, both, growth and defoliation (see Chapt. 2.1) are useful indicators of forest condition.

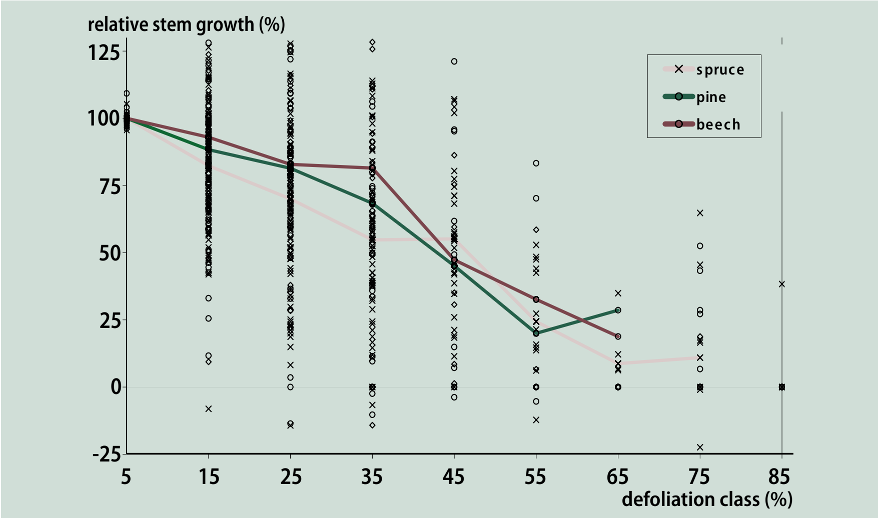


Figure 8: Tree growth in relation to defoliation (source: DEFOGRO).

Retrospective analysis of tree height increment

Tree ring analyses provide the possibility to compare the present height growth of trees to that of older sample trees at the same site when they had the same age. Such an analysis requires the felling of sample trees which was carried out in the buffer zone of 46 Level II plots. Results show that during the period 1960 to 2000 height increment of the younger Norway spruce, Scots pine and common beech sample trees is significantly and consistently larger than that of the older trees when they had the same age approximately 50 years ago.

Over the observation period the height increment has on average increased by 23% for Norway spruce and by 25% for Scots pine and beech (see Fig. 9). This also resulted in an increased wood volume increment and confirms earlier findings which also revealed a generally accelerated tree growth across Europe.

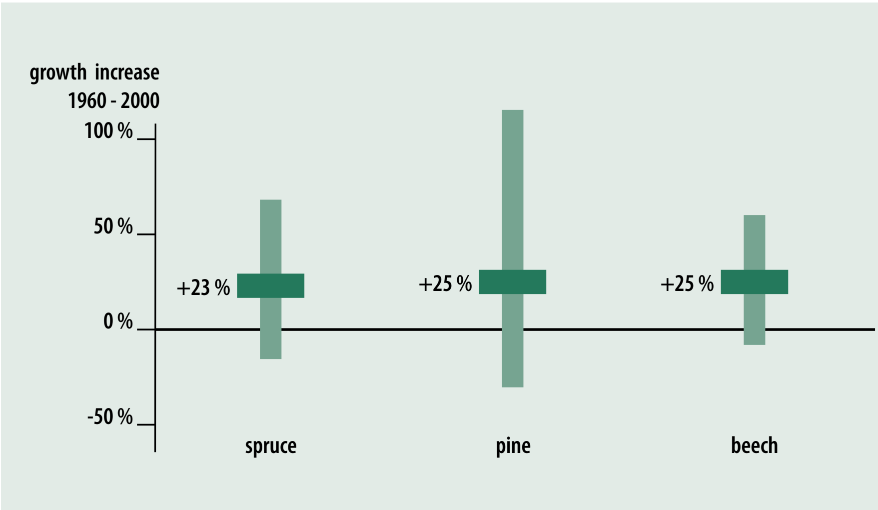


Figure 9: Tree height growth today and in the past (relative changes of annual height increment: observed minimum, median, maximum; source: RECOGNITION).

Atmospheric deposition influencing tree growth

It is, of course, of high interest to explore the reasons for the significantly increased tree growth. It is well known that under certain site and stand conditions depositions can enrich soils with nitrogen (eutrophication). Also increases of temperature


Stem disc of a mountain pine from the Level II plot in the Swiss National Park. Tree ring analyses and determination of annual height increment allow for a retrospective tree growth analysis.

and of atmospheric CO_2 concentrations can have stimulating effects.

In order to investigate the influence of environmental factors, Level II plots with Norway spruce and beech were selected from seven central European countries. A regression model was set up to account for internal factors like tree size measurements, site factors, stand density and competition. Results show that actual growth on beech plots with high nitrogen or sulphur deposition was less than estimated by the model, thus assuming reduced increment at high deposition (see Fig. 10). For spruce no clear trend was found between growth and deposition loads.

In another approach, changes in tree height growth in relation to nitrogen foliar content and nitrogen deposition were evaluated based on Level II plots in 14 European countries ranging from Finland to Spain. The calculations show a decreasing height increment for Norway spruce with high nitrogen foliar content and a reverse relationship for Scots pine and beech. At the sites where high nitrogen concentrations in the trees' foliage suggest a nitrogen saturation of the stands, the height growth acceleration is decreasing.

Outlook

The relations between environmental factors and tree growth are complex. Further investigations will be carried out after a repetition of the increment assessment in 2004/2005 in order to determine the underlying causes for the increasing tree growth. In this context, special attention will be paid to site and climatic conditions and atmospheric deposition.

Further information:
Lorenz, M., Becher, G., Mues, V., Fischer, R., Ulrich, E., Dobbertin, M., Stofer, S. 2004. Forest Condition in Europe. 2004 Technical Report. UNECE 2004, Geneva.

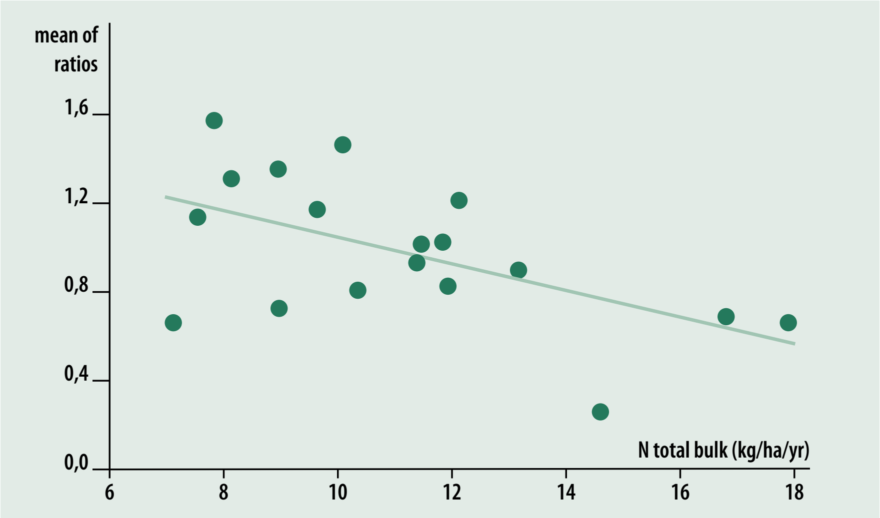


Figure 10: Increment of beech 1994 – 1999 in relation to total nitrogen bulk deposition (ratios between observed and modelled basal area increment, $R^2 = 0.3$; source: PROGNEU).

Measuring tree circumference.

2.3 Contributions to biodiversity monitoring - first results

Summary

- *Existing data of ICP Forests contribute to information needs in the field of forest biodiversity, e.g. through extensive data sets on crown condition, forest growth and stand structure.*
- *In 2003, the ForestBIOTA project was elaborated within ICP Forests. It aims at further contributions to European forest biodiversity monitoring through the development of additional stand structure, epiphytic lichens, deadwood, and ground vegetation assessments and the test wise implementation of a new forest classification. In a second phase, relationships between biodiversity key factors and environmental influences will be investigated.*

Deadwood provides habitats for numerous species.

Introduction

In an environment of changing deposition regimes, forest biological diversity is perceived to be under threat. The need for sustainable management of forests and the monitoring of their biological condition have been formulated on high political levels world wide. The monitoring of tree crown condition (see Chapt. 2.1) and tree growth (see Chapt. 2.2) contributes to these information needs. In 2003, 14 countries of the ICP Forests launched the ForestBIOTA project (Forest Biodiversity Test Phase Assessments).

Stand structure as basis for diversity in forest ecosystems

The assumption behind the stand structural approach is that more structurally diverse forests offer a greater range of habitat types. On the large scale this assumption has until today only been proven for a small number of species groups, like e.g. birds. ICP Forests can make a contribution to the monitoring of forest biodiversity in this context. The ForestBIOTA project aims at an improved survey of stand structure, deadwood, epiphytic lichens, and ground vegetation at Level II plots. Also correlative studies between these biodiversity key factors and environmental influences will be carried out. A new forest type classification has already been tested (see Fig. 11).

Epiphytic lichen pilot survey on Swiss Level II plots

Lichens are long-living organisms with a high sensitivity to environmental influences and past regional ecological disturbances. They depend on a range of climatic parameters and are also related to forest stand structure and history. This makes them a valuable tool for biodiversity assessments. The monitoring of epiphytic lichens living on tree bark is one component of the ForestBIOTA project and is foreseen to be started on around 100 plots throughout Europe in 2004, following harmonized methods. A pilot survey on 15 Swiss Level II plots was already carried out in 2003. In total, 132 different epiphytic lichen species and more than 1200 individuals were counted. A number of variables showed a significant relation to lichen species composition. The altitude of the plots above sea level had the strongest statistical influence, but also stand structural variables like the proportion of conifers and the diameter distribution of the stands were of significant importance. Deposition will be included into the analyses when a larger data set becomes available.

Multivariate statistical techniques could explain 27.5% of the total variation in the species data with the explanatory variables ‘altitude’ and ‘proportion of conifers’ (see Fig. 12). Already the comparatively small sample of this pilot study shows a good relation of epiphytic lichens to changing environmental factors. The data from a much larger number of plots will allow more detailed analyses in order to determine their potential for a large scale monitoring of biodiversity aspects in forests.

Steps towards an integrated international field assessment of biodiversity on Level II plots

Already in 2003, harmonized methods for the ForestBIOTA assessments were developed at an international workshop. All surveys are designed for the stand level on the Intensive Monitoring Plots where also the standard Level II surveys have been carried out for many years.

Before their large scale implementation they were tested on several Level II plots in Europe, some of them

The ForestBIOTA project aims at the development of harmonized assessment methods for deadwood, stand structure and epiphytic lichens.

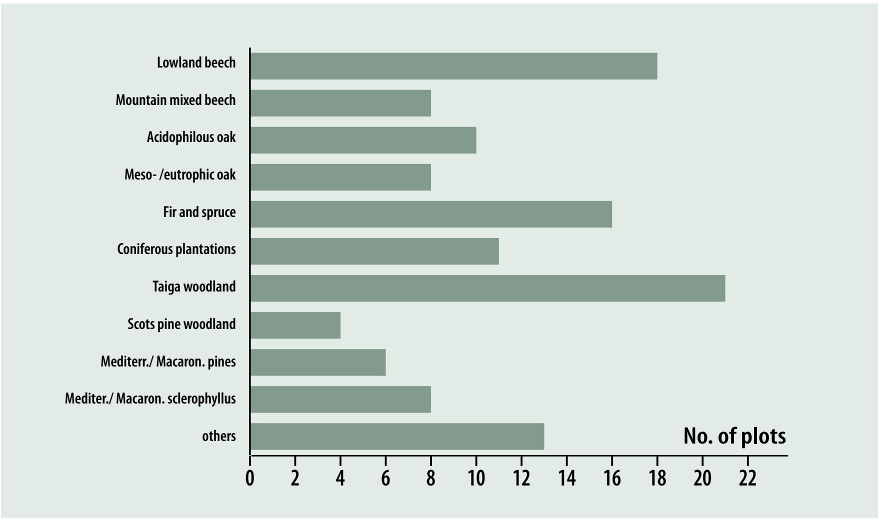


Figure 11: Forest types at Level II plots of the ForestBIOTA project. The classification is based on a new aggregation of the existing EUNIS types (European Nature Information System) into 28 European forest types. It mainly takes into account tree species, site factors and geographical region. ForestBIOTA plots cover the most important forest types.

Letharia vulpina **is an epiphytic lichen occurring in subalpine regions.**

in Italy (see Tab. 2). Here, the evaluation of stand structure revealed that all 9 calculated indices were statistically correlated. Around 100 epiphytic lichen species were assessed. With respect to ground vegetation, changes during the past 6-8 years show a slight but insignificant increase in species numbers. In addition to the transnationally harmonized assessments, naturalness, landscape biodiversity and insect communities were surveyed in the Italian context. An important additional result of the latter survey was the description of a world wide new insect species.

These first experiences in Italy show that at relatively low costs it is possible to obtain valuable indications on the biodiversity status of forest communities. The new and harmonized ForestBIOTA methods were applicable under field conditions and effective. The additionally tested parameters for naturalness, landscape diversity, and insect communities were coherent with other existing data. Finally, the qualitative results of surveys could help to increase the basic scientific knowledge in Italy.

Outlook

The international test phase may contribute to the development of monitoring methods applicable on a larger number of forest plots throughout Europe. Synergies are expected when an integrated evaluation of the new assessments in combination with the existing data sets will be performed. These correlative studies aim at relating changes in species composition and stand structure to air pollution and other stress factors. A close collaboration with the European National Forest Inventory Network (ENFIN) has already been established for the development of large scale applications.

Further information:

Lorenz, M., Becher, G., Mues, V., Fischer, R., Ulrich, E., Dobbertin, M., Stofer, S. 2004. Forest Condition in Europe. 2004 Technical Report. UNECE 2004, Geneva.

Petriccione B., 2004. First results of the ICP Forests biodiversity test-phase in Italy. In: Marchetti M., Barbati A., Estreguil C. & Larsson T.-B. (ed.) Monitoring and Indicators of Forest Biodiversity in Europe, From Ideas to Operationality. EFI Proceedings (in press).

Cerretti, P. 2004. A new species of Pseudogonia Brauer et Bergenstamm from Sardinia, and a key to the West Palaeartic species (Diptera: Tachinidae). Stuttgarter Beitrage zur Naturkunde, Series A (Biologie) 659: 1-11.

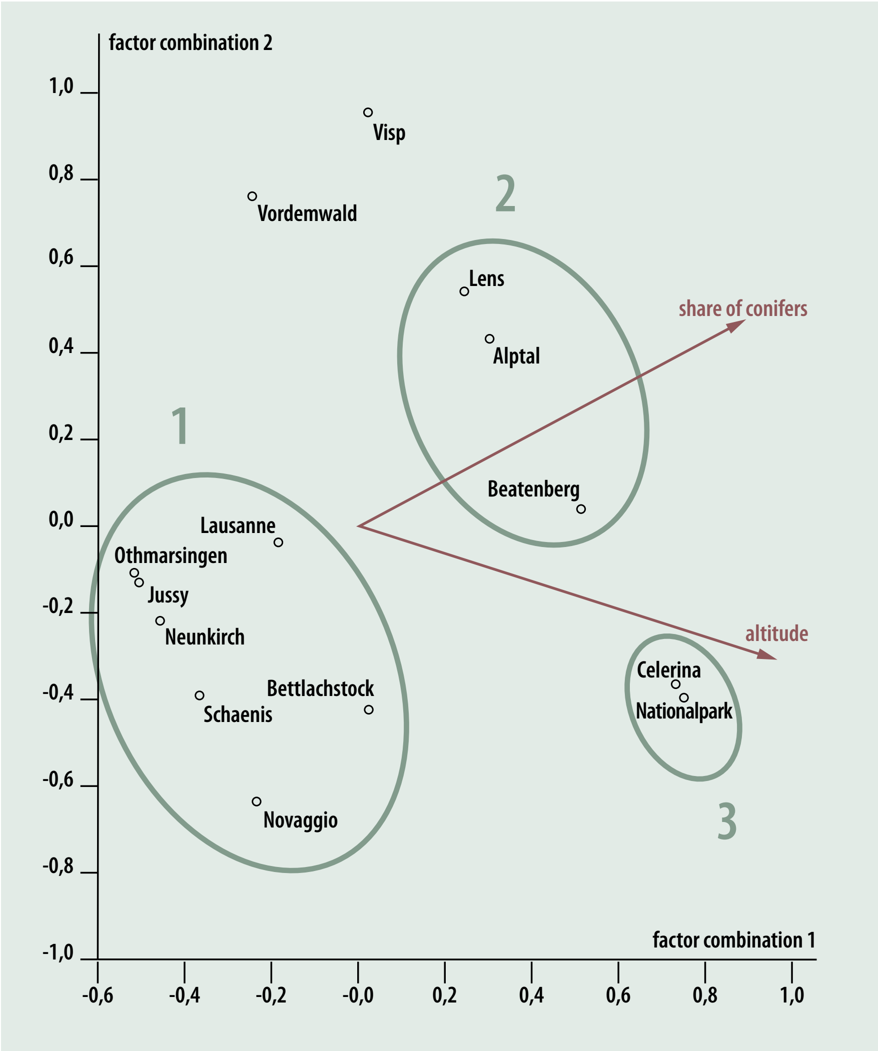


Figure 12: Ordination diagram of Swiss Level II plots in relation to 'altitude' and 'proportion of conifers'. The plots were grouped by factor combinations including lichen species composition. The lichen species growing on the trees reflect important ecological influences. 1: lowland plots (low altitude, low proportion of conifers), 2: pre-alpine plots (low altitude, high proportion of conifers), 3: alpine plots (high altitude, high proportion of conifers).

PLOT	vegetation	lichens	stand str.	deadwood	insects	naturalness	landscape
01	48	n.a.	8.87	n.a.	n.a.	4.6	n.a.
03	73	n.a.	7.59	6.4	169	n.a.	n.a.
08	78	16	18.34	n.a.	n.a.	0.2	n.a.
10	92	29	98.56	n.a.	n.a.	0.2	n.a.
17	31	116	12.91	n.a.	n.a.	4.7	7.65
27	54	n.a.	n.a.	n.a.	n.a.	2.8	6.26
15	81	n.a.	39.75	25.0	140	n.a.	n.a.
21	66	n.a.	n.a.	38.0	95	4.8	n.a.
14	38	n.a.	57.88	12.0	135	n.a.	n.a.
16	20	29	124.88	n.a.	n.a.	3.3	n.a.
22	54	n.a.	n.a.	n.a.	n.a.	4.0	n.a.
25	29	63	n.a.	n.a.	n.a.	5.0	n.a.

Table 2: Results of the biodiversity monitoring in Italy.
vegetation (number of ground vegetation species), lichens (Index of Lichen Biodiversity), stand structure (complexity index), deadwood (total amount in m^3/ha), insects (total no. of Coleoptera and Diptera species), naturalness (average value), landscape (Biological Territorial Capacity in Mcal/m^2/y), (n.a.: not assessed).

Drought stress in oak coppice forests in Germany, September 2003.

3. Environmental influences

The condition of forests can be seriously affected by natural factors such as extreme weather conditions, insect fluctuations and diseases or human influences such as climate change, fires and air pollution. Such threats can seriously affect and even destroy forests. Most natural and anthropogenic factors affecting forests can have cross-border effects. Their statistical relation to forest condition has been shown in many previous reports of ICP Forests. The following subchapters describe main natural and human influences and present related monitoring results.

3.1 Extreme heat and drought during summer 2003

Summary

- *The summer of 2003 was characterized by temperatures significantly above average and by extreme drought across large parts of Europe.*
- *Intensive monitoring data reveal growth reductions at lower altitudes, while at higher altitudes and in the far north the elevated temperatures accelerated tree growth. Forests in southern Europe seem to be better adapted to drought.*
- *The majority of ecosystem reactions including increased defoliation values and tree mortality in some regions may only become visible in the following years.*

Prematurely shed green beech leaves.

Introduction

Much of Europe was affected by heat waves during the summer of 2003. Nationwide seasonal temperatures were warmest on record in Germany, Switzerland, France and Spain. At many locations, temperatures rose above 40°C for several subsequent days. Globally, the 2003 temperatures are likely to be the third warmest in the instrumental record from 1861 to present, just behind 2002 and 1998, according to the World Meteorological Organization (WMO). Stands exposed to air pollution are more susceptible to drought effects. The ICP Forests intensive monitoring data offer a unique opportunity to measure the extreme weather events, to detect stress reactions of the forest ecosystems and to monitor the medium term effects.

Drought effects on many forest plots

As an example, measurements of soil water content on plots in Bavaria, southern Germany show that nearly irrespective of site type, water availability for plants was reduced to zero in late summer. Hydrological models based on the intensive monitoring data reveal that transpiration of the trees was distinctly reduced in 2003 (see Fig. 13). Under drought

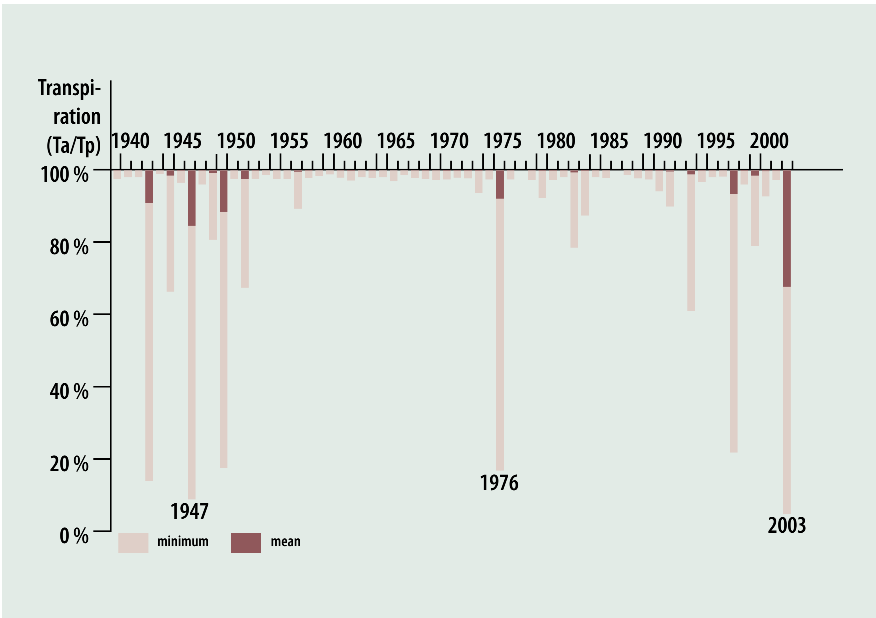


Figure 13: Index of the transpiration ability (ratio of actual to potential transpiration) from 1941 to 2003 during the periods May until August on the Intensive Monitoring Plot Ebersberg, Bavaria, Germany.
The data suggest that in central European forests 2003 had one of the most extreme summers in the past 50 years. On many plots it even exceeded the well-known drought years 1947 and 1976. The underlying hydrological models take into account precipitation, transpiration, seepage and water storage in the soil and relate them with other environmental data from the same plots.

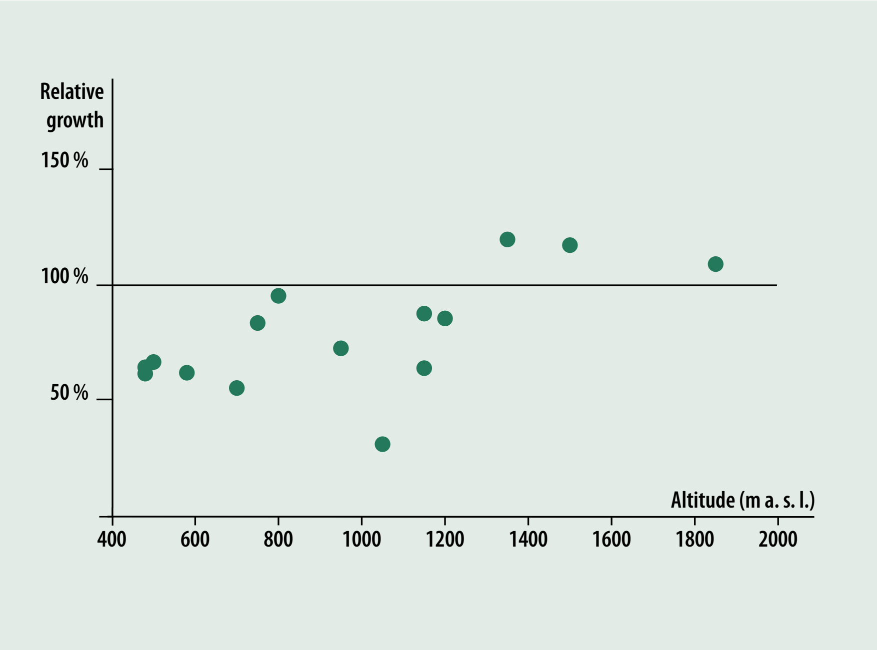


Figure 14: Stem diameter growth on Swiss Level II plots in 2003 in % of 2002.

Continuous girth band measurements can measure growth changes within single years.

conditions, trees reduce transpiration to prevent wilting. In extreme situations they can even shed green leaves. Severe water deficit thus limits or stops photosynthesis, cell growth and water and sugar transport in the plant. This is documented by continuous girth band measurements on the monitoring plots which showed a decrease in diameter development of between 30% and 40% for total 2003 compared to the previous year. Also, in Germany and Switzerland drought damage on leaves and needles was detected in late summer on many Intensive Monitoring Plots, which led to the premature shedding of foliage. All these growth limitations can weaken trees which are not adapted to such situations and which are already predisposed by stress factors such as air pollution.

Effects depending on the climate

At higher altitudes and in the far north low temperatures usually limit tree growth. This can however change in warm years like 2003. In this year stem growth increased at Swiss and Austrian sites above 1200 - 1500 m a.s.l. whereas it decreased at lower sites (see Fig. 14). In southern Norway an increase was registered for trees growing above 400 m a.s.l. and on all observation plots the northern part of the country.

In southern Europe, temperatures rising above 40° C and precipitation shortages occur frequently and the summer 2003 was just slightly warmer than usual in most regions. Forests in these regions are more adapted to such situations. The Spanish and Italian Level I and Level II assessments during summer 2003 do not show any short term drought symptoms or dramatic changes in forest condition. However, several Mediterranean regions suffered from excessive forest fires in 2003 (see Chapt. 3.2).

Consequences and outlook

A complete picture on forest damage caused by these weather extremes can not yet be given, as the majority of ecosystem reactions may only become visible in the following years. The defoliation values of 2003 (see Chapt. 2.1) do not fully reflect the drought, as assessments were mostly finalized before end of August and thus prior to the culmination of the drought stress.

It is, however, clear that the heat and drought extremes during summer 2003 were an unusual stress situation for forests across large parts of Europe. Based on the experiences of former drought years, a substantial decrease in tree vitality and in some situations also increased tree mortality are to be expected particularly for 2004 and the following years. In addition to the direct effects described above, elevated ozone concentrations are an additional threat (see Chapt. 3.5). Favoured by the drought, a new outbreak of bark beetles is expected to become a major problem in many countries. Research on drought influences is often based on Level II plots and will gain importance and some countries like e.g. France, Germany and Switzerland have started specific research programmes.

3.2 Forest fires

Summary

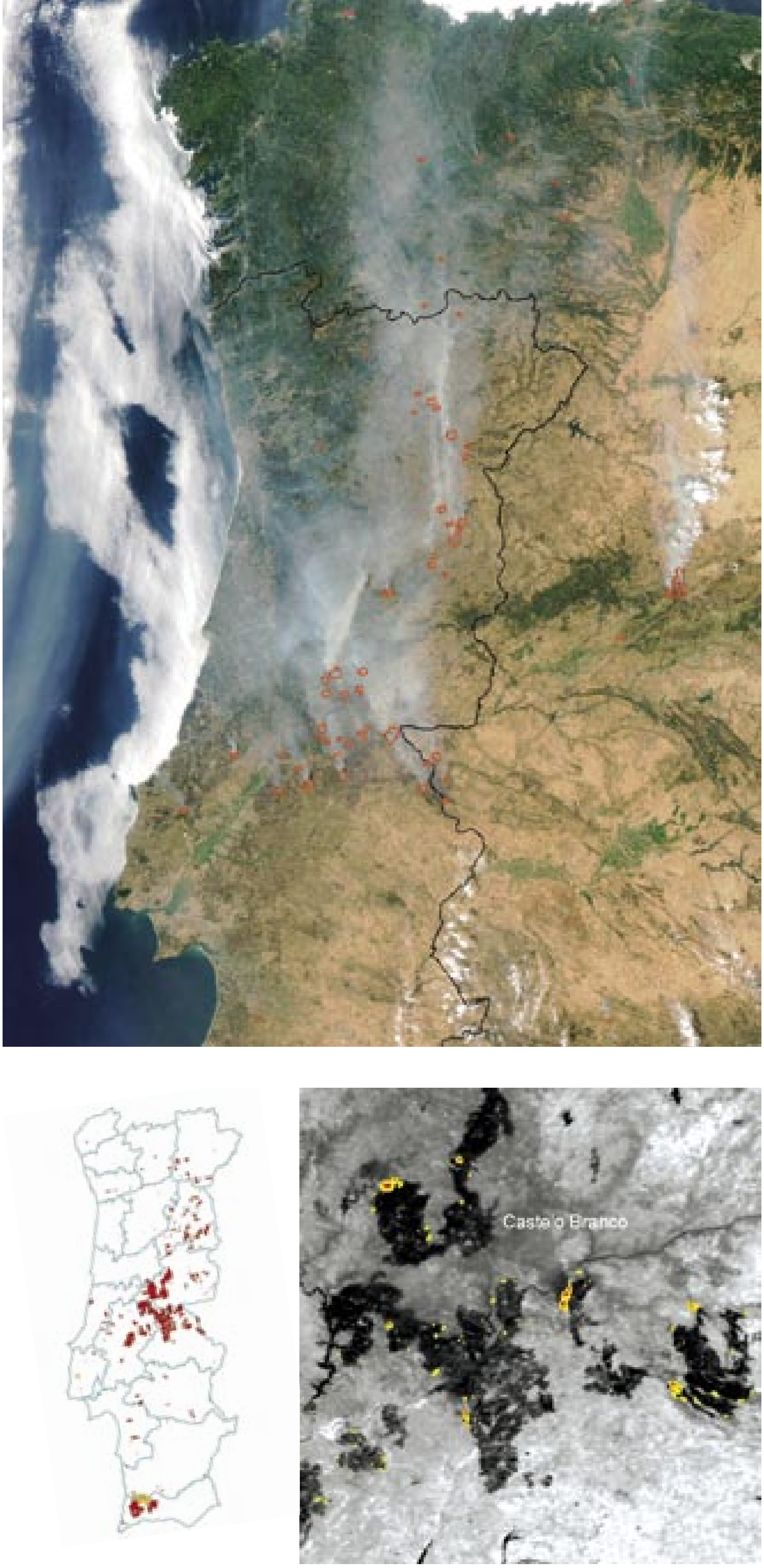
- *In summer 2003, extensive forest fires occurred in many parts of Europe, causing catastrophic damage mainly in the South. The largest areas affected were in Portugal, Spain and Italy. In some Mediterranean countries a doubling of the forest area annually affected by fire since 1970 was recorded.*
- *Originally, most forests in this region were adapted to low frequency fires. Changed land use practices in combination with extreme climatic conditions are main reasons for an increase in number and frequency of destructive fires.*

Introduction

In late summer 2003, extensive forest fires endangered lives and goods of many people in Europe and attracted the attention of the wide public. Specifically in Southern France and Portugal the situation was aggravated by extreme heat and drought waves (see Chapt. 3.1). Also, a number of monitoring plots of ICP Forests were affected.

The infrastructure of the programme was not designed for the reporting of forest fire events. Nevertheless, the Level I data contain information on fire damage for each tree observed in the annual assessments. It has, however, to be taken into account that the assessments primarily aim at crown condition monitoring and were thus finalized before the end of the fire season. In addition, countries participating in ICP Forests submitted annual written reports on forest condition with special focus on fire.

The Joint Research Centre (JRC) of the European Commission has established the European Forest Fires Information System (EFFIS). The activities aim at developing and implementing advanced methods for the evaluation of forest fire risk and for the estimation of burnt areas in the European Union. The two modules of EFFIS that have been



Example of fire monitoring from Space in Portugal in 2003.
top: daily overview image (4 August 2003, MODIS sensor);
bottom left: map of the burned areas in Portugal by the 15th of September 2003 (in orange the fires from September) as evaluated by the Joint Research Centre based on MODIS images;
bottom right: detailed image showing a coloured overlay of the fire intensity patterns in Megawatt per image pixel (MW/pix) for decision support (4 August 2003, BIRD sensor). These and other operational monitoring products are published daily on the website of the Global Fire Monitoring Centre (http://www.fire.uni-freiburg.de).

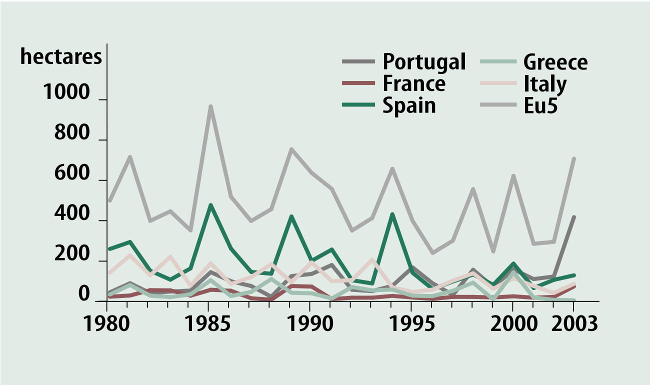


Figure 15: Forest Fire areas in five southern European Countries 1980 – 2003 in hectares per year. Source: Joint Research Centre.

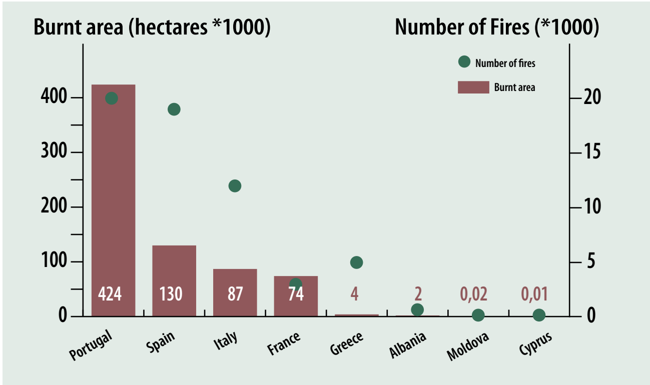


Figure 16: Burnt area and number of forest fires in selected southern European countries in 2003. Figures in the graph show burnt area. Source: National Focal Centres and Joint Research Centre.

developed so far are the European Forest Fire Risk Forecasting System (EFFRFS), and the European Forest Fire Damage Assessment System (EFFDAS), performing the mapping and evaluation of damages caused by fires of at least 50 hectares. Since 1998, collaboration has been established with the relevant services of Member States. Hence, EFFIS will also include forest fire information collected by the Member States.

The fire situation in 2003

During the crown condition assessments in summer 2003, 406 trees with fire damage were registered on 39 of the ICP Forests Level I plots. According to information received from southern European countries and from the Joint Research Centre of the European Commission, the largest forest fire areas and the largest percentage of affected forests occurred in Portugal (see Figs. 15 and 16), where the situation was unprecedented with a burnt area four fold the annual average.

In Spain, fire risk was extremely high in August when many fires larger than 500 ha occurred. France suffered the worst situation since 1990. Fires hit high forests as well as bush lands like garrigue and macchia formations which often develop on abandoned agricultural lands and where biomass and fuel loads have accumulated in previous years. In south-eastern Europe, the situation was not as tense. In Greece, only the south of the country experienced high-fire danger days, but no fire exceeded the size of 100 ha.

In more northern regions of Europe forest fire areas were smaller but in some cases also above the average. In Belarus, 8 Level I plots showed fire damage in 2003. In Poland the burnt area of 23 650 ha was five times above the value of the previous year; the number of forest fires was 40% above the previous maximum of 1992. Extreme drought was also reported from northern Sweden were a number of bigger forest fires attracted the attention of the public. The area of all burnt wooded land in Sweden was 2 640 ha in 2003, which is more than the double of the previous three year's average.

Further information:

- **Global Fire Monitoring Centre, Germany: http://www.fire.uni-freiburg.de**
- **Joint Research Centre of the European Commission, Italy: http://natural-hazards.jrc.it/fires**

High-intensity surface and crown fire occurring in a forest with artificial structure and composition.

Ecological importance of forest fires in Europe

Wildfires in Europe are occurring annually in all types of forests. Many forest ecosystems are adapted to low frequency fires; in very particular cases some forests even need fire to regenerate naturally. However, due to human activities forest fires are today occurring in higher frequencies than they used to and most fires are damaging where they burn out of control.

Boreal and Temperate Europe

In the boreal zone of the Nordic countries forests have co-evolved with low-frequency natural (lightning-caused) fires for thousands of years. Here, fire is a natural disturbance event that can initiate new forest regeneration on large areas. Scots pine as one of the main tree species in this region is fairly well adapted to recurrent low-intensity surface fires. Thus, not all fires burning in the northern forests are resulting in economic or ecological damages. Natural fires are nowadays considered an important dynamic ecosystem factor that also creates habitats for threatened species. Forest certification in Sweden, for instance, requires the application of prescribed fire on at least five percent of the annual reforestation area in large forestry enterprises.

In the hemi-boreal and temperate forests of central Europe regeneration does naturally not depend on such a large extent on forest fires. Here as in other regions, fire was an important agricultural instrument since the beginning of land cultivation. Fires can create forest development stages and other land use forms with higher species diversity as compared to pure commercial forestry. Particularly in not adapted lowland pine forests fire can however endanger the benefit of forest management.

Mediterranean Europe

In the Mediterranean Basin fire is the most important natural threat to forests and wooded lands. Southern European countries, including the Balkans, are characterized by a long fire season and highly flammable forest types. During the last two decades an annual average of approximately 500 000 ha of forests and other wooded land are affected by wildfires, a level twice that of the 1970s. It has however to be taken into account that data collection in earlier decades was much more difficult without the modern techniques and a comparison is often difficult. Most fires are due to negligent behavior and agricultural practices, with only 1-5% of fires caused by lightning. Arson fires are also quite prevalent.

The fundamental cause of an increasing fire severity is linked to land-use change and a transfer of population from the countryside to the cities. The abandonment of arable lands, as well as a disinterest in the forests as a source of energy has resulted in the expansion of wooded areas, erosion of the financial value of the wooded lands, a loss of inhabitants with a sense of responsibility for the forest with a resultant increase in the amount of available fuel. Regional climate change towards an increase in the frequency of extreme droughts aggravates the situation.

Even more than in northern Europe the forest and woodland ecosystems of southern Europe show remarkable adaptations to low frequency fires occurring in natural high forests with lower amounts of inflammable fuel.

Low- to medium-intensity surface fires burning in regular intervals in northern coniferous forests contribute to the cyclic reduction of fuel loads without damaging the timber. Mature, fire-maintained forests also provide habitats for wildlife and endangered species.

3.3 Storm damage to forests

Summary:

- *Storm damage to European forests has increased over the past decades with the highest damage reported in 1999.*
- *For Level I plots, forests on acidic soils or with a high proportion of conifers are found to have a higher storm risk.*
- *Windthrow or clear felling can interrupt the nutrient cycle in forest ecosystems as nitrogen uptake by the trees stops and nitrate is leached into the ground water. Existing or upcoming ground vegetation and natural regeneration can to a certain extent replace the nitrogen uptake of the fallen trees.*

Factors influencing the risk for storm damage

Storm damage is one of the most important economic factors of forest damage in Europe. Over the past decades, damage severity has increased. The storms in December 1999 caused the highest damage ever reported in Europe (nearly 200 million m^3 merchantable timber).

Data from 969 Level I plots in France, Southern Germany and Switzerland were analysed with multiple logistic regression techniques. They show that in 1999, storm damage occurred more often on sites with acidic soils (low pH-value) than on alkaline soils (see Fig. 17). Furthermore stands were more susceptible to storm damage when they had a high proportion of coniferous species, more gentle slopes, humus type 'mor', large stand height, or were growing at low altitudes. High rates of sulphur or nitrogen deposition were not related to increased storm damage.

Frequent damage on sites with low pH might be a result of root damage by toxic aluminium compounds or reduced biological soil activity which affects soil structure. Both, toxic aluminium compounds and reduced biological soil activity occur preferentially at lower pH values. At higher pH, carbonate stabilises the soil structure which results in a better root anchor-

Storm damage in France.

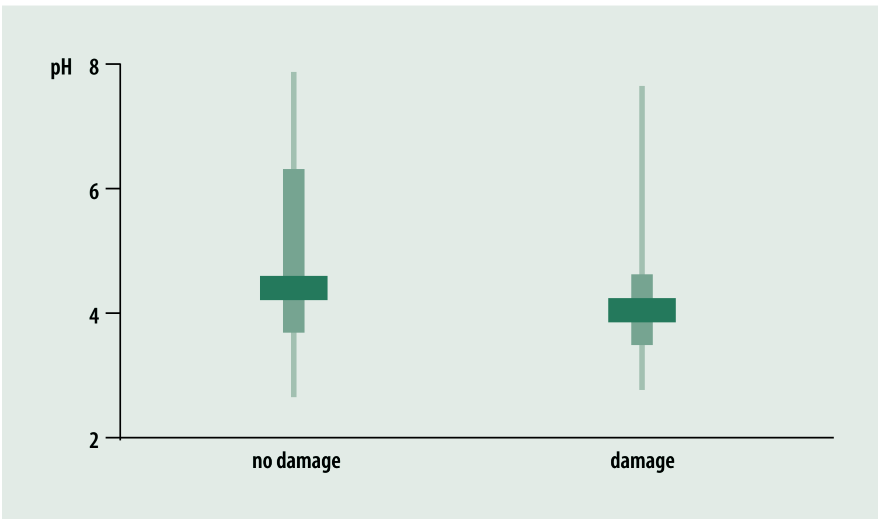


Figure 17: Relation between storm damage and soil pH. Dark green: median; green bars indicate 50% of the observations; light green bars show the min/max values. N= 965 Level I plots.

age. On sandy soils with mostly low pH root anchorage is low, and damage was more frequently observed. No single mechanism could explain the observed relationship between soil pH with storm damage. Complex soil-root interactions are assumed to be the underlying causes.

Deciduous trees are less susceptible to storm damage than conifers because storms as 'Lothar' and 'Martin' in 1999 usually occur during winter when deciduous trees have shed their leaves resulting in a lower wind resistance. More frequent damage on the humus type 'mor' fits well with the observed pH-effect, because 'mor' is usually found on acidic bedrock with a low soil-pH.

Nitrogen cycle after windthrow – a Danish example

Intensive monitoring continued after windthrow in 1999 on Danish plots with high atmospheric nitrogen inputs (see Fig. 18). In the un-touched silver fir windthrow, nitrate concentration in the seepage water decreased unexpectedly to levels much lower than recorded prior to the storm. This might firstly be caused by lower nitrogen inputs, which decreased from about 35 kg to 13 kg per ha and year. These lower inputs are due to the lack of the forest canopy which had filtered the air before the storm damage. Secondly, a nitrogen uptake by the remaining 1-5 m tall understorey of bushes and trees may also have occurred. When the understorey was destroyed by the harvest of fallen timber, nitrate leaching increased. Nitrate concentration increased strongly in the Norway spruce and Sitka spruce stands and remained high until late 2003 when it began to decrease. These stands had no ground cover. In 2002, two years after the storm, the ground vegetation covered only about 20% of the area.

The results show the risk of nitrate leaching after storm damage or clear felling. Leaching can be kept low after storm or felling even at sites with high nitrogen status by the use of already existing natural regeneration or a rapid establishment of a vegetation cover.

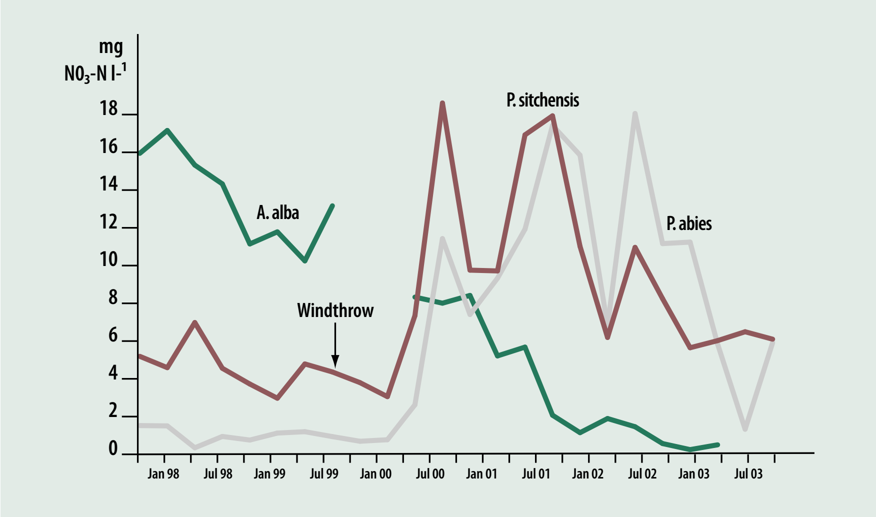


Figure 18: Nitrate leaching in untouched windthrows in Denmark

Storm damage on an Intensive Monitoring Plot.

Further reading:

- Schmidt and Gundersen, P. 2002. The effect of re-vegetation on soil water chemistry in response to different logging practices. In „Proceedings of the IUFRO conference on Forest Restoration in the Boreal and Temperate Zones, Vejle, Denmark April 28-May 3, 2002.
- Mayer, P., Brang, P., Dobbertin, M., Hallenbarter, D., Mayer, F.-M., Renaud, J.-P. Walthert, L., Zimmermann, S. 2004. Forest storm damage is more frequent on acidic soils. Annals of Forest Sciences (submitted).

3.4 Deposition

Summary

- *Overall, mean sulphate and nitrate concentrations in open field measurements have been decreasing on the large majority of the investigated Level II plots in the period from 1996 to 2001. Mean ammonium concentrations increased in 1997 and fluctuated since then.*
- *Highest concentrations of all these pollutants were found in parts of eastern Europe, northern Germany, The Netherlands and Belgium. Nevertheless, an improvement was observed on most of these plots.*

Introduction

Corresponding with its political mandate the programme pays particular attention to the deposition of air pollution and its effects to forests. Since the late 1990s, atmospheric deposition has been continuously measured on Intensive Monitoring Plots across Europe. Time trends have now been evaluated based on deposition measurements in open fields near to the Intensive Monitoring Plots. This so-called bulk deposition is usually lower than deposition in the forest stands as there are no trees that filter pollutants from the air. On the other hand, bulk deposition is not influenced by interactions between the tree foliage and the incoming deposition and enables thus a good large scale overview independent from the specific forest stands at the plots. After intensive checks for data quality, only those plots were evaluated which had continuous measurements over all the years. Means were weighted by the amount of precipitation. For the calculation of the development over time, the plot wise linear trends of annual concentration means were tested for significance. The importance of the results will increase in the future, when time series become longer.

Status and trends of main pollutants

Mean concentration of sulphate and nitrate in open field measurements at the Level II plots has decreased during the observation period. The sharpest decrease was recorded for sulphate.

Deposition samplers, Belgium.

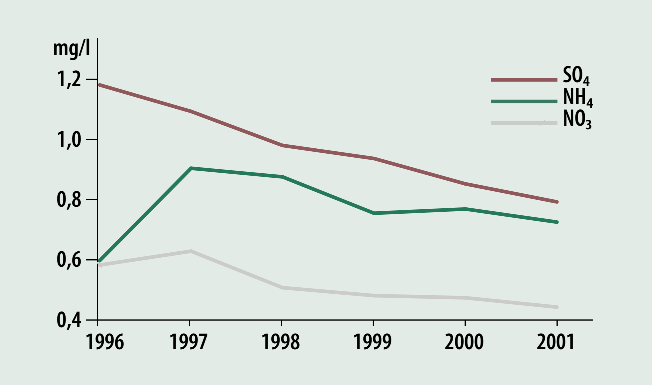


Figure 19: Development of mean plot concentration of sulphate (SO_4, 285 plots), nitrate (NO_3, 294 plots), and ammonium (NH_4, 294 plots); 1996 – 2001.

Nitrate had the lowest mean concentration throughout all years. The mean ammonium concentration increased in 1997 and decreased slowly in the years afterwards (see Fig. 19).

Clusters of plots with highest mean nitrate concentrations are located in Poland, northern Germany, The Netherlands and Belgium. At most of these plots a decrease has been recorded since 1996 which was however not significant in most cases. Concentrations in France were among the lowest, however with an increasing tendency in the south of the country. Concentration of nitrate has been significantly decreasing on 15% of the observed plots (see Figs. 20 and 21). The geographical distribution of ammonium inputs resembles that of nitrate. The temporal development shows however clusters of plots with an increase in eastern Europe. Accordingly, the share of plots where ammonium concentrations increased is distinctly higher (41.2%).

Sulphate concentrations have been highest at plots in eastern Europe and Belgium. On around 45% of all evaluated plots a significant decrease in sulphate concentrations has been recorded (see Figs. 22 and 23).

Further information:

Lorenz, M., Becher, G., Mues, V., Fischer, R., Ulrich, E., Dobbertin, M., Stofer, S. 2004. Forest Condition in Europe. 2004 Technical Report. UNECE 2004, Geneva.

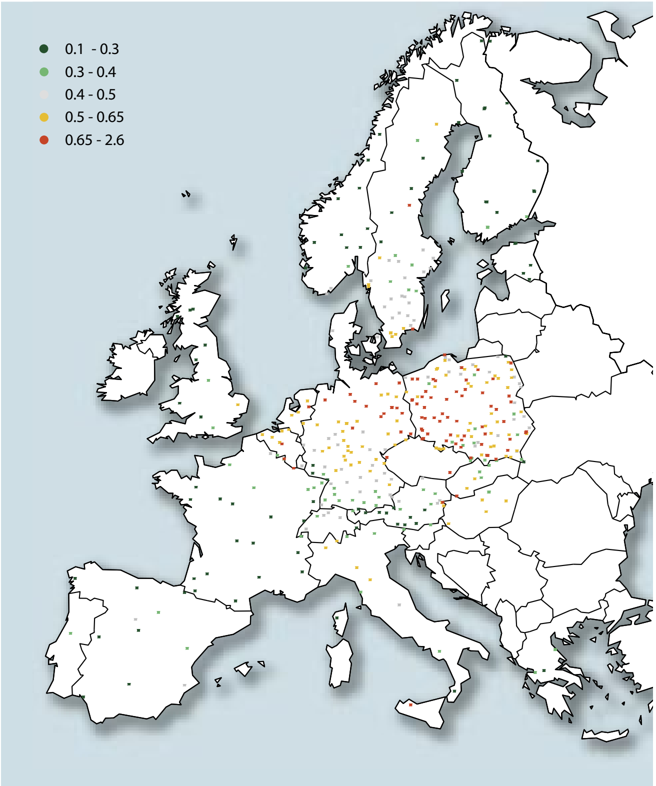


Figure: 20 Mean nitrate (NO_3-N) concentration in mg/l between 1999 and 2001 at 409 Level II plots.

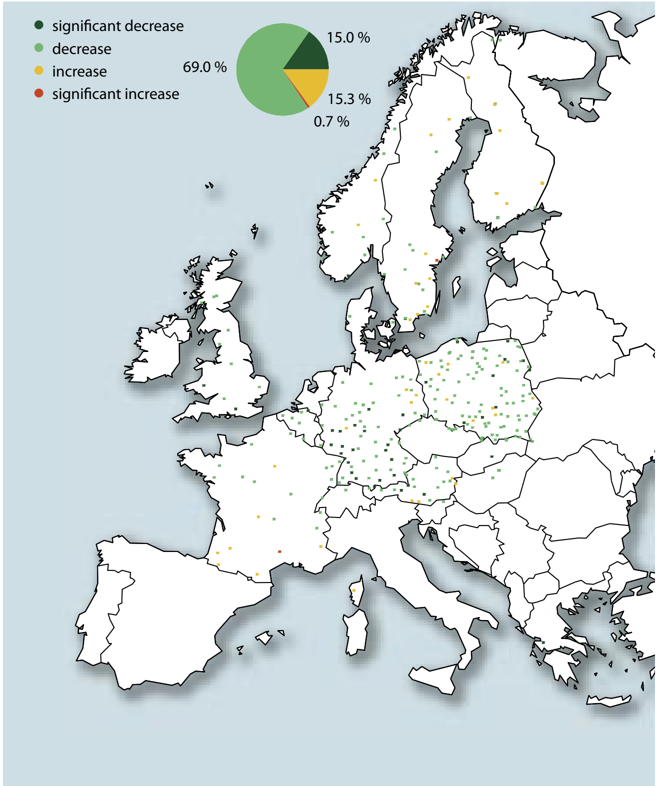


Figure 21: Development of mean nitrate concentration in mg/l between 1996 and 2001 at 294 Level II plots.

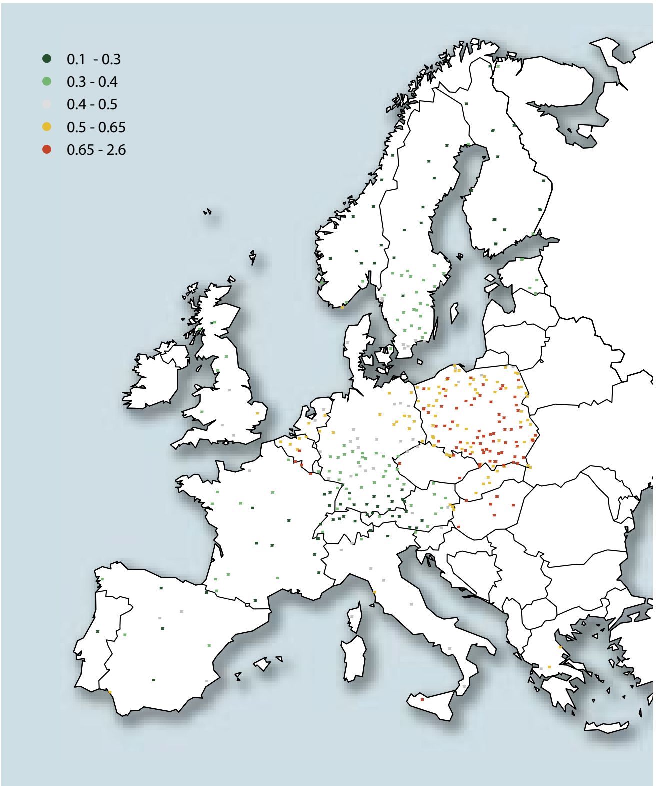


Figure 22: Mean sulphate (SO_4–S) concentration in mg/l between 1999 and 2001 at 401 Level II plots.

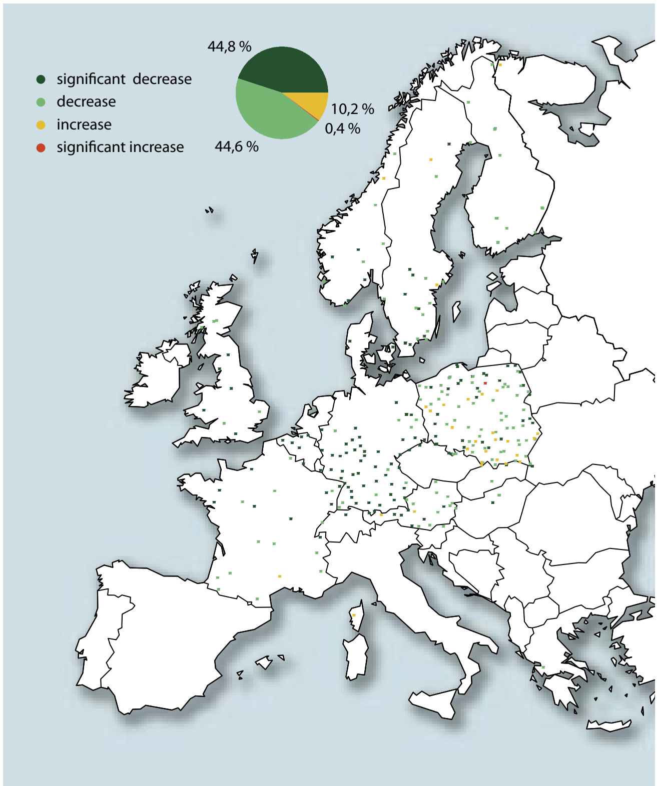


Figure 23: Development of mean sulphate concentrations in mg/l between 1996 and 2001 at 285 Level II plots.

Canopy Tower in the Pasoh Tropical Rain Forest Reserve, one of the EANET monitoring sites, Malaysia.

Forest and deposition monitoring in East Asia

Summary

- *ICP Forests cooperates with deposition monitoring networks in other parts of the world, like East Asia. The exchange of technical expertise and the common support of global clean air policies are essential to these cooperations.*

The East Asian region, as a result of rapid industrialization, faces increasing risks and problems related to excess deposition of acidic substances. In 1995, the World Bank estimated that by 2020 sulphur dioxide emissions in this region will almost triple the 1990 level if current industrialization and the energy and environmental policies remain unchanged. Against this background, the Acid Deposition Monitoring Network in East Asia (EANET) started its activities with a preparatory phase in 1998. The regular monitoring has been carried out since 2001. Today, 47 sites for the monitoring of acid deposition and its impacts on terrestrial ecosystems are installed in twelve participating countries, namely Cambodia, China, Indonesia, Japan, Lao PDR, Malaysia, Mongolia, Philippines, Republic of Korea, Russia, Thailand, and Vietnam.

Forest monitoring including vegetation and soil are part of the activities in EANET and are carried out in forest ecosystems ranging from coniferous species dominated forests (e.g. *Pinus sibirica*) in the sub-arctic zone to rain forests (e.g. *Dipterocarpaceae*) in the tropical zone. To date, severe tree decline symptoms have been observed only on the sites of Japan and Russia. It seems that natural environmental factors, such as insect attack, heavy snow, as well as site and soil condition were the main causes.

The latest wet deposition data from EANET sites in open fields are available for the year 2002. The results show that the median sulphate deposition on 33 plots was around 9 kg SO_4-S per ha and year. For the sum of NO_3 and NH_4 it was approximately 10 kg N (see Tab.). Due to the fact that 13 sites are located in urban areas, rather high values are included. Compared to these results, mean annual nitrogen deposition on ICP Forests plots in Europe is with 19 kg per ha and year higher. Mean sulphur inputs are with around 9 kg similar to the data from EANET.

EANET cooperates closely with ICP Forests. Experts routinely participate in each other's meetings and a joint workshop on monitoring methods was already carried out in Malaysia. Presently, monitoring methods suitable for forest condition in East Asia are under development taking into account the methods used by the ICP Forests. With increasing time series, the value of the presented EANET baseline data will increase and an early detection of impacts of acid deposition will be possible.

	kg SO_4-S/ha/yr	kg N/ ha/yr
Minimum	0.70	1.35
5% percentile	1.12	2.05
Mean	16.8	11.8
Median	9.11	10.3
95% percentile	61.6	27.6
Maximum	95.1	31.2

Wet deposition on 33 EANET sites in the year 2002 (N = NO_3-N + NH_4-N).

Further information:
http://www.eanet.cc

3.5 Ozone in the forests of south-western Europe

Summary

- *Ozone concentrations are measured by passive sampling on around 100 Level II plots as a part of an ICP Forests test phase since 2000. Passive sampling was confirmed to be a reliable method to obtain information on ozone concentrations in remote areas.*
- *The data from France, Italy, Spain and Switzerland were used to model hourly ozone values and then to estimate the AOT40 which is an indicator of potential risk. Estimated AOT40 values were evaluated against nearby automatic measurement stations. Results demonstrate that measured AOT40 can be predicted by models based on passive sampling data.*
- *Estimated ozone concentrations were higher in the south and at higher altitudes. On the 3-years average, critical levels as defined by the UNECE (5000 and 10000 ppb*h) were exceeded at 95% and 69% of the monitored sites, respectively.*
- *Future activities will include attempts of flux modelling and the evaluation of the response of plants in terms of crown transparency, growth and foliar symptoms.*

Passive samplers are small and do not require electricity. The ozone molecules diffuse into the sampler where they are absorbed, giving a concentration value integrated over time.

Introduction

In summer 2003, harmful ozone (O_3) pollution was the worst for almost a decade in large parts of Europe, particularly during the long August heat wave, according to a preliminary assessment by the European Environment Agency. Ozone is today regarded as one of the most important greenhouse gases after carbon dioxide and methane. It is invisible and forms in the atmosphere through the chemical reaction of oxygen with air pollutants such as nitrogen dioxide. This chemical process needs intensive sun radiation.

Up to date, even the basic knowledge of the actual exposure of forests to ozone in terms of AOT40 (definition see box) was limited in Europe: only few sites were equipped with automatic real-time monitors and information on the extent to which critical levels were exceeded were seldom available at the site level. Given its complexity and data requirements, the flux approach (see box) encountered even more problems to be implemented at site level and at the large-scale. With this background, one of the aims of the project “Ozone at the Intensive Monitoring Plots in South-Western European Forests – Levels, Risks, Actual and Potential Effects” is to provide AOT40 estimates for a number of forest sites in Europe. This project is co-financed by the European Commission. Despite of several criticisms, AOT40 so far remains the basis for estimating the potential risk to forests due to ozone and to set environmental quality objectives within the European Union (EU) and the United Nation Economic Commission for Europe (UNECE). Under this perspective, the knowledge about AOT40 values for forest monitoring sites is of considerable interest. The data of the project are mostly obtained from the ICP Forests test phase and are collected weekly to fortnightly by passive samplers on Level II plots. The evaluations build on results already presented in earlier reports of the programme. This test phase also aims at detecting visible ozone injuries on forest plants. Such injury is not directly related to ozone concentrations (see box).

Estimates of the AOT40 indicator

According to its definition (see box p. 43), the proper calculation of AOT40 values implies the availability and completeness of hourly concentration measurements through a six month vegetation period. Such data are hardly available. However, in a pilot project carried out in Italy the possibility was demonstrated to achieve AOT40 estimates from passive sampling data with a reasonable level of precision. This approach was now adopted for 57 EU and ICP Forests Intensive Monitoring Plots located in France, Italy, Spain and Switzerland with passive sampling data available for 2000, 2001 and 2002. Concentration data obtained by passive sampling were first validated against measurement stations in the near vicinity. Validated data were used to model the expected daily profile of the ozone concentrations in relation to the location of the site, its elevation, and the measured concentration level. Then, hourly values were processed to estimate AOT40 values which were again validated by the co-located automatic measurement devices. Although there

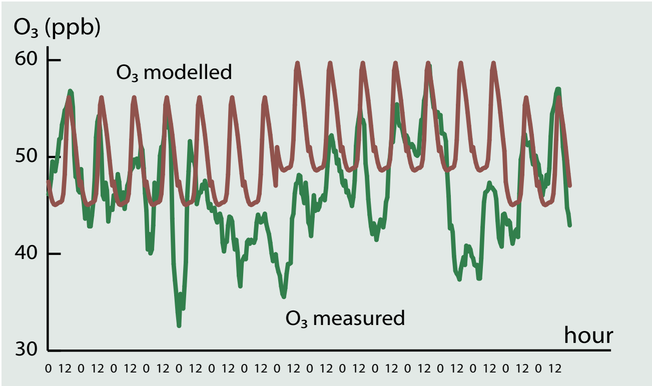


Figure 24: Example of modelled hourly ozone concentration plotted together with measured values on Level II plot, La Thuile, North-East Italy, 3-18 April 2001. Deviations between measured and modelled hourly concentrations occur for individual days.

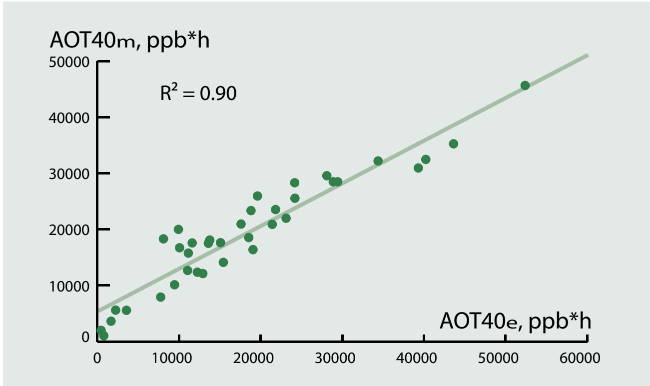
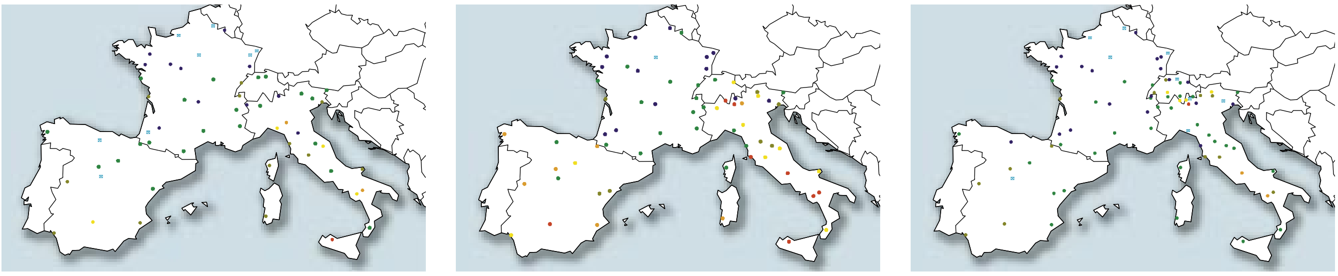


Figure 25: Measured AOT40 ($AOT40_m$) in relation to estimated AOT40 ($AOT40_e$) for 37 sites for which measured AOT 40 values were available. The AOT40 can reliably be predicted by models based on passive sampling data.

are high deviations between measured and modelled hourly concentrations for individual days (see Fig. 24), their importance is much less on a 6-month basis. The results (see Fig. 25) confirmed that the AOT40 can reliably be predicted by models based on passive sampling data.
The modelled AOT40 values show a considerable variation throughout the plots in south western Europe (see Fig. 26). However, there is a significant decrease towards Northern regions and a slighter, but still significant, increase with elevation, thus confirming in part a known pattern. Sites in Northern France have almost always a much lower AOT40 than sites throughout Italy and Spain. A cluster of sites with very high AOT40 values is also obvious at the border between Switzerland and Italy, a well-known area with high ozone pollution.
On the sites considered in the project, critical levels are commonly exceeded. Both critical levels derived at UNECE meetings in Kuopio 1996 and Gothenburg 2002 of 10 000 and 5 000 ppb*h, are exceeded for a large proportion of the sites (see Tab. 3). The median AOT40 for the respective sites is always higher than the critical levels, with the maximum in 2001. However, due to considerable variations in ozone concentrations, an improved calculation of the AOT40 is best done on a 5-years basis. Thus, the 3-years AOT40 should be regarded as a preliminary finding.

Perspective and outlook

The data reported above demonstrate the potential for (i) gaining



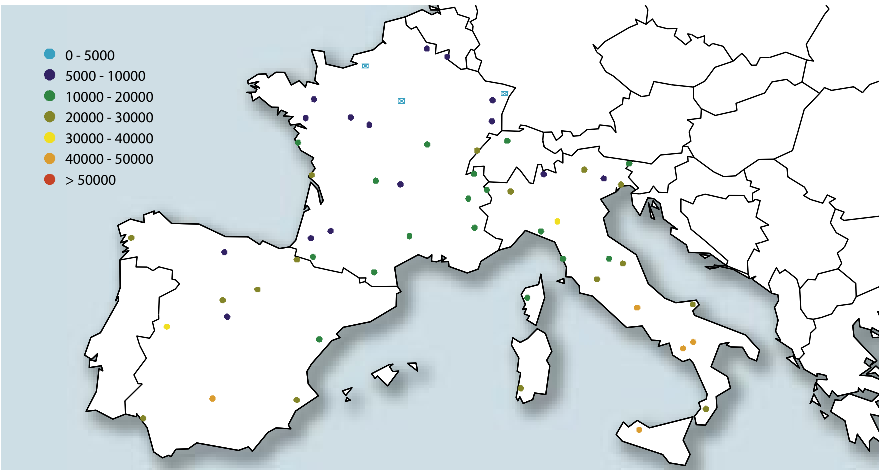


Figure 26: Estimated AOT 40 values for the various sites in the year 2000 (top-left), 2001 (top-middle), 2002 (top-right) and for the average 2000-2002 (bottom).

The AOT40 and the flux approach

For evaluating ozone risk to plants and forests there are currently two main approaches:

The concentration-based approach, according to which a potential risk is inferred if ozone exposure exceeds a critical level. A series of scientific workshops, held under the auspices of the UNECE, identified the critical level in terms of AOT40 (Ozone concentration Accumulated Over a Threshold of 40 parts per billion). The AOT40 is defined as the "sum of the differences between hourly ozone concentration and 40 ppb for each hour when the concentration exceeds 40 ppb during a relevant growing season". In Gothenburg (2002) the critical level of ozone for the most sensitive tree species under the most sensitive conditions was set at an AOT40 of 5000 ppb*h, thus replacing the 'old' critical level of 10000 ppb*h (Kuopio 1996). As these critical levels were derived from experiments with seedlings under controlled conditions, they cannot be readily used for field risk assessment, as a number of factors may influence the response of mature trees to ozone.

The flux-based approach relates the risk of ozone damage to plants to the portion of the gas that enters the leaves or needles (the flux). The fundamental difference in this approach is that the ozone concentration in terms of AOT40 is not directly related to the damage. Instead, the entry of ozone into the leaves and needles during plant respiration is considered here. This process is controlled by a number of environmental and physiological variables like e.g. water supply and is therefore not always proportional to the exposure. The flux-based approach is much more realistic, but related calculations are data intensive, and for forest sites in remote areas the necessary data are not always available or are very costly to gather.

information about the exposure of forests to ozone, (ii) estimating the potential risk in relation to existing critical levels and (iii) for contributing to validation of large scale models. However, great caution is recommended when interpreting the reported results in terms of actual risk: while it is obvious that high exposure is a factor of risk (and this is the basis for concentration-based critical levels), it is also known that sensitivity to ozone varies between and within species according to genetic and phenological characteristics and environmental conditions. For example, while ozone exposure is higher in southern Europe, it is recognized that beech (*Fagus sylvatica L.*) provenances from southern Europe are less sensitive to ozone than northern ones. In general, environmental factors such as dry weather conditions during the ozone season and the species compositions (e.g. Mediterranean evergreens) within southern European sites may limit the potential for adverse effects either by preventing ozone uptake or by resistance to oxidant stress. In order to consider the above mentioned influence factors, further development of the project includes the use of site and stand data, meteorological data and modelled hourly ozone concentration to attempt ozone flux modelling (according to data availability) and an evaluation of the effects of ozone exposure (and possibly flux) on foliar symptoms, growth and crown condition. These further steps will provide the basis for comparison with the output based on the potential risk inferred by AOT40 values. The EU and ICP Forests plots with passive sampling data and visual ozone injury assessments provide a good platform for these future undertakings.

Further information:

- Mediterranean Centre for Environmental Studies Foundation – CEAM: http://www.gva.es/ceam/ICP-forests/
- Swiss Federal Institute for Forest, Snow and Landscape Research - WSL: http://www.ozone.wsl.ch/

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- Sanz, M.J., Krause, G.H.M., Catalayud, V. 2003. Ozone exposure and ozone injury symptoms at intensive monitoring plots: results from the testphase 2001. in: de Vries, W. et al. 2003. Intensive Monitoring of Forest Ecosystems in Europe. Technical Report 2003. EC-UNECE, Brussels, Geneva, 2003. 161 pp.

				Mean values
	2000	2001	2002	2000-2002
Median AOT 40 ppb*h	14397	18306	13589	16263
% of sites >10000 ppb*h	68.97	75.86	60.34	68.97
% of sites >5000 ppb*h	86.21	98.28	86.21	94.83

Table 3: AOT40 levels at 57 Level II plots over the period April to September 2000-2002.
Median of AOT40 and percentage of exceedances.

3.6 Insects and other biotic factors

Summary

- *Insect presence was assessed and registered on 11% of the monitored trees. This is important for the interpretation of crown condition data, In particular, insects were reported on deciduous tree species.*
- *Bark beetles caused extensive damage in large regions of Europe. Their populations increased under the favourable warm and dry weather conditions in 2003. Additional insects and fungi were of more local importance.*
- *Air pollution can have an influence on insects in forests. Increased nitrogen deposition for example may result in a greater risk of insect damage.*
- *ICP Forests has developed an improved system for the monitoring of these biotic damage causes, which will provide more detailed information about their influence on tree condition in the future.*

Ips sexdentatus **is a bark beetle that reproduces on weakened pine trees.**

Introduction

For the interpretation of crown condition it is important to have information on the occurrence of insects and fungi as they may cause defoliation and discolouration and their actions can even be lethal to trees. Therefore, the presence of relevant amounts of insects is recorded annually within the crown condition assessments. On the other hand, these so-called biotic agents are an integral part of all forest ecosystems and play an important role in their functioning. In particular, the ecological importance of insects in forest ecosystems is very remarkable. With high species numbers they contribute largely to the diversity of forest ecosystems and play a key-role in stabilizing them.

Insect damage on Level I plots

Of all assessed trees on the transnational grid, 10.7% showed insect presence in 2003 (see Tab. 4). In all, 1 779 plots were affected. This is no major change compared to the previous year (1 573 plots). There are clear differences between the main tree species. Whereas every fourth oak tree was affected, only on 2% of the Norway spruce crowns insects were registered. This clearly reflects that on one hand European and sessile oak have much more insect species naturally living and feeding on them than other trees. On the other hand, these oak species belong to the most damaged tree species in terms of defoliation (see Chapt 2.1) and insects most probably add to this situation. More detailed regional studies have shown that repeated spring defoliation by insects, especially in combination with adverse weather conditions can be triggering factors in the process of oak decline.

A more detailed interpretation will in the future become possible when detailed information on the extent, intensity and type of insect and fungi occurrence become available. Insects often increasingly appear on weakened trees after drought, frost, hail, storm, and forest fires and thus may add to a destabilization of the stands. This is particularly true for bark beetles whose larvae develop beneath the trees' bark thus killing them in cases of severe attacks and causing tremendous economic loss. After the dry and hot summer in 2003, bark beetle attack was reported for large areas in Europe and it is expected that the beetle populations will still increase in central Europe.

Defoliating insects can locally cause significant damage. The United Kingdom, for example, reported severe defoliation of Sitka spruce by the green spruce aphid (*Elatobium abietinum*) with current attacks on 52% of the plots. Butterfly species of the genus *Thaumatopoea, Lymantria* and *Tortrix* were main defoliators in Spain in the past year. The major biotic damage cause in Cyprus was a processionary moth (*Thaumetopoea* *wilkinsoni*) which defoliated 20% of the assessed trees.

As concerns fungi infestations, an excessive outbreak of *Gremmeniella abietina* arose in Sweden in 2001 and still strongly influenced the tree health on Scots pine last year; however with a low level of new infections in 2003. Needle rust (*Chrysomyxa spp.*) occurred as a belt across Central Finland.

Effects of air pollution on insects

Air pollution can have an influence on insects in forests. Populations of the green spruce aphid (*Elatobium abietinum*) on Sitka spruce for example have been demonstrated to increase at elevated SO_2 concentrations. It has also been observed that ozone-damaged *Pinus ponderosa* trees were less resistant to attacks by bark beetles (*Dendroctonus spp*). Experiments have shown enhanced insect populations on fertilised plants compared with unfertilised plants. Therefore, where trees are adapted to low nitrogen availability, increased nitrogen deposition may result in greater risks.

Improved biotic agents monitoring within the ICP Forests

Information on biotic agents and their influence on the condition of trees are of great importance for the forest condition monitoring programme. In order to gain more insight in the relationships between biotic agents and tree condition, a new harmonised method for the assessment of damage causes has been developed. The available information will be expanded by collecting data not only on the occurrence of biotic agents in the forest monitoring plots but also on their influence on defoliation and other tree condition parameters. On the programme's Intensive Monitoring Plots the information on biotic agents will contribute to the interpretation of phenological observations, litterfall measurements and other data of the programme.

Further information:

- **ICP Forests Working Group on Biotic Agents: http://www.icp-forests.org/WGbiotic.htm**
- **Watt, A. D., Stork, N. E. & Hunter, M. D. (eds), 1997. Forests and insects, pp. 229 – 241. Chapman & Hall, London.**

SPECIES	number of all trees	number of trees with insect occurence	percent of trees with insect occurence
European and sessile oak	8262	2164	26,2
Common beech	11753	2244	19,1
other	49460	7405	15,0
Scots pine	35559	1707	4,8
Norway spruce	26469	584	2,2
all species	131503	14104	10,7

Table 4: Presence of insects on Level I trees in 2003.

Repeated defoliation by oak roller moth (*Tortrix viridana*) and winter moth (*Operophtera brumata*) larvae - see photo background - can in combination with additional stress factors such as climatic extremes trigger the dieback of oak trees.

Intensive Monitoring Plot, Belgium.

4. Conclusions

- *After a recuperation of tree crown condition in the mid 1990s, a worsening was recorded in 2003 with nearly 23% of the trees classified as damaged. This is partly ascribed to the extreme drought and heat during last summer. First evaluations reveal examples of related growth reductions. Forests in the Mediterranean region seem to be better adapted to dry conditions.*
- *Defoliation and growth of trees correlate. Forest growth has increased across Europe. This means that today in general both, healthy and defoliated trees, show larger increment. The absolute growth level of the defoliated trees is however lower. Under certain stand and site conditions, nitrogen deposition can contribute to this growth change, but also increasing temperature and carbon dioxide concentration can have stimulating effects. It has to be clarified whether this increased forest growth leads to improved forest condition and functioning on the long term.*
- *Atmospheric sulphur and nitrate depositions have been decreasing since 1996 and have been stable for ammonium at around 300 mostly remote forest plots. However, as shown in previous reports, the critical thresholds are still exceeded on many sites. For ozone, the critical levels were on average exceeded on 69% to 95% of the investigated plots in south western Europe in the years 2000 to 2002 according to the threshold used. Ozone concentrations are expected to be even higher for 2003 when sun radiation and temperatures were significantly above the long term average.*
- *Large forest fires occurred mainly in Portugal, southern France and some areas of Spain. In addition to the extreme climatic conditions, changes in land use practices had an effect on the increasing fire risk.*

- *Acidic soils and coniferous stands hold higher risks for storm damage in central European stands. After windthrow, remaining understory vegetation can mitigate nitrogen leaching into the ground water.*

Forest condition

Since the 1980s when a severe deterioration was observed in large areas of Europe, growing time series have shown that sharp increases in defoliation were followed by steady state phases or partly recuperation. However, today defoliation of most tree species is higher than at the beginning of the monitoring and it reacts to a multitude of natural and human stress factors. Forest condition monitoring has proven to be an essential instrument for the preservation of one of the most natural ecosystems on the continent.

Air pollution and clean air policy

Evidence of air pollution effects has led to seven legally binding agreements setting national emission ceilings for major pollutants under the UNECE Convention on Long-range Transboundary Air Pollution and related EU legislation. ICP Forests has substantiated first positive effects of air pollution abatement policies. However, model calculations indicate that recovery of forest soils will take decades even if recent international agreements will be fully implemented. Sustained clean air policy at the international level is vital to support this recovery in the future. The reduction of nitrogen deposition and ground-level ozone concentrations will remain the main challenge in this respect. There is need for further investigations to clarify the influence of nitrogen inputs in the context of increased forest growth and to consider factors affecting ozone uptake and plant responses. This will also support the further development of ozone threshold values.

A multifunctional and cooperating monitoring network

With its large and harmonized data sets and the increased knowledge of the experts involved, the monitoring network of ICP Forests has developed into a multifunctional network. Today it tackles questions beyond air pollution effects and covers many stress factors. In fields like sustainable forest management, biodiversity, climate change and nature conservation there is an increasing demand for the programme's data and results. The programme is pursuing the objectives of several resolutions of the Ministerial Conference on the Protection of Forests in Europe (MCPFE) already now. Future results on forest biodiversity may be relevant for the implementation of the Convention on Biological Diversity (CBD) and assessments of carbon sequestration in forests will contribute to the Kyoto Protocol under the Framework Convention on Climate Change (FCCC). ICP Forests will continue its cooperation with other monitoring programmes such as the European National Forest Inventory Network (ENFIN). The European Commission (EC) will remain the main partner of ICP Forests. The new EU Forest Focus regulation is thus a vital basis for the continuity of the programme. It is further essential for the programme to continue its partnerships with monitoring systems in Northern America and Eastern Asia as air pollution and changing climatic conditions deserve political actions at the global level.

Annex I: Forests, surveys and defoliation classes in European countries (2003)

Results of national surveys as submitted by National Focal Centres

Participating countries	Forest area (x 1000 ha)	% of forest area	Grid size (km x km)	No. of sample plots	No. of sample trees	Defoliation of all species by class (aggregates), national surveys		
						0	1	2-4
Albania	1030	35.8	10 x 10			no survey in 2003		
Austria	3878	46.2	16 x 16	131	3470	61.1	27.8	11.1
Belarus	7845	37.8	16 x 16	406	9691	36.0	52.7	11.3
Belgium	691	22.8	4^2 / 8^2	132	3087	40.7	42.0	17.3
Bulgaria	3314	29.9	$4^2/8^2/16^2$	139	5115	19.3	47.0	33.7
Croatia	2061	36.5	16 x 16	78	1869	36.0	42.1	21.9
Cyprus	298	32.2	16x16	15	360	21.1	60.5	18.4
Czech Republic	2630	33.4	$8^2/16^2$	140	6610	11.4	34.2	54.4
Denmark	468	10.9	$7^2/16^2$	20	479	62.1	27.7	10.2
Estonia	2206	49.9	16 x 16	93	2228	42.8	49.6	7.6
Finland	20032	65.8	16^2 / 24x32	453	8482	54.4	34.9	10.7
France	14591	26.6	16 x 16	515	10298	35.6	36.0	28.4
Germany	10264	28.9	16^2 / 4^2	447	13572	31.3	46.2	22.5
Greece	2512	19.5	16 x 16			no survey in 2003		
Hungary	1823	19.4	4 x 4	1153	27224	35.6	41.9	22.5
Ireland	650	6.3	16 x 16	19	403	52.9	33.2	13.9
Italy	8675	28.8	16 x 16	247	6866	19.8	42.6	37.6
Latvia	2932	44.9	8 x 8	361	8601	21.8	65.7	12.5
Liechtenstein	8	50.0				no survey in 2003		
Lithuania	2045	31.3	8x8/16x16	280	6758	13.3	72.0	14.7
Luxembourg	89	34.4				no survey in 2003		
Rep. of Moldova	318	9.4	2 x 2	490	14631	27.8	29.8	42.4
The Netherlands	334	9.6	16 x 16	11	233	53.2	28.8	18.0
Norway	12000	37.1	$3^2/9^2$	1531	7700	38.9	38.2	22.9
Poland	8894	28.0	varying	1257	25140	8.2	57.1	34.7
Portugal	3234	36.4	16 x 16	136	4080	45.0	42.0	13.0
Romania	6244	26.3	4 x 4	3840	101243	62.2	25.2	12.6
Russian Fed.	8125	73.2	varying			no survey in 2003		
Serbia Montenegro	2360		16 x 16	103	2390	41.0	36.2	22.8
Slovak Republic	1961	40.0	16 x 16	108	4253	9.6	59.0	31.4
Slovenia	1099	54.2	16 x 16	41	984	33.2	39.3	27.5
Spain	11588	30.9	16 x 16	620	14880	22.7	60.7	16.6
Sweden	23400	57.1	varying	2504	14713	46.7	35.1	18.2
Switzerland	1186	28.7	16 x 16	49	1054	31.6	53.6	14.9
Turkey	20199	25.9				no survey in 2003		
Ukraine	9316	15.4	16 x 16	54	1342	18.4	54.6	27.0
United Kingdom	2156	8.9	random	310	7440	28.8	46.5	24.7
TOTAL	200456		varying	15683	315196			

Note that some differences in the level of damage across national borders may be at least partly due to differences in standards used. This restriction, however, does not affect the reliability of the trends over time.

Annex II: Defoliation of all species (1992-2003)

Results of national surveys as submitted by National Focal Centres

Participating countries	All species defoliation classes 2-4												change% points
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2002/ 2003
Albania							9.8	9.9	10.1	10.2	13.1		
Austria	6.9	8.2	7.8	6.6	7.9	7.1	6.7	6.8	8.9	9.7	10.2	11.1	
Belarus	29.2	29.3	37.4	38.3	39.7	36.3	30.5	26.0	24.0	20.7	9.5	11.3	1.8
Belgium	16.9	14.8	16.9	24.5	21.2	17.4	17.0	17.7	19.0	17.9	17.8	17.3	-0.5
Bulgaria	23.1	23.2	28.9	38.0	39.2	49.6	60.2	44.2	46.3	33.8	37.1	33.7	-3.4
Croatia	15.6	19.2	28.8	39.8	30.1	33.1	25.6	23.1	23.4	25.0	20.6	22.0	1.4
Cyprus										8.9	2.8	18.4	15.6
Czech Rep.	56.1	51.8	57.7	58.5	71.9	68.6	48.8	50.4	51.7	52.1	53.4	54.4	1.0
Denmark	25.9	33.4	36.5	36.6	28.0	20.7	22.0	13.2	11.0	7.4	8.7	10.2	1.5
Estonia	28.5	20.3	15.7	13.6	14.2	11.2	8.7	8.7	7.4	8.5	7.6	7.6	0.0
Finland	14.5	15.2	13.0	13.3	13.2	12.2	11.8	11.4	11.6	11.0	11.5	10.7	-0.8
France	8.0	8.3	8.4	12.5	17.8	25.2	23.3	19.7	18.3	20.3	21.9	28.4	6.5
Germany	26.4	24.2	24.4	22.1	20.3	19.8	21.0	21.7	23.0	21.9	21.4	22.5	1.1
Greece	18.1	21.2	23.2	25.1	23.9	23.7	21.7	16.6	18.2	21.7	20.9		
Hungary	21.5	21.0	21.7	20.0	19.2	19.4	19.0	18.2	20.8	21.2	21.2	22.5	1.3
Ireland	15.7	29.6	19.7	26.3	13.0	13.6	16.1	13.0	14.6	17.4	20.7	13.9	-6.8
Italy	18.2	17.6	19.5	18.9	29.9	35.8	35.9	35.3	34.4	38.4	37.3	37.6	0.3
Latvia	37.0	35.0	30.0	20.0	21.2	19.2	16.6	18.9	20.7	15.6	13.8	12.5	-1.3
Liechtenstein	16.0												
Lithuania	17.5	27.4	25.4	24.9	12.6	14.5	15.7	11.6	13.9	11.7	12.8	14.7	1.9
Luxembourg	20.4	23.8	34.8	38.3	37.5	29.9	25.3	19.2	23.4				
Rep. of Moldova		50.8		40.4	41.2				29.1	36.9	42.5	42.4	-0.1
The Netherlands	33.4	25.0	19.4	32.0	34.1	34.6	31.0	12.9	21.8	19.9	21.7	18.0	-3.7
Norway	26.2	24.9	27.5	28.8	29.4	30.7	30.6	28.6	24.3	27.2	25.5	22.9	-2.6
Poland	48.8	50.0	54.9	52.6	39.7	36.6	34.6	30.6	32.0	30.6	32.7	34.7	2.0
Portugal	22.5	7.3	5.7	9.1	7.3	8.3	10.2	11.1	10.3	10.1	9.6	13.0	3.4
Romania	16.7	20.5	21.2	21.2	16.9	15.6	12.3	12.7	14.3	13.3	13.5	12.6	-0.9
Russian Fed.			10.7	12.5						9.8	10.9		
Serbia Monten.					3.6	7.7	8.4	11.2	8.4	14.0	3.9	22.8	18.9
Slovak Rep.	36.0	37.6	41.8	42.6	34.0	31.0	32.5	27.8	23.5	31.7	24.8	31.4	6.6
Slovenia		19.0	16.0	24.7	19.0	25.7	27.6	29.1	24.8	28.9	28.1	27.5	-0.6
Spain	12.3	13.0	19.4	23.5	19.4	13.7	13.6	12.9	13.8	13.0	16.4	16.6	0.2
Sweden				14.2	17.4	14.9	14.2	13.2	13.7	17.5	15.8	18.2	2.4
Switzerland	12.8	15.4	18.2	24.6	20.8	16.9	19.1	19.0	29.4	18.2	18.6	14.9	-3.7
Turkey													
Ukraine	16.3	21.5	32.4	29.6	46.0	31.4	51.5	56.2	60.7	39.6	27.7	27.0	-0.7
United Kingdom	58.3	16.9	13.9	13.6	14.3	19.0	21.1	21.4	21.6	21.1	27.3	24.7	-2.6

Austria: Results of 2003 are based on a wider gridnet than in previous years.

Czech Republic: Only trees older than 60 years assessed until 1997.

France: Due to methodological chanes, only the time series 1992-94 and 1997-2003 are consistent, but not comparable to each other.

Italy: Due to methodological changes, only the time series 1992-96 and 1997-2003 are consistent, but not comparable to each other.

United Kingdom: The difference between 1992 and subsequent years is mainly due to a change of assessment method in line with that used in other States.

Annex III:

Tree species referred to in the text

Birch	*Betula spp.*
Common beech	*Fagus sylvatica*
European oak	*Quercus robur*
Holm oak	*Quercus ilex*
Maritime pine	*Pinus pinaster*
Norway spruce	*Picea abies*
Scots pine	*Pinus sylvestris*
Sessile oak	*Quercus petraea*
Silver fir	*Abies alba*

Photo references

D. Aamlid: p. 21; L. Bourjot: pp. 26, 27 (top); M. Dobbertin: p. 31; EFI: p. 6; M. Ferm: p. 41; R. Fischer: pp. 8, 10, 12, 23; J.G. Goldammer: pp. 34, 35; A. Hildingsson: p. 14; N. Kräuchi: p. 24; L.-M. Nageleisen: p. 45; M. Neumann: p. 25; P. Roskams: pp. 38, 44, 46; G. Sanchez-Pena: p. 19; C. Scheidegger: p. 27 (bottom); H.-W. Schröck: pp. 29, 30; W. Seidling: p. 16; A. Takahashi: p. 40; E. Ulrich: pp. 36, 37; S. Wulff: p. 22.

For further information also contact:
Federal Research Centre for Forestry and Forest Products
PCC of ICP Forests
Attention Dr. M. Lorenz, R. Fischer
Leuschnerstr. 91
D-21031 HAMBURG

Internet:
http://www.icp-forests.org

Participating countries and contacts

Albania: Ministry of the Environment, Dep. of Biodiversity and Natural Resources Management, e-mail: cep@cep.tirana.al, Rruga e Durresit Nr. 27, Tirana.

Austria: Bundesamt und Forschungszentrum für Wald, Mr. Ferdinand Kristöfel, e-mail: ferdinand.kristoefel@bfw.gv.at, Seckendorff-Gudent-Weg 8, A-1131 Wien.

Belarus: Forest Inventory republican unitary company „Belgosles“, Mr. V. Kastsiukevich, e-mail: belgosles@open.minsk.by, 27, Zheleznodorozhnaja St., 220089 Minsk.

Belgium: Wallonia, Ministère de la Région Wallonne, Div. de la Nature et des Forêts, Mr. C. Laurent, e-mail: c.laurent@mrw.wallonie.be, Avenue Prince de Liège, 15, B-5000 Namur.

Flanders, Institute for Forestry and Game Management, Mr. Peter Roskams, e-mail: peter.roskams@lin.vlaanderen.be, Gaverstraat 4, B-9500 Geraardsbergen.

Bosnia and Herzegovina: Federalno Ministarstvo Poljop. Vodop. Sum., Mr. Bajram Pescovic, Maršala Tita br. 15, Sarajevo.

Bulgaria: Ministry of Environment and Waters, Ms. Penka Stoichkova, e-mail: forest@nfp-bg.eionet.eu.int, 136, Tzar Boris III blvd., BG-1618 Sofia.

Canada: Canadian Forest Service, Mr. Harry Hirvonen, e-mail: hirvonen@nrcan.gc.ca, 580 Booth Street – 7th Floor, CDN-Ottawa, ONT K1A 0E4. Quebec: Ministère des Ressources naturelles, Mr. Rock Ouimet, e-mail: rock.ouimet@mrn.gouv.qc.ca, 2700, Einstein, CDN-STE. FOY - Quebec G1P 3W8.

Croatia: Sumarski Institut, Mr. Joso Gracan, e-mail: josog@sumins.hr, Cvjetno Naselje 41, 10450 Jastrebarsko.

Cyprus: Ministry of Agriculture, Natural Resources and Environment, Mr. Andreas K. Christou, e-mail: Publicity@cytanet.com.cy, P.O.Box 4157, CY-1414-Lefkosia.

Czech Republic: Forestry and Game Management Research Institute (VULHM), Mr Bohumir Lomsky, e-mail: lomsky@vulhm.cz, Strnady 136, CZ-15604 Praha 516, Zbraslav.

Denmark: Danish Forest and Landscape Research Institute, Ms Annemarie Bastrup-Birk, e-mail: ab@kvl.dk, Hörsholm Kongevej 11, DK-2970 Hörsholm.

Estonia: Estonian Centre for Forest Protection and Silviculture, Mr. Kalle Karoles, kalle.karoles@metsad.ee, Rôômu tee 2, EE-51013 Tartu.

Finland: Finnish Forest Research Institute, Mr. John Derome, e-mail: john.derome@metla.fi, Rovaniemi Research Station, SF- 96301 Rovaniemi.

France: Ministère de l‘agriculture, de l‘alimentation, de la pêche et des affaires rurales, Mr. Jean Luc Flot, e-mail : jean-luc.flot@agriculture.gouv.fr, 19, avenue du Maine, F-75732 Paris Cedex 15.

Germany: Bundesministerium für Verbraucherschutz, Ernährung und Landwirtschaft– Ref. 533, Mr. Thomas Haußmann, e-mail: thomas.haussmann@bmvel.bund.de, Postfach 140270, D-53107 Bonn.

Greece: Institute of Mediterranean Forest Ecosystems, Mr. George Baloutsos, Mr. Anastasios Economou, e-mail: oika@fria.gr, Terma Alkmanos, GR-11528 Athens-Ilissia.

Hungary: Forest Management Planning Service, Mr. Andras Szepesi, e-mail: szepesi.andras@aesz.hu, Széchenyi u. 14, H-1054 Budapest 5.

Ireland: Coillte Teoranta, Research and Development, Mr. Pat Neville, e-mail: pat.Neville@coillte.ie, Newtownmountkennedy, IRL- CO. Wicklow.

Italy:Corpo Forestale dello Stato, Servizio Conecofor, Mr. Bruno Petriccione, e-mail: conecofor@corpoforestale.it, Via Sallustiana 10, I-00187 Roma.

Latvia: State Forest Service of Latvia, Ms Ieva Zadeika, e-mail: ieva.zadeika@vmd.gov.lv, 13. Janvara iela 15, LV-1932 Riga.

Liechtenstein: Amt für Wald, Natur und Landschaft, Mr. Felix Näscher, e-mail: felix.naescher@awnl.llv.li, Dr. Grass-Strasse 10, FL-9490 Vaduz.

Lithuania: State Forest Survey Service, Mr. Andrius Kuliesis, e-mail: vmt@lvmi.lt, Pramones ave. 11a, LT-3031 Kaunas.

Luxembourg: Administration des Eaux et Forêts, Claude Parini, e-mail: claude.parini@ef.etat.lu, 16, rue Eugène Ruppert, L-2453 Luxembourg-Ville (Cloche d'Or).

Moldova: State Forest Agency, Mr. Anatolie Popusoi, e-mail: safmoldsilva@yahoo.com, 124 bd. Stefan Cel Mare, MD-2012 Chisinau.

The Netherlands: Ministry of Agriculture, Nature Management & Fisheries, Mr. Gerald Grimberg, e-mail: g.t.m.grimberg@eclnv.agro.nl , Postbus 30, Marijke wag 24, NL-6700 AA Wageningen.

Norway: Norwegian Forest Research Institute, Mr. Dan Aamlid, e-mail: dan.aamlid@skogforsk.no, Høgskolevn. 12, N-1432 ÅS.

Poland: Forest Research Institute, Mr. Jerzy Wawrzoniak, e-mail: j.wawrzoniak@ibles.waw.pl, Bitwy Warszawskiej 1920 nr. 3, PL-00973 Warszawa.

Portugal: Ministerio da Agricultura, Desenvolvimento Rural e Pescas, Direcçao Geral dos Recursos Florestias, , Ms Maria Barros, e-mail: mbarros@dgf.min-agricultura.pt, Av. Joao Crisostomo 28-6°, P-1069-040 Lisboa.

Romania: Forest Research and Management Institute, Mr. Romica Tomescu/ Mr. Ovidiu Badea, e-mail: biometrie@icas.ro, Sos. Stefanesti nr. 128 sector 2, RO-72904 Bukarest.

Russian Federation: St. Petersburg State University (SpbSU). Biological Research Institute, Ms Natalia Goltsova, Natalia.Goltsova@pobox.spbu.ru, Oranienbaumskoe schosse 2, RUS-198504 Petrodvoretz.

Serbia and Montenegro: Institute for Forestry, Mr. Radovan Nevenic, e-mail: nevenic@Eunet.yu, Kneza Viseslava street 3, YU-11000 Novi-Beograd.

Slovak Republic: Lesnicky vyskumny ustav, Mr. Tomás Bucha, e-mail: tomas.bucha@fris.sk, T.G. Masaryka 22, SK-96092 Zvolen.

Slovenia: Gozdarski Institut Slovenije, Mr. Marko Kovac, e-mail: marko.kovac@gozdis.si, Vecna pot 2, SLO-1000 Ljubljana.

Spain: Dirección General para la Biodiversidad, Mr. Sanchez Peña, e-mail: gsanchez@mma.es, Gran Vía de San Francisco 4, E-28005 Madrid.

Sweden: National Board of Forestry, Mr. Sture Wijk, e-mail: sture.wijk@svo.se, Vallgatan 6, S-551 83 Jönköping.

Switzerland: Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft (WSL), Mr. Norbert Kräuchi, e-mail: kraeuchi@wsl.ch, Zürcherstr. 111, CH-8903 Birmensdorf.

Turkey: Ormancilik Arastirma Enstitüsü Müdürlügü, Mr. Yasar Simsek, P.K. 24 Bahcelievler, TR-06561 Gazi-Ankara.

Ukraine: Ukrainian Research Institute of Forestry and Forest Melioration, Mr. Igor F. Buksha, e-mail: buksha@uriffm.com.ua, Pushkinskaja 86, UKR-61024 Kharkiv.

United Kingdom: Forest Research Station, Alice Holt Lodge, Wrecclesham, Mr. Andrew J Moffat, e-mail: andy.moffat@forestry.gsi.gov.uk, UK-Farnham-Surrey GU10 4LH.

United States of America: USDA Forest Service, Mr. Al Riebau, e-mail: ariebau@fs.fed.us, P.O. Box 96090 USA – Washington, DC 20090-6090