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Forest Condition in Europe
2016 Technical Report of ICP Forests

Report under the UNECE Convention on Long-Range Transboundary Air Pollution (CLRTAP)

ALEXA MICHEL & WALTER SEIDLING (Eds.)

LRTAP
Long-range Transboundary Air Pollution

wge
Working Group on Effects
of the
Convention on Long-range Transboundary Air Pollution

BFW
Bundesforschungszentrum für Wald

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Alexa Michel and Walter Seidling (editors)

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We especially wish to thank all participating countries in ICP Forests that have provided their national data and written report. For a complete list of all countries that are participating in ICP Forests with their responsible Ministries and National Focal Centres (NFC), please refer to Annex IV. We also wish to thank the ICP Forests community for their valuable comments on draft versions of this report and Mr Ferdinand Kristöfel and the Austrian Research Centre for Forests (BFW) for its publication.

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http://icp-forests.net

LRTAP Long-range Transboundary Air Pollution

ICP Forests

wge Working Group on Effects of the Convention on Long-range Transboundary Air Pollution

SUMMARY

ICP Forests is one of the most diverse programmes within the Working Group on Effects (WGE) under the Convention on Long-range Transboundary Air Pollution (CLRTAP). To provide a regular overview of the major results of the programme, the Programme Co-ordinating Centre (PCC) of ICP Forests yearly invites all ICP Forests Expert Panels, Working Groups, and Committees to publish a comprehensive chapter on their most recent results in the annual ICP Forests Technical Report. This 2016 Technical Report presents results of the ICP Forests 2015 large-scale (Level I) and 2014 intensive (Level II) forest monitoring from up to 32 of the 42 countries participating in ICP Forests. It focuses on:

- a description of the **monitoring and research infrastructure** of ICP Forests;
- **tree crown condition and damage causes** in 2015 including trend analyses;
- the spatial variation of **atmospheric throughfall deposition** in forests in Europe in 2014;
- the spatial and temporal distribution of **ozone symptoms** across Europe from 2002 to 2014;
- the **water, soil, and foliage ring tests** within the quality assurance and control programme to guarantee the comparability of the analytical results between different laboratories;
- a description of the **ICP Forests Level I biodiversity data** on plant species and structural diversity in European forest ecosystems.

This year all ICP Forests Expert Panels, Working Groups, and Committees have additionally provided a concise description of their latest activities and outcomes in their specific field of study. The report also includes numerical results and national reports of the 2015 national crown condition survey in the participating countries. It contains information on the 4th ICP Forests Scientific Conference in Ljubljana in May 2015 and lists all 48 ICP Forests projects ongoing for at least one month between June 2015 and May 2016 and 28 scientific publications between January 2015 and May 2016 for which ICP Forests data and/or the ICP Forests infrastructure were used. For additional maps, tables, figures, and contact information of persons responsible, please refer to the extensive annex at the end of this report.

The assessment of **crown condition** has been a core feature of the ICP Forests monitoring for over 30 years. It is based on the concept that tree crowns are reflecting overall tree condition and may therefore provide an early warning signal of tree deterioration.

In 2015, the crown condition of 88 052 trees on 4 818 transnational Level I plots in 25 participating countries was assessed. The overall mean defoliation of all trees was 20.7%; means ranging between 19.6% and 29.3% for the major species and species groups. Broadleaved trees showed a slightly higher mean defoliation than coniferous trees (21.3% vs. 20.2%). Correspondingly, conifers had a higher frequency of trees in the defoliation classes 'none' or 'slight' (78.0%) than broadleaves (75.0%). Among the main tree species and tree species groups, evergreen oaks and deciduous temperate oaks displayed the highest mean defoliation (29.3% and 23.4%, respectively). Evergreen oaks had also by far the highest proportion of severely defoliated trees (4.9%), while deciduous (sub-) Mediterranean oaks and Austrian pine had the highest mortality rates (1.7% and 1.6%, respectively). Austrian pine and common beech had the lowest mean defoliation (19.5% and 19.6%, respectively). Evergreen oaks had the lowest percentage (54.2%) of not or only slightly defoliated trees (≤ 25% defoliation) while Mediterranean lowland pines had the highest (81.2%). Most species or species groups showed an improvement in defoliation in 2015 compared to 2014, especially the broadleaved species. An exception was the group of evergreen oaks with a strong increase in defoliation in 2015. However, this increase can largely be attributed to a much smaller sample in comparison with 2014. Due to Spanish data missing, the sample of evergreen oaks was reduced from 4 500 trees in 2014 to only 1 000 trees in 2015, located mostly in France.

The **causes of tree damage** were assessed on 88 052 trees on 4 818 plots in 25 countries and 42.3% of the trees showed symptoms of damage of at least one defined agent group. The predominant cause of damage, causing almost one quarter of all recorded damage symptoms (22.5%), were insects. Almost half of these insect-caused symptoms were attributed to defoliators (44.0%), which also represented the most frequent of all damage causes. Leaf-mining insects were responsible for damage on nearly 19.0% and wood-boring insects on 9.6% of the trees with insect-caused symptoms. Fungi were the second major causal agent group affecting 10.9% of all assessed trees. Of those 30% showed signs of canker, followed by needle cast and needle rust fungi (20.1%) and decay and root rot fungi (12.8%). The third major identified cause of tree damage was abiotic agents (10.1% of all damage symptoms). Within this agent group, 24.5% of the symptoms were attributed to drought, 11.4% to wind, and 7.9% to frost.

The measurement of atmospheric deposition is one of the core activities of ICP Forests, and it aims to quantify and qualify the acidifying, buffering, and eutrophying compounds deposited to forests. It is thus an important source of knowledge about the amount and type of anthropogenic and naturally emitted substances relevant for plants after they have been transported over more or less long distances by air. In this report, the spatial variation of **atmospheric throughfall deposition** in forests in Europe in 2014 is described for $N\text{-}NH_4$, $N\text{-}NO_3$, $S\text{-}SO_4$, Ca, and Mg. Maps for the input of calcium and magnesium are depicted with and without sea salt corrections.

- High throughfall deposition of **$N\text{-}NO_3$** was mainly found in central Europe, while the lower values (below 1 kg ha^{-1} y^{-1}) were found in Finland, Bulgaria and on the Alps.

- The central European area of high throughfall deposition (> 8 kg ha^{-1} y^{-1}) of **$N\text{-}NH_4$** is larger, covering parts of Belgium, the Netherlands, Germany, the Czech Republic, Austria, Slovenia and Serbia. Other plots with high $N\text{-}NH_4$ deposition are also found in Poland, Italy, France and Spain. Low values, below 1 kg ha^{-1} y^{-1}, were found again in Finland and Bulgaria, but also in parts of Switzerland and France.

- High throughfall deposition of **$S\text{-}SO_4$** is spread over all of Europe, partly due to the contribution of marine aerosol. After sea salt correction, the area with higher $S\text{-}SO_4$ deposition in central Europe is smaller than for $N\text{-}NO_3$ and $N\text{-}NH_4$ deposition, but high values are also found in southern and eastern Europe, partly due to the input of Saharan dust. The lowest values of $S\text{-}SO_4$ deposition are found in the Swiss Alps.

- High values of **Ca** throughfall deposition are recorded in almost all plots in southern Europe, from Spain to Romania, probably due to the relevant contribution of Saharan dust. Isolated plots with high Ca deposition are also found in Belgium, Germany, Denmark, the Czech Republic, Poland and Lithuania, probably related to local mineral sources. Low values of Ca deposition (below 2 kg ha^{-1} y^{-1}) were mainly found in northern Europe. The correction for the marine contribution does not affect the spatial pattern of Ca deposition.

- On the contrary, **Mg** throughfall deposition is mainly related to the marine aerosol. After sea salt correction, values below 1.5 kg ha^{-1} y^{-1} are found in most of Europe, while the highest values are reported in eastern Europe and on isolated plots in Italy, Germany and the Czech Republic.

Ozone-induced visible foliar injury has been assessed during 2002-2014 according to ICP Forests standardized methods on 285 woody plant species on 169 plots in 19 countries. Data were evaluated for the entire period 2002-2014 as well as for 2009 only, when spatial coverage was the greatest. First results reveal that 55.0% of the assessed plots were symptomatic, and 26.0% of species developed ozone visible injury. Beech (*Fagus sylvatica*) was the species with the highest frequency of symptomatic observations in both 2002-2014 (40.1%) and in 2009 (42.9%). The frequency of symptom reports occurred without a clear spatial pattern. Higher frequency of symptom occurrence seemed more common from northern Italy to north-western Germany, and towards East Europe. At country level, temporal trend analysis indicates a downward trend of mean frequency of symptomatic species for five out of six countries. Overall, there is a slightly decreasing trend, which is consistent with the decreasing trend observed for ambient ozone concentrations. These first results demonstrate the potential of the survey on visible foliar injury to detect the potential impact of ozone on European vegetation. Further, enhanced quality control procedures are underway to aggregate the datasets and promote a more in-depth exploitation of cause-effect relationships, considering ozone symptoms, ozone concentration and measurements on forest health, growth, nutrition, biodiversity and climate undertaken at the ICP Forests plots.

To guarantee the comparability of the analytical results between different laboratories that analyse water, soil and foliage samples from Level I and Level II plots in almost 30 countries and over time, a quality assurance (QA) programme is necessary. The main part of the external quality control (QC) programme is the implementation of **interlaboratory comparisons (ring tests) between all labs**.

The results of all water, soil and foliage ring tests within the last 20 years shows the development of the quality of the labs, but also the limitations due to different analytical methods can be seen. The participation in the regularly organised meetings of the heads of the labs, where many analytical problems are being discussed, has improved the laboratory quality and has led to better results in the ring tests during the last 10 years.

The best results were achieved for the foliage ring tests. Since 2004 only 5 to 10% of the results for the main parameters have been non-tolerable. In soil ring tests the ratio of non-tolerable results started with 20 to 60% in 1993 and decreased to 10 to 20% for most of the parameters in 2015. For water samples the percentage of non-tolerable results decreased from 20 to 60% in 2002 to 5 to 15% in 2015.

An explanation could be found in the growing (or increasing) experience of the laboratories over time, especially for foliar analyses. Also the use of better equipment in many laboratories has led to better results. One reason for the higher number of non-tolerable results for soil compared to other matrices is the inhomogeneity of sieved soil samples which have to be used for some of the extracts. A second reason could be found in the two steps analysis (extraction/digestion and measurement), which can bring a higher variation than the one step analysis used for water samples.

Structural and compositional biodiversity surveys on the ICP Forests extensive monitoring plots (Level I) have been incorporated into the ICP Forests database as **LI-BioDiv dataset**. Data were collected in the period 2005-2008 and delivered by 27 partners according to harmonized methods. During the integration process data was validated based on a complex system of checkroutines that had been defined before. Conflicts were solved in collaboration with the experts from National Focal Centres and the Expert Panels on Biodiversity and Ground Vegetation, and on Forest Growth.

The LI-BioDiv dataset is structured in six forms: GPL (general plot location and information, 3340 plots), DBH (tree diameter, status, and composition, 3201 plots), THT (tree top and crown base height, 3083 plots), CAN (canopy closure, layers, number of trees, 3210 plots), DWD (deadwood, 2950 plots), and GVG (ground vegetation composition, 3124 plots).

A transnational internal evaluation process was established and a set of items approved by the related Expert Panels and the ICP Forests Programme Co-ordinating Centre (PCC). Four working groups are producing the first results in terms of scientific papers; the other evaluation projects and the related groups of experts and scientists are described. Recommendations and lessons learned from this experience are shortly provided.

CONTENTS

1 INTRODUCTION

The International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) was established in 1985. Its main aim is to collect and compile data on the condition of forest ecosystems across the UNECE region and monitor their condition and performance over time. ICP Forests is led by Germany, and its Programme Co-ordinating Centre is based at the Thünen Institute of Forest Ecosystems in Eberswalde. It is one of eight subsidiary bodies (six ICPs, a Task Force, and a Joint Expert Group) that report to the Working Group on Effects (WGE) of the Convention on Long-range Transboundary Air Pollution (CLRTAP) on the effects of air pollution on a wide range of ecosystems, on materials, and on human health.

After more than 30 years ICP Forests is still constantly moving forward. The **most important recent activities of ICP Forests** include further developments in the domain of the ICP Forests Strategy, cooperation actvities, the ICP Forests Manual, and the data unit.

- The new **Strategy of ICP Forests (2016–2023)** was adopted at the ICP Forests Task Force Meeting (TFM) in Luxembourg in May 2016. It defines the mission of ICP Forests, its aims, current features, vision for the future, and actions to be taken.
- A **Letter of Intent** for future co-operation between the Wood Buffalo Environmental Association (WBEA, Canada) and ICP Forests was adopted at the last ICP Forests TFM in May 2016.
- The **ICP Forests Manual** is currently being updated. The manual ensures a standard approach for data collection among the participating countries. A new version will be available in 2016.
- The **data unit** at the Programme Co-ordinating Centre (PCC) of ICP Forests is constantly improving the data management, data availability and usability, and information flow within the programme and to the scientific community and the public. Recent developments of the data unit include the creation of a new online data documentation[1].

With the Strategy and the Manual, ICP Forests defines its aims and ways of implementation. As subsidiary body under the WGE, however, ICP Forests is first and foremost obliged and indebted to contribute to the **biannual workplan of the LRTAP Convention** which sets the objectives and deliverables of all bodies under the Convention. The joint 2016-2017 workplan (WP) for the further implementation of the Convention for EMEP (European Monitoring and Evaluation Programme), the WGE and the other subsidiary bodies of CLRTAP was adopted by the Executive Body (EB) at its 34th meeting on 18 December 2015 (ECE/EB.AIR/133/Add1[2]). Following is a list with the respective tasks and deliverables expected of ICP Forests in 2016-2017:

WP item	Description	Actions to be taken by ICP Forests
1.1.1.1	**Set priorities for monitoring** and other collection of data on effects by Parties in view of policy needs and given financial constraints. **Prioritize calls for data and data collection** for ICPs in view of the policy needs and given financial constraints.	This is meant as a general guideline to consolidate the Convention work under decreasing financial support. The expected outcome/deliverable is an updated list of monitoring and inventory priorities and recommendation to the Executive Body in 2016. This will be organised by the WGE.
1.1.1.7	Set up a contact group between EMEP and WGE to **compare WGE exposure measurements and modelled and monitored exposure by EMEP**.	The expected outcome/deliverable is the implementation of joint meetings. The Task Force on Measurement and Modelling (TFMM), the Task Force on Health, and all ICPs are requested to

[1] http://www.icp-forests.org/documentation/

[2] http://www.unece.org/fileadmin/DAM/env/documents/2015/AIR/EB/ece.eb.air.133_add1_E.pdf

WP item	Description	Actions to be taken by ICP Forests
		contribute.
1.1.1.10	Further investigate the **influence of N deposition on the more sensitive parts of forest ecosystems** (e.g., mycorrhiza, foliage N content of trees, N in soil solution).	Data analyses by ICP Forests and its partners.
1.1.1.10	Evaluate **ozone impacts on forest trees** (injury of leaves/needles, defoliation, and/or discolouration of tree crowns) and **responses of sensitive plant species at forest edges**.	Joint activity of ICP Forests and ICP Vegetation.
1.1.1.24	Further evaluate **ecosystem responses, in particular air pollution-induced changes in biodiversity, for setting critical loads**, based on long-term monitoring within ICPs, including the interactions between pollutants, climate change, land use and nutrients (including phosphorus).	It is expected that an annual report on the progress in dynamic modelling (2016) and a scientific paper (2017) is to be delivered. This activity will be carried out by all ecosystem-related ICPs and the Joint Expert Group on Dynamic Modelling (JEG).
1.1.4.2	Assess **implications of air pollution mitigation strategies** in the northern hemisphere for health, ecosystem and climate impact.	This is a global scale issue and aims at a workshop on impact assessment methods of regional and transported air pollution in cooperation between WGE, EMEP bodies (TFHTAP, CIAM, TFIAM) and similar expert groups from south and east Asia. This activity will be funded by the USA, the EU, and in-kind contributions from national experts.
1.4.1	Develop **common standards of all ICPs and a web portal approach** to enable access to data/information.	This is to improve the WGE/EMEP functioning incl. its subsidiary bodies and will result in an improvement of data access via the web, the development of a common web-based portal, and a formal set of agreed common standards. Here, EMEP, the WGE including the ICPs, and other subsidiary bodies are expected to work together.
1.4.2	– Explore ways to **combine/merge the activities of some ICPs** (e.g. Integrated Monitoring, ICP Forests, ICP Waters) – Improve **integrated working and reporting** – Organise **joint meetings**	These measures aim at a more effective overall organisation of the work carried out by the ICPs.
1.5.1	Assess the **long-term trends in air pollution and its adverse effects**.	To improve the transition domain between science and policy, two activities are planned: (1) This one will lead to another Trends Report issued by the WGE. These activities will be funded by mandatory EMEP contributions and France.
1.5.2	Assess **scientific and policy outcomes within the Convention over the past few decades**, including scientific understanding, trends and achievements under the Gothenburg Protocol, and outline future challenges	(2) The outcome will be a second comprehensive assessment report and an executive summary for policymakers (both in 2016).

We would like to hereby express again our sincere gratitude to everyone involved in ICP Forests and especially to the participating countries for their commitment. This co-operative programme depends on the help and support and constant extra input of many dedicated individuals given the limited resources available for ecosystem monitoring these days.

The 2016 Technical Report of ICP Forests can be downloaded from the ICP Forests website[3]. Please send comments and suggestions to pcc-icpforests@thuenen.de; we highly appreciate your feedback.

[3] http://icp-forests.net/page/icp-forests-technical-report

2 THE MONITORING AND RESEARCH INFRASTRUCTURE OF ICP FORESTS

Walter Seidling[4]

2.1 Background

For the last 30 years the aim of the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) has been to collect and compile data on the condition of forest ecosystems across the UNECE region and monitor its condition and performance over time (see Seidling & Michel 2015 for more explicit information). ICP Forests is not only addressing the scientific information needs of CLRTAP, thereby underpinning the advancement of air pollution abatement measures in Europe, but provides quantitative policy-relevant information on monitored and modelled air pollution effects on forests to a variety of other national and international forest and environmental bodies and programmes, such as Forest Europe (Ferretti et al. 2015 a,b) and the FAO Global Forest Survey (GFS).

According to the strategy of ICP Forests (Anonymus 2016), its mission is "*to carry out multifunctional long-term monitoring of forests within the UNECE region and beyond and provide scientific knowledge on the effects of air pollution, climate change and other stressors on forest ecosystems*". More explicit the main aims are to:

- provide a continuing overview on *forest health, forest vitality, forest soil condition* and the *biodiversity* status in relation to anthropogenic (air pollution, atmospheric deposition) and natural stressors;
- contribute to a better understanding of *cause-effect relationships* between anthropogenic as well as natural stressors and forest condition and processes;
- provide *high quality* and open access data managed in one central database for the risk assessment of forests across Europe, the large-scale and long-term trend analyses as well as model validation and calibration, serving also as a reference for global assessments;
- develop and maintain highly equipped forest measurement stations as central data hubs and standardized forest monitoring and research *infrastructures* across Europe.

An outstanding feature of both levels of the ICP Forests monitoring is the implementation of standardized methods and additional measures for quality control and quality assurance. The transnational standardisation of methods has led to consistent sampling practices across Europe. All methods are described in the extensive ICP Forests Manual (ICP Forests 2010), which has been developed over the years and is presented together with the respective scientific background of each of the surveys by Ferretti & Fischer (2013). Within ICP Forests the experience and expertise of eight Expert Panels is essential to further develop the monitoring methods of each survey (cf. Table 2-1).

At present, 42 countries are co-operating in ICP Forests. Of those, 27 are EU-Member States hence all EU countries but Malta are participating in the Programme. Of the 15 non-EU countries, nine are countries from Southeast Europe (SEE) or from Eastern Europe, the Caucasus, and Central Asia (EECCA).

[4] For contact information, please refer to Annex IV-4.

ICP Forests is further actively promoting membership across the wider UNECE region which is one of the aims of the CLRTAP Working Group on Effects (UNECE 2012).

Table 2-1. Surveys performed at ICP Forests monitoring sites.

Survey	Level I	Level II, standard	Level II, core
Crown condition	annually	annually	annually
Foliar chemistry	project	every 2 years	every 2 years
Tree growth		every 5 years	annually
Tree phenology			several times / year
Ozone induced injury		continuously	continuously
Litterfall			continuously
Ground vegetation diversity		every 5 years	every 5 years
Soil condition	project	every 10 years	every 10 years
Soil solution chemistry			continuously
Soil water			continuously
Deposition		continuously	continuously
Air quality		continuously	continuously
Meteorology		continuously	continuously

2.2 The large-scale forest monitoring (Level I)

The large-scale monitoring (Level I) is an annual, transnational survey to study the spatial and temporal variations in forest condition. The network consists of more than 7,500 plots on a 16 x 16 km transnational grid giving an overall density of one plot per 256 km² forested area (see Figure 2-1 for an overview on Level I plots active in 2015). In the early 1990s annual assessments of crown defoliation were complemented by data on soil condition (Vanmechelen et al. 1997) and the nutritional status of foliage (Stefan et al. 1997). Since then a second survey on Level I plots on soil condition (De Vos & Cools 2011) and a survey on ground vegetation have been performed within the BioSoil project under the EC Forest Focus Regulation No. 2152/2003.

After the end of the FutMon project in 2011 some participating countries and subnational territorial units have moved their Level I plots from their original positions to sites co-located with plots of the respective National Forest Inventories (NFIs) (Kovač et al. 2014). This shift of plots causes constraints for comprehensive longitudinal and time series analyses, due to disruptions of the plot-specific continuity of the crown condition assessment (cf. Chapter 3). However, the information drawn from the NFI surveys may foster biomass-oriented approaches in the future.

2.3 The intensive forest ecosystem monitoring (Level II)

Complementing the large-scale Level I monitoring, the *intensive and continuous monitoring of forest ecosystems (Level II)* was established in 1994 to study ecosystem related processes and their relationships with environmental influences in forest ecosystems and their compartments on permanent observation plots (De Vries et al. 2003a). The overall aim of the Level II monitoring is to better understand cause-effect relationships in forest ecosystems (cf. De Vries et al. 2000), including the assessment of crown and soil condition, carbon stocks and fluxes, climate change effects, and biodiversity-related issues. The selection and maintenance of the plots lies in the responsibility of each participating country (for details see Ferretti et al. 2010).

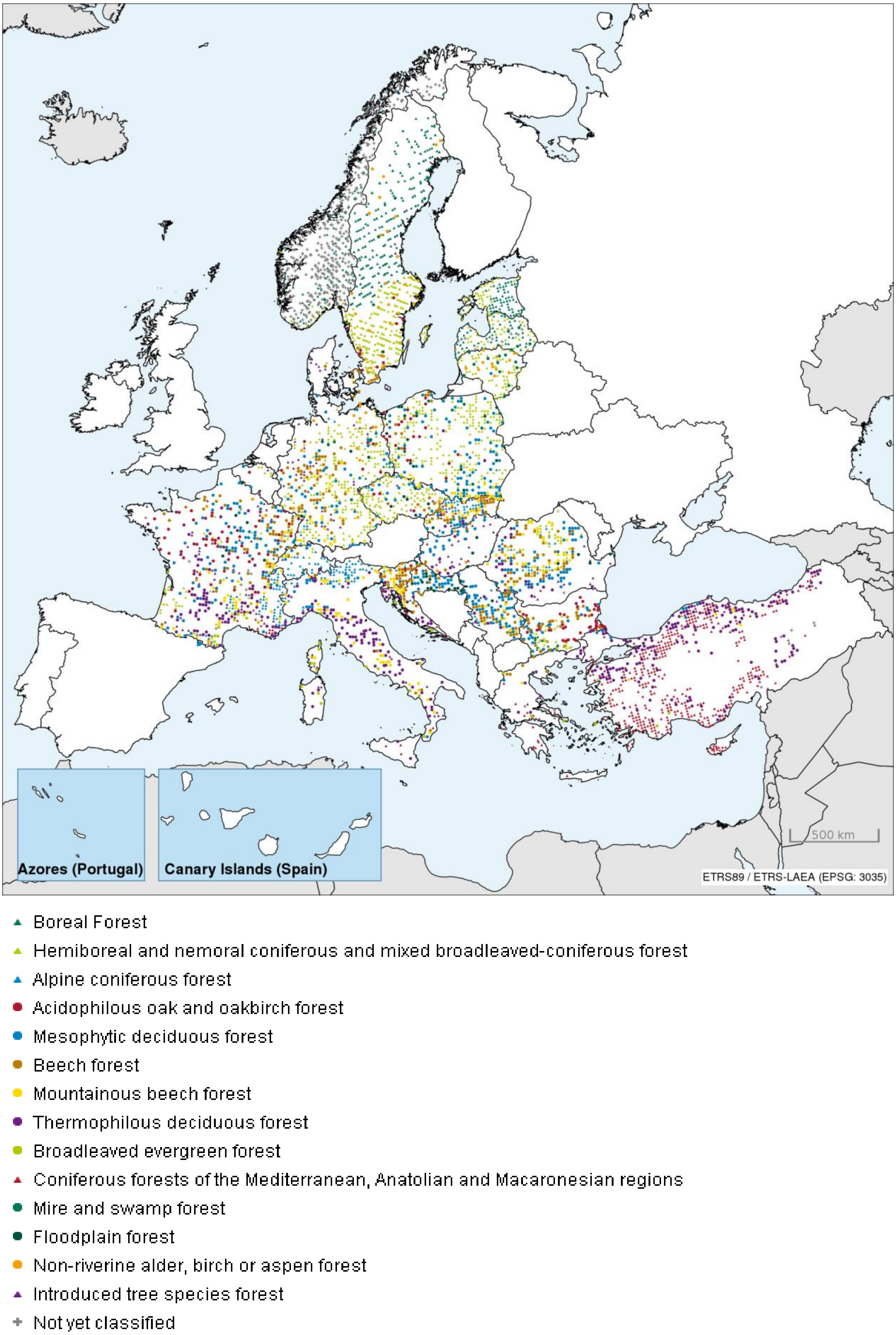

Figure 2-1. Location of Level I plots surveyed in 2015 underlaid by European forest type information.

The number of Level II plots varies over time for different reasons (e.g. windthrow, vandalism, or ceased funding). Therefore we find a number of 1041 ever registered Level II plots in the ICP Forests database, with 791 active around the year 2000 (De Vries et al. 2003b: 11). Later, Lorenz et al. (2005: 46) counted more than 860 active Level II plots; with for example deposition measurements carried out on 513 plots or meteorological data on 206 plots (De Vries et al. 2003b, Lorenz et al. 2005). Today from a total of 618 active Level II plots, we have 207 continuous deposition measurements from 2009 to 2013 and 164 with continuous meteorological measurements. A 60% reduction in deposition measurements against only 20% reduction of meteorological measurements reflects probably a shift in the perception of the grand societal challenges during the last decade towards climate change.

Many publications based on ICP Forests data (cf. Michel & Seidling 2015: 84 ff.) are derived from data collected at Level II sites. However, one problem faced while evaluating the data is the number of plots featuring respective measurements continuously. Combining, for example, meteorological and deposition data mentioned above, the final number of plots will be 128 (Figure 2-2). If species-specific evaluations are performed, this kind of reduction can even be stronger. For instance Ferretti et al. (2015c) could base their evaluations on a total of 71 plots, however, for the species-specific models 33 plots could be used for spruce, 20 for beech and 18 for Scots pine. Therefore, future reductions within the network should be properly planned, minimising consequences for statistical and other scientific evaluations.

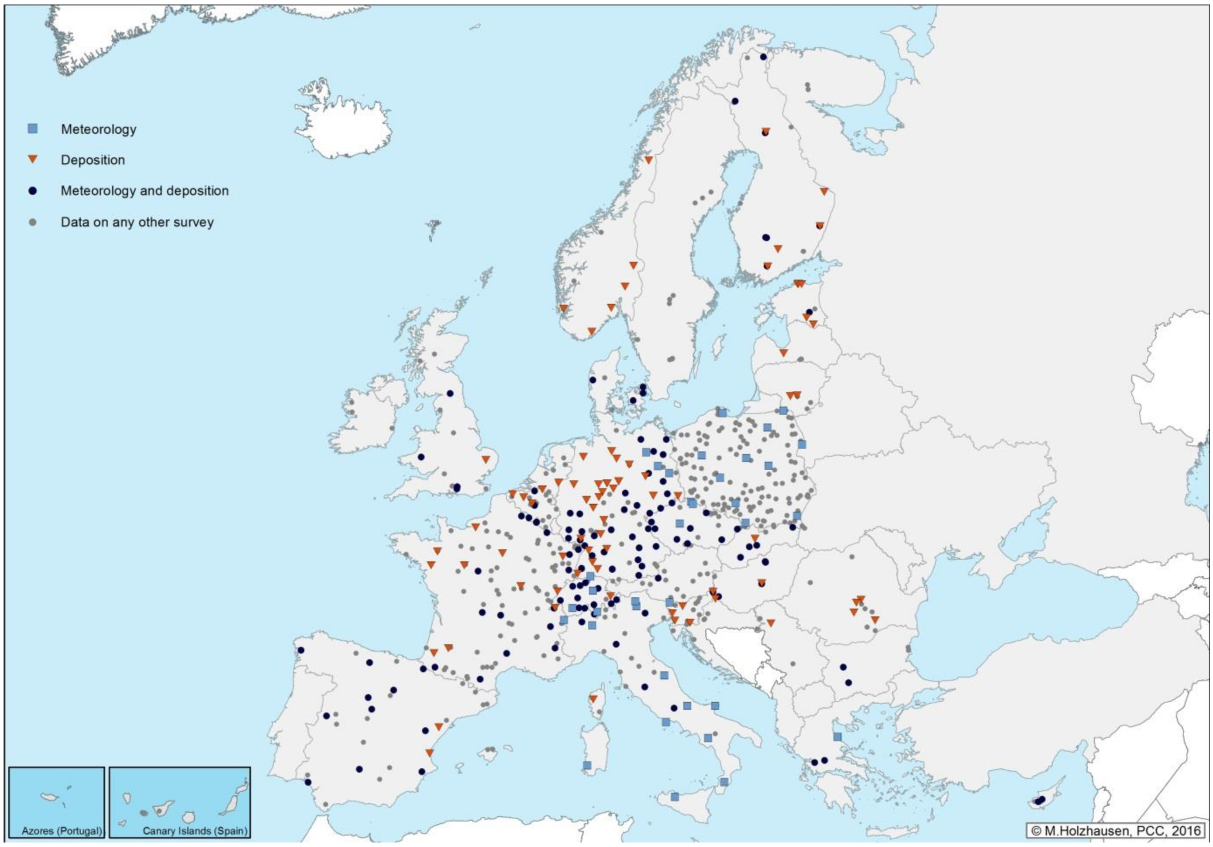

Figure 2-2. Level II plots with data submitted to the central data base of ICP Forests between 2009 and 2013 (as of October 2015) with continuous measurement of deposition between 2009 and 2013 or continuous recording of meteorological data or continuous measurements of both surveys; plots with data on any other survey are shown as well.

It is not only the mere number of plots limiting statistical evaluations, but also the geographical distributions may cause bias in statistical models. Even if the found sample concept introduced by Overton et al. (1993) may cover more general concerns about the applicability of statistical models performed with deliberately distributed sampling sites, biases caused by specific geographical distributions of plots – similar to the nonresponse bias in polls – have rarely been investigated in monitoring networks up to now. Resampling techniques might among other approaches be an appropriate means to investigate such effects, eventually based on relationships probably varying in geographic space.

This rather general issue cannot be solved within a country-based plot selection approach as contextual constrains are unequally distributed across the countries within the UNECE region. Both, Figure 2-2 and Figure 2-3, reveal certain geographic imbalances in the distribution of intensive monitoring plots across Europe generally and for certain combinations of surveys in particular. Therefore, both gap closure and complementing the network at the edges – especially in the eastern parts of the UNECE region – should be aspired and is a major goal for bringing ICP Forests into the future.

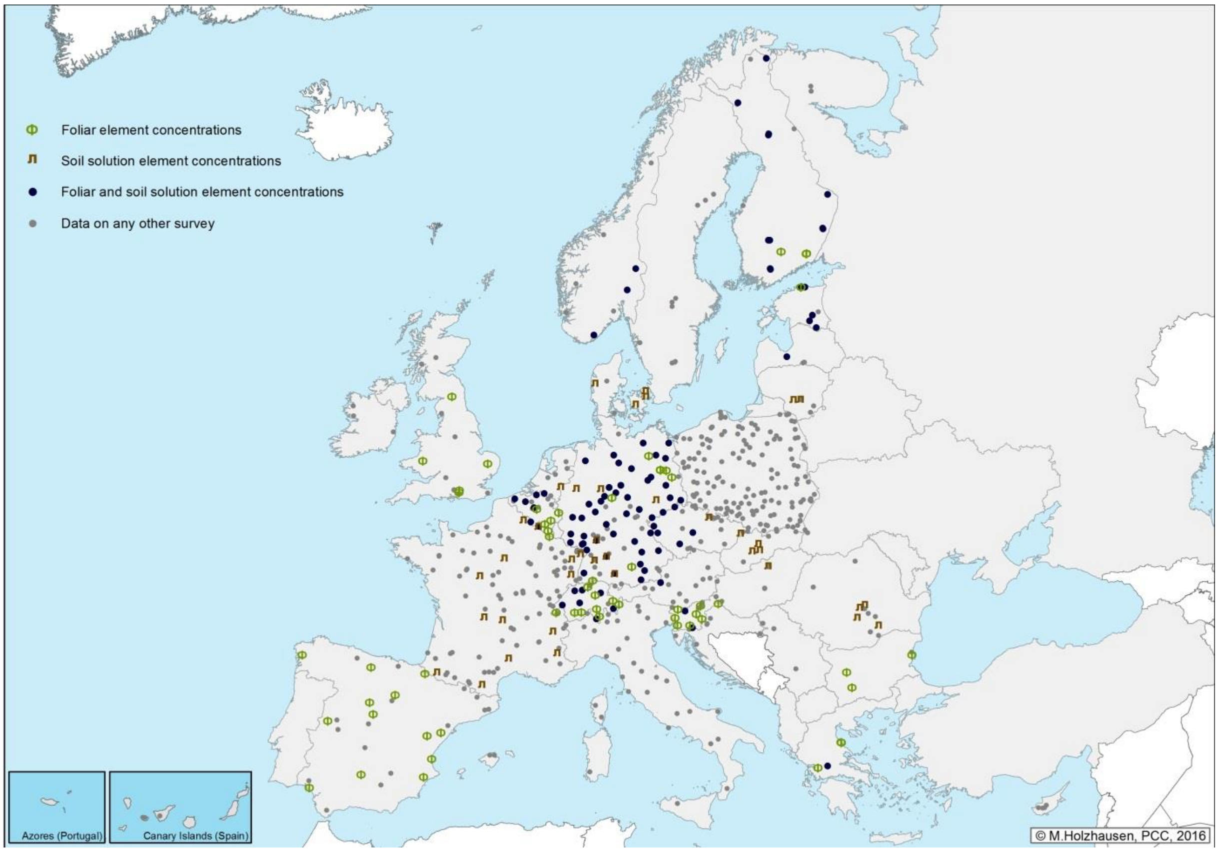

Figure 2-3. Level II plots with data submitted to the central database of ICP Forests between 2009 and 2013 (as of October 2015) with continuous biannual measurements of foliar element concentrations between 2009 and 2013 or continuous recording of soil solution element concentrations or measurements of both surveys together; plots with data on any other survey are shown as well.

Co-location of monitoring plots is one important mean to foster co-operations with other networks in- and outside the UNECE Working Group on Effects like ICP Integrated Monitoring (IM), the European Long-term Ecosystem Research network (LTER), the European Critical Zone Observatory Community, or the Integrated Carbon Observation System (ICOS). Also for promoting bilateral co-operations, like those with the mycorrhiza working group at the Imperial College London (Suz et al. 2015), well-structured documentations about the geographic extent of different aspects of the ICP Forests network is indispensable.

One important toehold for fostering co-operations with mutual benefits for all sides contributing to such systems is the knowledge about already existing collaboration at the plot level. Therefore, a questionnaire was sent out in September 2015 to all National Focal Centres (NFCs) of ICP Forests. It contained – besides the questions itself (Block 2-1) – country-wise lists of all 1041 Level II plots ever registered. In terms of numbers of plots the response rate was 57%; the results will be summarized in the following.

Since there is empirically no clear relationship between return rates of polls and the accuracy/precision of the results achieved, the respective shares have to be rated as best estimates available.

Block 2-1. Questions sent out to all NFCs of ICP Forests in September 2015 together with country-specific lists of all 1041 plots ever registered as Level II plots.

1) Plot is situated within an area protected by local (L), regional (R) or national (N) nature protection legislation stricto sensu.
2) Plot is part of an area protected by EU legislation: Natura 2000, Special Protection Areas of the Bird Directive (SPA), Site of Community Importance (SCI), Special Area of Conservation (SAC)
3) Plot is part of an area investigated by ICP Integrated Monitoring (IM)
4) At the plot samples of the ICP Vegetation moss survey are collected
5) At the plot activities of another sister ICP (please specify) take place
6) Plot belongs to a national (N) or the European (E) LTER (Long-term Ecosystem Research) programme
7) Plot belongs to another national monitoring programme (please specify)
8) Plot is part of another national research programme (please specify)
9) Plot is part of another international monitoring programme (please specify)
10) Plot is part of another international research programme (please specify)
11) Does the plot contain additional research infrastructures beyond the ICP Forests programme (Eddy flux tower etc.)?
12) Any additional remarks

Table 2-2 informs about the general plot status. While 59% are still active, a total of 232 plots have been declared as closed down, which is 39% of all registered plots. Six plots have been newly established in recent years. One question to follow up in this context is whether the ecologically more redundant plots have been closed down or those which cover important parts of natural or anthropogenic environmental gradients or those diminishing the geographic extent of the whole network. The latter two cases have to be seen much more critical and should be avoided (see also workplan item 1.1.1.1 in Table 1-1).

Table 2-2. Status of 593 Level II plots according to returns of a questionnaire sent out in September 2015 to all NFCs of ICP Forests; total number of plots ever registered: 1041.

Plot status	Active old	Active new	Unknown status	Closed down
Number (percentage)	352 (59.4%)	6 (1.0%)	3 (0.5%)	232 (39.1%)

The ability of the ICP Forests network to collaborate with different international programmes in- or outside CLRTAP depends largely on co-location of monitoring infrastructures. On the basis of all active Level II plots, a spatial integration or co-location with ICP Integrated Monitoring sites was indicated for 42 plots, which is ca. 12% of all active Level II sites. These sites may deliver a certain potential to directly compare estimates and relationships gained independently in both programmes (cf. De Vries et al. 2002). For altogether 69 Level II plots, samples for the ICP Vegetation moss survey were gained. Data from such sites have already been used in both programmes (e.g. Skudnik et al. 2014, Harmens et al. 2014) and the potentials for further respective collaborations have to be fathomed. For about 9% of all ICP Forests plots, collaboration with ICP Modelling and Mapping was indicated. This means that monitoring data are also used for calculations or calibration of estimates of Critical Loads and Levels (e.g. Bonanni et al. 2012, cf. Posch et al. 2015). For around 10% of the plots also a co-location or integration with sites of the ICP Waters network is declared giving the opportunity to connect sources and sinks of certain substances like DOC at the landscape scale (e.g. de Wit et al. 2015).

Table 2-3 also contains co-locations or integration between ICP Forests plots and sites registered within national (LTER) or European (E-LTER) Long-term Ecological Research networks. Here a total of 81 plots were indicated as being also part of a national or the European LTER network. Collaborations between both networks are highly recommended.

Table 2-3. Co-location or co-operation with infrastructure of other ICPs at 358 active Level II plots.

ICP IM	ICP Vegetation, moss survey	ICP M&M	ICP Waters	LTER and E-LTER	LTER and E-LTER proposed
42 (11.7%)	69 (19.2%)	33 (9.2%)	37 (10.3%)	81 (22.6%)	9 (2.5%)

The NFCs of ICP Forests were also asked about the involvement of plots and their infrastructure in research activities (Table 2-4). Four plots are directly involved in international research programmes and another 20 are involved in international and national research programmes. This means that almost 7% of all plots are part of an international research programme, while almost 44% are part of a national research programme.

Table 2-4. Research activities complementing ICP Forests monitoring at 358 active Level II plots.

No additional research activities	International research programmes	National and international research programmes	National research programmes
	4 (1.1%)	20 (5.6%)	156 (43.6%)
178 (49.7%)	180 (50.3%]		

Nature protection is another important societal issue at both, national and international level. The question how many Level II plots of ICP Forests are overlaid by any national or international nature protection regulation was also part of the poll. It turned out that 38% of all plots are subject to any area-related nature protection regulation (Table 2-5). 27% of all sites are part of one or more categories of Natura 2000 areas. Even if monitoring has not been established to serve directly any nature protection aims, there is a considerable potential to contribute to research related to nature protection in forests. Apart from the ground vegetation survey, which is directly related to questions concerning biodiversity and bio-indication, investigations in other domains of nature protection like plot-related bird censuses should be taken into consideration in the future.

Table 2-5. Nature protection status of 358 active Level II plots.

No nature protection	Any kind of national nature protection only	Both, national and Natura 2000 status	Any Natura 2000 status
	40 (11.2%)	65 (18.2%)	31 (8.7%)
222 (62.0%)	136 (38.0%)		

The ICP Forests database informs about the MCPFE (Forest Europe) management status (MCPFE 2006) of in total 95 Level II plots from five countries (Germany, Spain, Sweden, Slovenia and Latvia), however, even for those countries the datasets cannot be considered as complete (Table 2-6). Therefore no country-specific evaluation will be presented here. However, the overall figures give a higher percentage of non-protected sites than the evaluation above. As with 95 captured cases the statistical population is even smaller than those of the poll, no further conclusions can be drawn. What is interesting is the fact that almost all of the more management oriented MCPFE (Forest Europe) categories are covered by ICP Forests plots, even if the percentage is quite preliminary in sight of the low number of plots with this information available.

Table 2-6. Assignment of 95 Level II plots to MCPFE (Forest Europe) management classes according to ICP Forests database.

ICP F Code	MCPFE class	Main management objective	N of cases	Percen-tage	Sum protected [%]
1	1.1	"Biodiversity"- "No Active Intervention"	5	5.3	27.4
2	1.2	"Biodiversity"- "Minimum Intervention"	13	13.7	
3	1.3	"Biodiversity"- "Conservation Through Active Management"	6	6.3	
4	2	“Protection of Landscapes and Specific Natural Elements”	0	0.0	
5	3	“Protective Functions”	2	2.1	
9	-	No protection status	69	72.6	
Sum			**95**	**100**	

This overview highlights the importance of continuity within both, the plot locations and the methods, but also shows the immense potential for integrating evaluations and collaborations a long-standing programme like ICP Forests offers.

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3 TREE CROWN CONDITION AND DAMAGE CAUSES

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3.1 Introduction and scientific background

Tree crown defoliation and occurrence of biotic and abiotic damage are important indicators of forest health, and are considered within the Criterion 2, "Forest health and vitality", one of the six criteria adopted by Forest Europe (formerly the Ministerial Conference on the Protection of Forests in Europe – MCPFE) to provide information for sustainable forest management in Europe[6].

Defoliation surveys are linked with detailed assessments of biotic and abiotic damage causes. Unlike assessments of tree damage, which can in some instances trace the tree damage to a single cause, defoliation is an unspecific parameter of tree vitality, which can be influenced by a number of anthropogenic and natural factors. By combining visible damage symptoms and their causes with defoliation observations we are allowed to gain a better insight into the condition of trees, and the interpretation of the annual state of European forests and its trends in time and space is made easier.

This chapter presents results from the crown condition and tree damage cause assessments on the large-scale, representative, transnational monitoring network (Level I) of ICP Forests carried out in 2015, as well as long-term trends for the main species and species groups.

3.2 Methods of the 2015 survey

The assessment of tree condition in the transnational Level I network is conducted according to European-wide, harmonized methods described in the ICP Forests Manual by Eichhorn et al. (2010, see also Eichhorn & Roskams 2013). Regular national calibration trainings of the survey teams and international cross-comparison courses (ICCs) ensure the quality of the data and comparability across the participating countries (e.g. Dobbertin et al. 1997, Eickenscheidt 2015).

Defoliation

Defoliation is the key parameter of tree condition within forest monitoring describing a loss of needles or leaves in the assessable crown compared to a local reference tree in the field or an absolute, fully foliated reference tree from a photo guide. Defoliation is estimated in 5% steps, ranging from 0% (no defoliation) to 100% (dead tree). Defoliation values are grouped into five classes (Table 3-1). In the maps presenting the mean plot defoliation in the result part of this chapter and in Table 3-7, class 2 is divided (> 25–40% and > 40–60%).

[5] For contact information, please refer to Annex IV-4.

[6] http://www.foresteurope.org/docs/MC/MC_lisbon_resolution_annex1.pdf

Table 3-1. Defoliation classes.

Defoliation class	Needle/leaf loss	Degree of defoliation
0	up to 10%	None
1	> 10–25%	Slight (warning stage)
2	> 25–60%	Moderate
3	> 60–< 100%	Severe
4	100%	Dead

Damage cause assessments

The damage cause assessment of trees consists of three major parts:

– Symptom description

The description of damage symptoms indicates which part of a tree is affected and the type of symptom it shows. It focuses on important factors that may influence tree condition and it is important in the diagnosis of the causal agent and for the study of cause-effect mechanisms.

Three main categories indicate the affected part of a tree: (a) leaves/needles, (b) branches, shoots, and buds, and (c) stem and collar. For each affected part in the first two categories, also the position within the crown is given.

– Determination of the damage cause (causal agents / factors)

Causal agents are those thought to be directly responsible for the observed damage symptoms. Therefore, for each symptom description a causal agent should be determined, which is crucial for the study of cause-and-effect mechanisms. Causal agents are grouped into nine categories (Table 3-2). In each category a more detailed description is possible through a hierarchical coding system.

– Quantification of symptoms (damage extent)

The extent is the estimated percentage of affected parts caused by the action as specified by causal agents. The extent is classified in eight classes (Table 3-3). In trees with multiple types of damage (and thus multiple extent classes), all extent values are evaluated individually.

Table 3-2. Main categories of causal agents.

Causal agents
Game and grazing
Insects
Fungi
Abiotic agents
Direct action of man
Fire
Atmospheric pollutants (visible symptoms of direct atmospheric pollution impact only)
Other factors
(Investigated but) unidentified

Table 3-3. Classes of damage extent.

Class	Extent
0	0%
1	1–10%
2	11–20%
3	21–40%
4	41–60%
5	61–80%
6	81–99%
7	100%

Additional parameters

Besides defoliation and damaging agents, additional parameters are annually assessed providing information for the analysis of the crown condition data (Table 3-4). All data are checked for consistency by the participating countries and submitted online to the Programme Co-ordinating Centre (PCC) of ICP Forests.

Table 3-4. Tree, stand, and site parameters provided in the crown condition database.

Registry and location	Country	Country in which the plot is assessed [code]
	Plot number	Identification of each plot
	Plot coordinates	Latitude and longitude [degrees, minutes, seconds]
	Date	Day, month, and year of observation
Physiography	Altitude [m a.s.l.]	Elevation above sea level, in 50 m steps
	Aspect [°]	Aspect at the plot, direction of strongest decrease of altitude in eight classes (N, E, … , NW) and 'flat'
Soil	Water availability	Three classes: insufficient, sufficient, excessive water availability to main tree species
	Humus type	Mull, moder, mor, anmor, peat or other
Stand related data	Forest type	14 forest categories according to EEA (2007)
	Mean age of dominant storey	Classified age, class size 20 years; class 1: <20 years,…., class7: >121 years, class 8: irregular stands
Additional tree related data	Tree number	Tree ID, allows the identification of each particular tree over all observation years
	Tree age	Classified age for single trees, class size 20 years; class 1: <20 years,…., class 9: >160 years
	Tree species	Species of the observed tree [code]

Certain criteria were defined prior to data analysis. Only plots with a minimum number of three trees per plot were analysed. For analyses at species level, three trees per species had to be present. These criteria are consistent with earlier evaluations (e.g. Wellbrock et al. 2014, Becher et al. 2014) and explain the discrepancy between the number of trees in Table 3-6 and ANNEX II.

Participating countries

The annual transnational tree condition survey in 2015 was conducted on 4 962 plots in 24 countries (Table 3-5). In total, 91 741 trees were assessed in the field for crown condition (Table 3-6). Both the number of plots and the number of trees may vary in the course of time between countries due to e.g. mortality or changes in the sampling design. This fact may influence the suitability of the data for joint trend analyses. Spain for instance, is re-organising their Level I network and therefore did not submit crown condition data for 2015. As the sudden discontinuation of plots from a large country like Spain strongly biased the results of the overall aggregates for most Mediterranean tree species or tree species groups, data from Spain could not be considered in the respective time series and trend analyses. Referring to statistical coherent datasets, however, considerably reduced the sample sizes for Mediterranean lowland pines, evergreen oaks, and Austrian pine.

Table 3-5. Number of plots assessed for crown condition from 2005 to 2015 in countries with at least one Level I crown condition survey since 2005 according to the current database.

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Andorra		3	3	3	3	3	3	3	11	11	12
Austria	136	135				135					
Belarus	403	398	400	400	409	410	416		373		
Belgium	29	27	27	26	26	9	9	8	8	8	8
Bulgaria	102	97	104	98	159	159	159	159	159	159	159
Croatia	85	88	83	84	83	83	92	100	105	103	95
Cyprus	15	15	15	15	15	15	15	15	15	15	15
Czech Republic	138	136	132	136	133	132	136	135		138	136
Denmark	22	22	19	19	16	17	18	18	18	18	17
Estonia	92	92	93	92	92	97	98	97	96	96	97
Finland	605	606	593	475	886	931	717	784			
France	509	498	504	508	500	532	544	553	550	545	542
Germany	451	423	420	423	412	411	404	415	416	422	424
Greece	87				97	98				57	47
Hungary	73	73	72	72	73	71	72	74	68	68	67
Ireland	18	21	30	31	32	29		20			
Italy	238	251	238	236	252	253	253	245	247	244	234
Latvia	92	93	93	92	207	207	203	203	115	116	116
Lithuania	62	62	62	70	72	75	77	77	79	81	81
Luxembourg	4	4	4	4					4	4	4
Montenegro						49	49	49	49		
Netherlands	11	11			11	11					
Norway	460	463	476	481	487	491	493	496	461	488	411
Poland	432	376	458	453	376	374	367	369	364	365	361
Portugal	125	124									
Romania	229	228	218		227	239	242	240	236	240	242
Russian Fed.					365	288	292				
Serbia	129	127	125	123	122	121	119	121	121	128	127
Slovakia	108	107	107	108	108	108	109	108	108	106	105
Slovenia	44	45	44	44	44	44	44	44	44	44	44
Spain	620	620	620	620	620	620	620	620	620	620	
Sweden	784	790			789	752	571	570	684	842	837
Switzerland	48	48	48	48	48	48	47	47	47	47	47
Turkey			43	396	560	554	563	578	583	531	590
United Kingdom	84	82	32			76					
TOTAL	**6 235**	**6 065**	**5 063**	**5 057**	**7 224**	**7 442**	**6 732**	**6 148**	**5 581**	**5 496**	**4 818**

Table 3-6. Number of sample trees assessed for crown condition from 2005 to 2015 in countries with at least one Level I crown condition survey since 2005 according to the current database.

Country	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Andorra		74	72	72	73	72	72	72	264	264	289
Austria	3 528	3 425				3 087					
Belarus	9 484	9 373	9 424	9 438	9 615	9 617	9 583		8 503		
Belgium	676	618	611	599	599	216	217	206	195	194	187
Bulgaria	3 592	3 510	3 569	3 304	5 560	5 569	5 583	5 608	5 517	5 439	5 513
Croatia	2 046	2 109	2 013	2 015	1 991	1 992	2 208	400	2 520	2 472	2 280
Cyprus	361	360	360	360	362	360	360	360	360	361	360
Czech Republic	3 450	3 425	3 300	3 400	3 325	3 300	3 400	3 375		3 450	3 400
Denmark	528	527	442	452	384	408	411	411	419	409	389
Estonia	2 167	2 191	2 209	2 196	2 202	2 348	2 372	2 348	2 329	2 329	2 397
Finland	11 498	11 489	11 199	8 812	7 182	7 876	4 190	4 637			
France	10 129	9 950	10 073	10 138	9 949	10 584	11 111	11 129	11 065	10 959	10 892
Germany	13 630	10 327	10 241	10 347	10 088	10 063	9 635	9 917	9 997	10 142	10 178
Greece	2 054				2 289	2 311				1 345	1 113
Hungary	1 662	1 674	1 650	1 662	1 668	1 626	1 702	1 655	1 519	1 554	1 501
Ireland	382	445	646	679	717	641		486			
Italy	6 548	6 936	6 636	6 579	6 794	8 338	8 082	5 082	5 092	4 978	4 761
Latvia	2 263	2 242	2 228	2 183	3 911	3 888	3 797	3 879	1 718	1 743	1 732
Lithuania	1 512	1 505	1 507	1 688	1 734	1 814	1 846	1 847	1 907	1 956	1 956
Luxembourg	97	96	96	96					96	96	96
Montenegro						1 176	1 176	1 176	1 176		
Netherlands	232	230			247	227					
Norway	5 319	5 525	5 824	6 085	6 014	6 330	6 332	6 397	2 473	2 620	2 207
Poland	8 640	7 520	9 160	9 036	7 520	7 482	7 342	7 404	7 300	7 304	7 151
Portugal	3 748	3 748									
Romania	5 496	5 472	5 227		5 448	5 736	5 808	5 760	5 656	5 696	5 808
Russian Fed.					11 016	8 958	9 116				
Serbia	2 995	2 902	2 860	2 788	2 751	2 786	2 742	2 782	2 789	2 922	2 898
Slovakia	5 033	4 808	4 904	4 956	4 898	4 753	4 870	4 736	4 626	4 408	4 342
Slovenia	1 056	1 069	1 056	1 056	1 056	1 052	1 057	1 053	1 056	1 055	1 051
Spain	14 880	14 880	14 880	14 880	14 880	14 880	14 880	14 880	14 880	14 880	
Sweden	11 422	11 186			2 207	2 301	1 709	1 703	1 834	2 775	2 843
Switzerland	807	812	790	773	800	785	780	852	786	775	1 043
Turkey			941	9 291	13 156	12 974	13 282	13 603	13 553	12 332	13 665
United Kingdom	2 016	1 968	768			1 803					
TOTAL	**137 251**	**130 396**	**112 686**	**112 885**	**138 436**	**145 353**	**133 663**	**111 758**	**107 630**	**102 458**	**88 052**

In 2015, 44.9% of the plots were dominated by broadleaved and 55.1% by coniferous trees (Figure 3-1). This distribution illustrates the natural predominance of coniferous species in boreal and mountainous regions as well as the preference of forest management for coniferous species outside their natural distribution range.

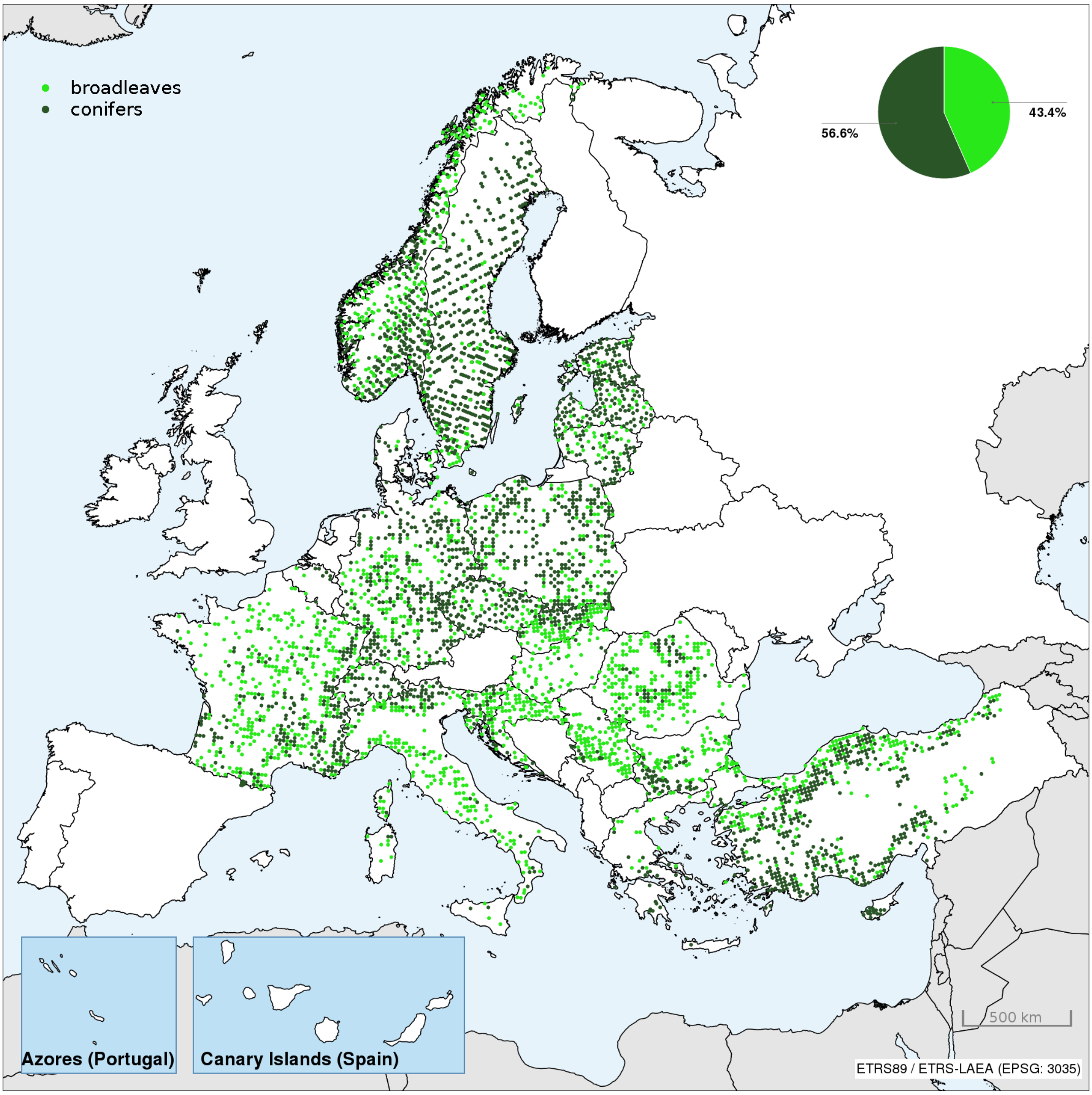


Figure 3-1. Distribution of Level I plots assessed in 2015 across the ICP Forests region and according to prevailing tree classification (broadleaves vs. conifers).

Tree species

Most Level I plots with crown condition assessments contained one (40.1%) or up to three (45.5%) tree species per plot (Figure 3-2). Only 2.4% of the plots featured more than five tree species per plot, most of those were located in Italy, Slovenia, parts of France, Germany, and Lithuania.

On all assessed Level I plots, *Pinus sylvestris* (18.3%) is the most abundant tree species followed by *Picea abies* (14.1%), *Fagus sylvatica* (12%), *Quercus petraea* (4.7%), *Pinus nigra* (4.5%), *Q. robur* (4.4%), *Pinus brutia* (3.9%) and *Q. cerris* (3.6%). Some tree species belonging to the *Pinus* and *Quercus* genus were combined into species groups before further analysis:

- Mediterranean lowland pines (*Pinus brutia*, *P. halepensis*, *P. pinaster*, *P. pinea*)
- Deciduous temperate oaks (*Quercus petraea* and *Q. robur*)
- Deciduous (sub-) Mediterranean oaks (*Quercus cerris*, *Q. frainetto*, *Q. pubescens*, *Q. pyrenaica*)
- Evergreen oaks (*Quercus coccifera*, *Q. ilex*, *Q rotundifolia*, *Q. suber*).

Statistical analyses

Trends in defoliation over time presented in this chapter were calculated according to Sen (1968) and their significance tested by the non-parametric Mann-Kendall test (tau). These methods are appropriate for monotonous, single-direction trends without the need to assume any particular distribution and they are robust against outliers (Sen 1968, Drápela & Drápelová 2011, Curtis & Simpson 2014). Therefore, trends are not influenced by individual outliers into one direction but are rather stable depicting the median of the slopes. The regional Sen's slopes for Europe were calculated according to Helsel & Frans (2006). For both the calculation of Mann-Kendall's tau and the plot-related as well as the regional Sen's slopes, the rkt package (Marchetto 2014) in the R version 3.1.3 (R Core Team 2015) was used.

The graphs with the over-all trend and yearly over-all mean defoliation display plot-related Sen's slopes, each singularly tested by Mann-Kendall's tau at a significance level of $p \leq 0.05$. All Sen's slope calculations and yearly over-all mean defoliation values were based on consistent plot selections with minimum three trees per species analysed per plot. Plots were included when data were available over the years 1992–2015 with a minimum assessment length of 20 years. For that reason some plots or countries could not be included in the long-term time series analyses presented in the graphs. For maps on the trends in defoliation over the years 2002–2015 with a minimum assessment length of 10 years and 2006–2015 with a minimum assessment length of 5 years, please refer to ANNEX I. Statistical analyses were performed with R version 3.1.3 (R Core Team 2015; Mann-Kendall test and Sen's slope) and SAS 9.4 (SAS Institute Inc. 2015).

National surveys

In addition to the transnational surveys, in many countries national surveys are conducted, relying on denser national grids and aiming at the documentation of forest condition and its development in the respective country. Since 1986, densities of national grids between 1x1 km and 32x32 km have been used due to differences in the size of forest area, structure of forests and forest policies. The results of defoliation assessments on national grids are presented in ANNEX I**.** Comparisons between the national surveys of different countries should be made with great care because of differences in species composition, site conditions and methods applied.

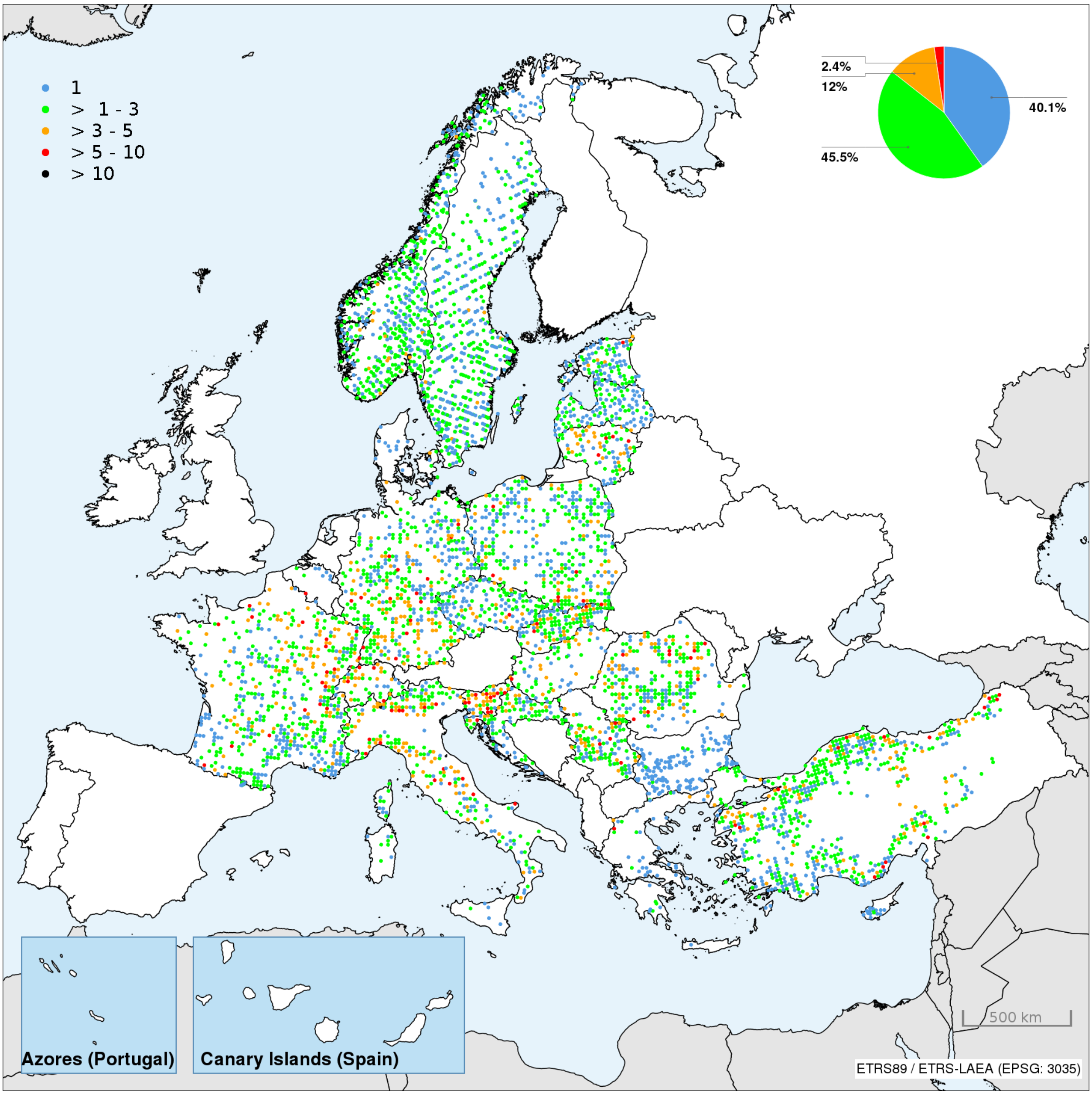


Figure 3-2. Number of tree species assessed on Level I plots in 2015.

3.3 Results of the transnational tree condition survey

Defoliation

In 2015, 88 052 trees were assessed for defoliation on 4 818 plots (Table 3-7). The overall mean defoliation for all species was 20.7%; with means ranging between 19.6% and 29.3% for the major species or species groups. Broadleaved trees showed a slightly higher mean defoliation than coniferous trees (21.3% vs. 20.2%). Correspondingly, conifers had a higher frequency of trees in the defoliation classes 'none' or 'slight' (78.0%) than broadleaves (75.0%).

Among the main tree species and tree species groups, evergreen oaks and deciduous temperate oaks displayed the highest mean defoliation (31.5% and 23.4%, respectively). Evergreen oaks had also by far the highest proportion of severely defoliated trees (5.8%). Of the specified groups deciduous (sub-) Mediterranean oaks and Austrian pine had the highest mortality rates (1.5% and 1.6%, respectively). Austrian pine and common beech had the lowest mean defoliation (19.5% and 19.6%, respectively). Of the specified groups Mediterranean lowland pine had the highest percentage (81.1%) of not or only slightly defoliated trees (≤ 25% defoliation) while evergreen oaks had the lowest (47.2%). Most species or species groups showed an improvement in defoliation in 2015 compared to 2014, especially the broadleaved species (Table 3-7). An exception was the group of evergreen oaks with a strong increase in defoliation in 2015. However, this increase can largely be attributed to a much smaller sample in comparison with 2014. Due to Spanish data missing, the sample of evergreen oaks was reduced from 4 500 trees in 2014 to only 1 000 trees in 2015, located mostly in France.

Table 3-7. Percentage of trees in defoliation classes 0-4 in 2015 (cf. Table 3-1, class 2 subdivided), mean defoliation for the main species or species groups (change from year 2014 in parentheses) and the number of trees in each group.

Main species or species groups	Class 0 (0-10% defoliation)	Class 1 (>10-25% defoliation)	Class 2 (>25-40% defoliation)	Class 2 (>40-60% defoliation)	Class 3 (>60% defoliation)	Class 4 Dead	Mean defoliation	No. of trees
Common beech (*Fagus sylvatica*)	38.9	39.6	14.8	4.0	1.6	1.1	19.6 (-1.7)	10 877
Deciduous temperate oaks	24.2	45.2	21.8	5.8	2.0	1.0	23.4 (-1.8)	8 316
Dec. (sub-) Mediterra-nean oaks	28.7	39.6	19.5	7.5	3.2	1.5	24.1 (-0.7)	3 547
Evergreen oaks	14.8	32.3	27.9	19.0	5.8	0.1	31.5 (+4.6)	795
Other broadleaves	39.8	38.8	12.1	4.4	3.2	1.7	20.4 (-1.6)	19 079
Scots pine (*Pinus sylvestris*)	24.3	54.2	14.8	4.1	1.7	0.9	21.4 (+0.7)	16 716
Norway spruce (*Picea abies*)	36.6	36.8	19.5	4.8	1.7	0.7	20.2 (-0.8)	12 706
Austrian pine (*Pinus nigra*)	42.0	38.5	12.2	3.8	2.0	1.6	19.5 (+1.3)	4 102
Mediterranean lowland pines	22.9	58.3	13.0	4.2	1.4	0.2	20.5 (-0.3)	4 720
Other conifers	44.9	36.6	12.2	4.1	1.7	0.4	17.7 (-0.9)	7 194
TOTAL								
Broadleaves	35.1	40.2	15.6	5.1	2.6	1.4	21.3 (-1.5)	42 614
Conifers	32.4	45.6	15.3	4.3	1.7	0.7	20.2 (-0.1)	45 438
All species	33.7	43.0	15.4	4.7	2.1	1.1	20.7 (-0.8)	**88 052**

Mean defoliation of all species at plot level is shown in Figure 3-3. Almost three quarters (73.2%) of all plots had a mean defoliation less than 25%, and only 0.9% of the plots showed severe defoliation (more than 60%). Plots with high mean defoliation (>40%) were primarily found in southern (Mediterranean) France and Corsica, northern Italy, Slovenia, coastal Croatia and the Czech Republic. Plots with low mean defoliation were found across almost all of Europe, but mainly in south-eastern Norway, Romania and Serbia as well as in Turkey.

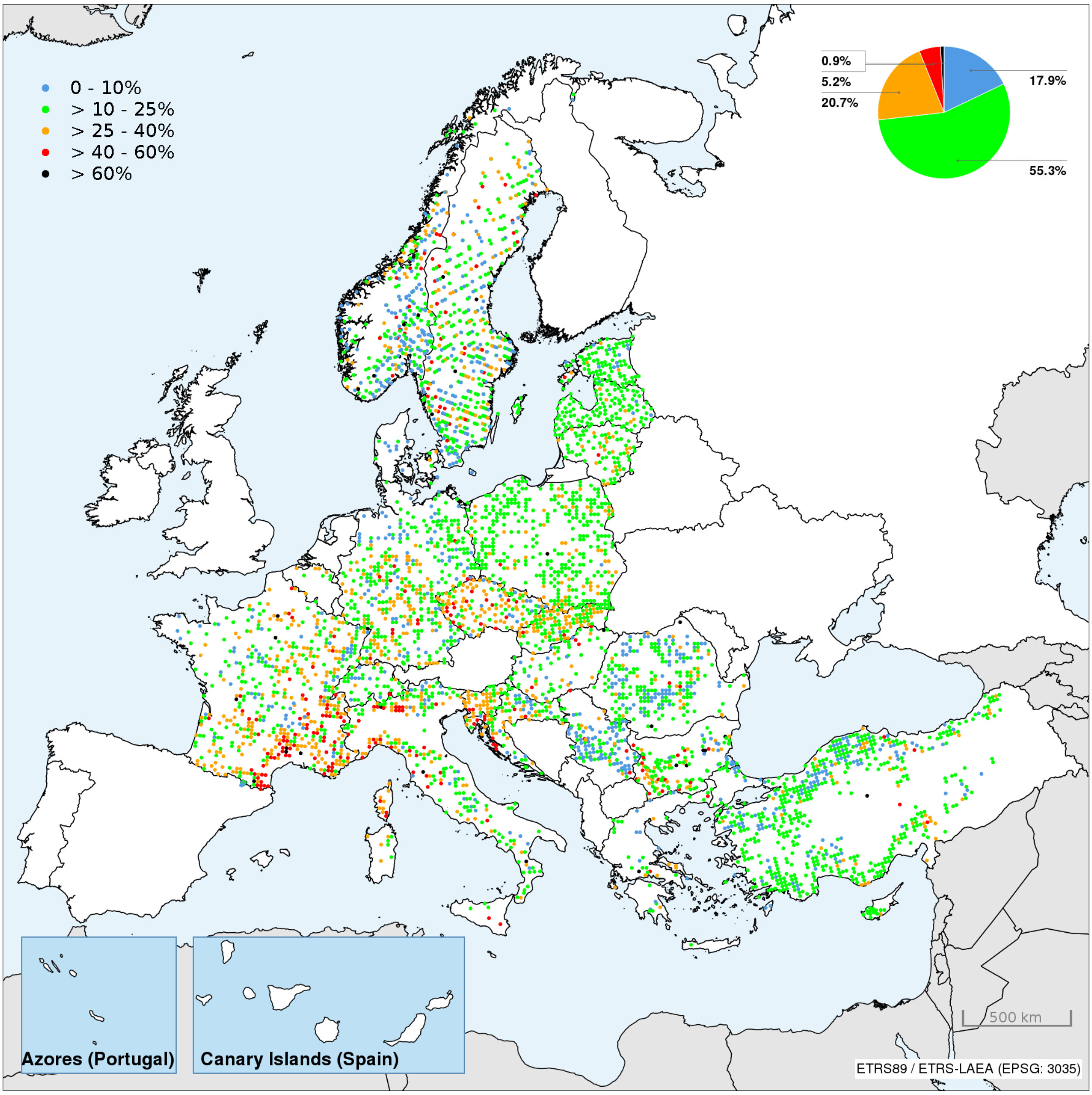


Figure 3-3. Mean plot defoliation of all species in 2015.

The following sections describe the species-specific mean plot defoliation in 2015 and the over-all trend and yearly mean plot defoliation from 1992 to 2015. For additional maps of trends in mean plot defoliation for the period 2002–2015 and 2006–2015, please refer to ANNEX I.

Scots pine

Scots pine (*Pinus sylvestris*) was the most frequently assessed tree species in the Level I network in 2015. It has a wide ecological niche due to its ability to grow on dry and nutrient poor soils and has frequently been used for reforestation. Scots pine is found over large parts of Europe from northern Scandinavia to the Mediterranean region and from Spain to Turkey and is also distributed considerably beyond the UNECE region.

More than three-fourths of the Scots pine plots (76.7%) showed no or only slight mean defoliation (≤ 25% defoliation) (Figure 3-4). Defoliation on 22.8% of the plots was classified as moderate (>25-60% defoliation) and on 0.5% of the plots as severe. Trees with no defoliation were primarily found in plots in southern Norway and northern Germany, whereas plots with comparably high defoliation were located in the Czech Republic, Slovakia, southern France and Bulgaria.

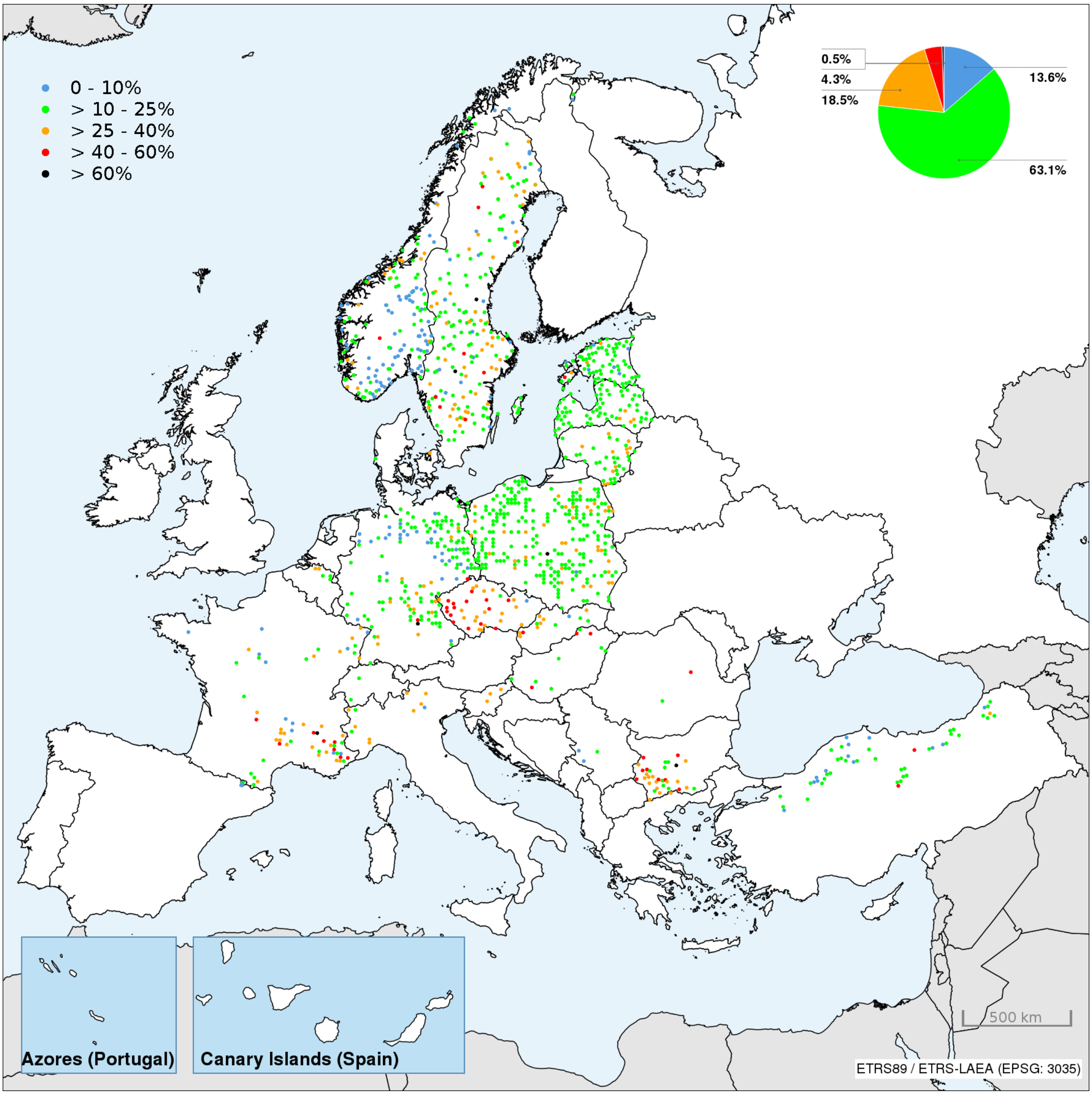


Figure 3-4. Mean plot defoliation of Scots pine (*Pinus sylvestris*) in 2015.

From 1992 to 2015, there was no over-all trend in mean plot defoliation of Scots pine (regional Sen's slope = 0, p > 0.05; Figure 3-5). The annual over-all mean defoliation hardly fluctuated from year to year although relative to the long-term mean a pronounced below average value was observed in 2000. However, from 2012 to 2015 annual mean defoliation in Scots pine has slightly but continuously been increasing.

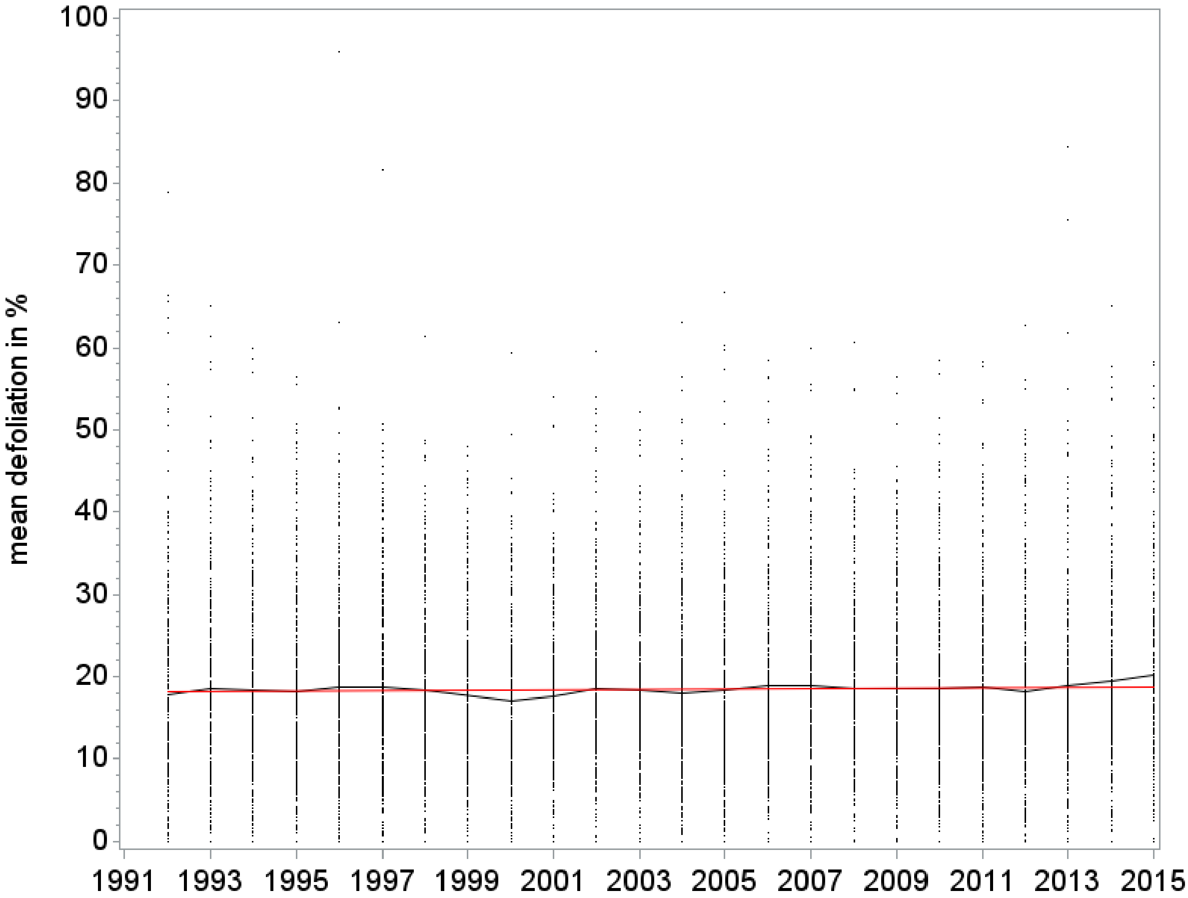


Figure 3-5. Over-all trend (regional Sen's slope = 0.0, p > 0.05; minimum length of time span: 20 years, red line) and yearly over-all mean defoliation (black line) of Scots pine at Level I sites; points represent annual plot means, for clarity these are not interconnected from year to year.

Norway spruce

Norway spruce (*Picea abies*) is the second most frequently assessed species on the Level I plots. The area of its distribution ranges from Scandinavia to northern Italy and from north-eastern Spain to Romania. Favouring cold and humid climate, Norway spruce is found at the southern edge of its distribution area only at higher elevations.

In 2015, trees on more than two-thirds of the Norway spruce plots (68.5%) were on average not or only slightly defoliated (≤ 25% defoliation; Figure 3-6). Defoliation on 30.8% of the plots was classified as moderate (>25-60% defoliation) and on 0.8% of the plots as severe. Plots with low mean defoliation were found e.g. in Norway, eastern France, and Romania. Clusters of plots with mean defoliation values above 25% were mainly found in Slovakia, in the mountainous regions of the Czech Republic, in the Black Forest and other mountainous regions in Germany, in central and western parts of Slovenia, in the French Alps, and more scattered, in Norway and Sweden.

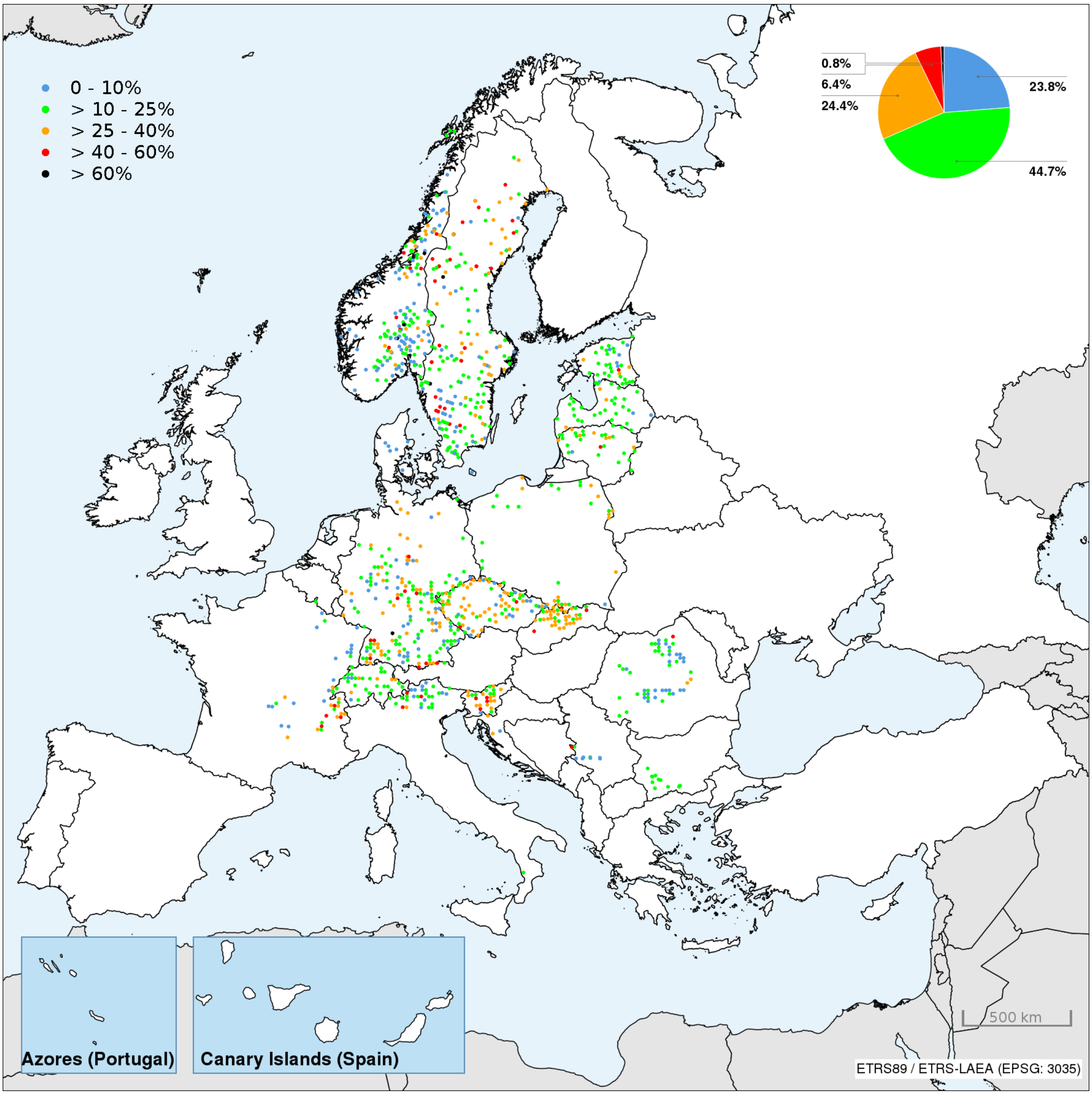


Figure 3-6. Mean plot defoliation of Norway spruce (*Picea abies*) in 2015.

From 1992 to 2015, a very slight but statistically significant increasing trend in mean plot defoliation of less than 1 percentage point every 10 years was observed (regional Sen's slope = 0.08 , p = 0.001; Figure 3-7). Deviations in the yearly mean plot defoliation of more than 2 percentage points from the trend line were observed only for the year 2013 (lower defoliation than average).

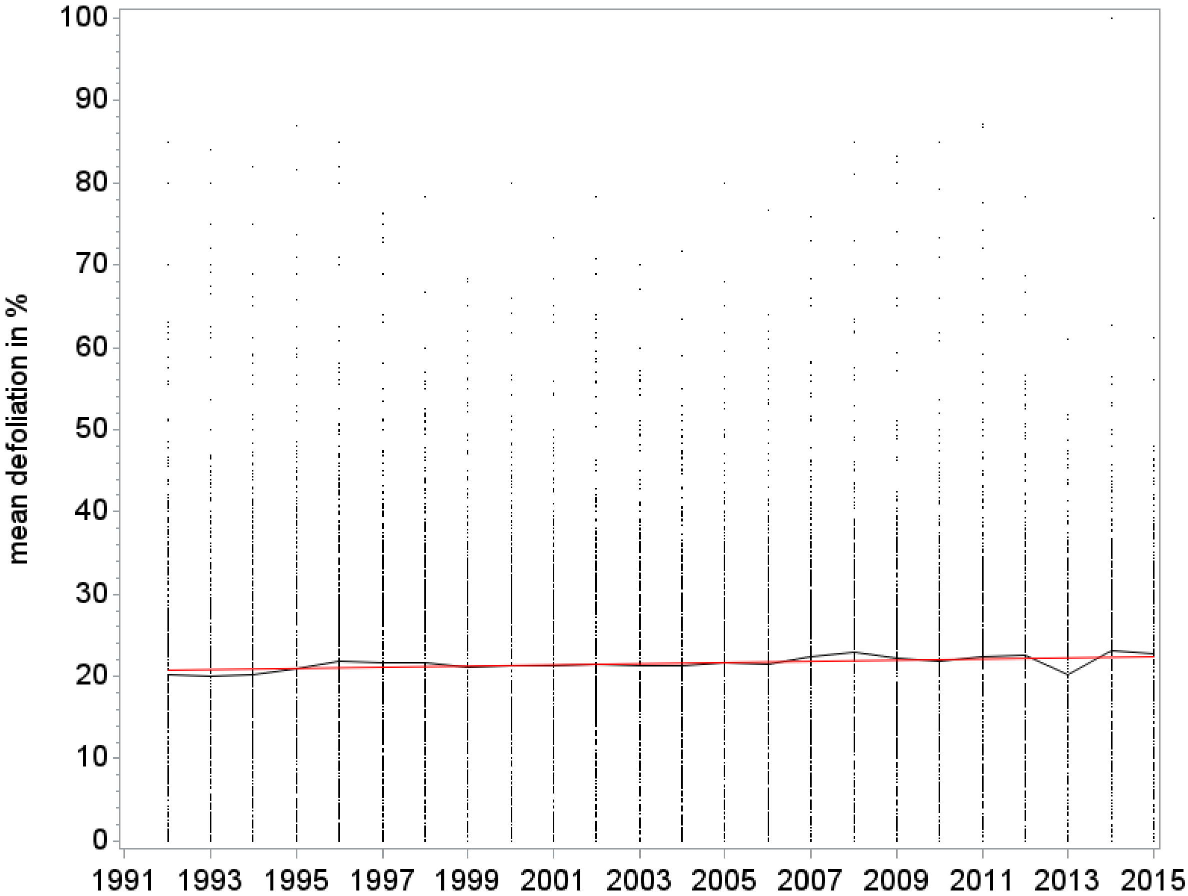


Figure 3-7. Over-all trend (regional Sen's slope = 0.076, p <0.001; minimum length of time span: 20 years, red line) and yearly over-all mean defoliation (black line) of Norway spruce at Level I sites; points represent annual plot means, for clarity these are not interconnected from year to year.

Austrian (or black) pine

The distribution range of Austrian pine (*Pinus nigra*) is mostly restricted to southern Europe. It is occurring in many Mediterranean countries and most frequently in Turkey. Scattered occurrences are found as far north as central France, northern Austria and northern Hungary.

In 2015, trees in more than two-thirds of the Austrian pine plots (77.5%) were on average not or only slightly defoliated (≤ 25% defoliation; Figure 3-8). Austrian pine showed the largest percentage of plots with less than 10% mean plot defoliation of all the considered tree species and species groups (23.4%), and these plots were primarily located in Turkey. Defoliation on 21.6% of the plots was classified as moderate (>25-60% defoliation) and on 0.9% of the plots as severe. Plots with no or low defoliation were mostly found in Turkey, while plots with high defoliation were scattered throughout Europe.

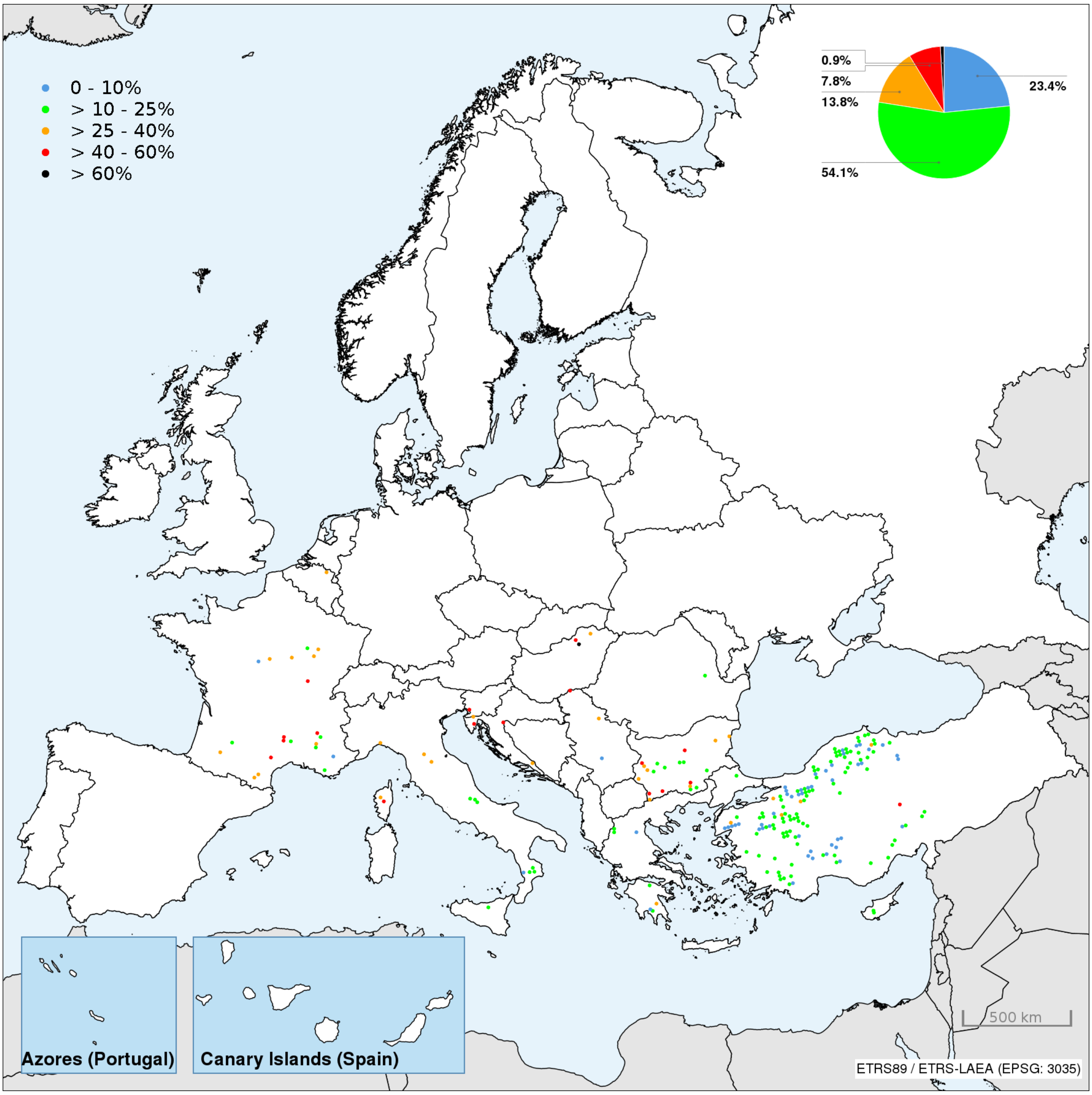


Figure3-8. Mean plot defoliation of Austrian pine (*Pinus nigra*) in 2015.

From 1992 to 2015, the over-all trend in mean plot defoliation in Austrian pine has been strongly increasing by five percentage points every 10 years with high statistical significance (regional Sen's slope = 0.5, $p < 0.001$; Figure 3-9). There were some deviations from this trend with lower defoliation in the early and late 1990s and from 2011 to 2012, while the years 2003, 2004, 2008 and 2015 were characterized by defoliation well above the mean trend. It is important to notice, however, that this trend analysis (as for the other species) is based on a consistent dataset with minimum of three trees of Austrian pine per plot and data available over the years 1992–2015 and a minimum assessment length of 20 years without Spain.

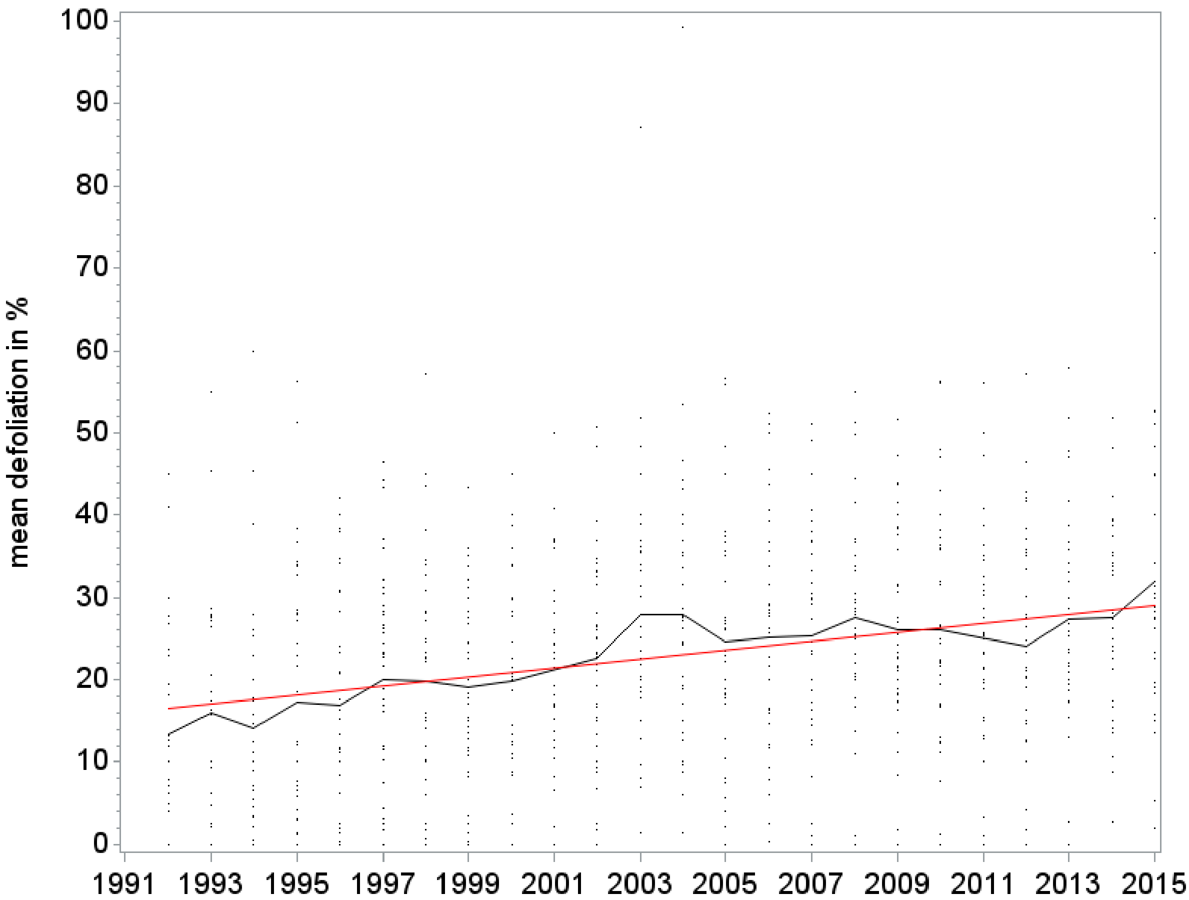


Figure 3-9. Over-all trend (regional Sen's slope = 0.5, p < 0.001; minimum length of time span: 20 years , red line) and yearly over-all mean defoliation (black line) of Austrian pine at Level I sites in France, Italy, Hungary, Romania, Bulgaria, Croatia and Belgium; points represent annual plot means, for clarity these are not interconnected from year to year.

Mediterranean lowland pines

Four pine species are included in the group of Mediterranean lowland pines: Aleppo pine (*Pinus halepensis*), maritime pine (*P. pinaster*), stone pine (*P. pinea*), and Turkish pine (*P. brutia*). These species occur in the Mediterranean region with warm and dry summers and mild and wet winters. Most plots dominated by Mediterranean lowland pines are located in Spain, some near the Atlantic and Mediterranean coasts in France, very few in Italy, Croatia, and Greece and again more in the lowlands of Turkey and Cyprus. Aleppo and maritime pine are more abundant in the western parts, and Turkish pine in the eastern parts of this area.

In 2015, trees in nearly four out of five plots with Mediterranean lowland pines (79.1%) were on average not or only slightly defoliated (Figure 3-10). Plots with moderate to high mean defoliation values (>40% defoliation) were mostly concentrated in south-eastern France, but also in northern Italy and Croatia, while plots with severe defoliation (>60%) were scattered in the distribution range.

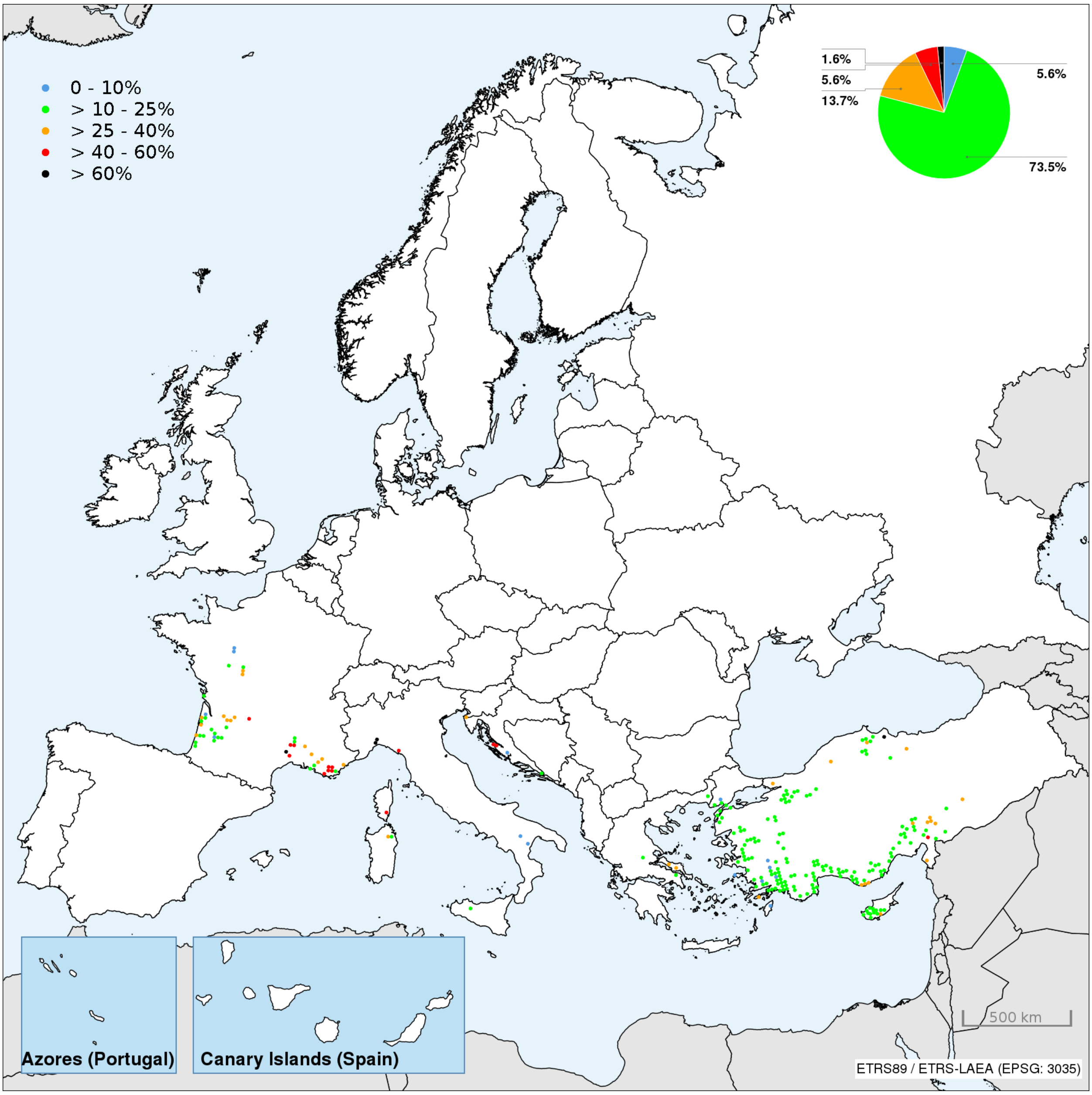


Figure 3-10. Mean plot defoliation of Mediterranean lowland pines (*Pinus halepensis*, *P. pinaster*, *P. pinea*, *P. brutia*) in 2015.

From 1992 to 2015, there was a strong and highly significant increase in the trend in mean plot defoliation of 8 percentage points every 10 years (regional Sen's slope = 0.8, $p < 0.001$; Figure 3-11). In the years 1992-1993, 2000-2002 and 2013, the yearly over-all mean plot defoliation was distinctly lower than the long-term trend. In contrast, in 1997 and 1998 values were higher than the trend with a maximum deviation of up to five percentage points from the trend. Concerning the strong increase in the trend line, it is important to notice that this trend analysis is based on a restricted sample of plots in only a few countries that have time series of minimum 20 years of assessments. Furthermore, due to the Spanish data missing in 2015, the sample of Mediterranean lowland pines was reduced from 8 100 trees in 2014 to 4 700 in 2015.

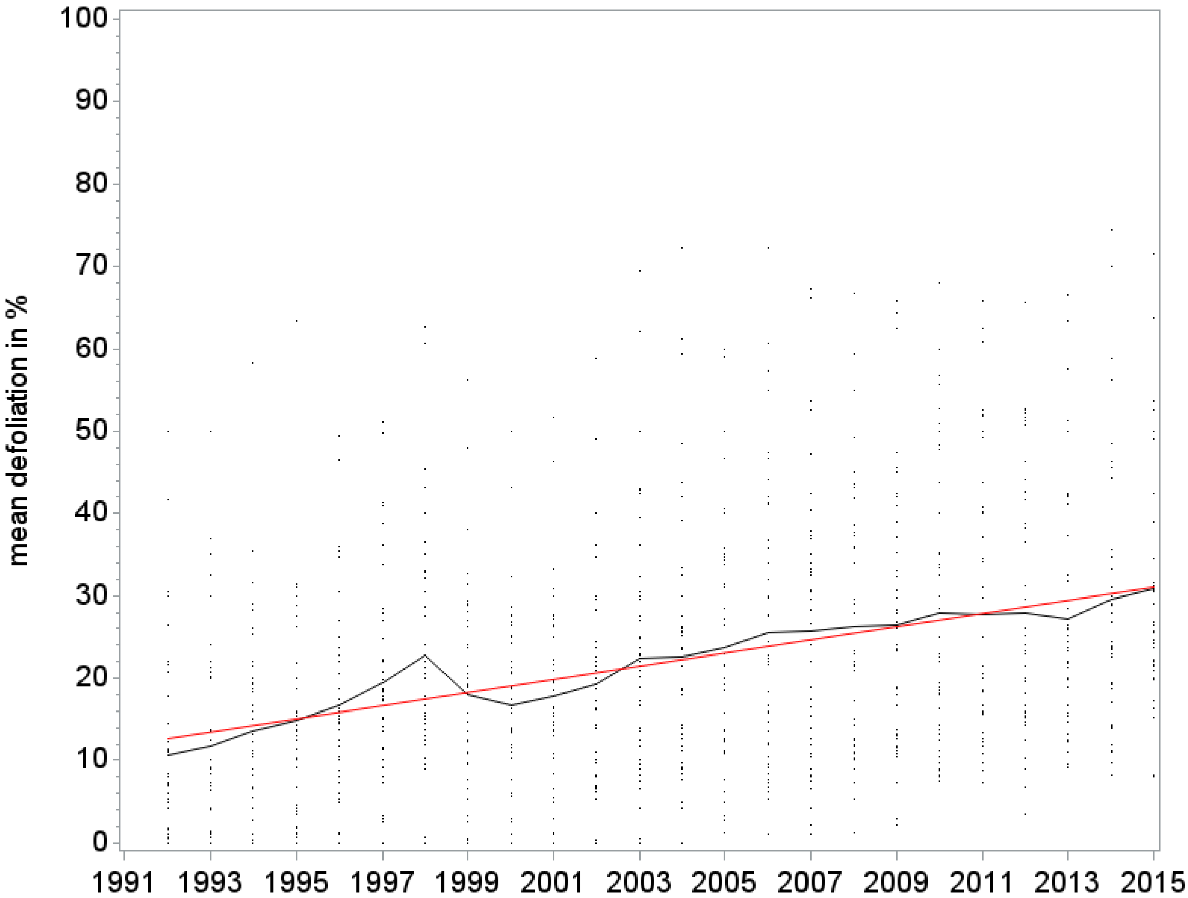


Figure 3-11. Over-all trend (regional Sen's slope = 0.8, p < 0.001; minimum length of time span: 20 years , red line) and yearly over-all mean defoliation (black line) of Mediterranean lowland pines (*Pinus halepensis*, *P. pinaster*, *P. pinea, P. brutia*) at Level I sites in France, Italy and Croatia; points represent annual plot means, for clarity these are not interconnected from year to year.

Common beech

Common beech (*Fagus sylvatica*) is the most frequently assessed deciduous tree species within the ICP Forests monitoring programme. It is found on Level I plots from southern Scandinavia in the north to southernmost Italy, and from the Atlantic coast of northern Spain in the West to the Bulgarian Black Sea coast in the east.

In 2015, common beech plots with less than 10% mean plot defoliation were primarily located in Romania (Figure 3-12). On more than half of the monitored plots (52.6%), trees were only slightly defoliated so that on three quarters (75.5%) of all beech plots defoliation was either absent or low (≤ 25% defoliation). Plots with moderate (23.6% of all plots) to severe (0.9% plots) mean defoliation values were predominantly located in Germany, France, northern Italy, Slovenia and Croatia.

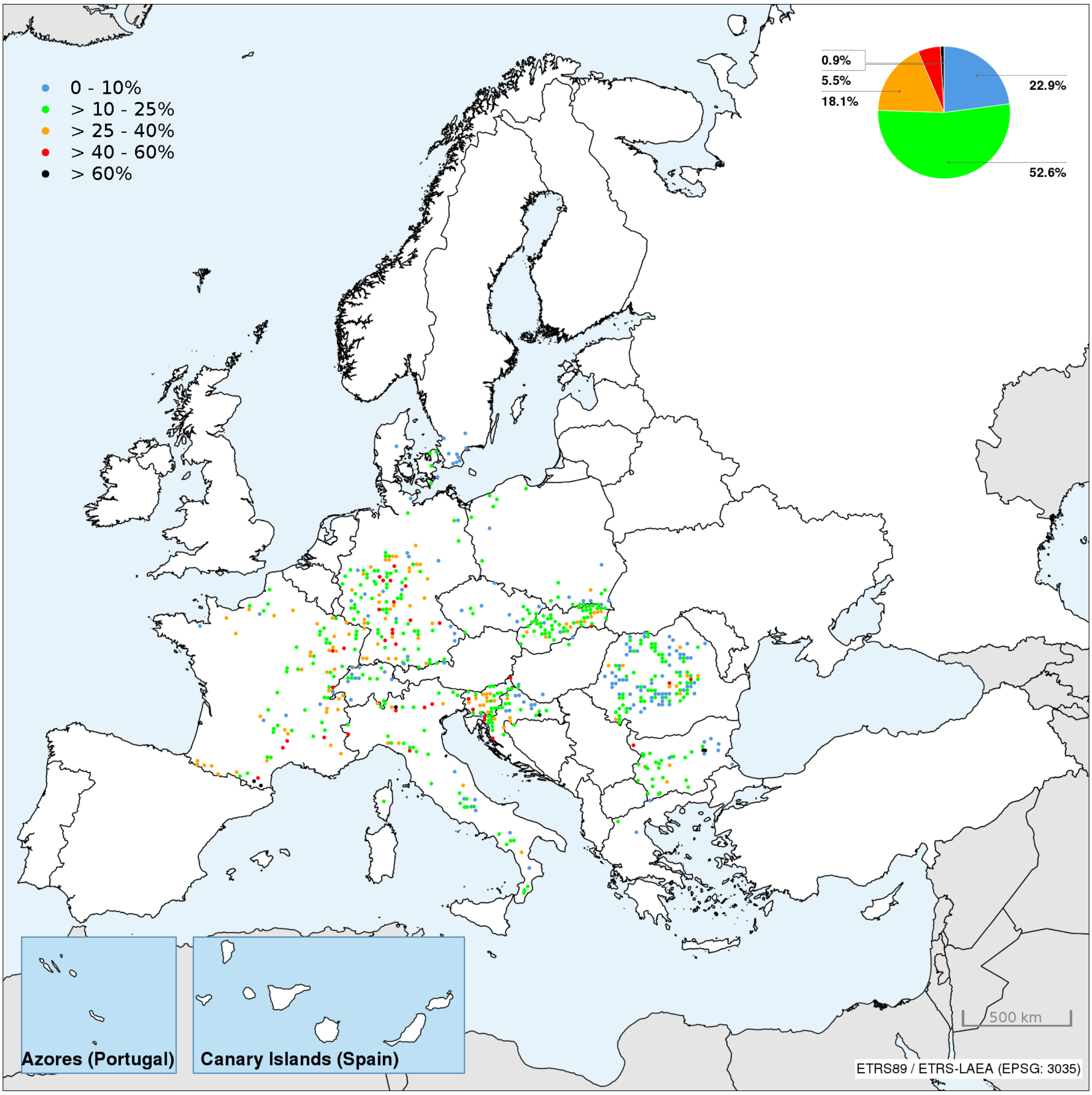


Figure 3-12. Mean plot defoliation of common beech (*Fagus sylvatica*) in 2015.

From 1992 to 2015, the over-all trend in mean plot defoliation in beech has been slightly but significantly increasing by approximately 2 percentage points every 10 years (regional Sen's slope = 0.17, p < 0.001; Figure 3-13). There were only a few deviations from this trend. In 2004, for example, the annual over-all mean defoliation was more than 4 percentage points higher than the trend, possibly as a result of the drought in the preceding year which had affected large parts of Europe (Ciais et al. 2005, Seidling 2007). In years like 1993, 2010 and 2015 on the other hand, trees have been recovering as indicated by a negative deviation from the over-all trend.

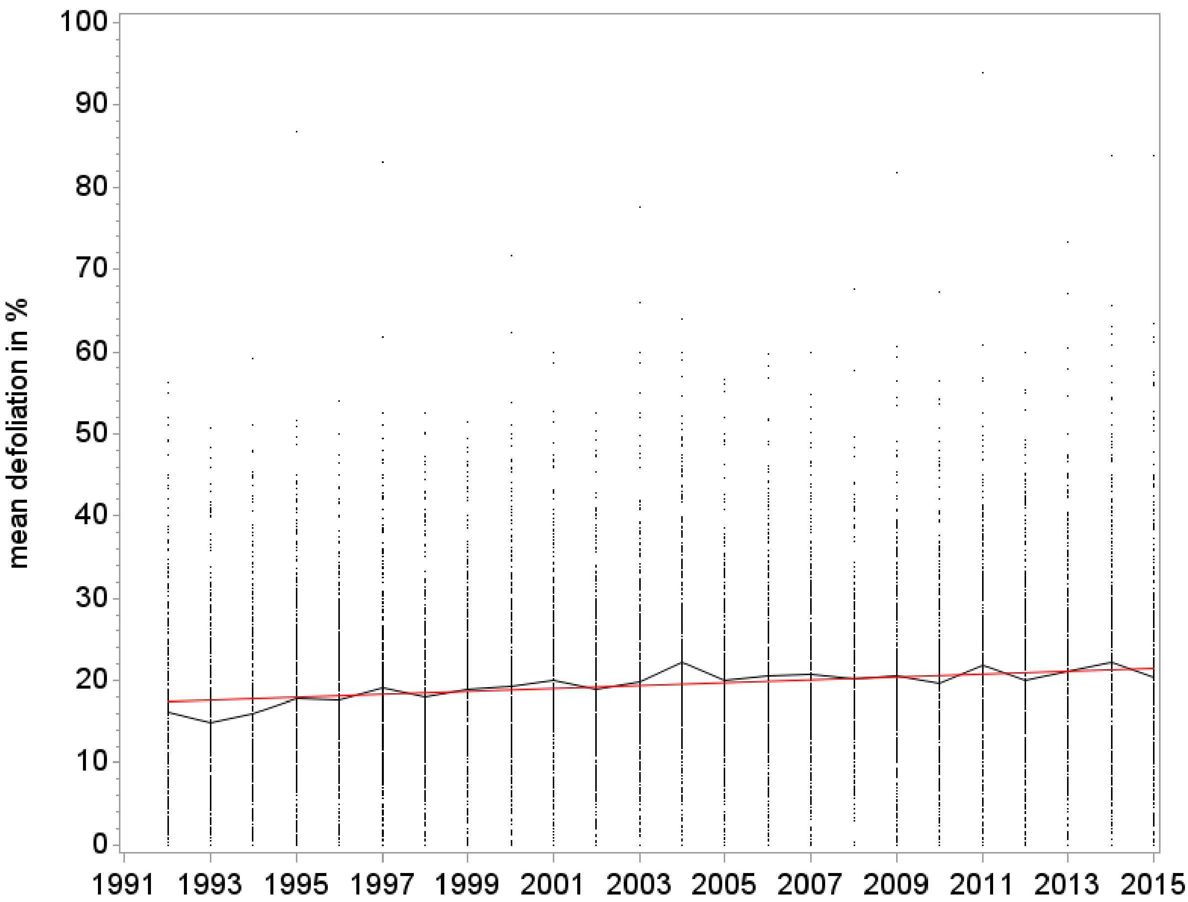


Figure 3-13. Over-all trend (regional Sen's slope = 0.174, p < 0.001; minimum length of time span: 20 years , red line) and yearly over-all mean defoliation (black line) of *Fagus sylvatica* at Level I sites; points represent annual plot means, for clarity these are not interconnected from year to year.

Deciduous temperate oaks

Deciduous temperate oaks include pedunculate and sessile oak (*Quercus robur* and *Q. petraea*) and their hybrids. They cover a large geographical area from southern Scandinavia to southern Italy and from the northern coast of Spain to the eastern parts of Turkey.

In 2015, deciduous temperate oaks were on average not or only slightly defoliated (≤ 25% defoliation) in more than half of the plots (58.1%), moderately defoliated (>25–60% defoliation) in 40.7% and severely defoliated (i.e. more than 60% defoliation) in 1.2% of the plots (Figure 3-14). Most of the plots with moderate to severe defoliation were located in France, on the other hand many other plots in France showed no or only little defoliation.

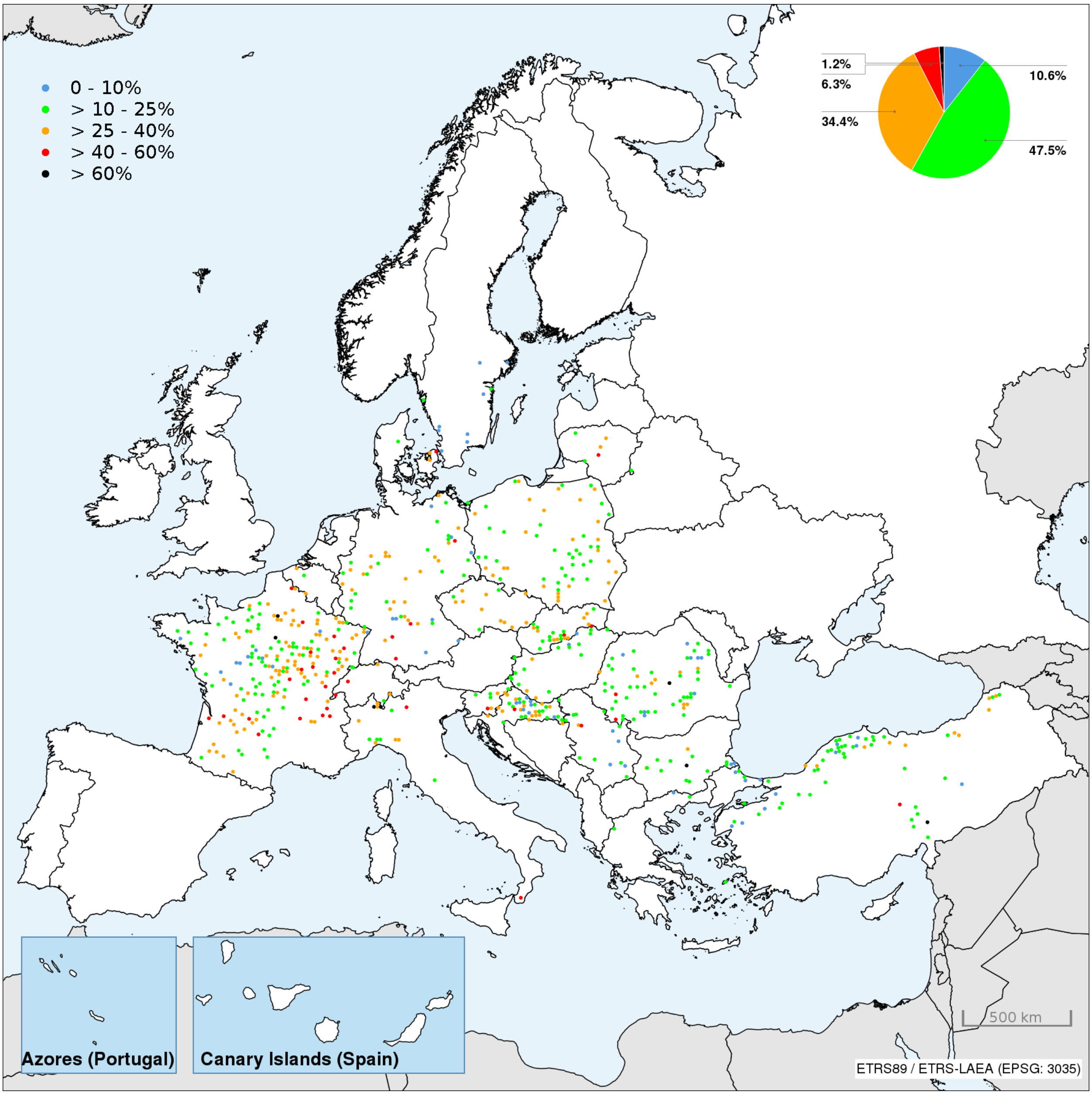


Figure 3-14. Mean plot defoliation of deciduous temperate oaks (*Quercus robur* and *Q. petraea*) in 2015.

Deciduous temperate oaks showed a rather strong increase of the over-all trend in mean plot defoliation from 1992 to 2015 with a statistically significant increase of 3.3 percentage points every 10 years (regional Sen's slope = 0.333, $p < 0.001$; Figure 3-15). The annual plot mean development has not been linear. Between 1992 and 1997 there was a steeper than average increase in defoliation and from 2005 onwards a stagnation at a comparatively high level took place. Apart from these long-term dynamics, short-term developments can also be identified with a peak around 1997 and a second peak between 2003 and 2005. The latter can be connected with the drought year 2003 and its medium-term consequences for trees (delayed recovery). With the exception of 2012, defoliation seems to have stabilized since 2009, and although still at a high level, the annual mean has been well below the over-all trend in this period.

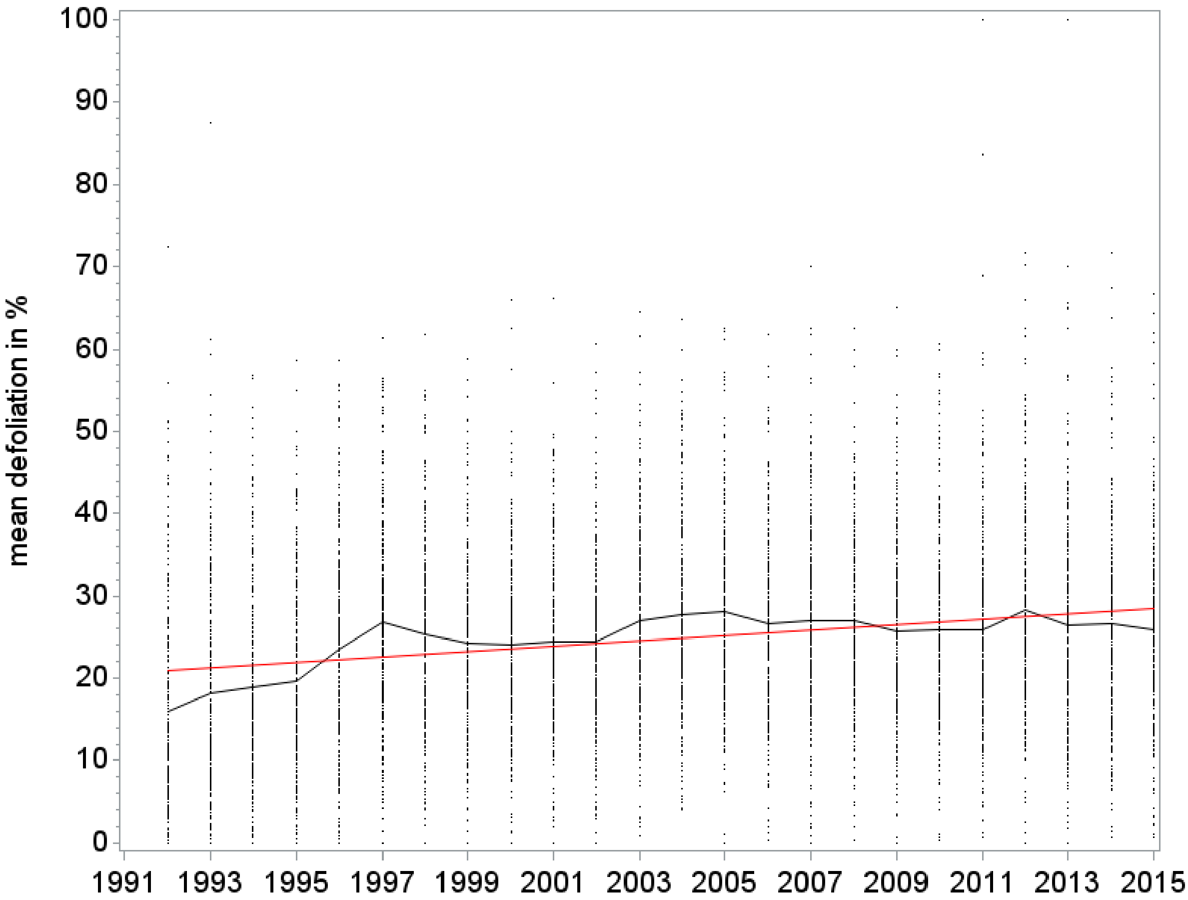


Figure 3-15. Over-all trend (regional Sen's slope = 0.333, p < 0.001; minimum length of time span: 20 years , red line) and yearly over-all mean defoliation (black line) of deciduous temperate oaks (*Quercus robur* and *Q. petraea*) at Level I sites; points represent annual plot means, for clarity these are not interconnected from year to year.

Deciduous (sub-) Mediterranean oaks

The group of deciduous (sub-) Mediterranean oaks includes Turkey oak (*Quercus cerris*), Hungarian or Italian oak (*Q. frainetto*), downy oak (*Q. pubescens*) and Pyrenean oak (*Q. pyrenaica*). The range of distribution of these oaks is confined to southern Europe.

In 2015, trees in more than two thirds (69.8%) of the plots dominated by deciduous (sub-) Mediterranean oaks were on average not or only slightly defoliated (Figure 3-16). These plots were spread all over the area of these oaks' distributions, although most of them were found in eastern countries like Hungary, Romania, Serbia and Turkey. 8% of the plots had a mean defoliation between 40% and 60%, and 1.4% of the plots had defoliation more than 60%. Most of those plots were located in southern France and scattered throughout Italy.

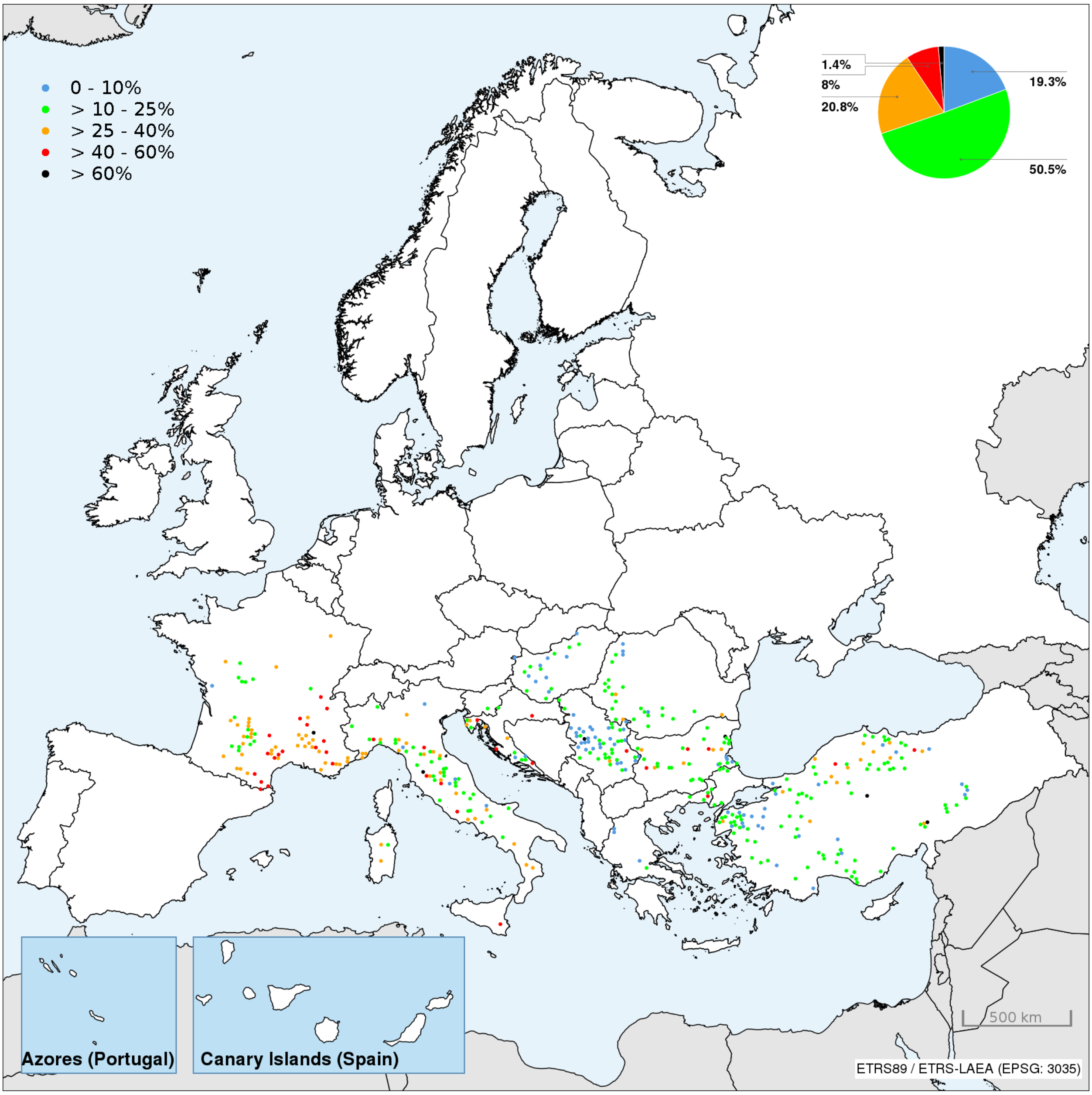


Figure 3-16. Mean plot defoliation of deciduous (sub-) Mediterranean oaks (*Quercus cerris*, *Q. frainetto*, *Q. pubescens*, *Q. pyrenaica*) in 2015.

From 1992 to 2015, the over-all trend in mean plot defoliation of deciduous (sub-) Mediterranean oaks showed the same statistically significant increase of 1 percentage point every 3 years (i.e. 3.3 percentage points every 10 years) as the deciduous temperate oaks (regional Sen's slope = 0.33, p < 0.001; Figure 3-17). Mean plot defoliation strongly increased from 1992 to 1996 before levelling off in the consecutive years.

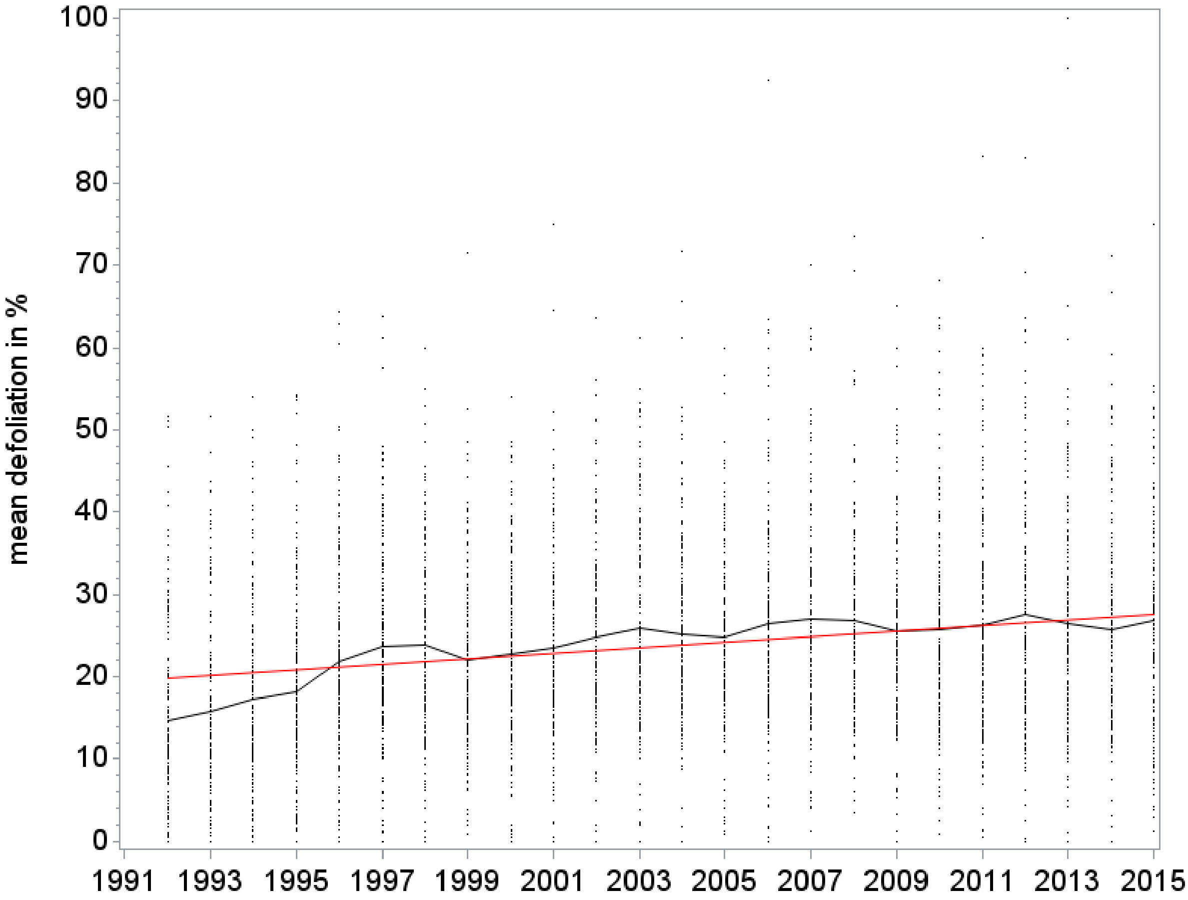


Figure 3-17. Over-all trend (regional Sen's slope = 0.333, p < 0.001; minimum length of time span: 20 years , red line) and yearly over-all mean defoliation (black line) of deciduous (sub-) Mediterranean oaks (*Quercus cerris*, *Q. frainetto*, *Q. pubescens*, *Q. pyrenaica*) at Level I sites; points represent annual plot means, for clarity these are not interconnected from year to year.

Evergreen oaks

The group of evergreen oaks consists of kermes oak (*Quercus coccifera*), holm oak (*Q. ilex*), Ballota oak (*Q. rotundifolia*) and cork oak (*Q. suber*). The occurrence of this species group as a typical element of the sclerophyllous woodlands is confined to the Mediterranean basin.

In 2015, evergreen oaks in roughly half of the plots (53.3%) were on average not or only slightly defoliated (Figure 3-18). The other half of the plots was either moderately defoliated (45%) or severely defoliated (1.7%). Trees in southern (Mediterranean) France (including Corsica) and one plot in northern Italy showed particularly high defoliation.

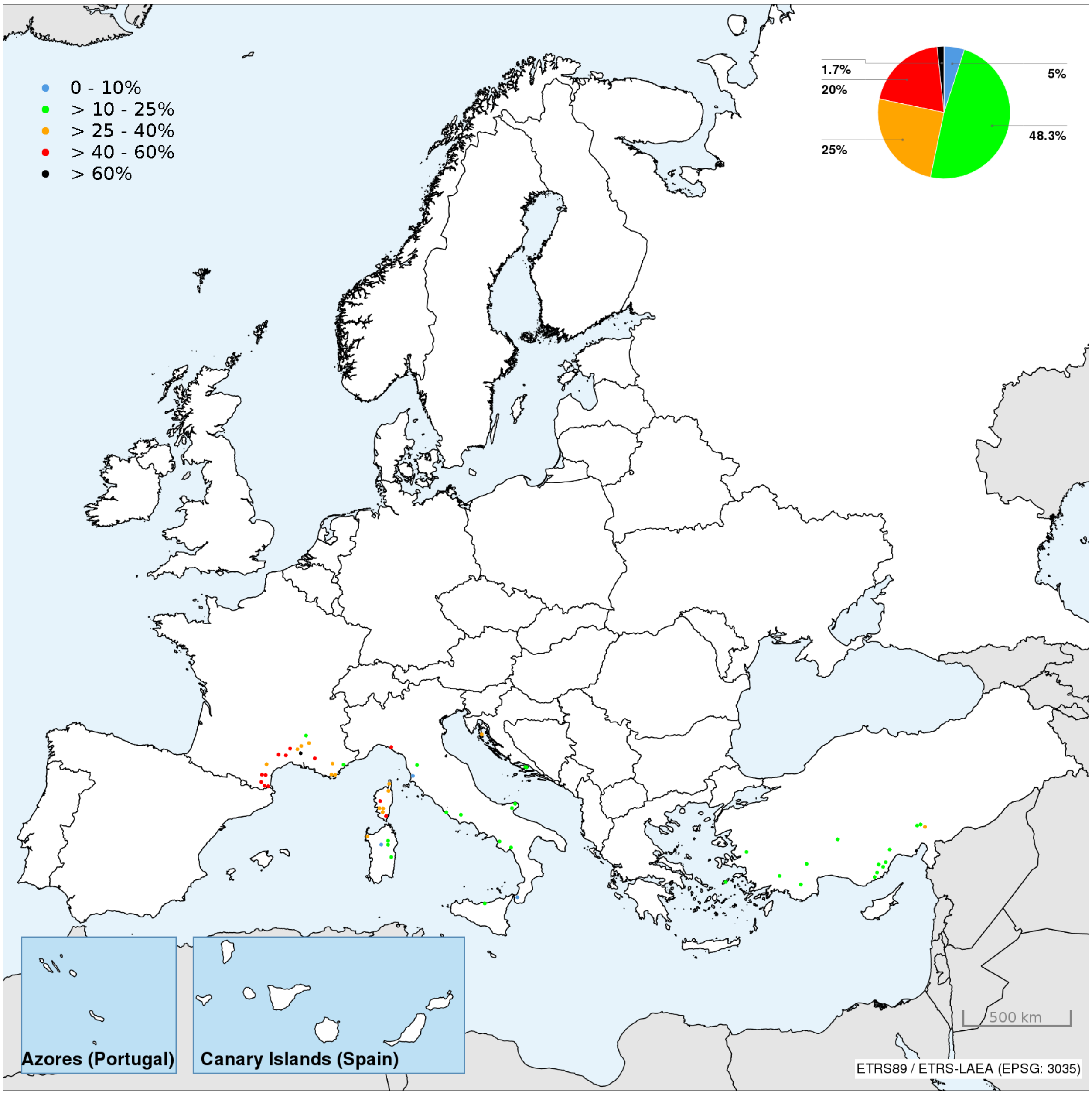


Figure 3-18. Mean plot defoliation of evergreen oaks (*Quercus coccifera*, *Q. ilex*, *Q. rotundifolia*, *Q. suber*) in 2015.

From 1992 to 2015, evergreen oak plots showed a dramatically increasing and statistically significant over-all trend in mean defoliation with an increase of 1 percentage point every year (regional Sen's slope of 1.0, $p < 0.001$; Figure 3-19). Several comparably large deviations from the linearly increasing trend were observed in both directions. As already mentioned in the subchapters on Austrian pine and Mediterranean lowland pines, it is important to notice that this trend analysis is based on a restricted sample of plots from a few countries. Furthermore, the sample of evergreen oak trees was reduced drastically from 4 600 in 2014 to only 950 in 2015 due to the Spanish data missing in 2015.

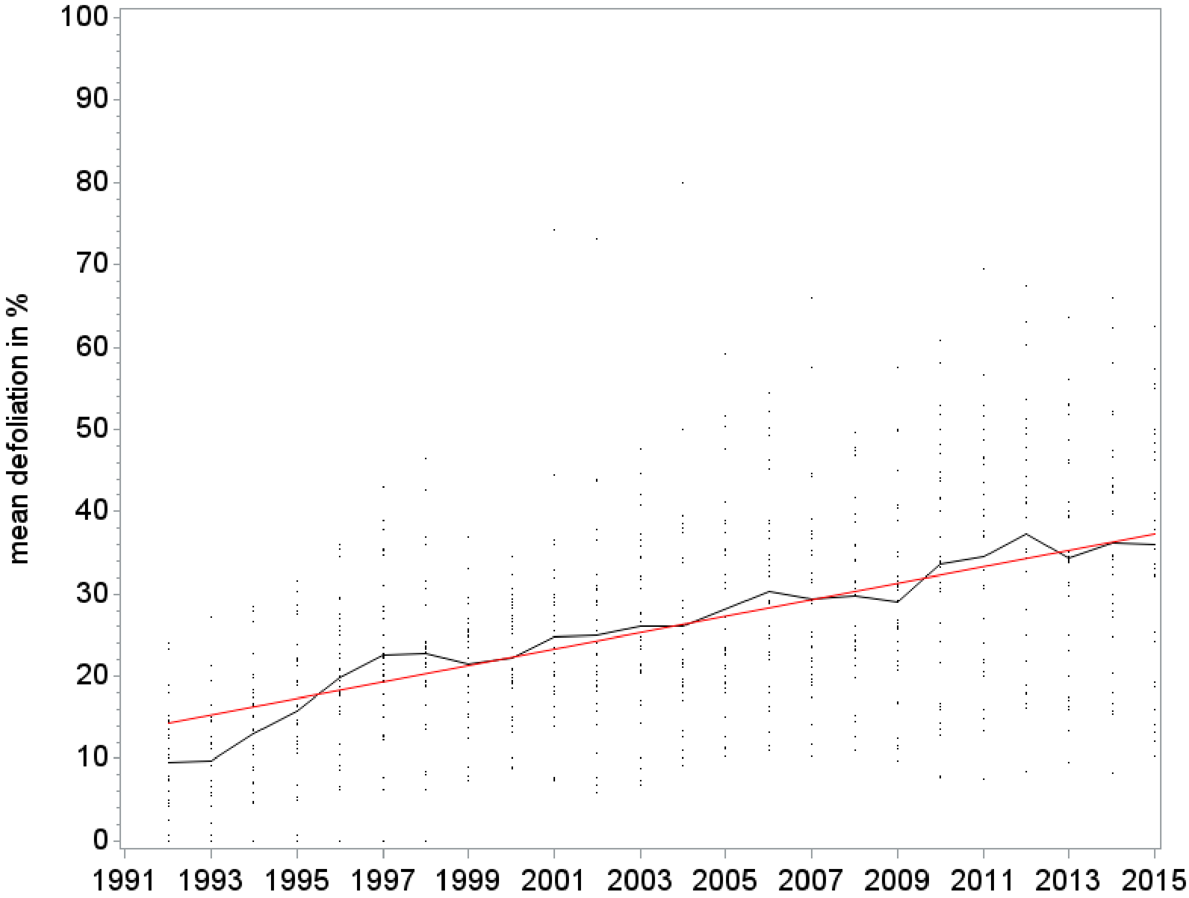


Figure 3-19. Over-all trend (regional Sen's slope = 1.0, p < 0.001; minimum length of time span: 20 years , red line) and yearly over-all mean defoliation (black line) of evergreen oaks (*Quercus coccifera*, *Q. ilex*, *Q. rotundifolia*, *Q. suber*) at Level I sites France, Italy and Croatia; points represent annual plot means, for clarity these are not interconnected from year to year.

Damage causes

In 2015, damage cause assessments were carried out on 88 052 trees on 4 818 plots in 25 countries (Figure 3-20). In total, 37 211 trees (42.3%) showed symptoms of damage of at least one defined agent group, of those 1 221 trees were deemed dead. In total 47 829 observations of damage were recorded. 1 539 plots showed no symptoms of damage on any tree. The number of damage on any individual tree can be more than one and the causes can also be multiple within one location. Therefore the number of cases analysed varies depending on the parameter.

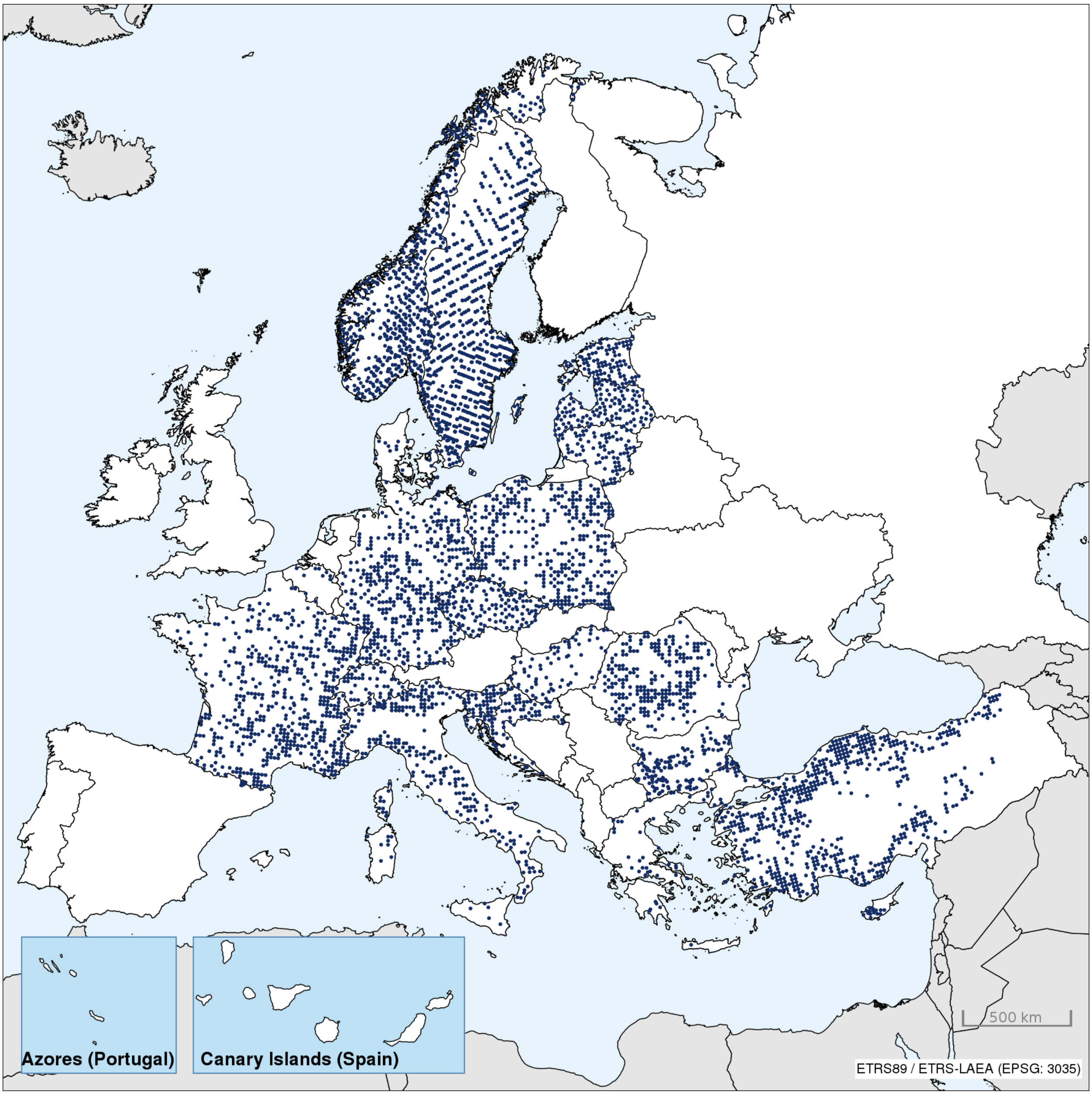


Figure 3-20. Plots with damage cause assessment in 2015.

Symptom description and damage extent

In total 47 829 damage symptoms were recorded, with some trees showing more than one symptom. For specification the affected parts of the tree or the location in the crown were recorded during the damage assessments (Figure 3-21). Most of the symptoms were observed on leaves (33.6%), followed by twigs and branches (23.7%), and the stem (20.6%). Needles were also often affected (13.8%), while roots & collar and shoots & buds were less frequently affected (3.2% and 0.1%, respectively).

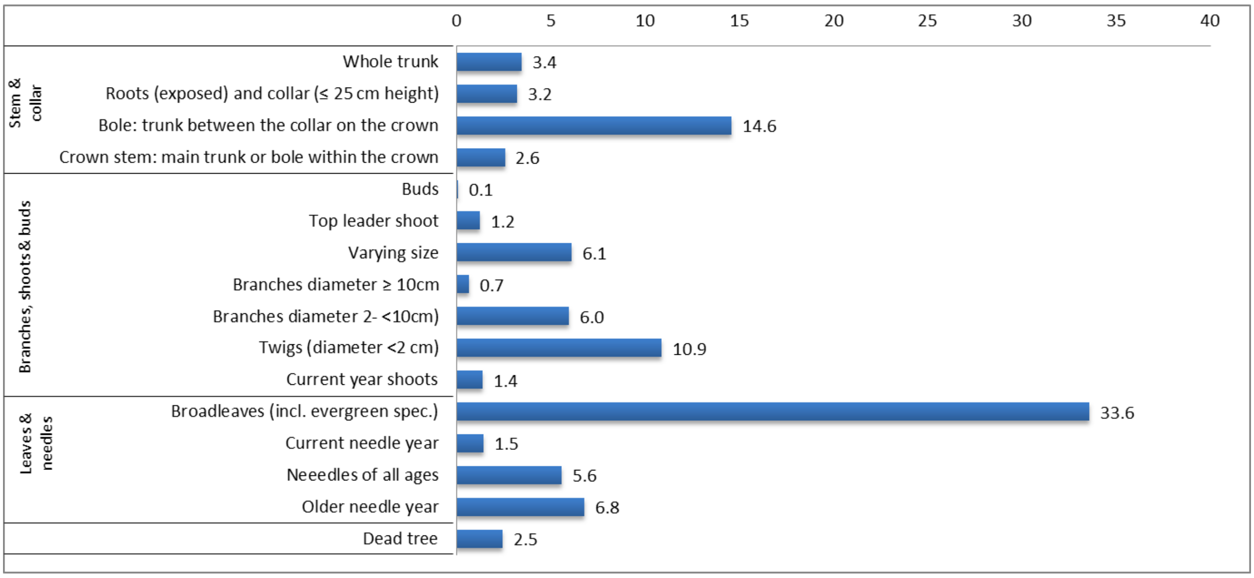


Figure 3-21. Damage symptoms (%) according to specifications of the affected part of a tree (n=47 829). Trees could have more than one affected part.

More than half (55.9%) of all recorded damage symptoms had an extent of up to 10% (extent classes 0 and 1, Figure 3-22; cf. Table 3-3), approximately one third (35.9%) had an extent of >11–40% (extent classes 2 and 3), and only 8.2% of the symptoms covered more than 40% of the affected part of a tree (extent classes 4 to 7).

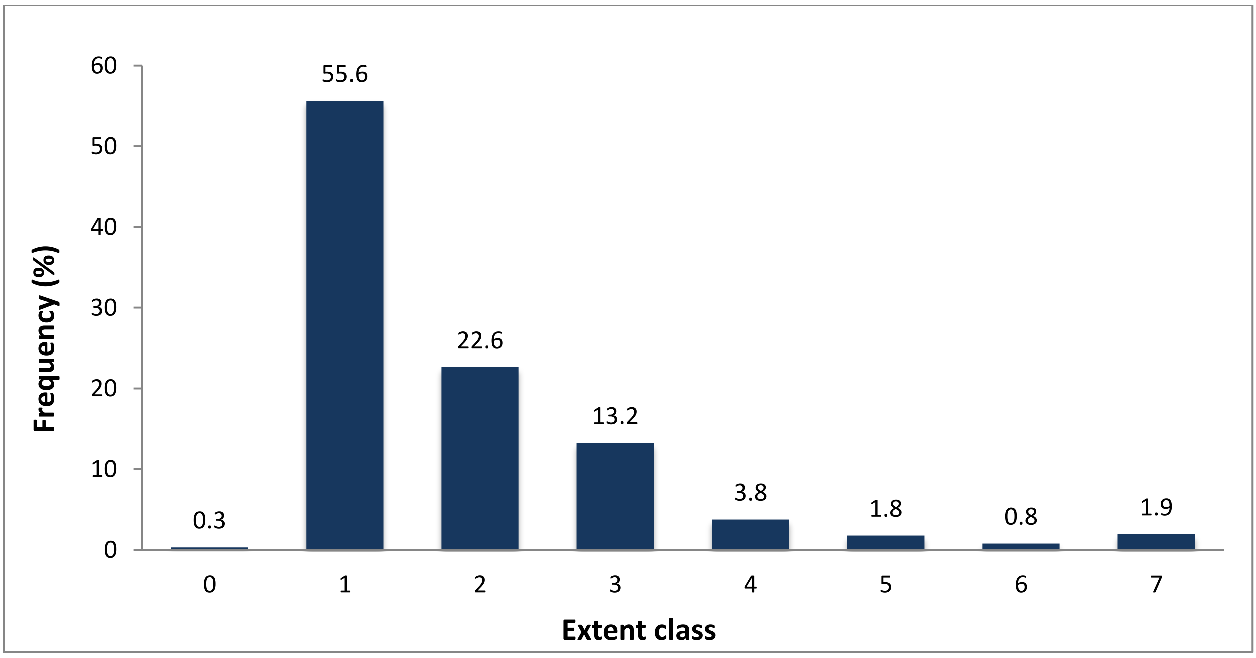


Figure 3-22. Damage symptoms according to their extent class in 2015 (n=47 095). In trees with multiple types of damage symptoms of different extents, all extent values were evaluated.

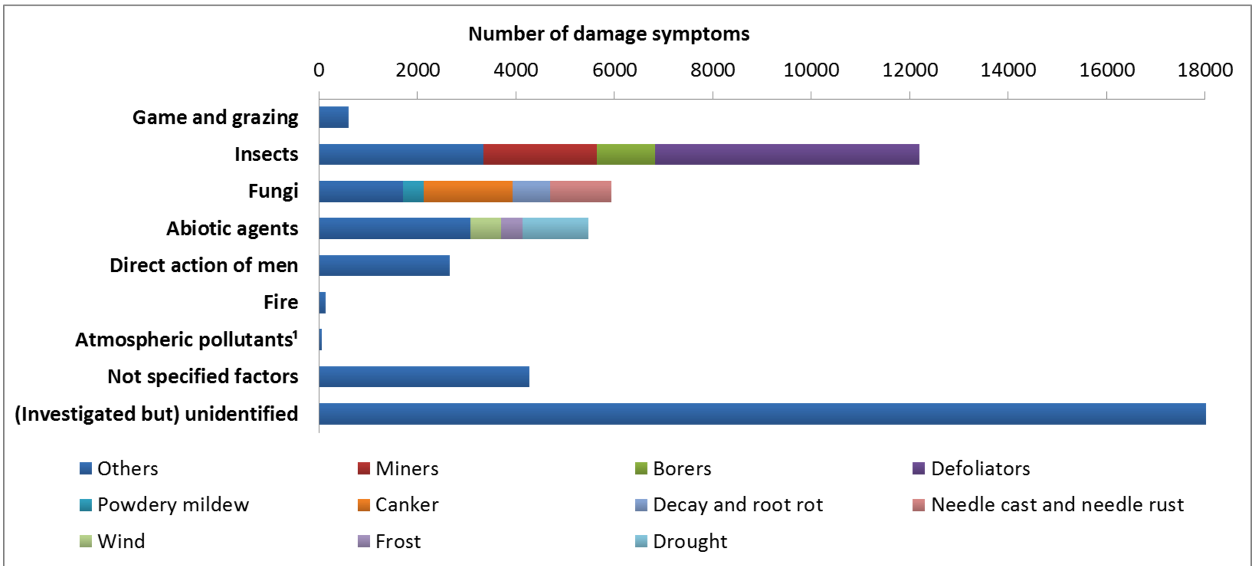
Causal agents and factors responsible for the observed damage symptoms

Insects were the predominant identified cause of damage, causing almost one quarter of all recorded damage symptoms (22.5%; Figure 3-23). Almost half of these insect-caused symptoms were attributed to defoliators (44%), which also represented the most frequent of all damage causes. Leaf-mining insects were responsible for damage on nearly 19% and wood-boring insects on 9.6% of the trees with insect-caused symptoms

Fungi were the second major causal agent group affecting 10.9% of all assessed trees. Of those 30% showed signs of canker, followed by needle cast and needle rust fungi (20.1%) and decay and root rot fungi (12.8%).

The third major identified cause of tree damage was abiotic agents (10.1% of all damage symptoms). Within this agent group, 24.5% of the symptoms were attributed to drought, while wind caused 11.4% and frost 7.9%.

The damaging agent group 'Game and grazing' was of minor importance (1%) and may mainly be relevant in young tree stands. Direct action of men, including amongst others silvicultural operations and mechanical damage from vehicles, accounted for 4.9% of all recorded damage symptoms. Fire caused only 0.2% of all damage symptoms. The agent group 'Atmospheric pollutants' refers to local incidents mainly in connection with factories, power plants, etc. Visible symptoms of direct atmospheric pollution impact, however, were rare (0.1% of all damage symptoms). Apart from these identifiable causes of damage symptoms, a considerable amount of symptoms could not be identified (42.1%) or was caused by other causal agents not explicitly listed here (7.9%).



[1] Visible symptoms of direct atmospheric pollution impact only

Figure 3-23. Damage symptoms according to agent group and specific agents/factors (n=54 029). Each agent group was only counted once per tree.

The occurrence of damaging agent groups slightly differed between major species or species groups. Of all of the identified damage causes, insects were the most prominent in four of the seven main groups. This holds especially for common beech (43.5%) and the decididous Mediterranean oak species (31.8%; Figure 3-24). Fungi as damaging agents were almost equally important in all species or species groups but for *Pinus sylvestris* which had more than 15% of fungal damage. Abiotic factors caused most damage in evergreen oak (15.6%) and *Pinus nigra* (19%). Damage from game and grazing played a minor role in all species and species groups but for *Picea abies* (6.2%).

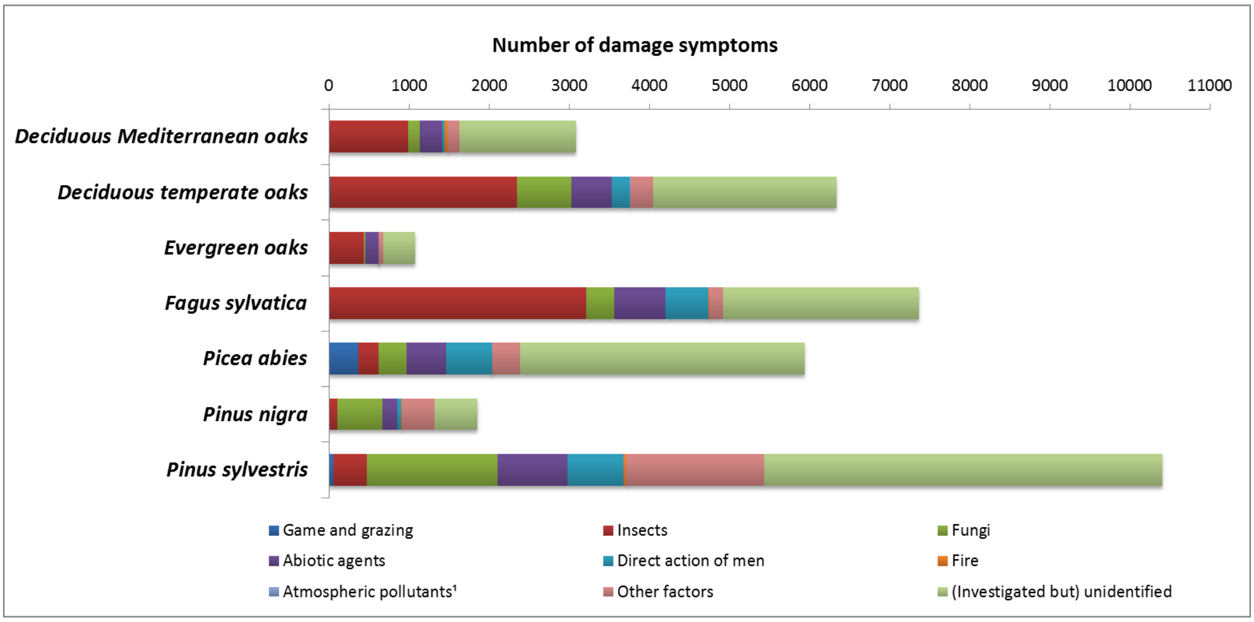


Figure 3-24. Damage symptoms according to agent group in the main tree species and species groups on Level I plots. [1] Visible symptoms of direct atmospheric pollution impact only.

Distribution of agent groups

The mean number of assessed trees per plot is 10.4, ranging from only one tree assessed to 56. The classification of agent groups on the following maps is based on the extent to which each individual agent group occurred. Values smaller or equal to the 1st Quantile are in class 1 (blue), between the 1st and 3rd Quantile are in class 2 (yellow) and greater than the 3rd Quantile are in class 3 (red). The specific ranges are given in Table 3-8.

Table 3-8. Quantiles for the specific agent groups.

Category	1st Quantile	Median	3rd Quantile
Game and grazing	1	1	3
Insects	2	6	14
Fungi	1	3	8
Abiotic agents	1	2	4
Direct action of men	1	2	4
Fire	1	3	7
Atmospheric pollutants	2	3	20
Other factors	1	3	7

The agent groups on the following maps will also be discussed with regard to the forest type they had occurred in. Of the assessed plots about 10% are located in broadleaved monocultures (Figure 3-25). The majority is found in broadleaved- or coniferous-mixed stands making up about 30% each. Another 25% are located in broadleaved-coniferous-mix stands and only 4% are coniferous monocultures.

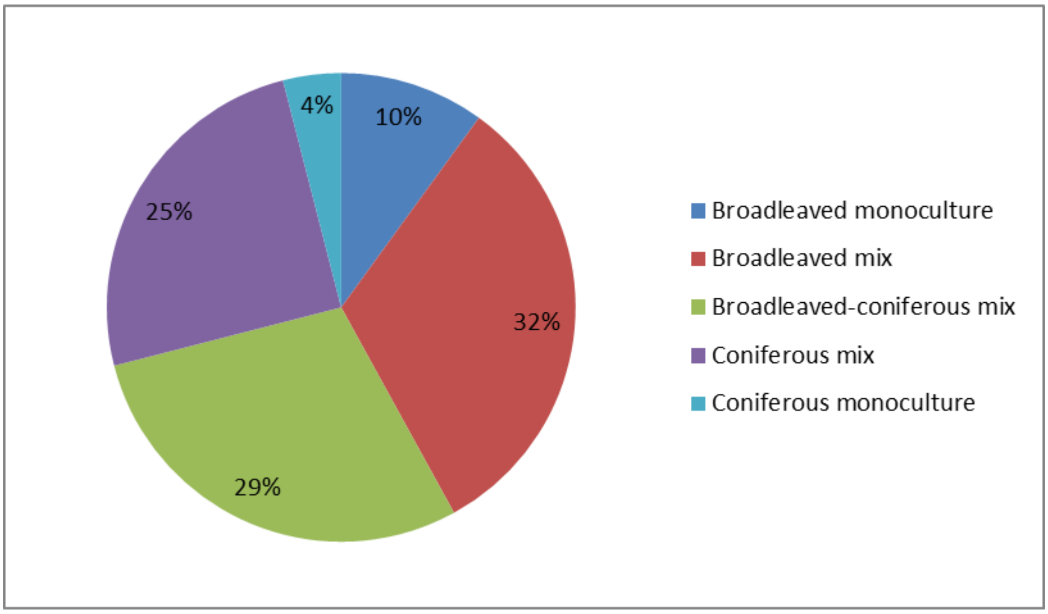


Figure 3-25: Location of assessed plots with regard to forest type.

Agent group 'Game and grazing'

In 2015, damage caused by game and grazing was mainly observed in the Baltic States (Figure 3-26). Futher plots heavily affected by game and grazing were found in the mountainous border regions between the Czech Republic, Germany, and Poland, as well as on some sites in Germany. It is important to note that these results are not representative as they may be biased due to the fact that young trees, the main target trees for game and grazing, are underrepresented in the damage assessments.

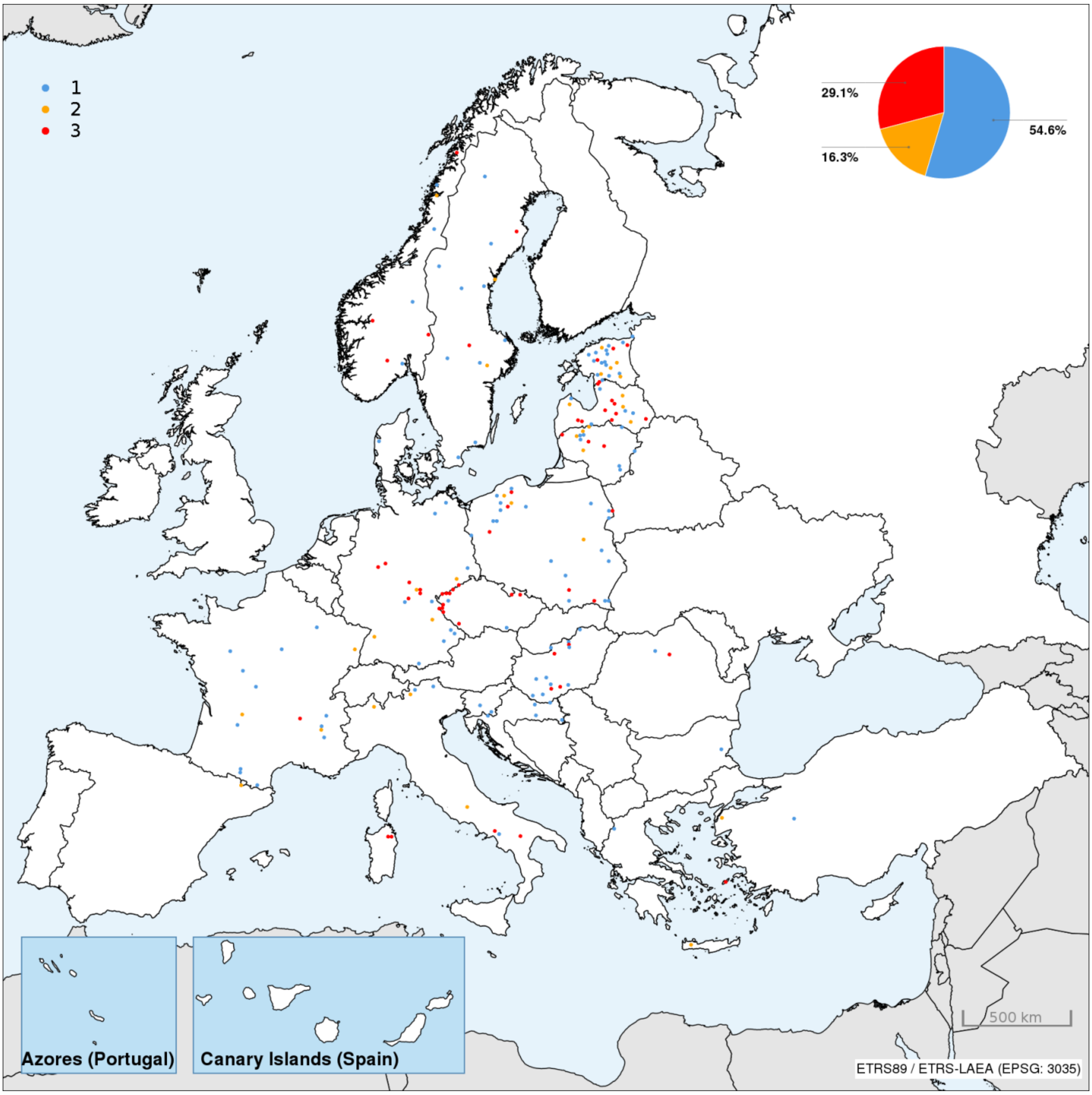


Figure 3-26. Extent of damaging agent group 'Game and grazing' in 2015. Values smaller or equal to the 1st Quantile are in class 1 (blue), values between the 1st and 3rd Quantile are in class 2 (yellow), and values greater than the 3rd Quantile are in class 3 (red). The specific ranges are given in Table 3-8.

Agent group 'Insects'

The most frequently observed agent group was 'Insects' with 19% of the plots affected by any damaging agent. Occurences are reported across Europe with very low numbers only found in Norway and Sweden in the north and the Czech Republic (Figure 3-27). The majority of plots affected by insect damage were found in broadleaved-mixed stands, followed by broadleave-coniferous-mixed stands; only a minority below 5% are broadleave monocultures, coniferous-mixed and coniferous monocultures.

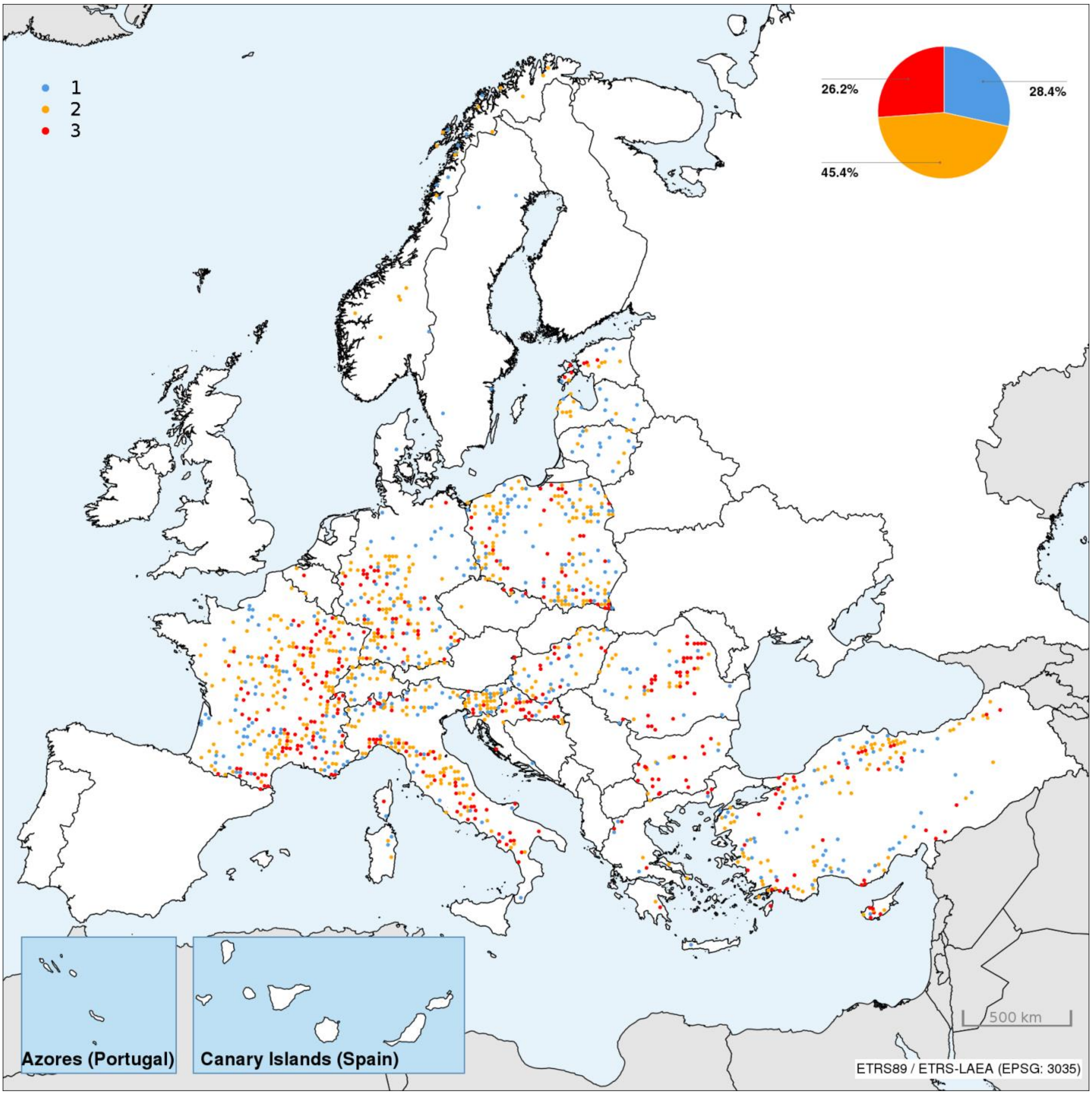


Figure 3-27. Extent of damaging agent group 'Insects' in 2015. Values smaller or equal to the 1st Quantile are in class 1 (blue), values between the 1st and 3rd Quantile are in class 2 (yellow), and values greater than the 3rd Quantile are in class 3 (red). The specific ranges are given in Table 3-8.

Agent group 'Fungi'

Plots with a high frequency of fungal occurances were reported from Estonia, the south-eastern border of Poland and Bulgaria (Figure 3-28). However there are also non clustered occurences in Romania, Hungary, Italy, France and Germany. Fungal damage occured mostly in broadleaved-coniferous-mixed stands (55.2%).

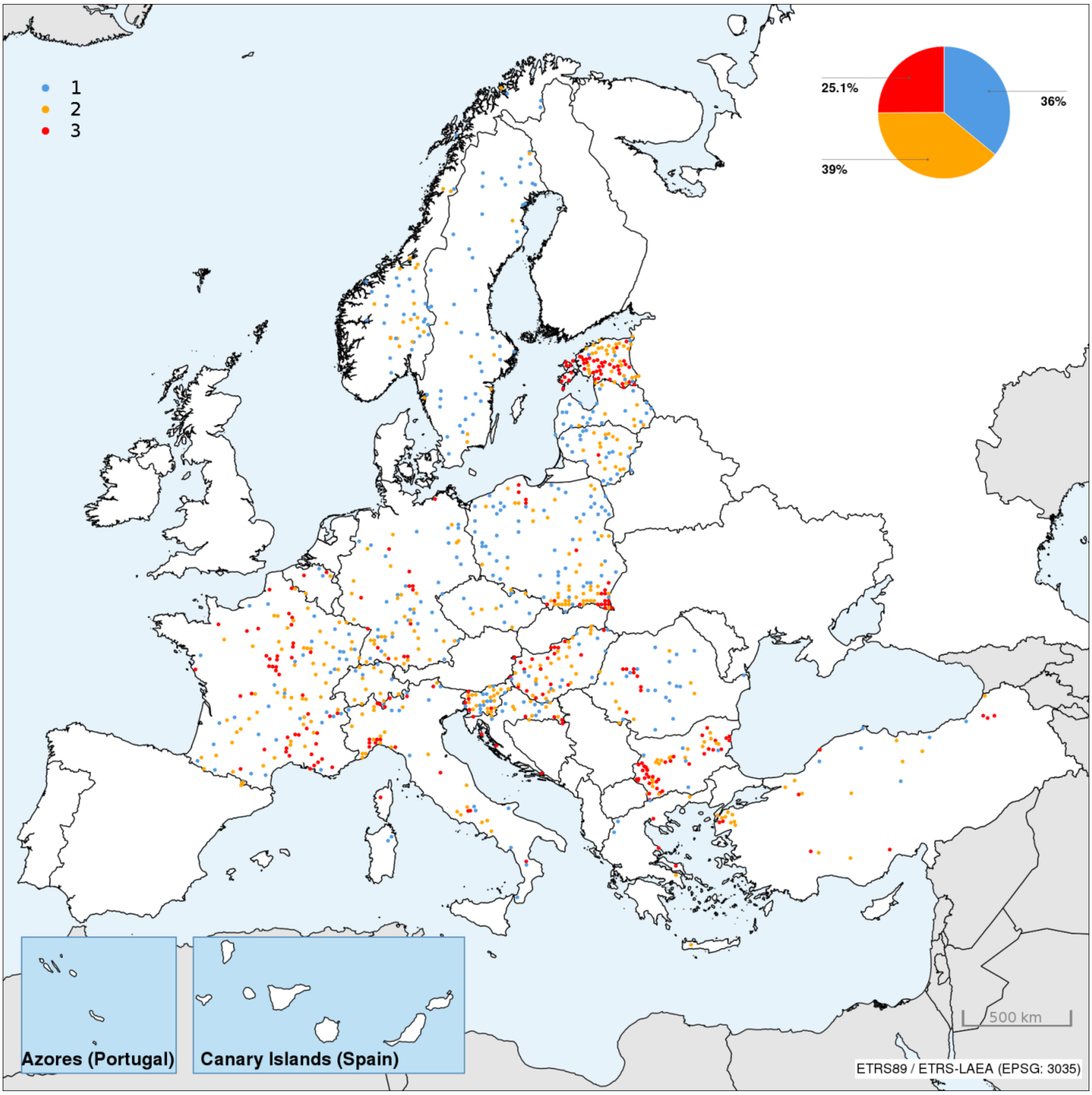


Figure 3-28. Extent of damaging agent group 'Fungi' in 2015. Values smaller or equal to the 1st Quantile are in class 1 (blue), values between the 1st and 3rd Quantile are in class 2 (yellow), and values greater than the 3rd Quantile are in class 3 (red). The specific ranges are given in Table 3-8.

Agent group 'Abiotic agents'

Abiotic agents comprise direct stress by e.g. drought, temperature, wind, or landslides. About a quarter (24.5%) of the recorded damage by abiotic agents was caused by drought in 2015. Plots heavily affected by abiotic agents were found throughout Europe but overall more pronounced in southern Europe. Plots with lower frequency of affected trees were widely distributed across the participating countries (Figure 3-29).

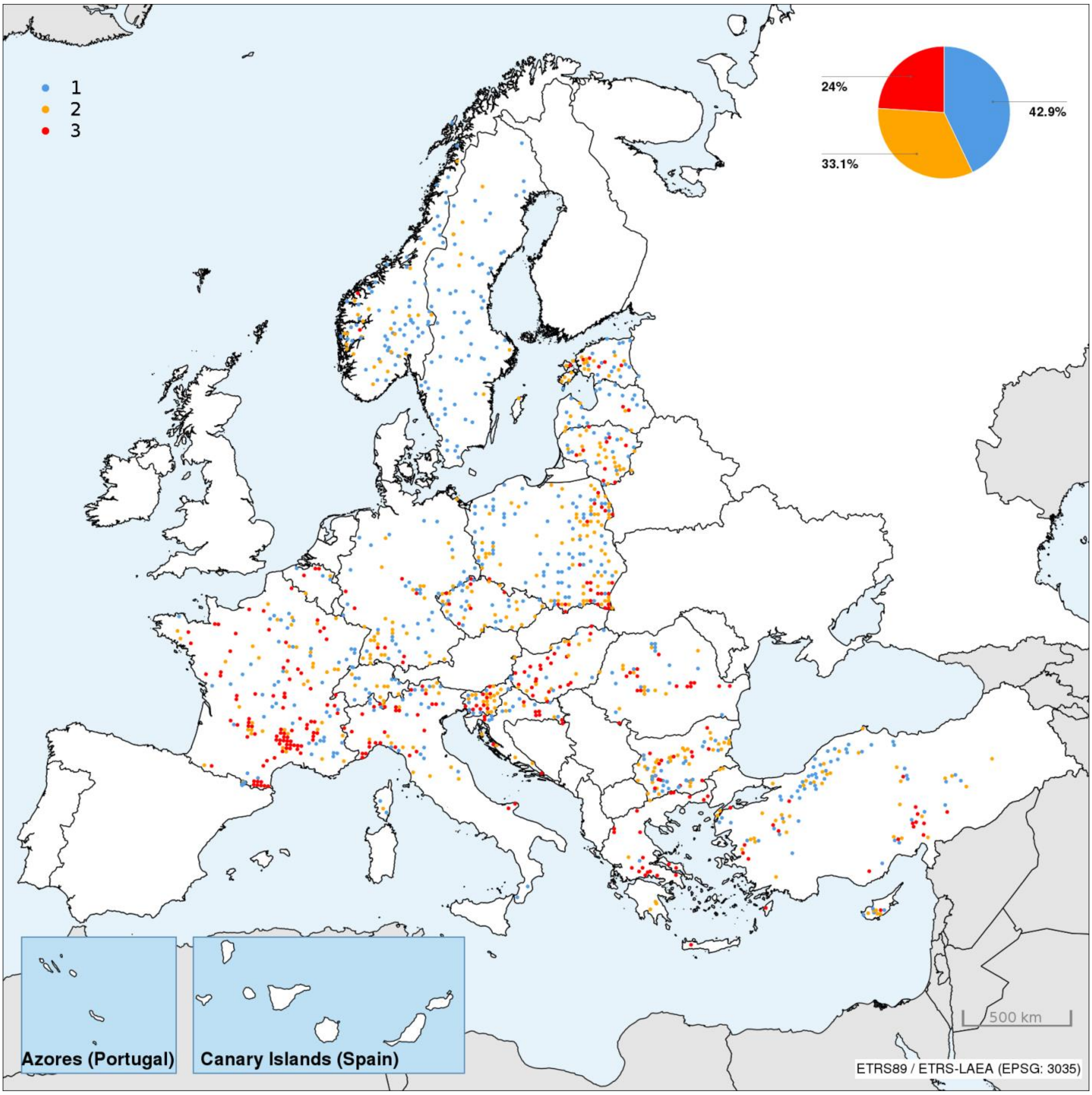


Figure 3-29. Extent of damaging agent group 'Abiotic agents' in 2015. Values smaller or equal to the 1st Quantile are in class 1 (blue), values between the 1st and 3rd Quantile are in class 2 (yellow), and values greater than the 3rd Quantile are in class 3 (red). The specific ranges are given in Table 3-8.

Agent group 'Direct action of man'

The damage agent group 'Direct action of man' refers mainly to impacts of silvicultural operations like soil compaction related to the use of heavy machinery, mechanical injuries caused by skidding etc. It was responsible for 4.9% of all damage symptoms in 2015 (Figure 3-30). Clusters of heavily impacted plots were found in Germany, Estonia, Poland, Hungary, Slovenia, Croatia, Bulgaria, and Turkey.

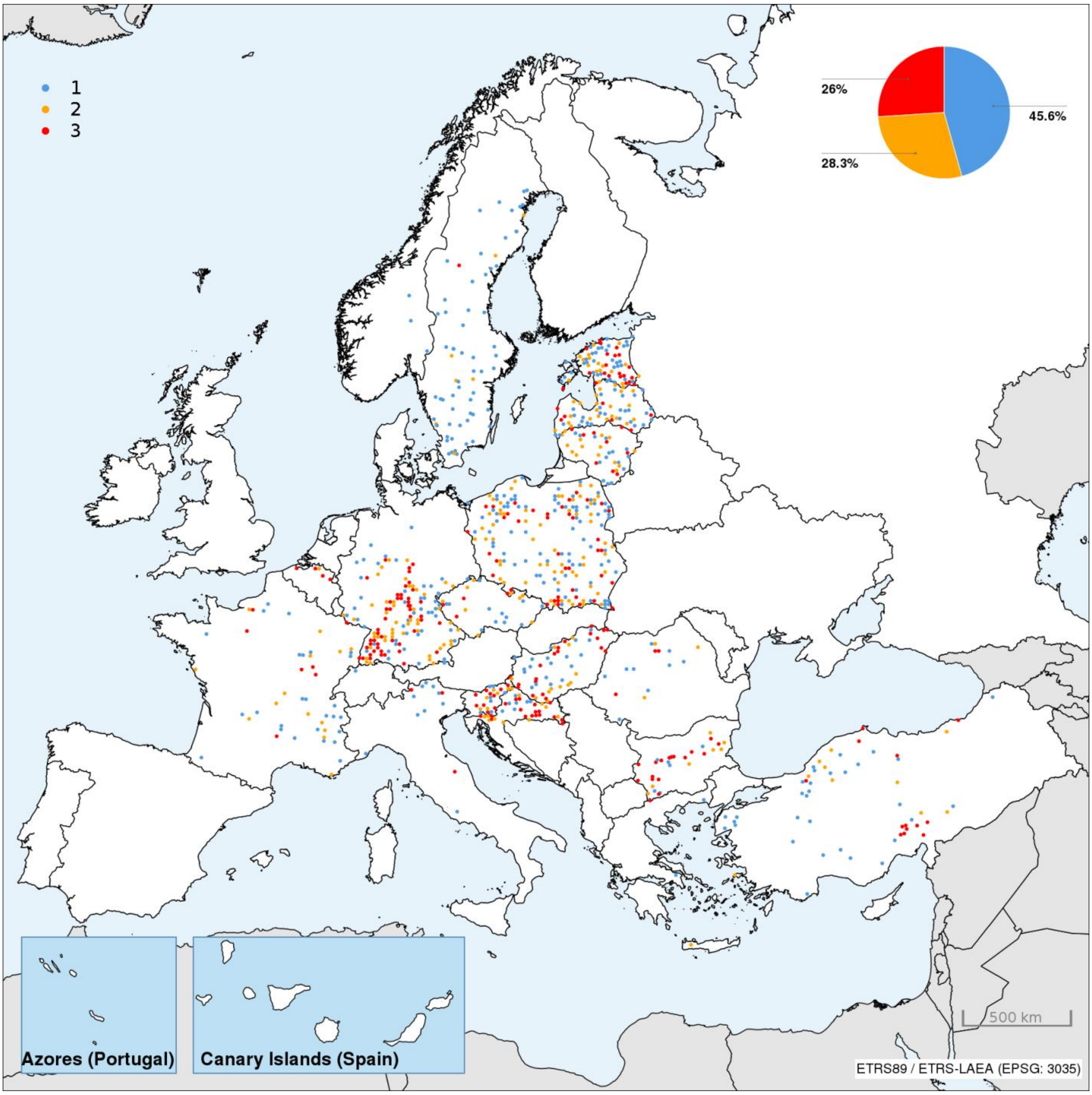


Figure 3-30. Extent of damaging agent group 'Direct action of man' in 2015. Values smaller or equal to the 1st Quantile are in class 1 (blue), values between the 1st and 3rd Quantile are in class 2 (yellow), and values greater than the 3rd Quantile are in class 3 (red). The specific ranges are given in Table 3-8.

Agent 'Fire'

There were few incidents of fire on Level I plots in Europe in 2015, with the only higher frequencies of affected trees found in Sicily, Croatia, and Hungary (Figure 3-31).

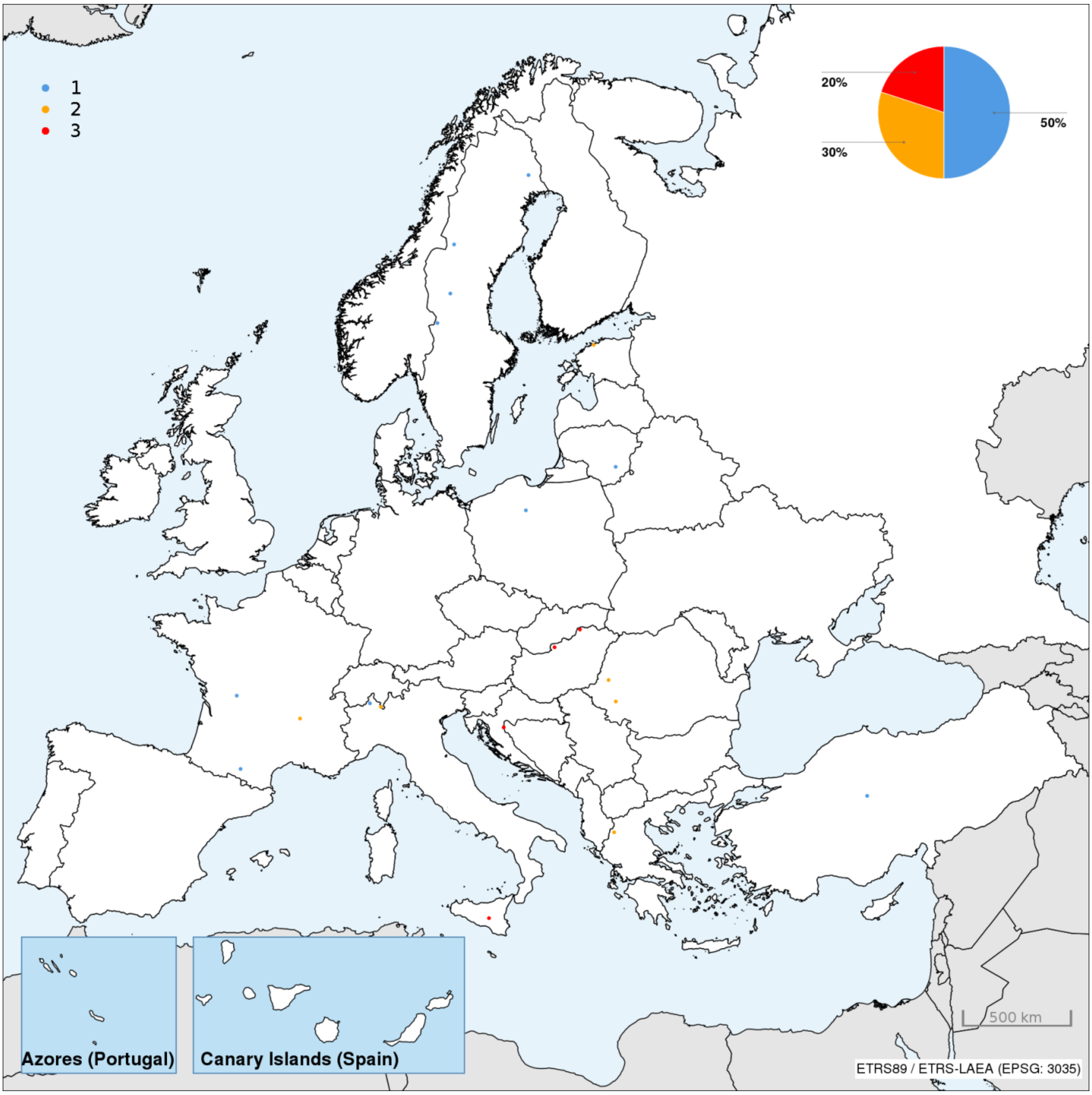


Figure 3-31. Extent of damaging agent group 'Fire' in 2015. Values smaller or equal to the 1st Quantile are in class 1 (blue), values between the 1st and 3rd Quantile are in class 2 (yellow), and values greater than the 3rd Quantile are in class 3 (red). The specific ranges are given in Table 3-8.

3.4 Conclusions

In 2015, crown condition assessments with defoliation being the key parameter were carried out on 88 052 trees on 4 818 plots in 25 countries. The sample trees were also assessed for visible symptoms of damaging agents. In most species or species groups an improvement in defoliation in 2015 compared to 2014 was observed, especially for broadleaved species. An exception was the group of evergreen oaks with a strong increase in defoliation in 2015, but this increase was mainly caused by a reduction in sample size (from 4 500 trees in 2014 to less than 1 000 in 2015). Damage symptoms of different agent groups were recorded on 37 211 trees. As in the year before, insects were the predominant identified cause of damage with more than 12 000 damaged trees reported, followed by fungi (over 5 900 damaged trees) and abiotic agents (more than 5 400 damaged trees). While the proportion of insect and fungal damage and other minor important agent groups in 2015 was comparable to that of 2014, the damage caused by abiotic agents was less than in 2014, mostly related to fewer drought problems in 2015. More than 40% of the observed damage symptoms could not be identified in the field, indicating the need for further training of field crews in symptom identification.

Presenting scientifically and statistically sound trends in defoliation is becoming more and more difficult due to interruptions in time series or methodological changes in some participating countries. For instance, the trend analyses in defoliation presented for Austrian pine, Mediterranean lowland pines and evergreen oaks are based on a relatively small sample of plots in a few countries having continuous data series of assessments for at least 20 years. Plots in countries that have changed their assessment (e.g. by changing plot location) or that have not delivered data in one or several years, had to be excluded from the trend analysis due to statistical reasons. Therefore, the trends presented for these three species/species groups are not representative for the whole Mediterranean region, but rather for the country/countries having the largest sample of plots with consecutive, long time series. The trend analyses for other species and species groups presented in this chapter are based on much larger samples of plots and countries and thus representative for Europe as a whole.

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4 SPATIAL VARIATION OF ATMOSPHERIC DEPOSITION IN EUROPE IN 2014

Aldo Marchetto, Peter Waldner[7]

Summary

The evaluation of the atmospheric deposition of major inorganic ions emitted into the atmosphere from natural sources and human activities is needed to quantify ion fluxes within the forest ecosystem. In this report we focus on acidifying, buffering, and eutrophying compounds in deposition collected under forest canopy (throughfall deposition).

High deposition of N-NO_3 deposition was mainly found in Central Europe, while the lower values (below 1 kg ha^{-1} y^{-1}) were found in Finland, Bulgaria and on the Alps.

The Central European area of high deposition (> 8 kg ha^{-1} y^{-1}) of N-NH_4 is larger, covering parts of Belgium, the Netherlands, Germany, the Czech Republic, Austria, Slovenia and Serbia. Other plots with high N-NH_4 deposition are also found in Poland, Italy, France and Spain. Low values, below 1 kg ha^{-1} y^{-1}, were found again in Finland and Bulgaria, but also in Switzerland and France.

High deposition of S-SO_4 deposition is spread over all Europe, partly due the contribution of marine aerosol. After sea-salt correction, the area with higher S-SO_4 deposition in Central Europe is smaller than for N-NO_3 and N-NH_4 deposition, but high values are also found in Southern and Eastern Europe, partly due to the input of Saharan dust. The lowest values of S-SO_4 deposition are found in the Swiss Alps.

High values of Ca deposition are recorded in almost all plots in Southern Europe, from Spain to Romania, probably due to the relevant contribution of Saharan dust. Isolated plots with high Ca deposition are also found in Belgium, Germany, Denmark, the Czech Republic, Poland and Lithuania, probably related to local mineral sources. Low values of Ca deposition (below 2 kg ha^{-1} y^{-1}) were mainly found in Northern Europe. The correction for the marine contribution does not affect the spatial pattern of Ca deposition.

On the contrary, Mg deposition is mainly related to the marine aerosol. After sea-salt correction, values below 1.5 kg ha^{-1} y^{-1} are found in most of Europe, while the highest values are reported in Eastern Europe and on isolated plots in Italy, Germany and the Czech Republic.

4.1 Introduction

The amount and seasonal pattern of precipitation is one of the main factors controlling the distribution of forest ecosystems. Beside this, precipitation, such as rain and snow, also carries to the forests a number of organic and inorganic substances that can affect, positively or negatively, forest growth and health (Rowe et al. 2014), or sensitive compartments of the forest ecosystem, such as epiphytic lichens (Giordani et al. 2014), or ground vegetation (Dirnböck et al. 2014) or forest soils (Ferretti et al. 2014).

Beside this “wet” deposition of substances, aerosol of natural origin or emitted into the atmosphere by human activities can settle directly forming the so-called “dry” deposition. Depending on leaf traits and

[7] For contact information, please refer to Annex IV-4.

humidity, forest canopies can collect significant amounts of aerosol by "filtering" large volumes of air (Mayer and Ulrich 1977). Finally, deposition related to the collection by leaves of fog droplets and atmospheric humidity is called "occult" deposition.

In this chapter, we focus on the deposition of nitrogen (N) and sulphur (S) compounds and of base cations, which represent the major inorganic compounds found in wet and dry deposition.

Anthropogenic sulphur dioxide (SO_2) emission, mainly resulting from combustion, has increased since the 1950s, and resulted in the deposition of sulphate (SO_4^{--}) and in an increase of deposition acidity, which can be partly buffered by the deposition of base cations, mainly calcium (Ca^{2+}), magnesium (Mg^{2+}) and potassium (K^+). Sulphate deposition can also be the consequence of natural processes, such as SO_2 emission by volcanoes and deposition of marine aerosol. In the last decades, a strong reduction in SO_2 emissions in Europe led to a marked negative trend in sulphate deposition and a similar decrease of deposition acidity (Waldner et al., 2014).

Atmospheric deposition mainly contains two inorganic N compounds: nitrate (NO_3^-) and ammonium (NH_4^+). The former originates from the transformation of nitrogen oxides (NO_x), which are also released during combustion, while the latter mainly derives from the emission of ammonia (NH_3) in agriculture and farming. Since N availability often controls forest productivity (Tamm 1991), N compounds carried out by atmospheric deposition can stimulate forest growth and enhance carbon uptake (e.g. Nair et al. 2016), but it can also cause, for example, forest growth decline (e.g. Silva et al. 2015) and alterations in soil biological activity (Janssen et al. 2010) and vegetation biodiversity (Bobbink et al. 2010), impacting the forest food-web (Meunier et al. 2016). N compounds are important nutrients that can produce ecosystem eutrophication, but they both can also act as acidifying compounds (Bobbink and Hettelingh, 2011).

Figure 4-1. Deposition sampler located under forest canopy to collect throughfall in Italy.

Figure 4-2. Stemflow sampler on a beech stem in Italy.

In the ICP Forests network, atmospheric bulk deposition is collected using bulk collectors (Figure 4-1), i.e. collectors which are always open. Apart from precipitation, they also collect particulate and gaseous deposition during dry periods, and to evaluate this effect, on a small number of plots wet-only samplers are also used, which open automatically during precipitation. A first series of bulk collectors are located in the open-field, to estimate wet deposition, not influenced by the exchange processes within the canopies. A second series of bulk collectors are located under the forest canopy, across the plot (througfall collectors) to collect total deposition (i.e. the sum of wet, dry and occult deposition). In the case of N compounds, throughfall deposition can be markedly affected by leaf uptake and/or canopy leaching. Stemflow collectors (Figure 4-2) are also used to collect precipitation that is intercepted in the canopy and runs off along branches and stems to the soil. In stands with trees suitable for stemflow (such as beech), contributions of stemflow to throughfall fluxes are typically about 15%.

In this report we will focus on througfall deposition collected by the bulk collectors below the forest canopy, which represent an estimate of the total amount of deposition reaching the forest plots. This estimate is a good proxy to assess temporal changes. For nitrogen, however, depending on site conditions leaf uptake and stemflow may result in total deposition being a factor 1 to 2 higher than throughfall (Clarke et al. 2010).

4.2 Materials and methods

Within ICP Forests, sampling procedures are harmonized according to a specific manual (Clarke et al. 2010), but througfall samplers differ from country to country, by type (including funnels and gutters), by number (3 to 27) and by location (random *vs*. systematic). However, an accurate intercomparison of the different collection methods (Žlindra et al. 2011) showed good agreement in the amount and the chemical composition of precipitation between all national collectors and a harmonized one.

Throughfall data for 2014 were available for 235 plots. Annual deposition of N, distinguishing nitrate N (NO_3-N) and ammonium N (NH_4-N), S from sulphate (S-SO_4), Ca and Mg were obtained by multiplying the volume weighted average concentrations by the annual amount of precipitation.

Quality assurance procedures were carried out to assure the quality of the data: plots were discarded when (i) analysed samples covered less than 321 days (90% of the year) or sampling periods were not correctly reported; or (ii) less than 30% of the samples passed the conductivity check (König et al. 2010).

As the deposition of marine aerosol represents an important contribution to the total deposition of SO_4, Ca and Mg, a sea-salt correction was applied, subtracting from the deposition fluxes the marine contribution, calculated as a fraction of the chloride deposition on the basis of the formulas reported in the manual of the ICP Modelling & Mapping (CLRTAP, 2004).

4.3 Results

High deposition of N-NO_3 deposition (Figure 4-3) was mainly found in Central Europe (parts of Germany, Denmark and the Czech Republic), while the lower values, below 1 kg ha^{-1} y^{-1}, were found in Finland, Bulgaria and on the Alps.

The Central European area of high deposition (> 8 kg ha^{-1} y^{-1}) of N-NH_4 is larger, covering parts of Belgium, the Netherlands, Germany, the Czech Republic, Austria, Slovenia and Serbia (Figure 4-4). Other plots with high N-NH_4 deposition are also found in Poland, Italy, France and Spain. Low values, below 1 kg ha^{-1} y^{-1}, were found again in Finland and Bulgaria, but also in Switzerland and France.

High deposition of S-SO_4 deposition is spread over all Europe (Figure 4-5), partly due the contribution of marine aerosol. After sea-salt correction, the area with higher S-SO_4 deposition in Central Europe is smaller than for N-NO_3 and N-NH_4 deposition (Figure 4-6), but high values are also found in Greece, the Balkans and in Southern Italy. In this last plot, volcanic contribution can be relevant. The high values in Southern and Eastern Europe can be partly ascribed to the input of Saharan dust (Loye-Pilot et al. 1986). The lowest values of S-SO_4 deposition are found in the Swiss Alps.

The spatial pattern of Ca deposition is different: high values of Ca deposition are recorded in almost all plots in Southern Europe, from Spain to Romania (Figure 4-7), and are probably due to the relevant contribution of Saharan dust, transported northward up to the Alps (Rogora et al. 2004). Isolated plots with high Ca deposition are also found in Belgium, Germany, Denmark, the Czech Republic, Poland and Lithuania, probably related to local mineral sources. Low values of Ca deposition (below 2 kg ha^{-1} y^{-1}) were mainly found in Northern Europe. The correction for the marine contribution (Figure 4-8) does not affect the spatial pattern of Ca deposition.

On the contrary, Mg deposition (Figure 4-9) is mainly related to the marine aerosol. After sea-salt correction (Figure 4-10), values below 1.5 kg ha^{-1} y^{-1} are found in most of Europe, while the highest values are reported in Eastern Europe and on isolated plots Southeastern Europe, Italy, Germany and the Czech Republic.

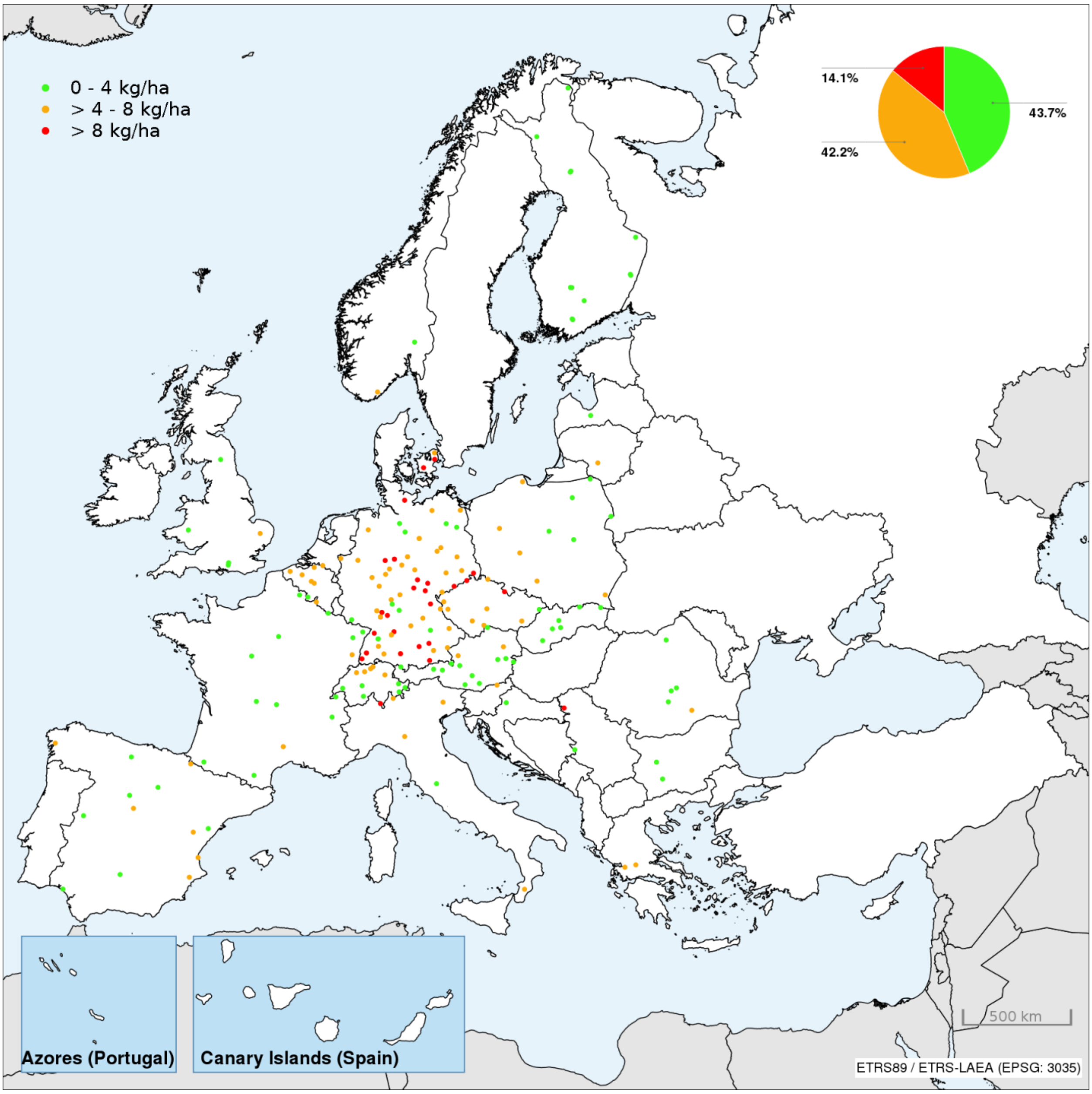

Figure 4-3. Throughfall atmospheric deposition of nitrate nitrogen (NO_3-N) in European forests in 2014.

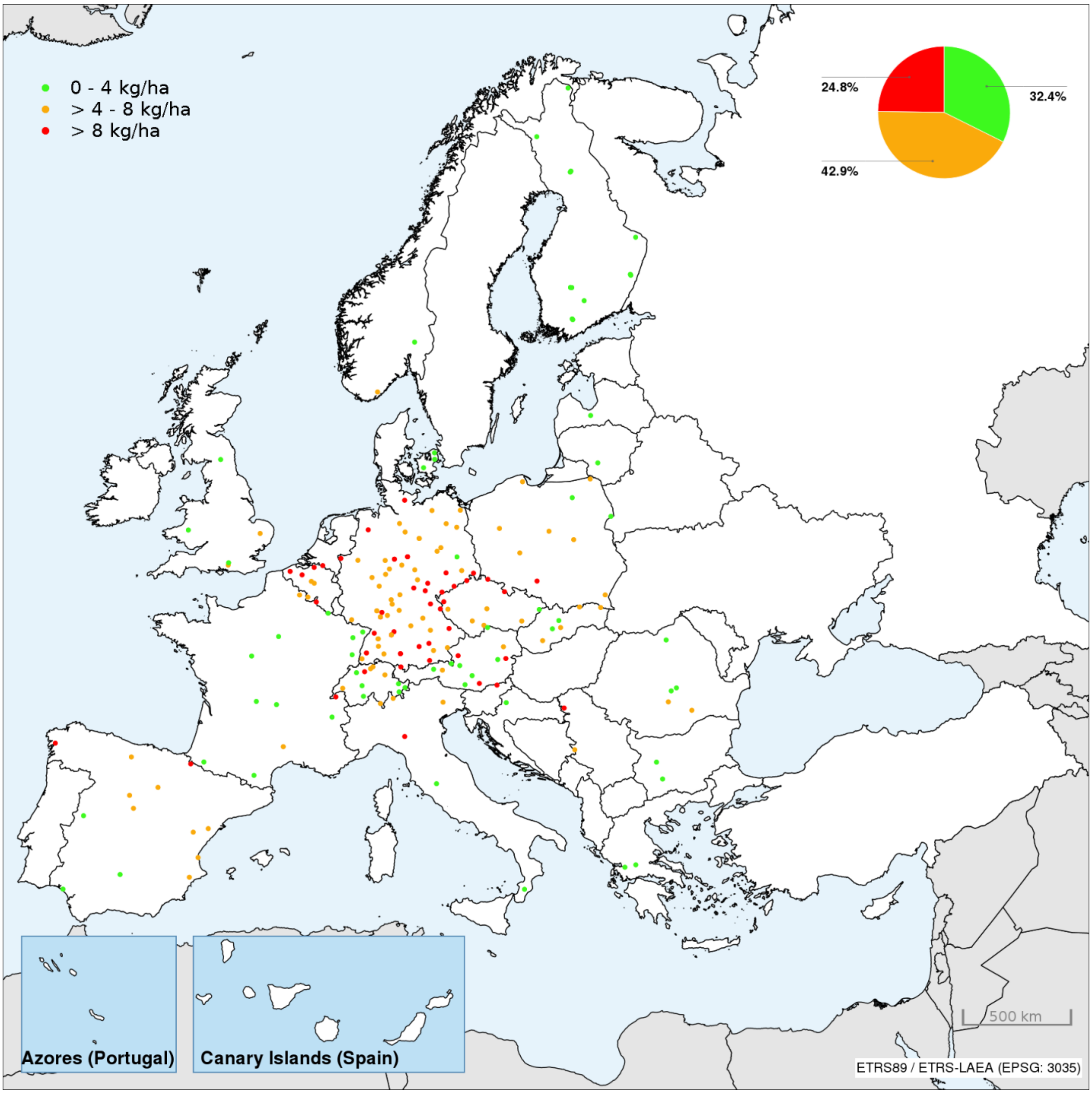

Figure 4-4. Throughfall atmospheric deposition of ammonium nitrogen (NH_4-N) in European forests in 2014.

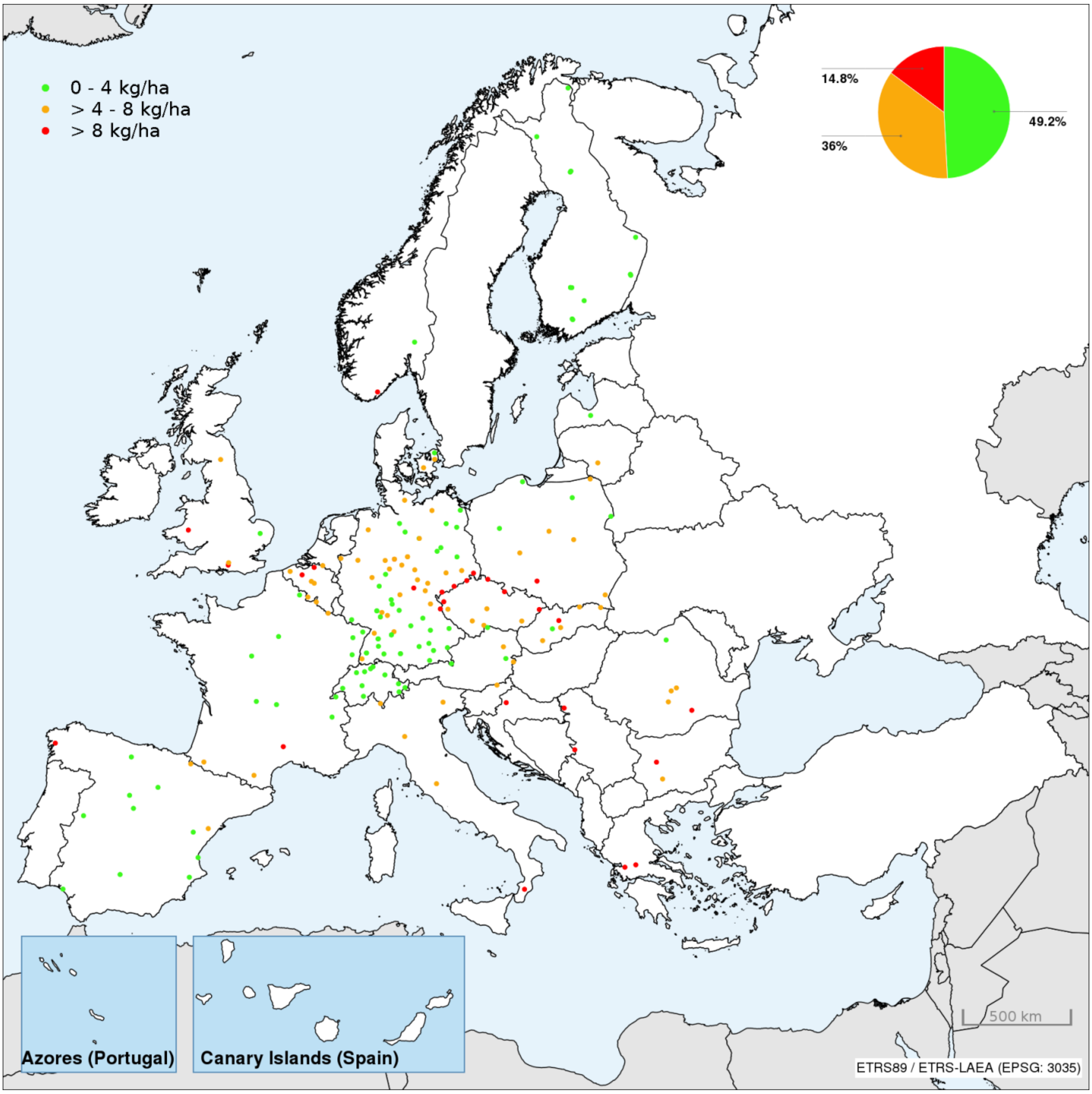

Figure 4-5. Throughfall atmospheric deposition of sulphate sulphur (SO_4-S) in European forests in 2014.

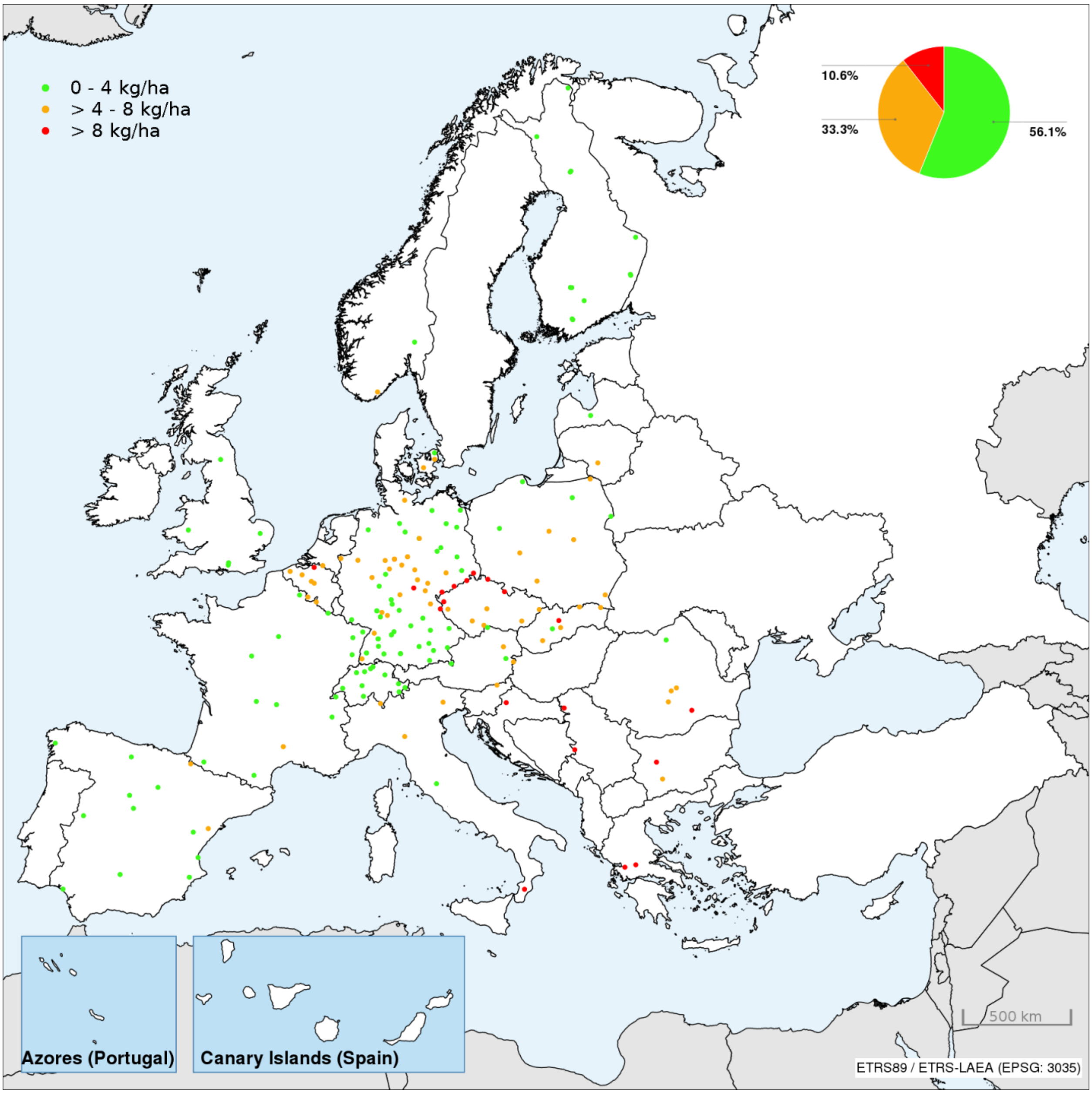

Figure 4-6. Sea-salt corrected throughfall atmospheric deposition of sulphate sulphur (SO_4-S) in European forests in 2014.

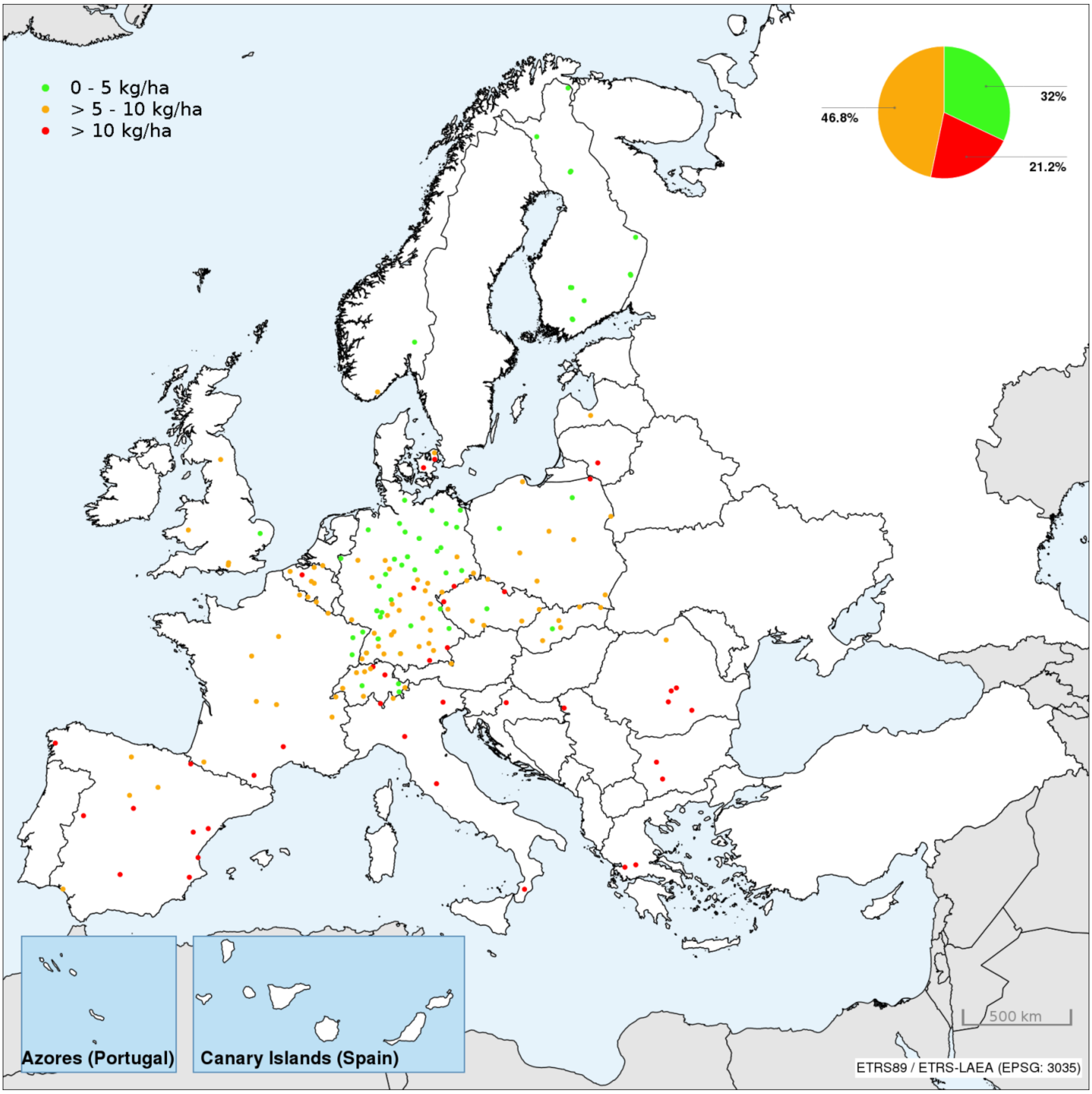

Figure 4-7. Throughfall atmospheric deposition of calcium in European forests in 2014.

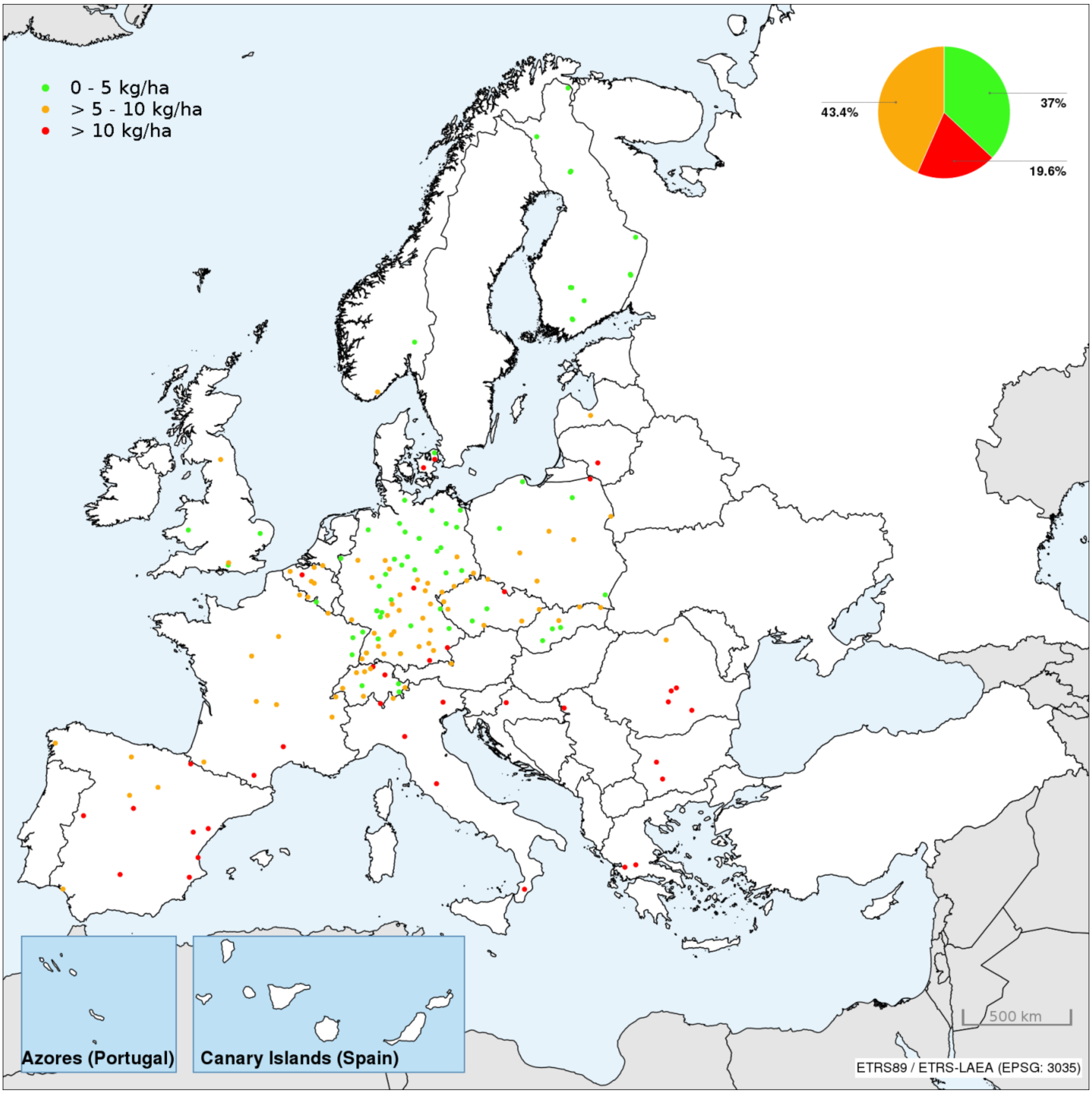

Figure 4-8. Sea-salt corrected throughfall atmospheric deposition of calcium in European forests in 2014.

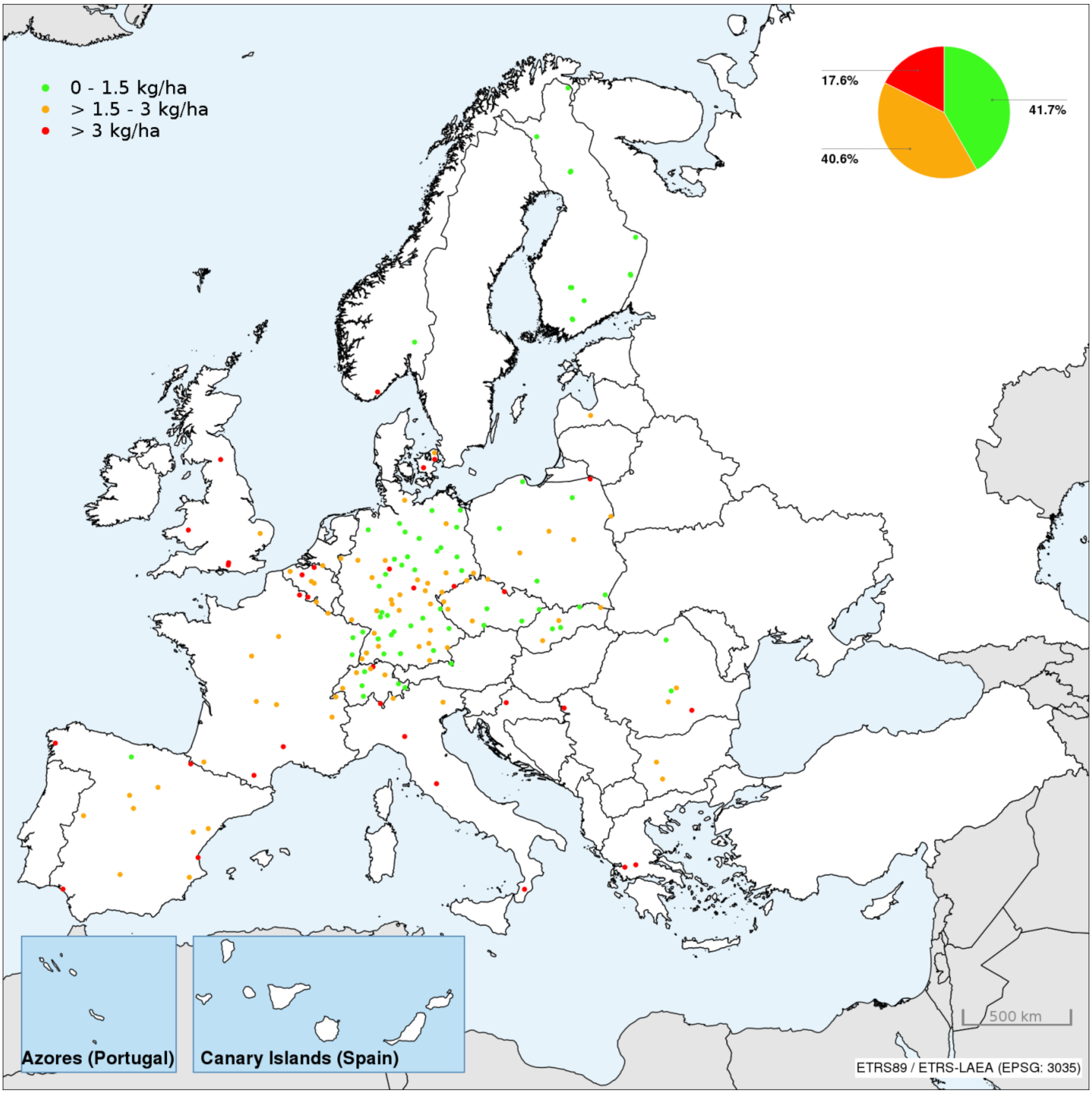

Figure 4-9. Throughfall atmospheric deposition of magnesium in European forests in 2014.

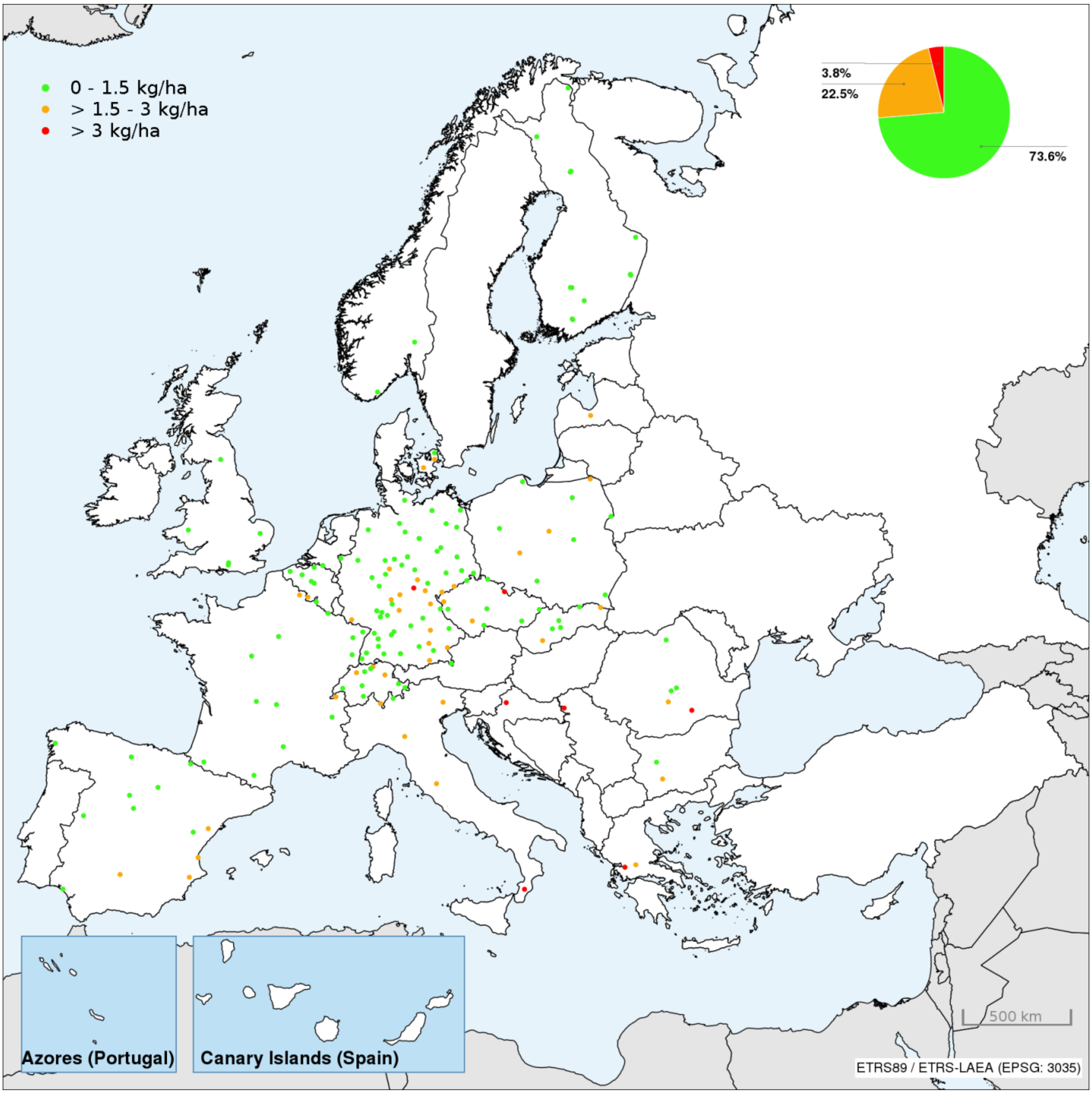

Figure 4-10. Sea-salt corrected throughfall atmospheric deposition of magnesium in European forests in 2014.

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5 SPATIAL AND TEMPORAL DISTRIBUTION OF OZONE SYMPTOMS ACROSS EUROPE FROM 2002 TO 2014

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Abstract

Ozone-induced visible foliar injury has been assessed during 2002-2014 according to ICP Forests standardized methods. This activity provided 29,809 records from 285 woody plant species, 169 plots and 19 countries. Data were evaluated for the entire period 2002-2014 as well as for 2009 only, when spatial coverage was the greatest. First results reveal that 55.0% of the assessed plots were symptomatic, and 26.0% of species developed ozone visible injury. Beech (*Fagus sylvatica*) was the species with the highest frequency of symptomatic observations (plot and years) in both 2002-2014 (40.1%) and 2009 (42.9%). The frequency of symptom reports occurred without a clear spatial pattern. In case, higher frequency of symptom occurrence seemed more common from northern Italy to North-West Germany, and towards East Europe. At country level, temporal trend analysis indicates a downward trend of mean frequency of symptomatic species for five out of six countries. Overall (all plots together), there is a slightly decreasing trend, which is consistent with the decreasing trend observed for ambient ozone concentrations. These first results demonstrate the potential of the survey on visible foliar injury to detect the potential impact of ozone on European vegetation. Further, enhanced quality control procedures are underway to aggregate the datasets and promote a more in-depth exploitation of cause-effect relationships, considering ozone symptoms, ozone concentration and measurements on forest health, growth, nutrition, biodiversity and climate undertaken at the ICP Forests plots.

Keywords: ICP Forests; ozone symptoms; woody species; forest edge; Light Exposed Sampling Site (LESS)

5.1 Introduction

Tropospheric ozone (O_3) is well known to be an air pollutant causing injury to plants (Innes et al. 2001; Karlsson et al. 2007; Matyssek et al. 2007). Ozone pollution leaves no elemental residue in plant tissues that can be detected by analytical techniques; therefore, visible injury on leaves and needles is the only easily detectable indication in the field. Although visible symptoms do not include all the possible forms of injury to vegetation (i.e. physiological changes, reduction in growth, etc.), observation of typical symptoms on foliage has turned out to be a valuable tool for the assessment of the impact of ambient ozone concentrations on sensitive plant species (Skelly et al. 1987; Schenone 1993; Lorenzini et al. 1995; Bussotti and Ferretti 1998; Inclán et al. 1999; Innes et al. 2001; VanderHeyden et al. 2001; Novak et al. 2003; Benham et al. 2010). The assessment of ozone visible injury serves therefore as a means to estimate the ozone potential risk for European ecosystems, and is very relevant in the context of ICP Forests (Schaub et al. 2010b).

Starting in the year 2000, a specific pan-European programme for the assessment, validation, and mapping of ozone visible injury on the vegetation has been launched, based on the ICP Forests intensive monitoring network (Level II plots, see http://icp-forests.net) where also ozone concentration is

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measured (Schaub et al. 2010a; 2015). The programme considers both the main tree species (MTS) of each plot and the vegetation in Light Exposed Sampling Sites (LESS) at the forest edge. A specific manual has been developed for this purpose (Schaub et al. 2010b). Alongside, Intercalibration Courses on the Assessment of Ozone Injury on European Species among experts from the participating European countries have been implemented to promote quality assurance (QA) and quality control (QC) (Bussotti et al. 2003). QA/QC procedures are essential to ensure spatial and temporal data comparability. Participants in the UN/ECE ICP Forests programme must therefore follow the methods and QA/QC procedures described in the Manual.

The main objective of assessing ozone visible injury is to contribute to an ozone risk assessment for European forest ecosystems. In this paper, we aim at providing first, comprehensive results on occurrence of visible foliar injury over space and time in Europe. We will present findings from data collected on woody plant species at the LESS over the period of 2002-2014 across Europe and stored in the central ICP Forests database. Although data have been subjected to routine QA/QC procedures, enhanced QA/QC is yet to be implemented. Therefore, results presented here should be considered as first outcome of the evaluation procedure, and interpreted with care.

5.2 Materials and methods

Sampling design and data collection

In order to assess ozone visible injury at the very site, a Light Exposed Sampling Site (LESS) has been established close to the off-plot sites of the ICP Forests Level II plots, where meteorological variables, deposition chemistry and ozone concentrations are also recorded. A LESS consists of a number of 2 x 1 m quadrates randomly selected along the forest edge. The number of randomly selected quadrates depends on the size (length) of the forest edge. Identification of ozone visible injury on woody species within the LESS quadrates has been carried out at least once during late summer and before natural leaf discoloration. Details on how to calculate the number of sampling units and conduct the assessment are outlined in Schaub et al. (2010b).

QA and QC

Field assessments of symptoms were carried out according to the standard QA/QC procedures of the ICP Forests described by Schaub et al. (2010b). Training and intercalibration courses were organised on an annual basis across Europe between 2002 and 2010, with most of the participating countries attending. Although uncertainty and subjectivity are impossible to be eliminated, they can be controlled: early results from 11 European field crews suggest that Data Quality Limits set by Schaub et al. (2010b) were achieved in most cases (Ferretti et al. 2013). Additional symptoms validation procedures, such as microscopical analysis, were implemented on a limited number of cases (872 out of 42,329 records).

Data used in this report were extracted from the ICP Forests database on 28 October 2015 for validation purposes within the activity of the Expert Panel on Ambient Air Quality. Data completeness (number of quadrates reported *vs*. expected) of at least 80% was mandatory for the field survey. Thus, we assume data were complete, and we just considered all the available data. On such a dataset, however, enhanced QA/QC has been (and is still being) implemented. Plot codes, species names and codes, distinction between perennial and annual species, woody and non-woody species have been controlled. These new datasets are now being verified by National Focal Centers of the participating countries. For France, additional data will be submitted and considered for further analysis.

Data description and analyses

Overall, the database on ozone foliar injuries (OZ_LSS) taken into account for this work consists of 42,329 records of data, collected between 2002 and 2014. For the present evaluation, only woody species have been considered (29,809 records).

Results for both, the entire period (2002-2014) and for 2009 only, i.e. the year with the highest number of countries participating in the programme, are reported. Specific analyses focusing on the most frequently recorded species were also carried out.

For the spatial pattern representation, the number of assessed years (three classes: 1; 2-5; >5 years) and the frequency of symptomatic years (three classes: 0%; >0-50%; >50%) at plot level was calculated, both considering all woody species and only *Fagus sylvatica*. A plot was classified as symptomatic if at least one species was found symptomatic in one year.

For the ranking of symptomatic species, only species observed on at least 30 plots (2002-2014) or 10 plots (2009) were considered.

For the detection of temporal trends, only countries and plots with at least seven years of data were considered. Mean values of symptomatic species percentage at country level were used for the statistical analysis. The MAKESENS application (Version 1.0 Freeware, Copyright Finnish Meteorological Institute 2002, http://en.ilmatieteenlaitos.fi/makesens) was used to perform the non-parametric Mann–Kendall (Hollander and Wolfe 1999) and the Sen's (Sen 1968) tests in order to verify the null hypothesis (H_0) of no temporal trend in the frequency of symptomatic species.

5.3 Results

Overview: occurrence of ozone foliar symptoms on woody species in Europe

For woody species grown at the Light Exposed Sampling Sites (LESS), we analyzed data from 285 species on 169 plots in 19 countries (Table 5-1; see Annex III for the full account). Nineteen countries have at least one plot observed for at least one year. Longest time series were provided by Spain and Switzerland (9 years), Hungary and Lithuania (8 years), Italy and the Slovak Republic (7 years) respectively. A number of plots was observed for less than 7 years in Belgium, the Czech Republic, Germany, Greece and Serbia (5 years), Romania (3 years), Austria, Cyprus and France (2 years) and Croatia, Latvia, Slovenia and UK (1 year). The largest spatial coverage was found in 2009-2011, which was likely due to the financial contribution by the LIFE project FutMon.

Over the entire period of 2002-2014, the majority of countries reported ozone visible injury at least on one single species in one single year and on one single plot. Four out of 19 countries, i.e. Cyprus, Romania, Serbia and the United Kingdom did not observe any ozone-induced symptoms. Over all, from 169 assessed plots, 55.0% plots were found symptomatic and 26.0% of the 285 assessed species developed ozone visible injury (Table 5-2). In 2009 however, the frequency of records was lower when 15 countries assessed a total of 194 species from 109 plots, of which 12.4% species (33.0% plots) were symptomatic.

Table 5-3 provides a list based on the 10 most symptomatic species in 2002-2014 (left) and 2009 (right), and their frequency of symptom records (observations at different years and plots). For the 2002-2014 period, only species recorded at least on 30 plots and for 2009, only species recorded on at least 10 plots were considered. Among the 10 most symptomatic species in 2002-2014 and the 10 most symptomatic species in 2009, seven were in common. The ranking of frequency of symptom records shifted between 2002-2014, with the exception of beech (*Fagus sylvatica*), which was found to be symptomatic with the highest frequency during both periods.

Table 5-1. Number of assessed plots per country and year.

Country code	Country	Survey year												
		2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
1	France				2								14	
2	Belgium					1	1	1	4	4				
4	Germany				3				18	25	11	11	11	
5	Italy			4	8	4	4	2	22	22	4	4		
6	United Kingdom			7										
9	Greece								2	3	3	3	3	
11	Spain	11	10	3		13	13	13	13	13	12			
14	Austria								6	6				
50	Switzerland			13	8	7	7	7	8		8	7	9	
51	Hungary		9	9	9	9			5	5	5	1		2
52	Romania								4	4	3			
54	Slovak Republic						1	3	8	8	8	3	3	
56	Lithuania			9			9	9	9	9	9	9	9	
57	Croatia										1			
58	Czech Republic						6	3	4	6	7			
60	Slovenia								4					
64	Latvia			1										
66	Cyprus								2	2				
67	Serbia								1	1	1	2	2	

Table 5-2. Number of countries, plots and species assessed during the entire period (2002-2014) and in 2009 only.

Informative stratum	2002 - 2014		2009	
	Tot (n)	**Symptomatic (%)**	**Tot (n)**	**Symptomatic (%)**
Country	19	68.4	15	60.0
Plot	169	55.0	109	33.0
Species	285	26.0	194	12.4

Table 5-3. Total number of observations and frequency of the ten most symptomatic species assessed at different years and on different plots in 2002-2014 and 2009 only. For the 2002-2014 period, only species recorded at least on 30 plots were considered; for 2009, only species recorded on at least 10 plots were considered.

Most symptomatic species	2002 - 2014		2009	
	Total number of observations (plots and years) (n)	**Frequency of symptom records (%)**	**Total number of observations (plots and years) (n)**	**Frequency of symptom records (%)**
Fagus sylvatica	237	40.1	42	42.9
Rubus idaeus	191	33.0	39	17.9
Carpinus betulus	113	24.8	20	10.0
Corylus avellana	160	22.5	21	23.8
Cornus sanguinea	58	22.4	11	27.3
Sambucus racemosa	30	20.0	-	-
Salix caprea	146	17.8	20	15.0
Viburnum lantana	33	18.2	-	-
Rubus fruticosus group	70	12.9	-	-
Fraxinus excelsior	118	16.9	15	13.3
Acer campestre	0	-	15	13.3
Acer pseudoplatanus	0	-	21	19.0
Frangula alnus	0	-	12	8.3

Spatial pattern

The spatial pattern of symptoms (all species) over the period 2002-2014 across Europe against the estimated seasonal mean ozone concentrations (see Schaub et al. 2015 for details) is shown in Figure 5-1. The map distinguishes the plots with respect of the number of available survey years (size of dots), and the frequency of survey years when the plot was found symptomatic (color of dots). A higher number of survey years (>5 years) was available for plots in Spain, Switzerland, Northern Italy, Hungary, the Slovak Republic and Lithuania. The frequency of symptom reports occurred without a clear spatial pattern. Higher frequency of symptom occurrence (red dots; >50%) seemed to be more common from northern Italy to North-West Germany, and towards East Europe. Interestingly, plots in regions with high ozone levels (e.g. central and southern Italy) showed no symptoms; and plots in regions with low ozone concentrations (e.g. South-West Germany, Lithuania and Latvia) showed frequent symptom occurrence. However, the majority of the plots seems to show a frequency of >0-50% symptom occurrence, with seasonal background ozone concentrations around 20-60 ppb. Figure 5-2 shows the same data for beech only. Also in this case, no clear pattern is obvious.

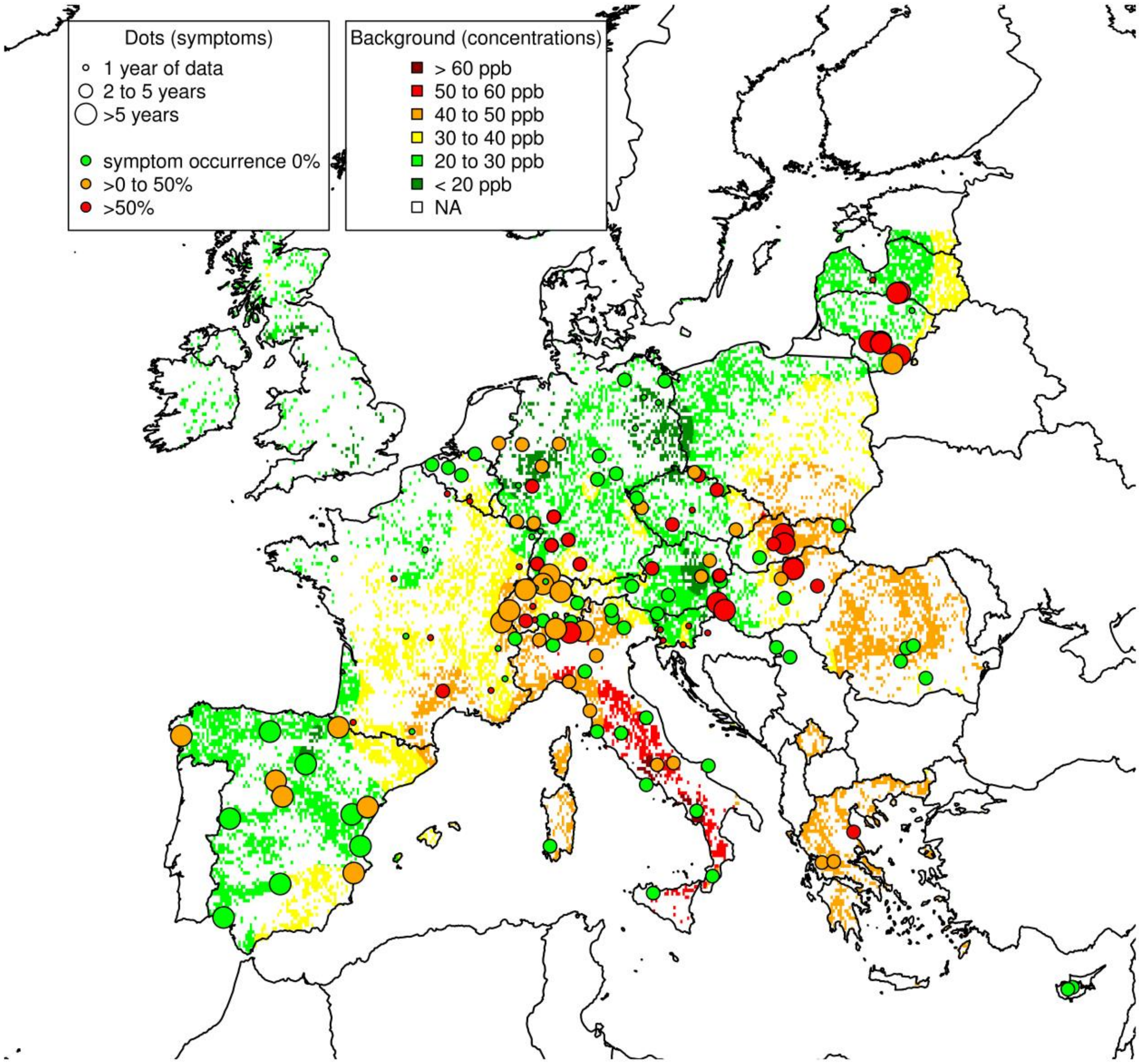

Figure 5-1. Spatial distribution of April – September mean ozone concentrations (ppb) from passive samplers on 203 plots and 20 countries during 2000-2013 and ozone symptom occurrence on 169 plots and 19 countries during 2002-2014. For ozone symptoms, dot size represents temporal data coverage (small = only 1 year; medium = 2-5 years; large > 5 years) and color represents frequency of symptom occurrence (green = 0%; orange = 0.1-50%; red = >50% of years measured were symptomatic).

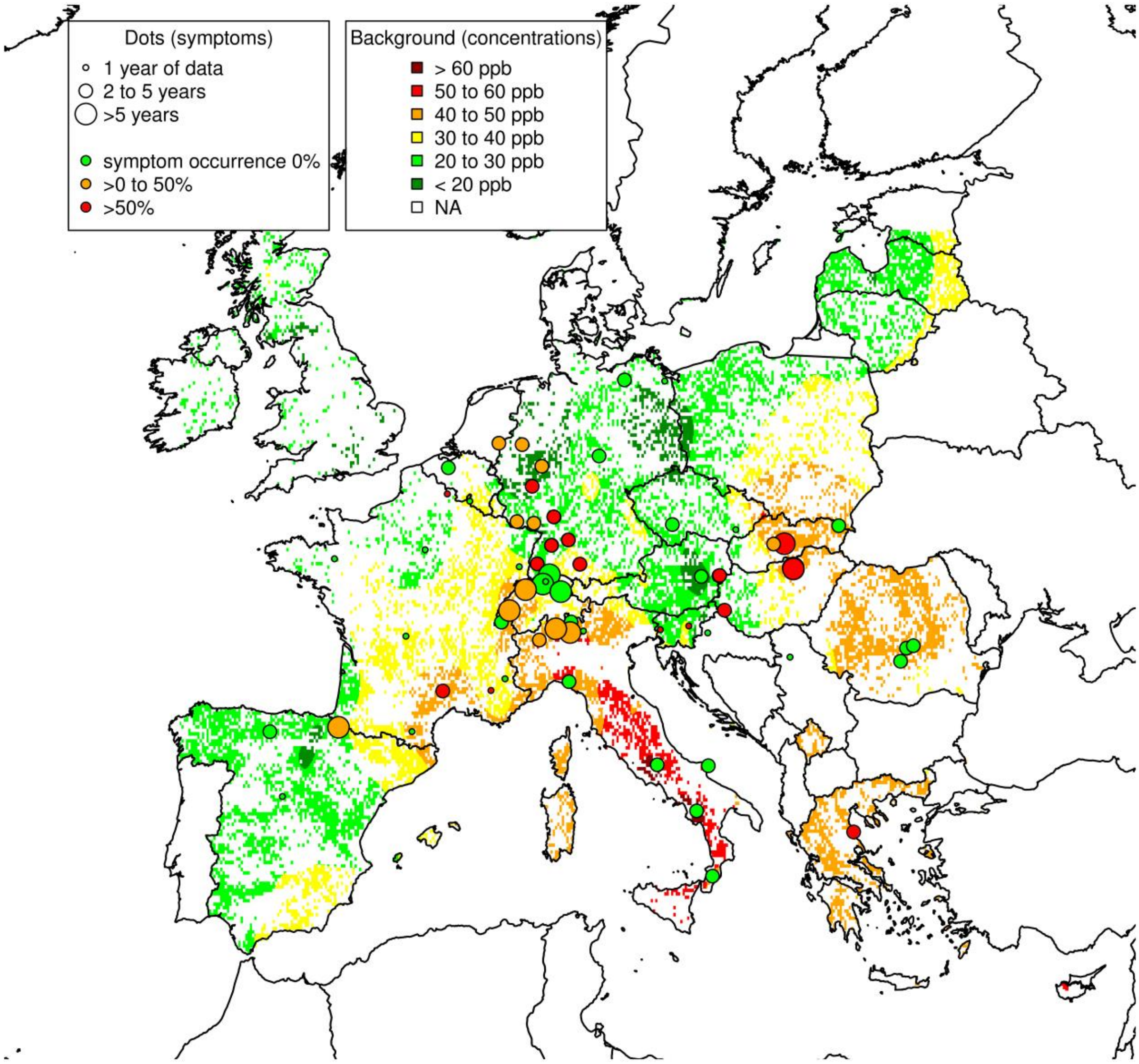

Figure 5-2. Spatial distribution of April – September mean ozone concentrations (ppb) from passive samplers on 203 plots and 20 countries during 2000-2013 and ozone symptoms occurrence for *Fagus sylvatica* on 74 plots and 15 countries during 2002-2014. For ozone symptoms, dot size represents temporal data coverage (small = only 1 year; medium = 2-5 years; large > 5 years) and color represents frequency of symptom occurrence (green = 0%; orange = 0.1-50%; red = >50% of years measured were symptomatic).

Temporal pattern

Mean frequency of symptomatic species per country and year is reported in Figure 5-3. The Mann–Kendall test (Table 5-4) indicates a downward trend of mean frequency of symptomatic species for 5 out of 6 countries, which is significant only for Hungary. When data are processed on the basis of individual plots (Figure 5-4), there is a slightly decreasing trend that is consistent with the decreasing trend of ambient ozone concentrations reported by Schaub et al. (2015).

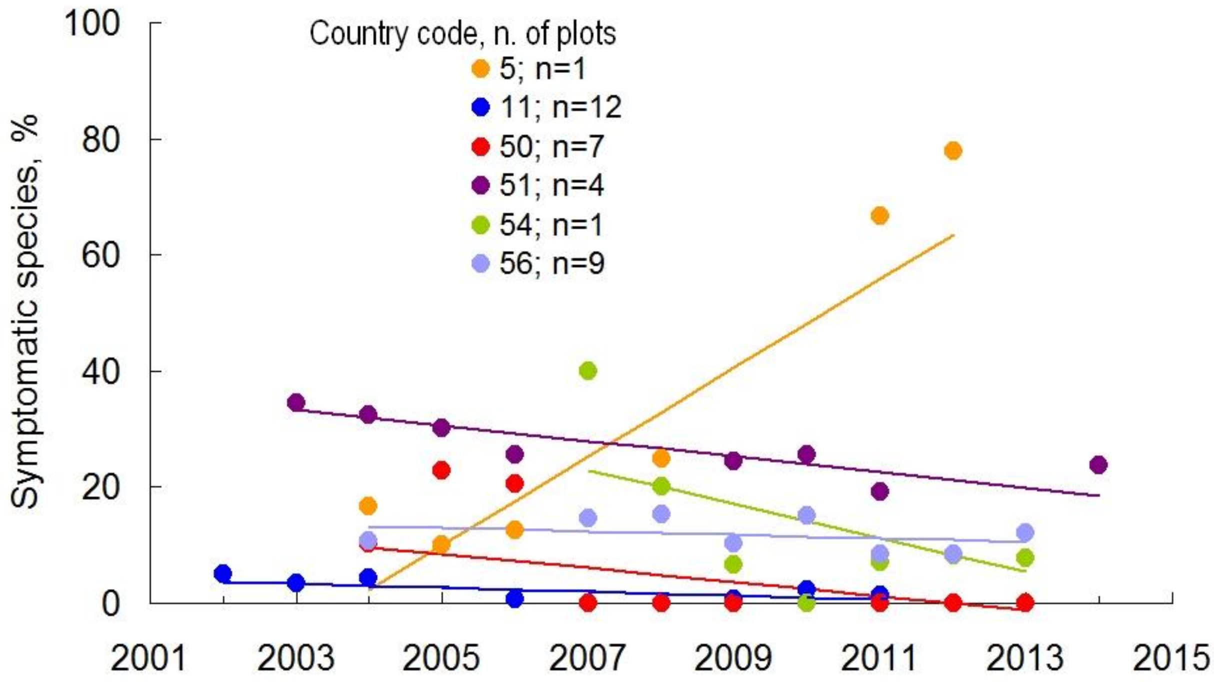

Figure 5-3. Temporal trend of the mean frequency of symptomatic species per country. For each country, only the plots with at least seven years of data have been considered. The legend reports the country codes and the correspondent number of plots.

Table 5-4. Makesens statistics (S Mann-Kendall test) to detect and estimate trend in time series 2002-2014 of frequency of symptomatic species in six European countries with at least seven years of data. Plots may vary from year to year. Ns, not significant; * P<0.05; ** P<0.01.

Country code	Country	No of years	No of plots	Mann-Kendall trend		Sen's slope estimate	
				S	Significance	Q	B
5	Italy	7	1	11	ns	7.639	-12.92
11	Spain	9	12	-11	ns	-0.335	3.67
50	Switzerland	9	7	-17	ns	-1.213	12.13
51	Hungary	8	4	-24	**	-1.352	34.71
54	Slovak Republic	7	1	-5	ns	-2.917	37.50
56	Lithuania	8	9	-8	ns	-0.302	13.94

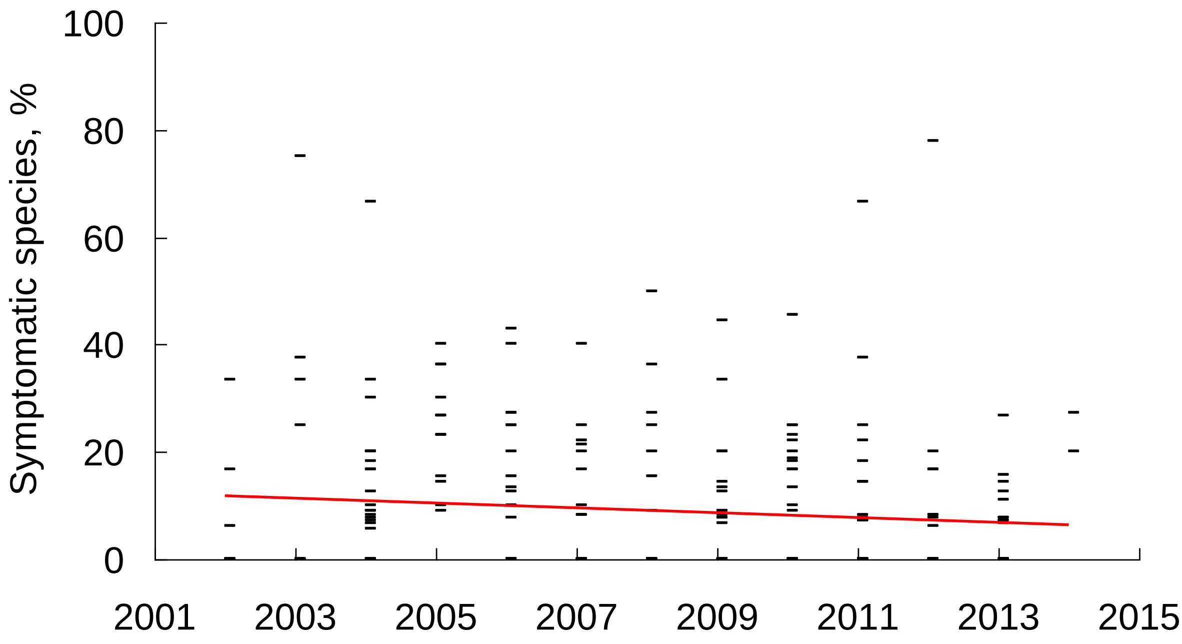

Figure 5-4. Overall temporal trend of the mean frequency of symptomatic species. Only the plots with at least seven years of data have been considered.

5.4 Discussion and conclusions

Ozone is the only air pollutant occurring in remote areas at concentrations that may cause visible injury on plants. Over the period 2002-2014, the assessment of ozone-induced symptoms on woody plant species at Light-Exposed Sampling Sites (LESS) nearby selected ICP Forests Level II plots reveals that visible injury attributed to ozone occurs every season on numerous plots and plant species across Europe. In fact, the 29,809 records from 169 plots in 19 countries, with 285 assessed species provide evidence that ozone still occurs at levels which are harmful to forest vegetation. Moreover, preliminary results demonstrate the complexity of the interactions between ozone exposures and forest ecosystems across Europe. As a matter of fact, symptoms were frequent even on plots with seasonal ozone background concentrations of 20-30 ppb. On the opposite, no or infrequent symptoms were found on plots with seasonal ozone background concentrations exceeding 50 ppb. A range of intermediate situations also occurred.

Among the symptomatic species, *Fagus sylvatica* turned out to be the species with the highest frequency of symptom occurrence, during both periods, 2002-2014 and 2009 only. VanderHeyden et al. (2001) compared 16 common woody species with each other and developed a sensitivity ranking, based on ozone visible injury development under ambient ozone concentrations. They found that among the symptomatic species, *Viburnum lantana* was the most sensitive one, followed by *Fraxinus excelsior*, *Frangula alnus*, and *Fagus sylvatica*. Novak et al. (2003) also found *Viburnum lantana* to be the most sensitive species, followed by *Fraxinus excelsior* and others, which are not included in Table 3. It must be noted, however, that for some species (e.g., *Fagus sylvatica*, *Rubus* sp.), identification of ozone symptoms in the field can be confounded by various factors (see Bussoti et al. 2003; 2006). Therefore, further QA/QC checks and training are necessary to gain a better insight.

The discrepancy between spatial distribution of seasonal ozone concentrations, frequency of symptom occurrence, and species specific sensitivity may be explained by the influence of internal and external factors affecting the sensitivity of an individual plant to ozone. External phenomena affecting ozone sensitivity include both a range of factors that influence gaseous uptake rates in the leaf and the characteristics of the ozone regime. Nutrition, water availability, temperature, atmospheric and soil humidity, wind speed, and incident light levels are all known to affect ozone uptake (Sandermann et al. 1997). These factors interact in a complex fashion to determine whether or not the leaf will develop symptoms of injury, making the experimental simulation of ozone exposures extremely difficult.

Leuzinger et al. (2011) postulated that the larger the spatial perspective of estimating water use under elevated CO_2, the smaller the response compared to the control scenario – often being conducted under experimental conditions. Here, we may face a similar phenomenon. Although much is known about the mechanistic understanding of plant-ozone interactions under experimental conditions, the actual effects on forest ecosystems in the real world is less certain (e.g. Bussotti and Ferretti 2009).

In combination with the measurement of ozone concentrations at the very forest sites, the assessment of ozone visible injury across Europe and in different forest ecosystems can be valuable to evaluate the risk for vegetation and to document spatial patterns, temporal variability, and trends of ozone effects. The results presented here, originated from the first comprehensive, European-wide evaluation of the data collected by the participants to the ICP Forests, and must be considered with caution due to some pending issues in terms of QA/QC checks. With this limitation in mind, however, results demonstrate that the survey on ozone visible injury can provide important indication for ozone risk assessment. Given the extended spatial and long-term coverage as well as the concurrent measurements of ozone concentrations and several other variables on forest health, growth, nutrition, biodiversity and climate, the potential of the ICP Forests ozone symptom dataset is unique. Enhanced QA/QC are being performed, new perspectives (e.g., survey restricted only to sensitive species or bio-indicators) and follow-up studies are being designed to study spatial and temporal trends and the relationship between ozone, ozone-induced symptoms, tree health and growth.

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6 RING TESTS AS MAIN PARTS OF THE QUALITY ASSURANCE AND CONTROL PROGRAMME FOR THE COMPARABILITY OF ANALYTICAL DATA WITHIN THE ICP FORESTS MONITORING PROGRAMME

Nils König, Nathalie Cools, Kirsti Derome, Alfred Fürst, Tamara Jakovljević, Aldo Marchetto

Many laboratories from almost 30 different European countries are producing hundreds of thousands of analytical results each year within the ICP Forests monitoring programme. They are analysing water, soil and foliage samples from Level I and Level II plots all over Europe (Table 6-1).

Table 6-1: Number of laboratories within ICP Forests during the FutMon programme 2009–2011

Kind of laboratories (2009–2011)	Number of labs
Labs for water analysis (deposition, soil solution)	41
Labs for plant analysis (foliage, litterfall, vegetation)	36
Labs for soil analysis (soil, humus layer)	38
Labs for soil physical analysis	25
Total number of labs (some labs are analysing two or more sample types)	63

To guarantee the comparability of the analytical results between different laboratories in several countries and over time, a quality assurance (QA) programme is necessary with participation of all laboratories. The ICP Forests QA programme is based on three pillars:

- the use of harmonized, well-defined and documented analytical methods
- an internal quality control (QC) procedure within each lab
- an external QC programme coordinated by the monitoring programme organisers

To assure comparable results, first of all harmonized, well-defined and documented analytical methods are needed and have to be used by all laboratories. Therefore the expert panels and working groups of ICP Forests have compiled the “ICP Forests Manual on methods and criteria for harmonized sampling assessment, monitoring and analysis of the effect of air pollution on forests”, where all analytical reference methods have been described and published.

On the basis of this ICP Forests manual each participating laboratory has developed its own quality control system. Basics are:

- the use of the reference methods in the ICP Forests programme
- different quality checks like ion balance checks (for water samples), nitrogen balance checks (for water samples), comparison of measured and calculated conductivity (for water samples), sum checks (for soil samples) or plausible range checks (for all types of samples)
- repeated measurement of standard material
- the use of control charts for continuous controlling of analytical repeatability and instrument stability

Control charts are mandatory within the ICP Forests monitoring programme; the results have to be submitted to the ICP Forests database together with analytical data.

The main part of the external QC programme is the implementation of interlaboratory comparisons (ring tests) between all labs. At present the participation is mandatory; ring tests for water (every 2 years), soil (every 3 years) and plant (annualy) samples are organised regularly. So far 8 soil, 7 water and 18 foliar ring tests have been organised within the ICP Forests programme and the FutMon-project. For each parameter the different expert panels have determined tolerable limits (in percentage of the mean) to assess the ring tests. The percentage of non-tolerable results in ring tests can be seen as a degree of quality and comparability of results from participating labs.

When the ring test programmes have been started, the tolerable limits were higher than today. For comparing the ring tests over time all ring tests have been evaluated again on the basis of the latest tolerable limits.

The results of all water, soil and foliage ring tests within the last 20 years are shown in the following graphs. The development of the quality of the labs, but also the limitations due to different analytical methods can be seen from these results.

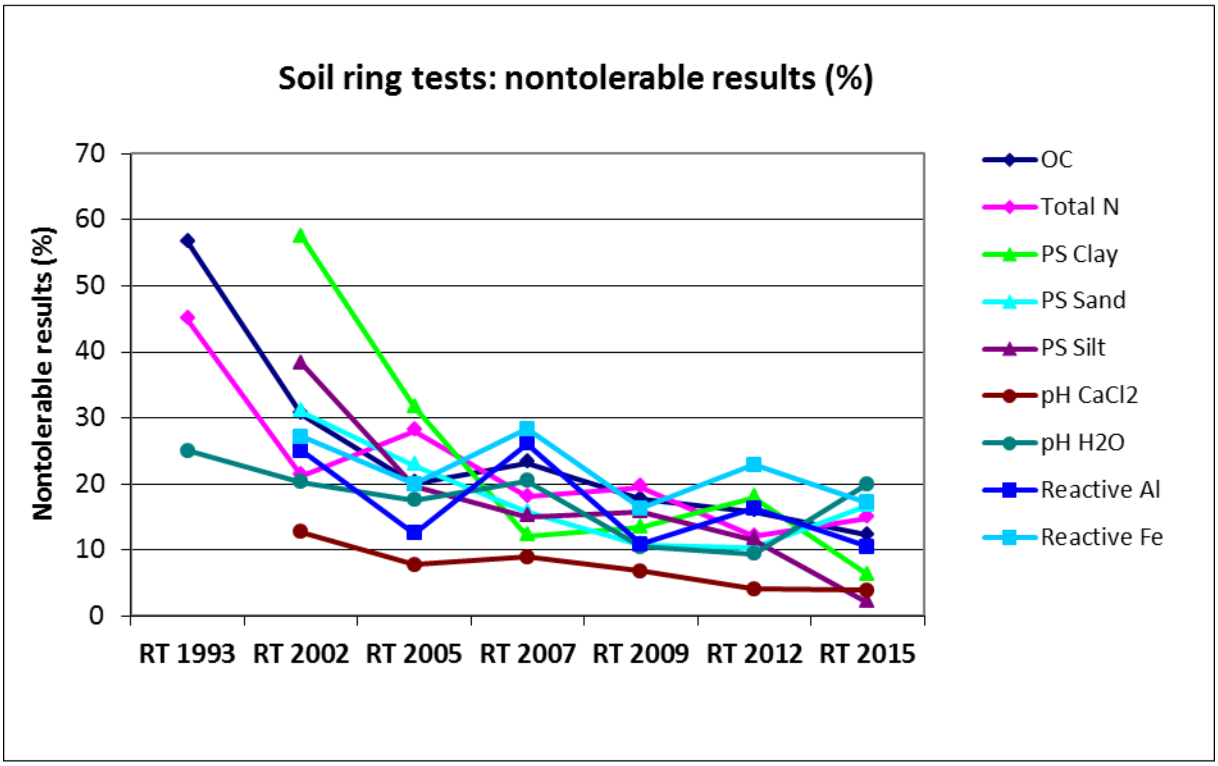

Figure 6-1a: Percentage of non-tolerable results in soil ring tests from 1993 to 2015 (parameters: OC = Organic Carbon, Total N = total nitrogen, PS Clay = particle size distribution clay, PS Sand = particle size distribution sand, PS Silt = particle size distribution silt, pH $CaCl_2$ = soil pH in 0.01 M $CaCl_2$, pH H_2O = soil pH in water, Reactive Fe = acid oxalate extractable iron, Reactive Al = acid oxalate extractable aluminium)

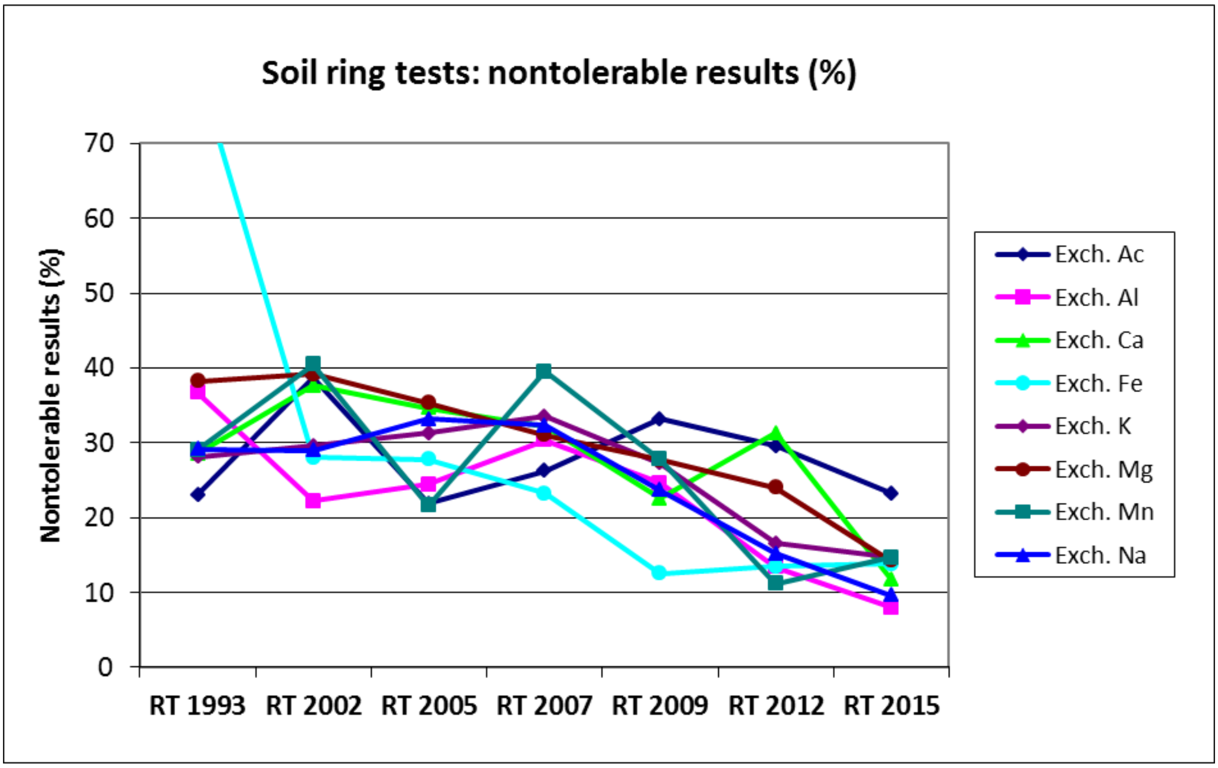

Figure 6-1b: Percentage of non-tolerable results in soil ring tests from 1993 to 2015 (parameters: Exchangeable cations and acidity; Ac = acidity, Al = aluminium, Ca = calcium, Fe = iron, K = potassium, Mg = magnesium, Mn = manganese, Na = sodium)

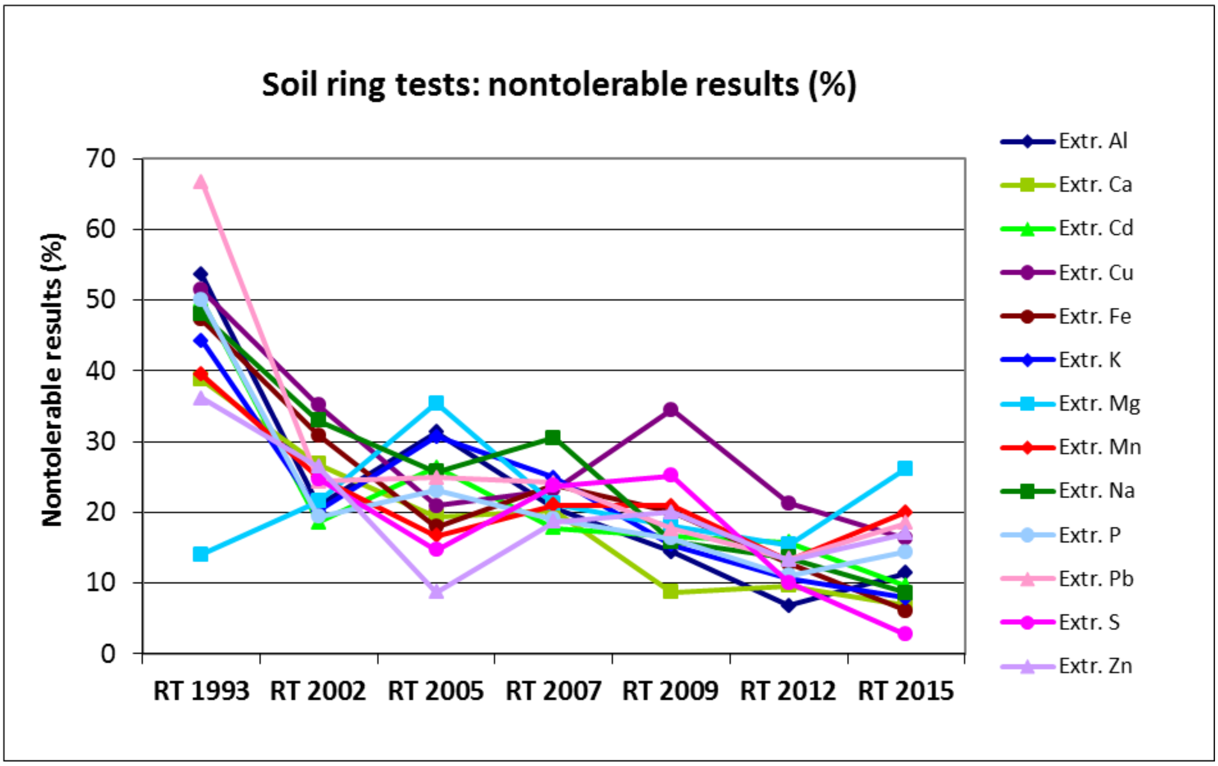

Figure 6-1c: Percentage of non-tolerable results in soil ring tests from 1993 to 2015 (parameters: aqua regia extractable elements; Al = aluminium, Ca = calcium, Cd = cadmium, Cu = copper, Fe = iron, K = potassium, Mg = magnesium, Mn = manganese, Na = sodium, P = phosphorus, Pb = lead, S = sulphur, Zn = zinc)

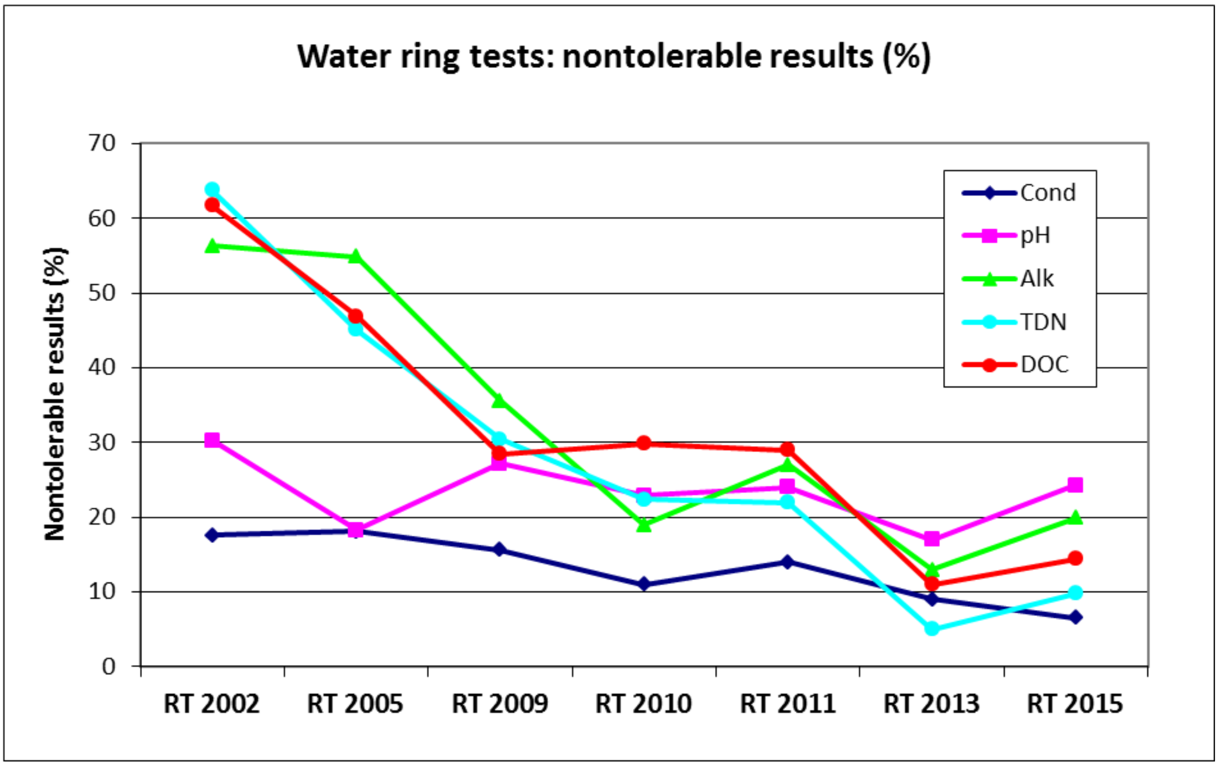

Figure 6-2a: Percentage of non-tolerable results in water ring tests from 2002 to 2015 (parameters: Cond = conductivity, pH, Alk = alkalinity, TDN = total dissolved nitrogen, DOC = dissolved organic carbon)

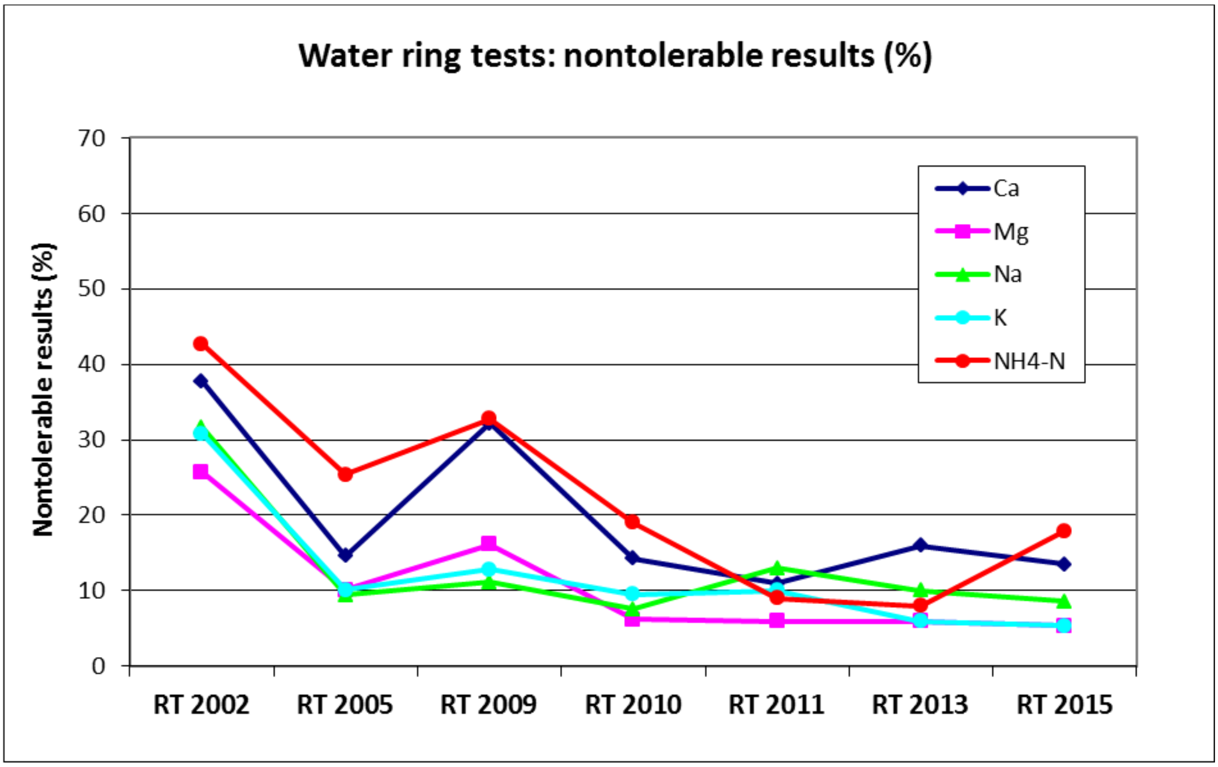

Figure 6-2b: Percentage of non-tolerable results in water ring tests from 2002 to 2015 (parameters: cations; Ca = calcium, Mg = magnesium, Na = sodium, K = potassium, NH4-N = ammonium-N)

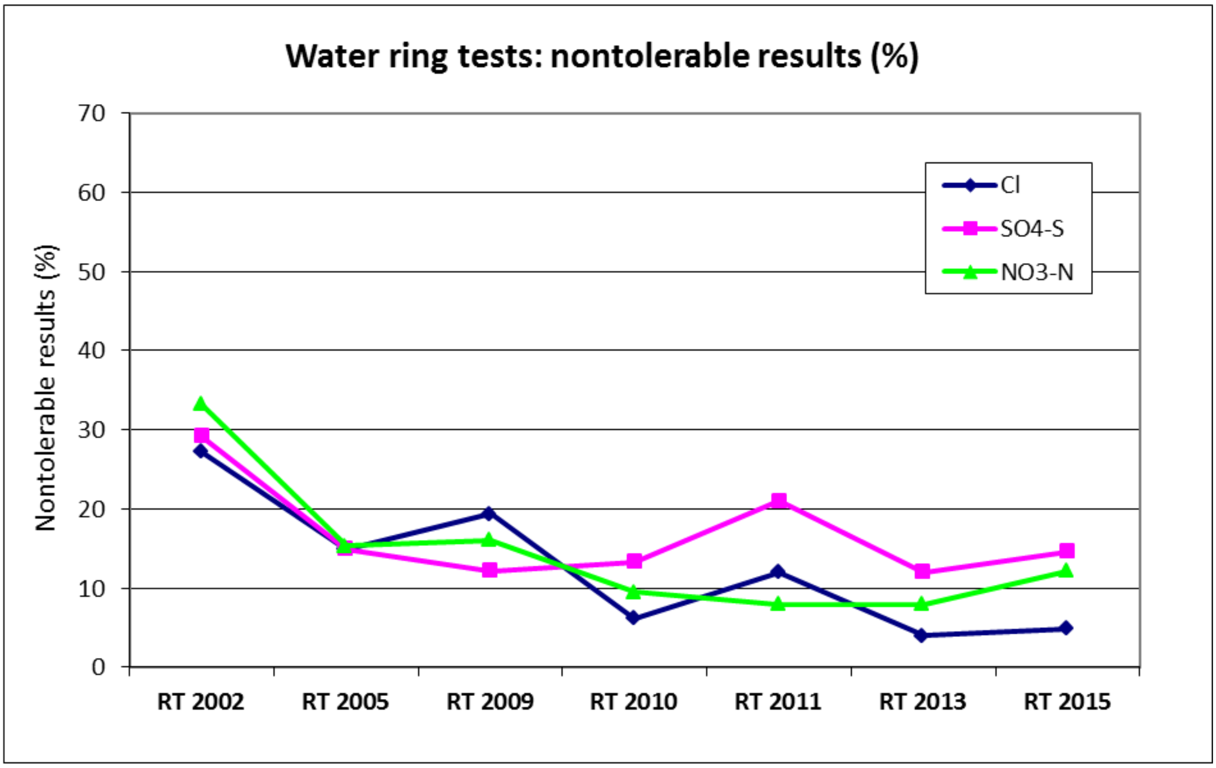

Figure 6-2c: Percentage of non-tolerable results in water ring tests from 2002 to 2015 (parameters: anions; Cl = chloride, SO4-S = sulphate-S, NO3-N = nitrate-N)

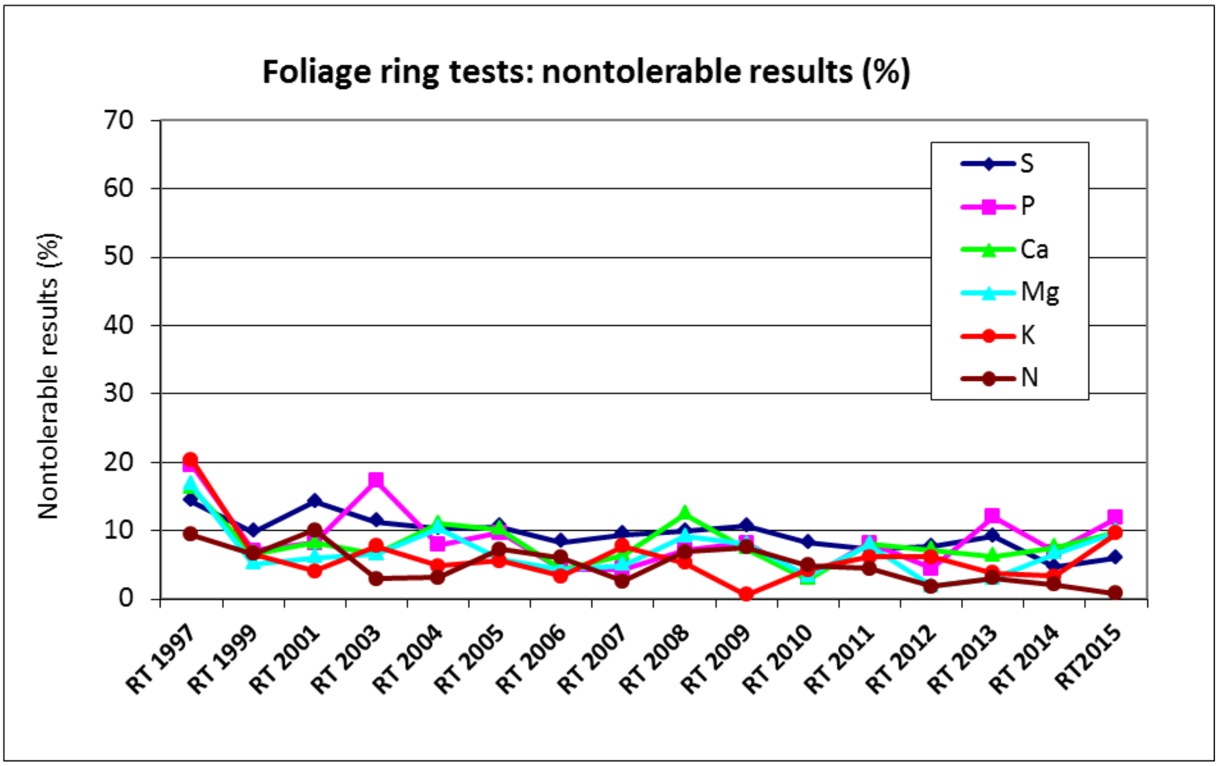

Figure 6-3: Percentage of non-tolerable results in foliage ring tests from 1997 to 2015 (parameters: S = sulphur, P = phosphorus, Ca = calcium, Mg =magnesium, K = potassium, N = nitrogen)

The best results have been achieved for the foliage ring tests. Since 2004 only 5 to 10% of the results for the main parameters have been non-tolerable. In soil ring tests the ratio of non-tolerable results started with 20 to 60% in 1993 and decreased to 10 to 20% for most of the parameters in 2015. For water samples the percentage of non-tolerable results decreased from 20 to 60% in 2002 to 5 to 15% in 2015.

The explanation could be found in the growing (or increasing) experience of the laboratories over time, especially for foliar analyses. Also the use of better equipment in many laboratories has led to better results.

One reason for the higher number of non-tolerable results for soil compared to the other matrices is the inhomogeneity of sieved soil samples which have to be used for some of the extracts. A second reason could be found in the two steps analysis (extraction/digestion and measurement), which can bring a higher variation than one step analysis used for water samples.

The participation in the regularly organised meetings of the heads of the labs, where many analytical problems have been discussed, has improved the laboratory quality and has led to better results in the ring tests during the last 10 years.

7 THE ICP FORESTS LEVEL I BIODIVERSITY DATA

A HARMONIZED DATA SOURCE AND BASELINE FOR PLANT SPECIES AND STRUCTURAL DIVERSITY ON EUROPEAN FOREST ECOSYSTEMS

Roberto Canullo

Abstract

Structural and compositional biodiversity surveys on the ICP Forests extensive monitoring plots (Level I) have been incorporated into the collaborative ICP Forests database as LI-BioDiv dataset. Data were collected in the period 2005-2008 and delivered by 27 partners according to harmonized methods. During the integration process data was validated based on a complex system of checkroutines that had been defined before. Conflicts were solved in collaboration with the experts from National Focal Centres (NFCs) and the Expert Panels (EPs) on Biodiversity and Ground Vegetation, and on Forest Growth.

Each Level I plot is georeferenced, commonly related to the soil pit and the crown condition survey. It consists of a circular plot of 2000 m^2 which contains a concentric subplot (400 m^2), and a second smaller circle (30 m^2) designed for different field variables assessments.

The LI-BioDiv dataset is structured in six forms: GPL (general plot location and information, 3340 plots), DBH (tree diameter, status, and composition, 3201 plots), THT (tree top and crown base height, 3083 plots), CAN (canopy closure, layers, number of trees, 3210 plots), DWD (deadwood, 2950 plots), and GVG (ground vegetation composition, 3124 plots).

A transnational internal evaluation process was established and a set of items approved by the related Expert Panels and the ICP Forests Programme Co-ordinating Centre (PCC). Four working groups are producing the first results in terms of scientific papers; the other evaluation projects and the related groups of experts and scientists are described. Recommendations and lessons learned from this experience are shortly provided.

Keywords: ICP Forests, Level I, biodiversity, LI-BioDiv dataset, validation

7.1 Introduction

In 1985 ICP Forests established a large-scale monitoring network (Level I), aimed at gaining insights into the geographic patterns and temporal variations in forest condition. The extensive European monitoring network is based on a probabilistic sampling design, assured by around 6000 plots on a representative 16 x 16 km systematic grid (Ferretti et al. 2010). Annual crown condition assessments were performed as well as foliar nutrient and soil surveys under the EC Regulation 2152/03 Forest Focus, addressed to a harmonised, broad-based, comprehensive and long-term monitoring of European forest ecosystems (following EEC Regulation 3528/86).

Forest Focus also promoted studies and pilot or demonstration projects to broaden the scope of the monitoring scheme from the protection of forests against atmospheric pollution and forest fires, towards environmental issues such as soils and forest biodiversity.

A first draft of a demonstration project including information relevant to forest biodiversity at the European scale, based on the Level I network, was prepared along 2005. The proposal was conceived with two modules addressed to a harmonised collection, handling and assessment of soil data and biodiversity indicators, consistent with the scope of European forest research and policy.

The "BioSoil-Biodiversity" module, treasuring the achievements of the ForestBIOTA project and the COST ACTION E43[9], was developed by the "Working Group on Forest Biodiversity" (WGFB) and discussed at the meetings of the ICP Forests Expert Panel on Biodiversity and Ground Vegetation (EPBDGV) and the Expert Panel on Forest Growth (EPFG). The stand structural approach was adopted, assuming that structurally diverse stands have more associated habitats, thus higher potential for biological diversity (WGFB 2007; Olivier 1981).

Sampling effort was directed to few, simple and most recognised, robust and operational indicators of forest compositional and structural diversity, to be assessed with common harmonized or standardized methods and techniques. The reference to this respect was taken from existing forest monitoring parameters related to ground vegetation, forest growth and crown condition, adding new surveys on forest deadwood, and forest classification. With respect to the traditional Level I network, BioSoil moved from sampling point to circular sampling plots. A common manual was prepared for field activities (WGFB 2007).

This experience was defined as a valuable baseline on forest biodiversity monitoring, in the frame of both the EU biodiversity policy and the EU 2020 biodiversity strategy (Durrant et al. 2011). Unfortunately, the original BioSoil datasets were unavailable for running projects or submitted proposals (e.g. EU Life+ FutMon project; Blust et al. 2013).

ICP Forests, after some preliminary discussion in 2012 (Joint Expert Panel Meeting on European Level Data Evaluation, Helsinki, FI; 28th Task Force Meeting, Białowieża, PL) recognised the relevance of this data on forest biodiversity, as supported by the research community (e.g.: Clarke et al. 2011, Mikkelsen et al. 2013; Danielewska 2013). The need of a Level I dataset for species and structural diversity on European forest ecosystems was pinpointed, aimed to:

- corroborate the Level I network as European infrastructure for biodiversity assessment,
- provide harmonised, representative data to be combined with other information,
- built a benchmark against which temporal and spatial patterns should be further monitored,
- facilitate the ICP Forests internal evaluation effort, and
- improve data access according to internationally accepted rules.

The task to get together the defined dataset was undertaken by the PCC and the Chair of the EPBDGV (through Camerino University).

The objective was to collect all the datasets from biodiversity surveys realised on the plots of the Level I European network, asking the NFCs to submit the data to the ICP Forests network. This was intended to be the founding action of a new common harmonised dataset on European forest biodiversity (LI BioDiv) based on a representative network of plots.

7.2 Data source

All the NFCs participating in ICP Forests received a formal request to voluntarily submit the national datasets, potentially originating in different projects, according to the expected categories: general information about the plot (GPL), tree dbh, status, and composition (DBH), tree height and height of the

[9] Details can be found on the web at http://www.forestbiota.org/ and http://www.metla.fi/eu/cost/e43/

canopy base (THT), canopy closure and number of tree layers (CAN), lying deadwood (DWD), and ground vegetation (GVG).

Validation and integration of national datasets was a complex task which has been discussed at the joint Expert Panels meetings in Wien 2012, Freising 2013, and Eberswalde 2014, before the data could finally be integrated into the collaborative ICP Forests database.

The first version of the dataset is at the moment further evaluated within internal projects by the ICP Forests network. The documentation of the above steps and the revised system of checkroutines, will allow further data submissions for comparable repeated surveys.

The countries that have acknowledged the new LI-BioDiv dataset, by delivering data, are reported in Table 7-1, with the respective surveys performed in different years (2005-2008).

Table 7-1 Submitted datasets by country and survey years. GPL - general plot location and information; CAN - canopy closure and tree density; DBH - tree species, diameter, and status; DWD - deadwood dimensions and status; GVG - ground vegetation vascular species and cover; THT – heights of the largest trees. Codes and Country description and alphanumeric coding refer to LI-Biodiv dataset and ICP Forests identification.

Country[10]		2005						2006						2007						2008					
		GPL	CAN	DBH	DWD	GVG	THT	GPL	CAN	DBH	DWD	GVG	THT	GPL	CAN	DBH	DWD	GVG	THT	GPL	CAN	DBH	DWD	GVG	THT
Austria	14							•	•	•	•	•	•												
Belgium FL	102							•	•	•	•	•	•												
Cyprus	66							•	•	•	•	•	•	•	•	•	•	•	•						
Czech Republic	58							•	•	•	•	•	•	•	•	•	•	•	•	•				•	
Germany BW	280													•	•	•	•	•	•						
Germany BY	290													•				•							
Germany BB	270							•	•	•		•	•	•			•								
Germany NWD	300							•		•			•	•		•		•	•	•	•	•	•		•
Germany MV	310							•	•	•	•	•	•	•	•	•	•	•	•						
Germany NW	320							•		•			•	•		•		•	•	•	•		•		
Germany RP	330	•				•								•	•	•	•		•						
Germany SL	350													•	•	•	•		•						
Denmark	08							•	•	•	•		•	•				•							
Canaries	95																			•	•	•	•	•	•
Spain	11													•	•	•	•	•	•	•	•	•	•	•	•
Finland	15							•	•	•	•	•	•	•	•	•	•	•	•						
France	01							•	•	•	•	•	•	•	•	•	•	•	•						
Hungary	51							•	•	•	•	•	•												
Ireland	07							•	•	•	•	•	•	•	•	•	•	•	•						
Italy	05							•	•	•	•		•	•	•	•	•	•	•	•	•	•	•		•
Lithuania	56							•	•	•	•	•	•												
Latvia	64							•	•	•	•	•	•	•	•	•	•	•	•						
Poland	53													•	•	•	•	•	•	•					•
Sweden	13							•	•	•	•														
Slovenia	60							•	•	•	•	•	•	•				•							
Slovak Republic	54	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
United	06							•	•	•	•	•	•	•	•	•	•	•	•	•	•	•		•	•
Belgium WL	202	*early negotiation*																							
Switzerland	50	*advanced negotiation*																							
Netherlands	03	*early negotiation*																							

The Level I network is here represented by 19 countries (Germany with eight federal states, Belgium with only Flanders, Spain and the Canaries), accounting to overall 27 partners. Contacts are established to include additional data at a later stage.

[10] ICP Forests partners (code)

7.3 Materials and methods

A common field methodology was adopted as described in the BioSoil-Biodiversity field manual (WGFB 2007), which allows different interpretations when translated in the operational manual at national level. Moreover, the fact that different national projects have been included, introduced some deviation from the standard, which was considered as far as possible by following a conservative principle. All the cases have been discussed with national experts and in dedicated sessions of the EPBDGV and EPFG meetings, in order to harmonise the data of the LI-BioDiv dataset.

The location of each Level I plot is commonly related to the soil pit and the crown condition survey plots of the Level I network, from which they are established; geo-referencing is provided by countries.

Each plot is consistent with the following scheme: a circular plot with a radius of 25.24 m (2000 m^2) contains a first concentric subplot (r = 11.28 m, thus 400 m^2), and a second smaller circle with a radius of 3.09 m (30 m^2), identified as subplot no. 3, 2, and 1 respectively (Figure 7-1). Each subplot is devoted to particular measurements or assessments (Table 7-2) while the entire plot is used for data assessment of the GPL form.

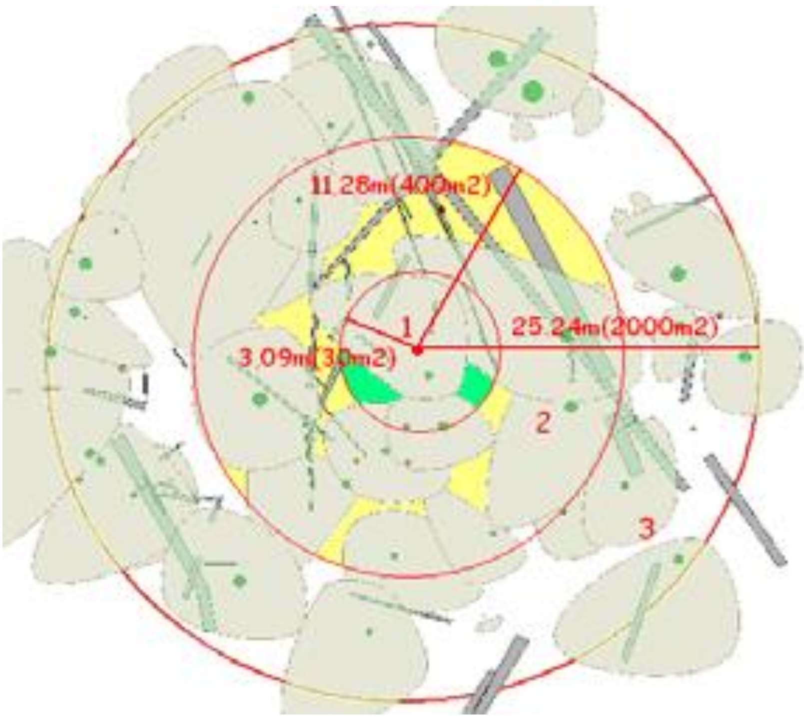

Figure 7-1. Representation of the LI plot and the concentric subplots (Pavlenda and Pajtík 2008).

Table 7-2. Mandatory minimum measurements \ assessments, with optional actions and designs in the Level I plots for forest biodiversity. Variables, subplots and related thresholds are indicated.

Category	Variables	Mandatory\ optional	Subplots and thresholds 1 - 30 m^2	2 - 400 m^2	3 - 2000 m^2
GPL	Previous land use, origin, age, management, forest type and classification, deadwood removal, tree mixture, slope, orientation, fencing	m	at plot level		
DBH	Diameter at breast height of all woody plants	m	h > 130 cm; D > 0 cm	h > 130 cm; D ≥ 10 cm	h > 130 cm; D ≥ 50 cm
	Species determination	m			
	Status (standing living or dead, lying)	m			
	Decay stage	m			
	Distance and azimuth from plot centre	o			
THT	Top height	m	At least 3 largest measured trees for DBH		
	Height of canopy base	m			
DWD	Coarse woody debris (diameter, length, species type, decay class)	m	D > 10 cm		Optional design: 4 replicates 10x10 m
	Snags (diameter, height, species type, decay class)	m	h > 130 cm; D > 10 cm		
	Stumps (diameter, length, species type, decay class)	m	h < 130 cm; D > 10 cm		
	Fine woody debris (diameter, height, species type)	o	5 < D ≤ 10 cm		
CAN	Canopy closure	m	subplots 1 and 2		
	No. of tree layers	m			
	Number and fraction of trees assessed for DBH	m			
GVG	Overall vascular species list	m	subplots 1 and 2		
	Specific cover	o			
	Tree layers distinction	o			
	Mosses and lichens	o			

To complement the tree stand structural parameters, deadwood assessments have been added with a common developed methodology, while the vascular plant communities of the ground vegetation were also assessed according to the *Flora Europaea* with reference to the ICP Forests manual and eventual amendments in the current updated version (Aamlid et al. 2007, Canullo et al. 2010). Forest classification is considered a strategic issue to account for large variability of forest biodiversity information and to adopt ecologically sound stratification for the interpretation of forest monitoring results and harmonized reporting (Barbati et al. 2007, 2014). Pre-assessed European Forest Type Classification was adopted, consisting of 14 categories (Barbati and Marchetti 2005, EEA 2006), to be validated in the field at the plot level.

Tree variables for DBH and THT categories are assessed across the entire BioSoil plot, according to the thresholds shown above. DWD, CAN, and GVG categories are based on surveys referred to a common sampling area of 400 m^2 usually achieved by the circular subplot 2; optional design with four replicates 10 x 10 m each, randomly distributed on the overall area (subplot 3) is allowed to account for local heterogeneity.

Countries representatives have participated in a Forest Biosoil Field Training at Radovljica (Slovenian Forestry Institute) from 19 to 21 April 2006.

Structure of the dataset

The LI-BioDiv dataset consists of six forms:

- **GPL** general plot location and information
- **DBH** tree diameter, status, and composition
- **THT** tree top and crown base height
- **CAN** canopy closure, layers, number of trees
- **DWD** deadwood
- **GVG** ground vegetation composition

Each form contains variables related to specific items, and the common reference to country, Level I plot, subplot, and survey. The definition of the objects of survey, the employed methods and techniques for selection, assessments, and measurements of parameters and variables follows the general statements reported in the BioSoil-Biodiversity manual (WFFB 2007) with additional specifications and integrations linked both to operational and harmonising needs and the optional vs. mandatory specifications (see Materials and Methods).

GPL

The General Plot Location and information (GPL) describes the geographical location and a number of environmental and management characteristics of each plot. A detailed documentation of the form is available under http://icp-forests.org/documentation/BD/GPL.html

DBH and *THT*

Structural biodiversity information on the individual trees are contained in two forms: DBH reports the measured diameters, the species and the biological condition (standing dead or living, lying), and THT contains tree top and crown base heights, as assessed on selected largest trees within the plots (as previously included in the DBH dataset). A detailed documentation of the forms is available under:
http://icp-forests.org/documentation/BD/DBH.html
http://icp-forests.org/documentation/BD/THT.html

DWD

Deadwood typology, dimensions and status are contained in the DWD form where each record reports the variables of a single deadwood piece. A detailed documentation of the form is available under http://icp-forests.org/documentation/BD/DWD.html

CAN

In this form details of the state of canopy closure and the number of layers are reported. The number of trees assessed for DBH within the sampling area and the percentage of the total in case of sampling are also included. A detailed documentation of the form is available under
http://icp-forests.org/documentation/BD/CAN/html

GVG

The form GVG (ground vegetation composition) contains the list of all species and the layers and cover assessments if performed. A detailed documentation of the form is available under
http://icp-forests.org/documentation/BD/GVG.html

Plant species codes are given according to a taxonomic reference table based on *Flora Europaea*, available through EPBDGV (Canullo et al. 2010). Vegetation layers are reported by codes defining the vertical stratification in the system; cover assessment is submitted as percentage.

Results

Validation of available data could be finalized and data could be integrated into the collaborative ICP Forests database. The approved ongoing projects for internal evaluation with the general items and research questions are also summarized, with the indication of involved researchers.

Data processing and validation issues

The creation of the LI-BioDiv dataset, was not yet served by web-based submission tools: the files have been delivered to the working group (PCC and EPBDGV) in different formats. Forms are then affected by different national projects, have been submitted by subject aggregation irrespective of the survey, suffered misinterpretation of the common definition, etc.

Thus, the first action to assure a high quality of the dataset was the translation of the received files in correct formats, sequence, and survey year. In order to harmonise the whole dataset, the introduction of ancillary parameters was necessary (as common WGS84 coordinates, creation of UTM zones, etc.), as well as the fine-tuning of definitions, data dictionaries, the improvement of identifier fields (as for deadwood pieces, or tree number), the description of objects, thresholds, and intervals, etc. These operations have been conducted by harmonizing the content of the Bio Soil Biodiversity manual (WGFB 2007, and previous versions), the national field manuals and the descriptions of the experimental designs (when available).

The validation process started in strict co-operation with the PCC, the company DigSyLand, and the chair of the EPBDGV, by the early identification of attributes defined as primary keys, mandatory and obligatory fields for the six forms.

The overall strategy used in the FutMon project was adopted for validation (Granke et al. 2010; Figure 7-2).

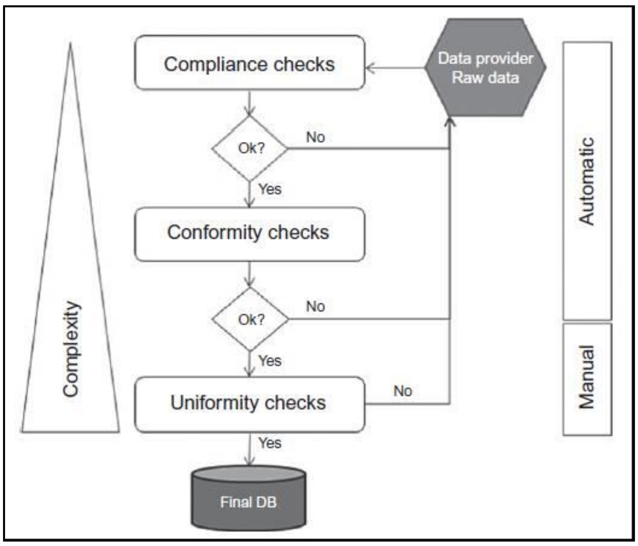

Figure 7-2. The sequence of the data checks applied to the LI-BioDiv dataset (Granke, 2013).

The first validation has been processed according to the given format specifications, reference to codes, and data completeness or duplicates (Compliance checks). The second validation was performed by rules covering plausibility and temporal or spatial consistency of the dataset (conformity checks).

In both cases, the automatic control resulted in error flags (data to be changed or deleted as implausible) or warning flags (out of defined ranges, can be changed or confirmed). Data was modified and confirmed only after a series of feedback with the data providers.

Uniformity testing is to be verified based on expert-based plausibility checks and interpretation of the data with respect to neighbouring and temporal consistency. This issue will be part of the internal evaluation process, as it includes data aggregation analyses, spatial patterns and time series evaluation. A set of simple elaborations have been preliminarily proposed as a tool to support uniformity checks (Table 7-3).

Table 7-3. Description of uniformity checks queries, by proposed tests for selected variables and aggregation levels.

Category	Test
GPL	*age, forest_type, origin, preuse* (descriptive to present plots, distribution)
DBH	*dbh* (mean and SD per species, and subplot) *trees* (count, per subplot, and decay I\0)
THT	*height* (mean and SD per subplot, main species, and all species) *canopy_height* (mean and SD per subplot, main species, and all species)
DWD	*dw_ID* (count per decay, and subplot) *diameter* (count, mean and SD per type, and subplot)
CAN	*n_treelayer* (per sublot) *canopy* (per subplot)
GVG	*species_code* (count per plot per layer - by layer, and all layers) *species_code* (sum)

It is worth to note that, in some cases, not all parameters were assessed (e.g., mandatory variables) or correctly reported; in other cases some scores are missing or still unclear. For these cases additional options in the reference tables (data dictionary) had to be defined. Nevertheless, including some late contacts with national experts, files integrity can be considered quite complete. Doubtful cases, as well as the differences in sampling design or field techniques, will be documented precisely. The documentation of the LI-BioDiv dataset could be improved continuously during the validation process.

The number of plots, and the overall records of the LI-BioDiv dataset by countries are shown in the Table 7-4 and Table 7-5. In some cases, the data from France and Ireland is not fully validated due to lack of information.

Table 7-4. Number of plots delivered by country\region as incorporated into the LI-BioDiv dataset.

Country	Code[11]	GPL	DBH	THT	CAN	DWD	GVG
Austria	14	136	135	129	133	128	136
Belgium Flanders	102	10	10	10	10	10	10
Cyprus	66	19	19	19	19	19	19
Czech Republic	58	146	139	138	141	142	146
Germany Baden-Württemberg	2804	50	49	49	49	50	50
Germany Bavaria\Bayern	2904	97					96
Germany Brandenburg-Berlin	2704	53	53	53	53	40	53
Germany Hessen	3004	29	29	29	29	29	29
Germany Mecklenburg-Vorpommern	3104	17	17	17	17	16	17
Germany Niedersachsen	3204	42	42	42	42	42	42
Germany Rheinland-Pfalz	3304	26	26	25	26	26	25
Germany Saarland	3504	9	9	9	7	9	
Denmark	08	22	22	22	22	5	22
Spain	11	151	145	147	151	92	151
Spain Canaries	95	4	4	4	4	4	4
Finland	15	630	621	617	630	577	629
France	01	548	539	526	538	504	547
Hungary	51	78	77	77	78	74	18
Ireland	07	35	35	35	35	35	29
Italy	05	224	219	220	220	179	201
Lithuania	56	62	62	62	62	58	62
Latvia	64	95	95	95	95	88	95
Poland	53	438	432	431	438	408	438
Sweden	13	100	100		100	85	
Slovenia	60	44	40	40	44	40	39
Slovak Republic	54	108	107	107	108	104	108
United Kingdom	06	167	163	161	163	121	157
Sum of plots		3340	3189	3064	3214	2885	3123

[11] ICP Forests partners (code)

Table 7-5. Number of records included in the LI-BioDiv dataset by country\region and category.

Country	Code[12]	GPL	DBH	THT	CAN	DWD	GVG
Austria	14	136	3773	628	241	2176	3280
Belgium Flanders	102	10	223	46	20	173	153
Cyprus	66	19	239	95	57	201	478
Czech Republic	58	146	4874	436	417	3772	5692
Germany Baden-Württemberg	2804	50	1425	149	92	1253	1738
Germany Bavaria\Bayern	2904	97					3048
Germany Brandenburg-Berlin	2704	53	1927	160	82	446	429
Germany Hessen	3004	29	667	246	58	794	773
Germany Mecklenburg-Vorpommern	3104	17	532	103	34	289	820
Germany Niedersachsen	3204	42	1050	358	84	1048	1239
Germany Rheinland-Pfalz	3304	26	780	189	52	666	636
Germany Saarland	3504	9	292	292	18	186	
Denmark	08	22	699	80	66	8	274
Spain	11	151	2855	737	299	771	3807
Spain Canaries	95	4	105	20	8	15	58
Finland	15	630	20088	1844	1260	6817	18060
France	01	548	18111	2562	1206	6665	15917
Hungary	51	78	2488	284	159	1312	430
Ireland	07	35	1836	173	105	633	278
Italy	05	224	7933	825	1319	3663	17540
Lithuania	56	62	2369	291	186	646	2000
Latvia	64	95	3483	450	190	1182	2746
Poland	53	438	12929	1425	953	4640	13523
Sweden	13	100	2835		100	805	
Slovenia	60	44	1372	243	132	460	2391
Slovak Republic	54	108	2898	440	216	1537	2925
United Kingdom	06	167	5092	755	484	1454	2156
Sum of records		3340	100875	12831	7838	41612	100391

Transnational internal evaluation process

The discussion about a possible transnational internal evaluation process started at the Joint Meeting of the ICP Forests Expert Panels on Forest Growth and on Biodiversity and Ground Vegetation (Wien, October 23-25, 2012), when the experts agreed to a list of common evaluation items. Further improvements have been reached during the Combined Meeting of Expert Panels on Biodiversity and Ground Vegetation, Forest Growth and Meteorology, Phenology and LAI (Freising, June 17-19, 2013) and finalised at the Combined Meeting of the Expert Panels on Ambient Air Quality, Biodiversity and Ground Vegetation, Crown Condition and Damage Causes, Forest Growth, and Meteorology, Phenology and Leaf Area Index (Eberswalde, March 3-6, 2014).

The correct use of the LI-BioDiv dataset is linked to the aim of producing insights into European forests' biodiversity, covering continental-, landscape-, and stand-level definition. Biodiversity patterns through scales and their drivers are suggested as key focus, as well as contribution to functional diversity and mechanisms, which can be used to model the development of forest biodiversity, e.g. to face global changes.

[12] ICP Forests partners (code)

The scientific evaluations based on the new LI BioDiv dataset are open to participation by country experts of the EPs and external cooperation by the scientific community is foreseen, provided the needs of clear coordination by the Panels, and following the Intellectual Property Policy as defined in the Annex of Part I of the ICP Forests Manual (Hansen et al 2010).

The Internal Evaluation Level I-Biodiversity discussion group was created on the ICP Forests website[13] as a showcase to appreciate the state of the art on the internal evaluation process related to the new LI BioDiv dataset. The topics which have been launched are described and periodically updated. Each research topic, led by an internal member of the ICP Forests community, will be afforded within a strict Working Group (private), edited for merely information. Invited members, contributing to the elaboration themes, will share the operative information and discussions.

The working groups established for each evaluation item are voluntary based, according to the common objective of publishing sound scientific papers, increasing the visibility and the scientific relevance of the ICP Forests infrastructure.

Active internal evaluation projects are listed below, which are expected to be finalized, at least partially, within 2016.

UPSPEX, under the responsibility of Gherardo Chirici (University of Florence, WGFB), is dealing with up-scaling and spatially explicit estimation of biophysical variables with remote sensing; data consistency and some presentation at national and international congresses have been produced; a paper on testing a GIS expert-based algorithm for automatic classification of the overall ICP Forests Level I monitoring plots by EFCTs, was recently submitted. The working group is composed of up to 16 members[14].

Δ-Drivers BIOPART, under the responsibility of Roberto Canullo (University of Camerino, EPBDGV), is focused on the driving factors of beta-diversity in European forests, namely assessing interactive effects of ecology and biogeography in determining the total diversity of European forests. A paper was submitted to an international journal about plant species diversity of Italian forests as a first attempt for large scale analyses. European dataset analyses have been presented at various international congresses (EVS, IBS). At present, seven members have joined the related working group[15].

DWpools, led by Janusz Czerepko (IBLES, EPBDGV), proposes to analyse deadwood volume, decay, type and their diversity in relation to forest parameters across Europe. Results will be necessary to possibly explain the variation among forest types and to provide preliminary estimates of deadwood, which could be used as a reference for sustainable forest management. Data conformity and first general analyses have been performed, national attempts for deadwood estimates have been presented at the EPBDGV meetings. The working group was recently created on the ICP Forests website[16], aggregating interested colleagues.

NICHES, by Karl Mellert (LWF, EPBDGV), includes studies on the ecological characterisation of marginal (xeric limits) sites for tree species. Pre-evaluation of data structures is running, subsets of data have been already used within papers on modeling forest sensitivity to climate change, and will be used in running projects like MARGINS, for the specification of thresholds for the cultivation of tree species. A discussion about niche models is launched, based on the PROPS model.

[13] To be found at http://icp-forests.net/group/inteval1biodiv

[14] Cf. http://icp-forests.net/group/upspex

[15] Cf. http://icp-forests.net/group/drivers-biopart

[16] Cf. http://icp-forests.net/group/dwpool

NICHES being a complex issue, a sub task is guided by Han van Dobben (ALTERRA, EPBDGV) who opened the discussion about the modelling approach. Abiotic model (VSD+) combined with niche model calibration should be expanded by using Level I and Level II ground vegetation together with soil data. Members are listed in the discussion group[17].

The full list of topics, including items on the early stage of progress, is given in Table 7-6. It is possible, of course, that some task or hypothesis which has been defined under a given item, may be merged while the process is underway, in agreement among the participants, for specific effort.

Some items have been acknowledged by EPs, but the leadership remained uncertain and they are likely to be included in some other running project. Namely, some multi-indicator approach to a naturalness description was indicated, as well as the linkage of the LI-BioDiv dataset to Natura 2000 (to inspect the distribution of forest habitat types inside and outside of Natura 2000 sites, inspect the relative incidence and changes of the endangered or alien plant species, etc.). Comparison of the representativeness of performances of the Level II with respect to the Level I network in terms of accuracy and representativeness was also commonly underlined as a possible target.

“Country effect” as one of the drivers of distribution patterns of biodiversity variables was also claimed due to previous studies underlying the possible differences in the methodology and socio-economic models (e.g. Ferretti 1998, Klap et al. 2000). Related to that, some evaluation of quality issues data (e.g. biased increase in the number of species, thresholds for significant trends, intercalibration of field surveyors, etc.) have been suggested, and some experts will possibly tackle the task.

Vegetation response to nitrification was another interesting subject that was partially addressed by an integrated group with ICP Integrated Monitoring (ICP IM), including time series from the ICP Forests Level II network (Dirnböck et al. 2014); the availability of large scale representative datasets at Level I can be of great help for further gradient simulation analyses.

The influence of deadwood diversity on bryophytes and vascular plants diversity was the last proposed item, with the deadwood variables being proposed as a possible indicator of the forest ecosystem status.

[17] Cf. http://icp-forests.net/group/niche-model-calibration

Table 7-6. Updated topics for the internal evaluation of Level I-biodiversity datasets. An extended version is to be found at http://icp-forests.net/group/inteval1biodiv Participating scientists are listed upon their willingness to contribute to a given project.

Short name	Resp. persons	Title	Participation	Hypothesis being tested
Δ-Drivers BIOPART	Roberto Canullo	Driving factors of beta-diversity in European forests.	Chiarucci UNIBO, Landi & Giorgini UNISI, Wellstein UNIBZ, Campetella & Chelli UNICAM, Klinck NW-FVA, Grandin SLU, Salemaa & Tonteri LUKE, Oksanen UNIOULU, Wohlgemuth WSL, Kutnar GODZIS	Weight and assess interactive effects of ecology and biogeography in determining the total diversity of European forests using a spatially representative sample: the effects of ecological factors are less important than biogeographical factors.
PHYLOPAT	Roberto Canullo	Phylogenetic patterns at bio-geographical scale.	Mucina UWA, Campetella UNICAM, Wellstein UNIBZ	Competitive exclusion principle emphasises the limited coexistence of similar species. There is a similarity limit in the niches of competing species; species niches constrained by their evolutionary history. Hypothesis of limiting similarity at the phylogenetic level.
FORGUILD	Roberto Canullo	Plant Functional Groups and species diversity patterns.	Campetella UNICAM, Wellstein UNIBZ, Chiarucci UNIBO, Giorgini UNISI, Bartha MTA, Grandin SLU	Is evenness in Plant Functional Groups (guild) distribution associated with a higher species richness? Can this explain plant diversity patterns in European forests?
FUTPA	Roberto Canullo	Plant functional trait patterns in key EU forest types	Wellstein UNIBZ, Spada UNIR1, Chelli & Campetella UNICAM, Msalemaa & Tonteri LUKE, Wohlgemuth WSL, Kutnar GODZIS	The plant functional composition of forest phytocoenosis can be explained by soil parameters, present day climate and legacy of past climate.
NICHES	Walter Seidling	Main drivers of ground vegetation at local and continental scale	Fischer (?) TI	Drivers acting at different spatial scales are influencing floristic composition of ground vegetation
	Maija Salemaa	Niche definition prediction	Mäkipää & Jöksanen LUKE, vanDobben ALTERRA, Klinck NW-FVA, Dupouey INRA, Walthert WSL	Species with narrow niche as bioindicators
	Jean-Luc Dupouey	Soil and species		
	Han van Dobben	Calibration of niche models on EU scale (incl. non-forest vegetation)	Mellert LWF, Ewald HSWT, Canullo UNICAM, Wamelink ALTERRA	Species occurrence can be predicted from abiotic model (VSD+) combined with niche model
	Karl Mellert	Ecological characterisation of tree species marginal (xeric limits) sites	Ewald HSWT, Canullo UNICAM,	1) SDMs based on coarse resolution climate data require refinement; 2) Topography & soil conditions modulate tree sp. response to climate; 3) Ground vegetation provides proxies for site properties; 4) Refined site variables allow to identify false absences
	Han van Dobben	Indicator values, functional traits\groups	Wellstein UNIBZ, Canullo & Chelli UNICAM, Dupouey INRA	
DWpools	Janusz Czerepko	Deadwood estimation through forest ecosystems in Europe	Gawryś, Sokołowski & Cieśla IBLES, Herrmann WSL, Neumann BFW, Canullo, Campetella & Chelli UNICAM, Puletti CRA	What drives deadwood pools and C stocks? Reference patterns - classes; relations with climate gradient, plant richness, productivity?

Short name	Resp. persons	Title	Participation	Hypothesis being tested
WP-KS-KW	Henning Meesenburg	Forest Productivity, Carbon Sequestration, Climate Change	De Vos & Cools INBO, Canullo UNICAM, Michopoulos FRIA, Graf Pannatier WSL, Ilvesniemi & Lindroos LUKE, Mette LWF, Schmidt-Walter NFV	Forest productivity is driven by several climatic and site (soil) specific variables; forest growth models can lead to estimates of the future potential of raw timber stocks and carbon storage of forests and face future climate.
UPSPEX	Gherardo Chirici	Upscaling & spatially explicit estimation of biophysical variables with remote sensing	Travaglini & Giannetti UNIFI, Attorre UNIR1, Canullo & Campetella UNICAM, Bastrup-Birk EEA, Puletti CRA, Barbati, Corona & Mancini UNITUS, Galic UNS	Nearest neighbors techniques for predicting forest variables from satellite imagery and Level I ground data. Population unit predictions as combinations of sample observations (most similar, or nearest, in a space of ancillary variables, to predicted unit)
Small Scale	Maija Salemaa	Small-scale variation of forest floristic diversity under different environmental conditions	Thimonier WSL, Canullo UNICAM, Seidling TI	Null-hypotheses: z-values and intercepts may not depend on forest type, climatic or edaphic climatic conditions, or anthropogenic influences

7.4 Conclusions

Some conclusions can be considered in terms of lessons learned from the process of validation and evaluation of the LI-BioDiv dataset and the definition and implementation of the system of checkroutines.

A noteworthy remark would be that a harmonized large-scale survey is feasible, and the good cooperation among countries enabled ICP Forests to get valuable insights into biodiversity indicators of the European forest systems. To this respect, the BioSoil-Biodiversity experience should be regarded as a funding milestone, and can be used also to avoid the problems linked to incorrect interpretation and lack of logical univocal descriptions, e.g. between the manual and the data forms.

The possibility to include, after validation routines, the Level I dataset on biodiversity within the most developed and experienced infrastructure for forest research and monitoring, was the next important step to this respect. The work behind this is an investment that must be structurally included in further projects, as well as the evaluation process.

The improved documentation of the methodology and the implementation of the system of checkroutines enables to consider a standard for next biodiversity surveys on the Level I network. During the process of validation it became evident that also a bottom-up approach can be considered, enabling the inclusion of other comparable datasets.

For such kind of international surveys, it seems essential to prepare conveniently in advance a manual implementation with clear background, common definitions and the explanation of admissible values, thresholds and selection criteria, to be tested in the field. The experience of the last update of the ICP Forests manual can be of reference for that issue. Any international manual should be translated into an operational field manual for field crews, and the observer errors, both in the application of the sequence of protocols and the field surveys, is a relevant target to be afforded at this level by means of standard field training and intercalibration workshops.

The variables to be considered as mandatory must be fixed, and their number, as used in the BioSoil-Biodiversity project, was probably the best agreement between effort and results. Optional parameters and alternative designs must be well regulated as well. The high number of sites (3340) and the hundreds of thousands of records must be somehow optimized in terms of time spent in the field, simplification of the procedures, and selection of the best representative network, in a way that the feasibility can considerably increase, together with the comparability across Europe. The latter issue is the target of a running Life+ project for the Italian CONECOFOR network (SMART4Action[1]), the results of which could suggest a similar approach for the European Level I network.

As for the BioSoil-Soil module (Blust et al. 2013) here we can highlight the need for clear rules in the ownership and distributed rights, according to internationally accepted rules and standards: data availability and engagement for sharing datasets are relevant issues to ensure continuity and benefit for the community.

[1] http://www.corpoforestale.it/smart4action

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8 ACTIVITIES RELATED TO ICP FORESTS OF THE EXPERT PANELS, WORKING GROUPS, AND COMMITTEES 06/2015 – 05/2016

8.1 Scientific Evaluation Committee (Chair: Marco Ferretti, Italy)

Main activities/developments

Over the period 2015/16, the Scientific Evaluation Committe (SEC) was active in promoting scientific initiatives, presentations and publications, networking, and participation in ICP Forests meetings.

Scientific initiatives included the organisation of the 5th ICP Forests Scientific Conference, planned back to back with the Task Force in Luxembourg, May 2016.

Presentations and publications included: finalization of the Special Issue of Annals of Forest Science (Rautio and Ferretti, Eds. 2015) arising after the 2nd ICP Forests Scientific Conference in Belgrade (Serbia); oral presentation at the IUFRO Conference “Global Challenges of Air Pollution and Climate Change to Forests”; invited talk at the Wood Buffalo Environmental Association (WBEA), Fort McMurray, Canada; oral presentation at the “Epidemiology and Critical Levels Methodology Workshops” (Hindas, Sweden); editorship and contribution to the ICP Forests Executive Report 2014 and Anniversary Report.

Networking included cooperation with ICP Vegetation and the promotion of a Memorandum of Understanding with the Wood Buffalo Environmental Association (WBEA), Canada.

Participation to ICP Forests meetings included: Programme Co-ordinating Group meeting (Berlin, Germany); Combined Expert Panel meeting (Piteşti, Romania).

Major results/highlights

- Special Issue of Annals of Forest Science, Rautio P, Ferretti M (2015) Monitoring European forests: results for science, policy, and society. Ann For Sci 72:875-876. doi: 10.1007/s13595-015-0505-6
- Executive Report 2014
- Anniversary Report
- 4th ICP Forests Scientific Conference, Ljubljana, Slovenia, 2015
- Contribution to the organisation of the 5th ICP Forests Scientific Conference, Luxembourg, 2016
- MoU with WBEA (to be submitted to the Task Force 2016)

Meetings (organised/attended)

Date	Location	Title	Role / Function / Activity
01.-05.06.2015	Nice, FRA	IUFRO Conference “Global Challenges of Air Pollution and Climate Change to Forests”	Oral presentation
07.-08.10.2015	Berlin, DEU	ICP Forests Programme Coordinating Group	Chair of the Scientific Evaluation Committee
22.-24.10.2015	Fort McMurray, CAN	Visit to WBEA	Invited talk and visit
23.-25.11.2015	Hindas, SWE	ICP Vegetation: Epidemiology and Critical Levels Methodology Workshop	Oral presentation

Date	Location	Title	Role / Function / Activity
18.-22.04.2016	Piteşti, ROU	Combined Meeting (EPs Biodiversity and Ground Vegetation; Forest Growth; Meteorology, Phenology and LAI)	Proposal for oral presentation
10.-12.05.2016	Luxembourg City, LUX	5th ICP Forests Scientific Conference	Organisation of the Conference, Chair of the Scientific Committee

Co-operations

- IUFRO, by means of participation to meetings
- ICP Vegetation, by means of participation to meetings
- WBEA, by means of promotion of an MoU
- All other EPs of the ICP Forests.

Outlook

- Continuation of scientific initiatives and networking within the ICP Forests community
- Preparation of a joint, co-operative study within the ICP Forests community
- Further development of networking at global level.

8.2 Quality Assurance Committee (Chair: Marco Ferretti, Italy; Co-chair: Nils König, Germany; Co-chair: Anna Kowalska, Poland)

Main activities/developments

Over the period 2015/16, the Quality Assurance Committee (QAC) was active only in promoting the revision of the ICP Forests Manual. On the operational part, much work has been carried out by the WG on Quality Assurance/Quality Control in Laboratories (see below).

Besides, the QAC attended ICP Forests meetings (Programme Co-ordinating Group meeting, Berlin, Germany; Combined Expert Panel meeting, Piteşti, Romania) and contributed to the ICP Forests Anniversary Report.

Major results/highlights

- Continuation of the process necessary to keep the Manual fully updated, and according to the designated revision programme
- Revision of individual chapter of the Manual
- Field-related QA/QC activity remains to be fully accounted for.

Meetings (organised/attended)

Date	Location	Title	Role / Function / Activity
07.-08.10.2015	Berlin, DEU	Programme Coordinating Group	Chair of the Quality Assurance Committee
18.-22.04.2016	Piteşti, ROU	Combined Meeting (EPs Biodiversity and Ground Vegetation; Forest Growth; Meteorology, Phenology and LAI)	Observer for the QA/QC part

Co-operations

- WG on Quality Assurance/Quality Control in Laboratories
- Other EPs of the ICP Forests
- WBEA data and QA managers

Outlook

Continuation of the activity to control the update of the Manual.

8.3 Working Group on Quality Assurance and Quality Control (QA/QC) in Laboratories
(Chair: Nils König, Germany; Co-chair: Anna Kowalska, Poland)

Main activities/developments

In 2015/16, the Working Group finalized a new method code system for all analytical methods used in the monitoring programme and in the ring tests. The code system now describes three analytical steps: sample preparation, pretreatment and determination. With this new code system the structure of the code is harmonized and simplified over all sample types and some discrepancies between the codes for deposition and soil solution samples have been eliminated.

In the framework of the regularly mandatory ring test programme of ICP Forests, this year a soil and a needle/leaf interlaboratory comparison test was organised by Tamara Jakovljević (Croatian Forest Research Institute) and Alfred Fürst (Austrian Federal Research and Training Centre for Forests, Natural Hazards and Landscape).

At the 5th meeting of the heads of the labs in Vienna, the participants gave 15 presentations about analytical problems and solutions. Anna Kowalska (Polish Forest Research Institute) took over the organisation of the deposition and soil solution ring tests from Kirsti Derome (Natural Resources Institute Finland) and Aldo Marchetto (Italian Institute for Ecosystem Study). The results of the last four ring tests have been discussed. The percentage of non-tolerable results has decreased again for water parameters and also some soil parameters.

Meetings (organised/attended)

Date	Location	Title	Role / Function / Activity
22.04.2015	Göttingen, DEU	Meeting of the Working Group QA/QC in Labs Combined meeting of the WG together with the Expert Panels Deposition and Foliage	Summarizing of the organisational issues of the ring-tests, preparation of the next meeting of the heads of the labs, presentation of the new codes of analytical methods, discussing the plans for assistance programme and QA forms in the database
17.-18.09.2015	Vienna, AUT	5th Meeting of the heads of the labs	Presentation of the results of the last foliar, soil, deposition and soil solution ring tests; exchange of the knowledge between laboratories by presenting analytical problems and new methods.

Outlook

In 2016/17, the 19th Needle/Leaf Interlaboratory Comparison Test and the 8th Atmospheric Deposition And Soil Solution Working Ringtest is planned.

8.4 Expert Panel on Ambient Air Quality (Chair: Marcus Schaub, Switzerland; Co-chair: Elena Gottardini, Italy)

Main activities/developments

The entire 2000-2014 dataset on ozone concentrations was validated and aggregated in 2015. Respective results habe been presented and published at various conferences and in several reports. Continuous data validation and aggregation including enhanced QA/QC for data on ozone-induced injury has been (and is still being) implemented. In close collaboration with the national experts from participating countries, the resubmission of the cleaned datasets for both, ozone concentration and ozone symptoms is anticipated for 2016.

Data availability

The submitted Level II data was collected in 2014.

Survey	Data submission		External data usage / data dissemination
	No. of plots	No. of participating countries	No. of ongoing projects (06/2015–05/2016)
Air quality	17 Level II	4	12
Assessment of ozone injury	64 Level II	9	8

Major results/highlights

Calatayud V, Diéguez JJ, Sicard P, Schaub M, De Marco A. Testing approaches for calculating stomatal ozone fluxes from passive samplers. Science of the Total Environment (in review)

De Vries W, Solberg S, van Dobben H, Schaub M (2015) Impacts of acid deposition, ozone exposure and weather conditions on forest ecosystems in Europe derived from long-term monitoring. In: Sicard P, Paoletti E, Bytnerowicz A (eds) Challenges of Air Pollution and Climate Change to Forests, Programme and Abstracts, IUFRO Research Group 7.01, 1-5 June 2015, Nice, France, 171 pp

De Vries, Etzold S, Posch M, Reinds GJ, Bonten LTC, Solberg S, Waldner P, Schaub M, Simpson D (2015) Assessment of impacts of nitrogen deposition, ozone exposure and climate change on carbon sequestration by monitoring and modeling. In: Sicard P, Paoletti E, Bytnerowicz A (eds) Challenges of Air Pollution and Climate Change to Forests, Programme and Abstracts, IUFRO Research Group 7.01, 1-5 June 2015, Nice, France, 171 pp

Ferretti M, Hansen K, Calatayud V, Camino-Serrano M, Cools N, De Vos B, Nieminen TM, Potocic N, Rautio P, Schaub M, Timmermann V, Ukonmaanaho L, Waldner P (2015) Monitoring and modeling the long-term impact of air pollution on forest health and growth in Europe. In: Sicard P, Paoletti E, Bytnerowicz A (eds) Challenges of Air Pollution and Climate Change to Forests, Programme and Abstracts, IUFRO Research Group 7.01, 1-5 June 2015, Nice, France, 171 pp

Schaub M, Ferretti M, Gottardini E, Calatayud V, Haeni M (2015) 2000-2013 ozone trends across Europe, p. 38. In: Seidling W (ed) Book of abstracts: Long-term trends and effects of air pollution on forest ecosystems, their services, and sustainability, 4th ICP Forests Scientific Conference, May 2015, Ljubljana, Slovenia, 52 pp

Schaub M, Haeni M, Ferretti M, Gottardini E, Simpson D, Calatayud V (2015) Ozone risk assessment for European forests – a ten-year study on permanent monitoring plot. In: Sicard P, Paoletti E, Bytnerowicz A (eds) Challenges of Air Pollution and Climate Change to Forests, Programme and Abstracts, IUFRO Research Group 7.01, 1-5 June 2015, Nice, France, 171 pp

Schaub M, Haeni M, Ferretti M, Gottardini E, Calatayud V (2015) Ground level ozone concentrations and exposures (ICP Forests). In: De Wit H, Hettelingh JP, Harmens H (eds) Trends in ecosystem and health responses to long-range transported atmospheric pollutants. ICP Waters report 125/2015, pp 48-50

Meetings (organised/attended)

Date	Location	Title	Role / Function / Activity
22.04.2015	Göttingen, DEU	Combined meeting of the Expert Panels on Deposition, Soil and Soil Solution, Foliar Analysis and Litterfall, and Ambient Air Quality	Latest new findings and new initiatives were presented. Suggested changes for the Manual were discussed.
23.11.2015	Hindas, SWE	ICP Vegetation Epidemiology and Critical Levels Methodology Workshops	Interaction with ICP Vegetation
18.04.2016	Piteşti, ROU	Combined Meeting (EPs Biodiversity and Ground Vegetation; Forest Growth; Meteorology, Phenology and LAI)	Chairship and interaction with EPs. Preparation of intercalibration course.
10.05.2016	Luxembourg City, LUX	5th ICP Forests Scientific Conference	Member of Scientific Committee, chairing session with five presentations on ozone.

Co-operations

ICP Vegetation, EMEP

8.5 Expert Panel on Biodiversity and Ground Vegetation (Chair: Roberto Canullo, Italy; Co-chair: pending)

Main activities/developments

The chairman of the EP continued the activity for the full validation of the LI BioDiv dataset with continuous advice from experts from the NFCs and EPs; very last contacts with the colleagues of some country and other NFCs experts have been useful for refining the uploaded files. The procedure was completed for the finalisation in more than 95% of cases; pending interpretations and open questions have been isolated, and possible amendments to compliance and conformity checks discussed with the PCC.

Consulting exchanges have been also established in order to allow data submission from different countries, form “new” datasets; this claims for harmonization activities through EP experts.

In the case of Switzerland, uploading of data based on the same LI BioDiv dataset protocols seems very feasible. Spain has the possibility to apply for submission of some datasets coming from repetition of surveys, compatible with the Level I dataset on biodiversity. The same willingness was expressed by the Netherlands.

Recent contacts with Wallonia (BE) have confirmed the possibility of data submission of ground vegetation surveys (4 repetitions since 1998, ending with 2005) but some format conversion should be verified.

The Panel was active in promoting internal evaluation processes of the datasets, namely about the Biodiversity module of the Level I network.

Some members and the EP chair attended ICP Forests meetings (TF, Joint EPs meetings, etc.).

Data availability

The submitted Level II data was collected in 2014.

Survey	Data submission		External data usage / data dissemination
	No. of plots	No. of participating countries	No. of ongoing projects (06/2015–05/2016)
Assessment of ground vegetation	64 Level II	7	15
Ground vegetation biomass	13 Level II	1	8
Biodiversity	Levei I		11

Major results/highlights

EP Biodiversity and Ground Vegetation members co-operated with other EPs in producing published results or providing national reporting, such as:

- Mellert KH, Deffner V, Küchenhoff H, Kölling C (2015) Modeling sensitivity to climate change and estimating the uncertainty of its impact: A probabilistic concept for risk assessment in forestry. Ecol Model 316:211-216
- Chirici G and coll. (including R. Canullo) have submitted a paper about the application to ICP Level I plots of a rule-based expert system for the classification of European Forest Types.

- Canullo R & coll. have submitted a paper on biogeography influences on plant species diversity of Italian forests by using Level I datasets.
- Some preliminary results at national or EU level have been presented at international and national scientific congresses and symposia (e.g. International Biogeography Society 7th Biennial Meeting, 8–12 January 2015, Bayreuth; 4th ICP Forests Scientific Conference, May 19–20 2015, Ljubljana; 58th Symposium of the IAVS, 19–24 July 2015, Brno; 10th SISEF National Congress, 15–18 September 2015, Firenze; 5th ICP Forests Scientific Conference, 10–12 May 2016, Luxembourg).
- Contribution to the 30th Anniversary Report

Meetings (organised/attended)

Date	Location	Title	Role / Function / Activity
19.-24.07.2015	Brno, CZE	58th IAVS Symposium	Poster presentation about the possible use of ICP Forests LI BioDiv dataset to assess the potential distribution of Nature 2000 forest habitats
15.-18.09.2015	Firenze, ITA	10th SISEF National Congress	Participation to a poster presentation about deadwood availability and stand forest attributes from ICP Forest LI BioDiv datasets
18.-22.04.2016	Piteşti, ROU	Combined Meeting (EPs Biodiversity and Ground Vegetation; Forest Growth; Meteorology, Phenology and LAI)	Chairship: status of internal evaluation on LI-Biodiversity; Running evaluations and activities (Sue Benham: volume and carbon storage in deadwood in British Woodland; Silvia Guerrero: LI deadwood assessments, repetitions, harmonization with NFI in Spain; Janusz Czerepko, *DWpools*: amount and quality of deadwood by forest type and stand age)
10.-12.05.2016	Luxembourg city, LUX	5th ICP Forests Scientific Conference & Task Force Meeting	Participation to the conference through EP members and related institutions; poster presentations

Co-operations

In the frame of running projects aimed at internal evaluations of the Level I biodiversity data, scientific cooperation with EPs and other groups, colleagues and external researchers (from Universities, Scientific Academies, Forest Research Centers) have been pursued under the leadership of some of the EP participants.

Related discussion groups have been created in the ICP Forests website.

Outlook

Surveys of ground vegetation and\or deadwood on Level II national networks are foreseen in the summer 2016, sometimes within parallel projects (as in the case of the LIFE+ SMART4Action project in Italy, Level I resampling for soil and plot information with suggested vegetation surveys in Poland, and NFI vs. Level I comparison for deadwood and EFTC in Spain). Normal repetition of 5-yearly Level II surveys will continue in several countries; Latvia will start the ground vegetation assessments in 2016.

The internal evaluation of the Level I biodiversity data will continue, aiming at scientific sound papers and dissemination at international congresses. The dataset on biodiversity in the Level I network will be completely included, with some accompanying notes, and opened to external evaluations.

Species diversity is one of the targets of a proposal submitted within the H2020 call INFRAIA (ForAccess), and some of the EP members have been involved it it through their institutions.

8.6 Expert Panel on Crown Condition and Damage Causes (Chair: Nenad Potočić, Croatia; Co-chair: Volkmar Timmermann, Norway)

Main activities/developments

Update of Manual Part IV Visual Assessment of Crown Condition and Damaging Agents and the corresponding online documentation.

Data availability

The submitted data from Level I plots was collected in 2015, from Level II plots in 2014.

Survey	**Data submission**		**External data usage / data dissemination**
	No. of plots	No. of participating countries	No. of ongoing projects (06/2015–05/2016)
Visual assessment of crown condition	4986 Level I	25	20
Visual assessment of crown condition	491 Level II	22	25

Major results/highlights

Updated manual was adopted at the TFM in Luxembourg in May 2016.

Co-operations

A cooperation with the SEED-C project in data analysis and writing of manuscripts regarding the fruiting of trees on Level I plots, involving a number of EP members.

Outlook

Expert Panel meeting is foreseen to take place in spring 2017 in Croatia. Two International cross-comparison courses are foreseen in 2017, to be held in the Czech Republic and Turkey.

8.7 Expert Panel on Deposition (Chair: Karin Hansen, Sweden; Co-chair: Daniel Žlindra, Slovenia)

Main activities/developments

Continuous internal data evaluations are forthgoing in the Expert Panel and many member participants take leading roles in this work. Most evaluations were thoroughly discussed at the combined EP meeting in Göttingen April 2015, but continuous mail contact around these evaluations are taking place and developing it further. Furthermore, the deposition data has been requested and provided several times for external evaluations. No manual updates are needed for the time being.

Data availability

The submitted Level II data was collected in 2014.

Survey	Data submission		External data usage / data dissemination
	No. of plots / year	No. of participating countries	No. of ongoing projects (06/2015–05/2016)
Deposition	248 Level II	23	23

Major results/highlights

EP Deposition has co-operated with other EPs in producing results published in following articles:

Ferretti M et al (2015) Variables related to nitrogen deposition improve defoliation models for European forests. Ann For Sci 72(7):897-906. doi: 10.1007/s13595-014-0445-6

Erratum: Ferretti M et al (2015) Erratum to: Variables related to nitrogen deposition improve defoliation models for European forests. Ann For Sci 72(7):907-907. doi:10.1007/s13595-015-0472-y

Jonard M et al (2015) Tree mineral nutrition is deteriorating in Europe. Glob Change Biol 21(1):418-430. doi: 10.1111/gcb.12657

Waldner P et al (2015) Exceedance of critical loads and of critical limits impacts trees. Ann For Sci 72(7): 929-939. doi: 10.1007/s13595-015-0489-2

Meetings (organised/attended)

Date	Location	Title	Role / Function / Activity
22.04.2015	Göttingen, DEU	Combined meeting of the Expert Panels on Deposition, Soil and Soil Solution, Foliar Analysis and Litterfall, and Ambient Air Quality.	The meeting summarized the latest results on projects and data evaluations concerning deposition to forests. Discussions on the aggregated depostion data and on future new data evaluations.

Co-operations

The EP is co-operating with many of the other EPs on joint data evaluations. Also, a co-operation with EMEP has been started where the following comparisons have been initiated:

- Comparison of measured ICP Forests bulk and throughfall deposition with modelled EMEP (50 x 50 km grid model and the 7 x 7 km grid) for the year 2013 (Lead: Aldo Marchetto)
- Comparison of temporal trend of EMEP model, EMEP measurements and ICP Forests bulk and throughfall deposition measurements (Lead: Hilde Fagerli)
- Comparison of total deposition estimates calculated with canopy budget models based on ICP Forests Level II bulk, throughfall and stemflow measurements (Lead: Peter Waldner)

Outlook

The Expert Panel on Deposition will have its next panel meeting in the spring of 2017. Meanwhile we continue working on evaluations of ICP Forests deposition data.

8.8 Expert Panel on Foliar Analysis and Litterfall (Chair: Pasi Rautio, Finland; Co-chair: Liisa Ukonmaanaho, Finland)

Main activities/developments

18th needle/leaf interlaboratory comparison test 2015/2016 (http://bfw.ac.at/rz/bfwcms2.web?dok=6008224)

Data availability

The submitted Level II data was collected in 2014.

Survey	Data submission		External data usage / data dissemination
	No. of plots	No. of participating countries	No. of ongoing projects (06/2015–05/2016)
Foliage	99 Level II	5	18
Foliage	Level I		15
Litterfall	151 Level II	16	15

Major results/highlights

EP foliage and litterfall co-operated with other EPs in producing results published in following articles:

Ferretti M et al (2015) Variables related to nitrogen deposition improve defoliation models for European forests. Ann For Sci 72:897-906

Jonard M et al (2015) Tree mineral nutrition is deteriorating in Europe. Glob Change Biol 21:418-430

Nussbaumer A et al (2016) Patterns of mast fruiting of common beech, sessile and common oak, Norway spruce and Scots pine in Central and Northern Europe. Forest Ecol Manag 363:237-251

Rautio P., Ferretti M (2015) Monitoring European forests: results for science, policy, and society. Ann For Sci 72: 875-876.

Talkner U et al (2015) Phosphorus nutrition of beech is decreasing in Europe. Ann For Sci 72:919-928

Waldner P et al (2015) Exceedance of critical limits for soil solution and its impact on tree nutrition. Ann For Sci 72: 929-939

8.9 Expert Panel on Forest Growth (Chair: Tom Levanič, Slovenia; Co-chair: pending)

Main activities/developments

Evaluation of the 2014/2015 Level II Growth and Yield inventory data

Data availability

The submitted Level II data was collected in 2014.

Survey	Data submission		External data usage / data dissemination
	No. of plots	No. of participating countries	No. of ongoing projects (06/2015–05/2016)
Growth and yield	270 Level II	15	28

Meetings (organised/attended)

Date	Location	Title	Role / Function / Activity
18.-22.04.2016	Piteşti, ROU	Combined Meeting (EPs Biodiversity and Ground Vegetation; Forest Growth; Meteorology, Phenology and LAI)	Active participation of EP Growth
18.-20.05.2015	Ljubljana, SVN	4th ICP Forests Scientific Conference *Long-term trends and effects of air pollution on forest ecosystems, their services, and sustainability*	Participation and reporting of the EP Growth chair to TF board
10.-12.05.2016	Luxembourg, LUX	5th ICP Forests Scientific Conference	Participation to the Conference through EP members and related institutions, with poster presentations.

Outlook

- Evaluation of data colleted in the inventory 2014/15 and removal of errors in the database
- Changes to the Manual are to be completed till TF meeting in Luxemburg.

8.10 Expert Panel on Meteorology, Phenology and Leaf Area Index (Chair: Stephan Raspe, Germany; Co-chair: Stefan Fleck, Germany)

Main activities/developments

Main activities in the period 2015/2016 were the development of gap-filled meteo data for the Level II plots, the comprehensive renewal of the manual chapters on phenological observations and leaf area index (LAI) measurements, the phenological observation course at the Expert Panel meeting 2016, and the development of a common standard for the evaluation of hemispherical photographs in cooperation with the ICOS project.

The technological development in the area of indirect optical methods for LAI determination in the years since 2012, when the manual was approved, was quick due to the improvements of digital cameras and LAI-related software, the availability of new efficient methods for mean leaf angle determination in canopies, and the newly invented scattering correction that enables hemispherical measurements with the LAI-2200 under direct sunlight conditions. The standardisation of the evaluation of hemispherical photographs was also urgent due to too many degrees of freedom for the operator in the image acquisition and analysis process.

Data availability

The submitted Level II data was collected in 2014.

Survey	Data submission		External data usage / data dissemination
	No. of plots	No. of participating countries	No. of ongoing projects (06/2015–05/2016)
Meteorological measurements	163 Level II	18	26
Leaf Area Index (LAI)	45 Level II	7	14
Phenology	158 Level II	13	14

Major results/highlights

Meteorology

In cooperation with the Swiss project “NitLeach II” quality and completeness of the whole meteorological dataset of ICP Forests were improved. After asking the member states for additional meteorological data the remaining gaps were filled with data from global reanalysis ERA-Interim dataset (http://www.ecmwf.int/). Era-Interim model data was extracted at plot location using bilinear interpolation method between 4 pixels. Before downscaling and gap filling outliers in the measured data were removed with usage of Mahalanobis (*Mahalanobis, 1936)* distance and a critical distance driven from chi square distribution at a p of 0.995. In order to prevent bias during the gap filling procedure the data was downscaled to plot level using Kernel Density Distribution Mapping (KDDM; *McGinnis et al., 2014*). As a result a dataset of quality checked and gapless meteorological data for 355 Level II plots and from 1979 to 2013 were established. For 46 Level II plots water budget modelling was conducted by using the model LWF-Brook90.

During the Expert Panel meeting in Piteşti atmospheric pressure was added as a new optional variable within the measurement programme. Properties, measurement requirements, plausibility limits, and a formula for calculations of local data from nearby weather stations are given in the ICP Forests Manual, Part IX Meteorological Measurements.

Phenology

Among other changes, the improved standardisation of phenological observations in the manual comprised a clearer definition of the assessed tree crown, which now in general excludes epicormic branches and preferentially orients the observation to the upper third(s) of the crown. Experiences from the use of phenological cameras were used to clearer define the selection of at least four trees to be assessed with this method. The phenological observation course showed once again how important the timing of phenological observations is: While abundant flowering of beech trees was observed on a pre-excursion to the observation plot, nearly no flowers were left after a heavy thunderstorm a few days later.

LAI

An in-depth analysis of the whole measurement procedure for hemispherical photographs resulted in several changes to the accepted methods in the manual: The histograms of grey values produced by recent digital cameras allow an easier and more reproducible image acquisition process (now accepted as second option). In order to reach a better comparability to LAI-2200 data, the inversion method used in image analysis is now updated to the method after Norman & Campbell (1989), after it has been Miller (1967) before. Automated thresholding is set as a standard, preferentially using the Ridler & Clavard (1978) method, which has been shown to be most sensitive to gaps in the canopy. The requirements for the camera and lens used are now more precisely defined and a new geometric calibration protocol for the camera-lens combination has been included. Lens projection functions for the most widespread hemispherical lens brands are now included in the annex to the manual. The measurement grid for photograph acquisition was not changed. While it covers in accordance with ICOS an area of 30m x 30m, the measurement density is still a bit higher in ICP Forests. As a consequence, a distance of at least 5 times the stem diameter has to be held to tree stems, while this number is 5.7 within ICOS.

The LAI measurement under direct sunlight conditions with LAI-2200 is accepted in the manual. Needle-to-shoot area and woody-to-total area were selected from literature sources as species-specific correction factors for 23 conifer species. Mean leaf angles to be used for ceptometer measurements were compiled and made available for the 20 most common tree species in Europe.

Meetings (organised/attended)

Date	Location	Title	Role / Function / Activity
04.-05.03.2015	Antwerp, BEL	LAI Expert Meeting	Consultant of ICP Forests
07.-08.10.2015	Berlin, DEU	PCG Meeting	Chair and Co-Chair
18.-22.04.2016	Piteşti, ROU	Combined Expert Panel Meeting	Chairing three sessions, phenological observation course
10.-13.05.2016	Luxembourg, LUX	Scientific Conference and Task Force Meeting	Oral presentations

Co-operations

The collaboration with ICOS has the goal to adapt the standards used in both programs in order to increase comparability of the results. It is based on the common interest of both programs to use hemispherical photographs for LAI determination on long-term monitoring plots, which are partly the same plots in both programs and the development of own measurement protocols in the newly funded ICOS program. A series of meetings of LAI experts was set up starting with two meetings in Antwerp (2013 and 2015).

Outlook

The improved meteorological dataset allows several new analyses and applications in the future. Thus, deviations of recent weather conditions from the long-term averages could be calculated. This could be used to calculate meteorological stress on forest vitality. Moreover this data could be used for parameterisation of different deterministic models (e.g. water budget, phenology, ozone uptake etc.).

After the Expert Panel meeting in Piteşti (2016), the necessity to adapt the used methods to future improvements in LAI measurement technology was acknowledged. A follow-up meeting of LAI experts was planned together with Dr. Francesco Chianucci, who will organise this event in 2017 in Italy. Cooperation with other Expert panels such as on Crow Condition and Damage Causes especially should be intensified.

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Miller JB (1967) A formula for average foliage density. Aust J Bot 15:141-144

Norman JM, Campbell GS (1989) Canopy Structure. In: Pearcy RW, Ehleringer J, Mooney HA, Rundel P (eds) Plant Physiological Ecology. Chapman and Hall, London, pp 301-325

Ridler TW, Calvard S (1978) Picture thresholding using an iterative selection method. IEEE T Syst Man Cyb 8(8):630-632

8.11 Expert Panel on Soil and Soil Solution (Chair: Bruno De Vos, Belgium; Co-chair: Nathalie Cools, Belgium; Co-chair: Tiina Nieminen, Finland)

Main activities/developments

Since June 2015 updates of both the solid soil and soil solution manuals were prepared based on the recommendations of the 19th Soil Expert Panel Meeting (Göttingen, April 2015) in order to be presented and adopted by the Task Force meeting in Luxembourg.

Regarding the forest soil condition databases, specific initiatives were taken. A dedicated two-day Technical Meeting of the FSCC and the database manager of PCC (Till Kirchner) was held in Geraarsbergen, Belgium (March 2016) to plan the further harmonisation and combination of the solid soil datasets of Level I and Level II, and their full integration into the ICP Forests database. In this process, old soil data (roughly before 2003) and more recent soil data will be combined with consistent coding and definitions in the new online documentation system.

For the Level II aggregated soil database, a data paper (Fleck et al.) submitted to Annals of Forest Science was further revised and is expected to be published in 2016. This AFSCDB.LII.2.2 dataset contains 130 soil variables of 286 Level II plots, including derived data as total carbon and nitrogen stocks, C:N ratios, available water capacity, water retention parameters and many more. Also for the aggregated soil solution database, elaborated by Elisabeth Graf Pannatier (CH), work is now continued by Jim Johnson (IE) and other EP members.

New solid Level II soil data (Russia 100 plots, France 100 plots and Wallonia 8 plots) has been submitted and is currently under evaluation. Twenty countries submitted soil solution data, in total over 11 000 soil solution samples.

A proposal called SoilBio4CN on functional soil biodiversity was submitted for the BiodivERsA 2015 call. Soil Expert Panel members were active in several studies and data evaluations, COST actions (e.g. EuMIXFOR), and related publications.

The EP participated in the 8th Solid Soil ringtest and the 8th Deposition and Soil Solution ringtest.

A strategy is further developed for better reporting of State of European Forests SFM 2.2 indicators using soil solution quality indicators (every 4 years) in addition to solid soil indicators (available every 10-15 years). Hence, the EP investigates the need and willingness of countries to organise a harmonized third pan-European Level I soil survey synchronized between 2020 and 2025.

Data availability

The submitted Level II data was collected in 2014.

Survey	**Data submission** No. of plots	No. of participating countries	**External data usage / data dissemination** No. of ongoing projects (06/2015–05/2016)
Soil	208 Level II	3	22
Soil	Level I		18
Soil solution	178 Level II	20	20
Soil water	Level II		9

Major results/highlights

- Supporting several ongoing data evaluations using soil and soil solution data
- Process was started of combining all solid soil data in Level I and Level II soil datasets and full integration in ICP Forests database and online documentation system
- Publication of data paper on Level II aggregated Forest Soil Condition database (AFSCDB.LII.2.2)

Meetings (organised/attended)

Date	Location	Title	Role / Function / Activity
07.-08.10.2015	Berlin, DEU	PCG Meeting	Chair Expert Panel on Soil & Soil Solution
16.03.2016	Louvain-la-Neuve, BEL	EuMIXFOR meeting COST Action FP1206: European mixed forests. Integrating Scientific Knowledge in Sustainable Forest Management	Contributions from Soil Expert Panel members (Nathalie Cools, Mathieu Jonard, Lars Vesterdal) on possible evaluations of ICP Forests soil data
17.-18.03.2016	Geraardsbergen, BEL	Technical Meeting FSCC – PCC database manager	Planning and preliminary work on combining forest soil condition databases for Level I and Level II
10.-12.05.2016	Luxembourg, LUX	5th ICP Forests Scientific Conference	Member of the Scientific Committee, session chair

Co-operations

- Co-operation with Alternet for elaboration of the SoilBio4CN proposal
- Co-operation in COST Action FP1206 (EuMIXFOR) for joint data analyses

Outlook

- Presentation of the new combined Level I Forest Soil Condition database and Level II FSCDB
- Elaboration of the new Aggregated Level II soil solution database
- Organisation of next Soil EP meeting (20th anniversary edition!) combined with other EPs in March-April 2017

9 REVIEW OF THE 4TH ICP FORESTS SCIENTIFIC CONFERENCE, LJUBLJANA, 19-20 MAY 2015

The 4th ICP Forests Scientific Conference *Long-term trends and effects of air pollution on forest ecosystems, their services, and sustainability* was hosted by the Slovenian Forestry Institute and held at the Grand Hotel Union in Ljubljana, Slovenia, on May 19–20, 2015 with 73 participants from 26 countries.

The conference was aimed at scientists and experts from ICP Forests, the UNECE ICP community under the Working Group on Effects (WGE), partners and respective stakeholders, as well as all interested scientists and experts from related fields. Researchers engaged in projects, evaluations and modelling exercises based on ICP Forests data, or working in co-operation with ICP Forests were encouraged to present and discuss their work and results.

The 4th Scientific Conference of ICP Forests addressed the role of air pollution as primary or secondary stressor and its effects on tree growth, crown condition, biodiversity, ecosystem services, and the sustainability of forests.

Main topics were:

- The temporal development (possibly with predictions) of air pollution effects on forests, including nitrogen deposition and ozone impacts, on different spatial scales
- The temporal and spatial development of forest performance indicators, forest ecosystem services, their sustainability and interactions with climate trends
- Integrative analyses and modelling exercises based on the above indicated data

The conference provided an overview on the latest research in policy relevant fields, such as air pollution trends, trends of response variables and interactions with climate change, as well as on nutrient and water cycles, biodiversity, and forest condition. A comprehensive platform was offered for scientists to discuss scientific questions and share experiences. The conference provided an annual platform to bring together monitoring experts, researchers, and modellers.

Data users benefited from background information related to the datasets. Data providers profited from an advanced insight into the latest statistical applications based on "their" data. Data users were able to take advantage of getting in touch with data experts to discuss data availability and data quality as well as metadata. Both, data and evaluations provide a sound basis for future activities at all levels of integration and differentiation: spatial, temporal, and functional.

9.1 PRESENTATIONS AT 4th ICP FORESTS SCIENTIFIC CONFERENCE

The following list includes all presentations given at the 4th ICP Forests Scientific Conference. All conference abstracts are available on the ICP Forests website[1].

Andreassen K, Aas W. **Effects of nitrogen deposition on growth of Norway spruce in Norway.**

Berger T, Muras A. **Predicting recovery from Acid Rain using the micro-spatial heterogeneity of soil columns downhill the infiltration zone of beech stemflow.**

[1] http://www.icp-forests.net/page/icp-forests-other-publications

Berki I, Rasztovits E, Móricz N, Kolozs L. **Retreating sessile oak forest with improving vitality – including tree mortality in vitality assessment.**

Canini L, Farina A, Marchetto A, Matteucci G, Fares S, Fabbio G, Salvati L, Cecchini G, Bussotti F, Ferretti M. **Making forest monitoring cheaper and closer to society: The LIFE+ Project »SMART4Action«.**

Čater M. **A 20-year overview of *Quercus robur* L. mortality and crown condition in Slovenia.**

Chirici G, Barbati A, Giannetti F, Travaglini D, Canullo R. **The use of ICP Forests Level I BIOSOIL-BIODIVERSITY plots for pan-European estimation of forest variables.**

Dolschak K, Berger T.W. **Modelling sulphur biogeochemistry of beech (*Fagus sylvatica*) stands at the Vienna Woods.**

Ferretti M, Calderisi M, Gottardini E, Nicolas M. **Defoliation reconsidered?**

Finžgar D, Westergren M, Fussi B, Konnert M, Aravanopoulos P, Božič G, Kraigher H. **LIFEGENMON - LIFE for European Forest Genetic Monitoring System: Development of a system for forest genetic monitoring.**

Serdar RG, Stefanović T, Češljar G, Bilibajkić S, Nevenić R, Đorđević I, Poduška Z, Rakonjac L. **Monitoring within integrated pest management as essential precondition for sustainable governance of natural resources in Serbia – defoliation comparable analysis on ICP Forests plots during period 2009-2014.**

Galic Z. **Soil properties on the level I plots in lowland forests in Serbia.**

Johnson J, Cummins T, Aherne J. **Contrasting responses of two Sitka spruce forest plots in Ireland to reductions in sulphur emissions: results of 20 years of monitoring.**

Kattge J, Díaz S, Lavorel S, Prentice C, Leadley P, Bönisch G, Wirth C, and the TRY consortium. **TRY – the global database of plant traits.**

König N, Cools N, Derome K, Fürst A, Marchetto A, Blum U, Schönfelder E. **Comparability of analytical data as a basis of possible evaluation of European deposition, soil and foliage data.**

Kutnar L, Eler K. **Use of ICP Forests methodology for assessment of species diversity and invasibility of (peri-) urban forests.**

Leca S, Popa I, Badea O, Neagu S. **Intra-annual dynamics of stand basal area increment in four intensive monitoring plots (Level II) in Romania.**

Marchetto A, Bacaro G, Amici B, Ferretti M. **Geo-statistical modelling of bulk deposition of inorganic nitrogen to Italian forests.**

Merilä P, Starr M, Stephens B, Lindroos A-J, Nieminen TM, Nöjd P, Derome K, Ukonmaanaho L. **Impacts of harvesting practice on base cation budgets of coniferous stands in Finland – a sustainability study.**

Michopoulos P, Bourletsikas A, Kaoukis K, Karetsos G, Tsagari C, Daskalakou E, Samara C, Lazarou D. **Deposition and soil solution chemistry in two adjacent mountainous forest ecosystems in Greece.**

Mues V, Jochheim H, Olschofsky K, Janott M, Köhl M. **Forest Management Scenario Study with BiomeBGC at nine ICP Forests Plots.**

Neagu S, Barbu I, Iacoban C, Angheluş C, Ionescu M. **Impact of weather conditions, atmospheric deposition and foliar nutrients in the Romanian intensive monitoring system.**

Nevalainen S. **A trend analysis of the defoliation in boreal forests of Finland.**

Nicolas M, Le Roncé I, Boulanger V, Pousse N, Dupouey J-L. **Plant bio-indicators do not reflect temporal changes measured in forest soil pH and C/N ratio over 15 years.**

Novotný R, Šrámek V, Hůnová I, Zapletal M. **Chemistry of forest soils and the deposition load in the Czech Republic within the last two decades.**

Príncipe A, Nunes A, Pinho P, do Rosário L, Correia O, Branquinho C. **Microclimate matters for the long-term natural regeneration potential of woodlands in semi-arid regions.**

Proietti C, Anav A, Vitale M, De Marco A. **Ozone impacts on forest's productivity and health in Europe.**

Saenger A, Jonard M, Ponette Q, Nicolas M. **Changes in nutrient and carbon stocks in French forest soils under decreasing atmospheric deposition.**

Schaub M, Ferretti M, Gottardini E, Calatayud V, Haeni M. **2000-2013 ozone trends across Europe.**

Scheuschner T, Flügel I, Schlutow A. **Impact of air pollution and climate change on forest ecosystems in the Polish-Saxon border region.**

Schröder W, Nickel S, Jenssen M, Riediger J. **Methodology to assess and map potential developments of forest ecosystems exposed to climate change and atmospheric nitrogen deposition by example of Germany.**

Schröder W, Nickel S, Meyer M. **Heavy metals and nitrogen concentrations in moss collected across Europe from 1990-2010: Meaningful for ICP Forests / Modelling and Mapping?**

Silaghi D, Popa I, Paoletti E, Badea O. **Radial growth response to ozone exposure and uptake of sessile oak (*Quercus petraea*) in Mihaesti Level II forest monitoring plot, Romania.**

Skudnik M, Jeran Z, Batič F, Simončič P, Kastelec D. **Environmental factors explaining the N and δ15N values in the moss collected inside and outside canopy drip lines.**

Türtscher S, Berger TW. **The change of forest soil conditions in beech stands (*Fagus sylvatica*) of the Vienna Woods within the last three decades due to declining deposition of atmospheric pollutants.**

Vanguelova EI, Benham S. **Long term trends and effects of air pollution on British forests and soils.**

Vilhar U, Skudnik M, Ferlan M, Simončič P. **Tree phenology in relation to meteorological conditions and crown defoliation on intensive forest monitoring plots in Slovenia.**

Wattel-Koekkoek EJW, Boumans LJM, van der Swaluw E. **Changes over the past 25 years in rainwater and groundwater quality in nature areas in The Netherlands as a result of emission reduction policy.**

Žlindra D, Levanič T, Rupel M, Skudnik M. **Degradation of Fagus sylvatica on Trnovo plateau in southwest Slovenia.**

10 ONGOING ICP FORESTS PROJECTS

ICP Forests welcomes scientists from within and outside the ICP Forests community to use ICP Forests data for research purposes. Data applicants must fill out a data request form and send it to the Programme Co-ordinating Centre of ICP Forests thereby consenting to the ICP Forests Data Policy. For more information, please refer to the ICP Forests website[1].

The following list provides an overview of all the 48 ICP Forests projects that were ongoing for at least one month between June 2015 and May 2016. In this period, 13 new projects have started (s. ID number with *). All past and present ICP Forests data uses are listed on the ICP Forests website[2].

ID	Name of Applicant	Institution	Project Title	External/ Internal
14	John Caspersen	Swiss Federal Institute for Forest, Snow and Landscape Research (WSL)	Global Forest Monitoring	External
25	Nicole Augustin	University of Bath	Spatial-temporal modelling of defoliation in European forests	External
26	Kirsti Ashworth	Institute for Meteorology and Climate Research, Atmospheric Environmental Research	LPJ-MLC: In-canopy ozone processes	External
30	Volker Mues	Institute for World Forestry	FORMIT, Grant Agreement No. 311970 under the 7th EU-Framework Programme "FORest management strategies to enhance the MITigation potential of European forests"	Internal
43	Sietse van der Linde	Imperial College London	What are the large-scale diversity, distribution and fate of Europe's forest mycorrhiza?	External
47	Martina Roß-Nickoll	RWTH Aachen University, Institute for	Quantifying the effect of sustainable forest management: A case study in the Eiffel region	External

[1] http://icp-forests.net

[2] http://icp-forests.net/page/project-list

ID	Name of Applicant	Institution	Project Title	External/ Internal
		Environmental Research		
48	Susanne Jochner	Technische Universität München	Atmosphere - biosphere interactions	External
51	Christine Rösch	Karlsruhe Institute of Technology	BioenNW - Delivering Local Bioenergy for North-West Europe	External
52	Steffen Taeger, Karl Mellert	Bavarian State Institute of Forestry (LWF)	MARGINS – Specification of threshold values for cultivation of tree species facing climate change using marginal occurrences	External
54	Elke Keup-Thiel, Juliane Otto	Climate Service Center 2.0	Calculation of climate changes impacts indicators for tree species distribution	External
55	Ivan Janssen	University of Antwerp	Effects of phosphorus limitations on Life, Earth system and Society (IMBALANCE-P)	External
56	Elisabeth Graf Pannatier	Swiss Federal Institute for Forest, Snow and Landscape Research (WSL)	Temporal trends of dissolved organic carbon (DOC) in soil solution in European forests	Internal
58	Henning Meesenburg	NW-FVA / EP Soil and Soil Solution	Forest productivity, carbon sequestration, climate change	Internal
59	Gherardo Chirici	Università degli Studi di Firenze	Upscaling & spatially explicit estimation of biophysical variables with remote sensing (UPSPEX)	Internal
60	Sebastiaan Luyssaert, Yuan Yan	Commissariat à l'énergie atomique et aux énergies alternatives (CEA)	ERC-DOFOCO: Do forests cool the Earth? Reconciling sustained productivity and minimum climate response with portfolios of contrasting forest management strategies	External
61	Roberto Canullo	Università degli Studi di Camerino School of Biosciences and Veterinary Medicine	FUTPA: Plant functional trait patterns in key EU forest types	Internal
62	Roberto Canullo	Università degli Studi di Camerino School of Biosciences and Veterinary Medicine	Δ-Drivers BIOPART: Driving factors of beta-diversity in European Forests	Internal
63	Jesus San-Miguel	European Commission - Joint Research Centre	Distribution maps of forest tree species	External
64	Marcos Fernández-Martínez	CREAF - Center for Ecological Research and Forestry Applications	Reproductive productivity and masting behaviour in multiple tree species from the European forests	External
65	Mark R. Theobald	Centre for Energy, Environmental and Technological Research (CIEMAT)	ÉCLAIRE IP [Effects of Climate Change on Air Pollution and Response Strategies for European Ecosystems]	External
66	Mark R. Theobald	Centre for Energy, Environmental and Technological Research (CIEMAT)	EURODELTA III [Intercomparison of European Air Quality Models]	External
67	Stefan Fleck	Northwest German Forest Research Institute (NW-FVA)	LAI-estimations with allometry, litter collections, and optical measurements in relation to stand properties and microclimate	Internal
68	Shengwei Shi	College of Forestry, Northwest A & F	Modeling dissolved organic carbon in forest soils usig a TRIPLEX-DOC model	External

ID	Name of Applicant	Institution	Project Title	External/ Internal
		University, China		
69	J. Julio Camarero	Instituto Pirenaico de Ecología (IPE)	Growth and defoliation across European forests: continental patterns and trends of tree vitality	External
70	Stefan Fleck	Northwest-German Forest Research Station	Preparation of the 2nd version of the aggregated soil database of the Level II second soil survey	Internal
71	Elena Moreno	Universidad Politénica de Madrid	Study marginal populations of *Pinus uncinata*	External
72	Marcus Schaub	Swiss Federal Institute for Forest, Snow and Landscape Research	2000 - 2014 ground level ozone concentrations and exposures across Europe	Internal
73	Christopher Reyer	Potsdam Institute for Climate Impact Research (PIK)	COST Action FP 1304 Towards robust projections of European forests under climate change (PROFOUND)	External
74	Lisa Pedersen	Institut for Geovidenskab og Naturforvaltning, Københavns Universitet	How different forest covers influence on deep percolation during 120 years – Modelling of the water balance for the tree species beech, Norway spruce and poplar with the CoupModel	External
75*	Andres Bravo Oviedo	INIA-Forest Research Centre	ICP Forests-EuMIXFOR Interaction: Evaluation of soil and foliar nutrient status of mixed vs. pure stands in Europe as categorized by European Forest Types	External
76	Karin Hansen	IVL Swedish Environmental Research Institute	Atmospheric Deposition: EMEP - ICP Forests comparisons of level, trend and canopy exchange	Internal
77	Mathieu Decuyper	Wageningen University - Laboratory of Geo-information Science and Remote Sensing and the Forest Ecology and Management group	Leaf phenology and canopy status with remote sensing in relation to climate	External
78*	Elisabeth Graf Pannatier	Swiss Federal Institute for Forest, Snow and Landscape Research (WSL)	Temporal trends in soil solution acidity in European forests	Internal
79	Peter Waldner	Swiss Federal Institute for Forest, Snow and Landscape Research (WSL)	Nitrate leaching risk mapping (NitLeach)	Internal
81*	Robert Weigel	Ernst-Moritz-Arndt-University (Greifswald)	"The ecological and biogeochemical importance of snow cover for temperate forest ecosystems" and "Phenotypic plasticity and local adaptation in beech provenances (Fagus sylvatica)"	External
82	Axel Weinreich, Konstantin Straub	Unique - forestry and land use GmbH	Maximising the yield of biomass from residues of agricultural crops and forestry	External
84	Yasmina Loozen	Utrecht University, Faculty of Geosciences	Taking a remote look at canopy nitrogen to improve global climate models	External

ID	Name of Applicant	Institution	Project Title	External/ Internal
85*	Sietse van der Linde	Imperial College London & Royal Botanic Garden, Kew	Large-scale diversity, distribution and fate of Europe's forest mycorrhizas	Internal
86*	Josep Peñuelas | Jordi Sardans	CREAF - Global Ecology Unit	Plant-soil Stoichiometry relationships with tree growth and health along Environmental gradients	External
87	Valerio Avitabile	Wageningen University	GlobBiomass	External
88*	Axel Göttlein	Technical University Munich	Specification of biogeochemical thresholds for the cultivation of important forest tree species in the face of climate change	External
89*	Janusz Czerepko	Instytut Badawczy Leśnictwa	DWpool: Deadwood estimation through forest ecosystems in Europe	Internal
90*	Mathias Neumann	University of Natural Resources and Life Sciences	FORMIT – Forest management strategies to enhance the mitigation potential of European forests	External
91*	Peter Waldner	Swiss Federal Institute for Forest; Snow and Landscape (WSL)	Seed C 2 – Carbon allocation to fruits and seeds in European forests as a function of climate, atmospheric deposition and nutrient supply	Internal
92*	Ece Aksoy	European Topic Center - Urban, Land, Soil (ETC_ ULS) of European Environment Agency (EEA)	Land Resource Efficiency Task of European Environment Agency	External
93*	Martina Temunović	University of Zagreb, Faculty of Forestry	Phenotypic and Genetic Diversity of Pedunculate oak (Quercus robur L.) in Europe – FGErobur	External
94*	Hrvoje Marjanović	Croatian Forest Research Institute	Estimating and Forecasting Forest Ecosystem Productivity by Integrating Field Measurements, Remote Sensing and Modelling	External
96*	Myriam Legay	Office National des Forêts	IKSMaps: Providing precalculated future distribution maps for the main French forestry species through IKS model	External

11 ICP FORESTS SCIENTIFIC PUBLICATIONS IN 2015/16

The following list includes all 28 English online and in print publications in scientific journals between January 2015 and May 2016 that contain data that either originate from the ICP Forests database or from ICP Forests plots and that have been reported to the ICP Forests Programme Co-ordinating Centre. For a list of all ICP Forests publications throughout the years, please refer to the ICP Forests website[1].

Achat DL, Pousse N, Nicolas M,. Brédoire F, Augusto L (2016) **Soil properties controlling inorganic phosphorus availability: general results from a national forest network and a global compilation of the literature**. Biogeochemistry 127:255-272. doi: 10.1007/s10533-015-0178-0

Cristofori A, Bacaro G, Confalonieri M, Cristofolini F, Frati L, Geri F, Gottardini E, Tonidandel G, Zottele F, Ferretti M (2015) **Estimating ozone risks using forest monitoring networks – results for science, policy, and society**. Ann For Sci 72:887-896. doi: 10.1007/s13595-014-0440-y

De Vos B, Cools N, Ilvesniemi H, Vesterdal L, Vanguelova E, Carnicelli S, Ferretti M (2015) **Benchmark values for forest soil carbon stocks in Europe: Results from a large scale forest soil survey.** Geoderma 251-252: 33-46. doi: 10.1016/j.geoderma.2015.03.008

Ferretti M, Calderisi M, Marchetto A, Waldner P, Thimonier A, Jonard M, Cools N, Rautio P, Clarke N, Hansen K, Merilä P, Potocic N (2015) **Variables related to nitrogen deposition improve defoliation models for European forests.** Ann For Sci 72(7):897-906. doi: 10.1007/s13595-014-0445-6. Erratum: Ferretti M, Calderisi M, Marchetto A, Waldner P, Thimonier A, Jonard M, Cools N, Rautio P, Clarke N, Hansen K, Merilä P, Potočić N (2015) Erratum to: Variables related to nitrogen deposition improve defoliation models for European forests. Ann For Sci 72(7):907-907. doi: 10.1007/s13595-015-0472-y

Gaudio N, Belyazid S, Gendre X, Mansat A, Nicolas M, Rizzetto S, Sverdrup H, Probst A (2015) **Combined effect of atmospheric nitrogen deposition and climate change on temperate forest soil biogeochemistry: A modeling approach**. Ecol Model 306:24-34. doi: 10.1016/j.ecolmodel.2014.10.002

Guillemot J, Martin-St Paul NK, Dufrêne E, François C, Soudani K, Ourcival JM, Delpierre N (2015) **The dynamic of the annual carbon allocation to wood in European tree species is consistent with a combined source–sink limitation of growth: implications for modelling**. Biogeosciences 12:2773-2790. doi: 10.5194/bg-12-2773-2015

Hůnová I, Kurfürst P, Vlček O, Stráník V, Stoklasová P, Schovánková J, Svbová D (2016) **Towards a better spatial quantification of nitrogen deposition: A case study for Czech forests.** Environ Pollut 213:1028-1041. doi: 10.1016/j.envpol.2016.01.061

Johnson J, Aherne J, Cummins T (2015) **Base cation budgets under residue removal in temperate maritime plantation forests.** Forest Ecol Manag 343:144-156. doi: http://dx.doi.org/10.1016/j.foreco.2015.01.022

Jonard M, Fürst A, Verstraeten A, Thimonier A, Timmermann V, Potočić N, Waldner P, Benham S, Hansen K, Merilä P, Ponette Q, de la Cruz A, Roskams P, Nicolas M, Croisé L, Ingerslev M, Matteuci G, Decinti B, Bascietto M, Rautio P, Aherne J, Cummins T (2015) **Tree mineral nutrition is deteriorating in Europe.** Glob Change Biol 21(1):418-430. doi: 10.1111/gcb.12657

Jorge-Araújo P, Quiquampoix H, Matumoto-Pintro PT, Staunton S (2015) **Glomalin-related soil protein in French temperate forest soils: interference in the Bradford assay caused by co-extracted humic substances**. Eur J Soil Sci 66:311-319. doi: 10.1111/ejss.12218

Kowalska A, Astel A, Boczoń A, Polkowska Ż (2016) **Atmospheric deposition in coniferous and deciduous tree stands in Poland**. Atmos Environ 133:145-155. doi: 10.1016/j.atmosenv.2016.03.033

Kowalska A, Boczoń A, Hildebrand R, Polkowska Ż (2016) **Spatial variability of throughfall in a stand of Scots pine (*Pinus sylvestris* L.) with deciduous admixture as influenced by canopy cover and stem distance**. J Hydrol 538:231-242. doi: 10.1016/j.jhydrol.2016.04.023

Mellert KH, Deffner V, Küchenhoff H, Kölling C (2015) **Modeling sensitivity to climate change and estimating the uncertainty of its impact: A probabilistic concept for risk assessment in forestry**. Ecol Model 316:211-216. doi: 10.1016/j.ecolmodel.2015.08.014

[1] http://icp-forests.net/page/publications

Mellert KH, Ewald J, Horstein D, Dorado–Liñán I, Jantsch M, Taeger S, Zang C, Menzel A, Kölling C (2016) **Climatic marginality: a new metric for the susceptibility of tree species to warming exemplified by *Fagus sylvatica* L. and Ellenberg's quotient**. Eur J For Res 135:137-152. doi: 10.1007/s10342-015-0924-9

Meyer M, Schröder W, Nickel S, Leblond S, Lindroos A-J, Mohr K, Poikolainen J, Santamaria JM, Skudnik M, Thöni L, Beudert B, Dieffenbach-Fries H, Schulte-Bisping H, Zechmeister HG (2015) **Relevance of canopy drip for the accumulation of nitrogen in moss used as biomonitors for atmospheric nitrogen deposition in Europe.** Sci Total Environ 538:600-610. doi: 10.1016/j.scitotenv.2015.07.069

Napa Ü, Kabral N, Liiv S, Asi E, Timmusk T, Frey J (2015) **Current and historical patterns of heavy metals pollution in Estonia as reflected in natural media of different ages: ICP Vegetation, ICP Forests and ICP Integrated Monitoring**. Ecol Indic 52:31-39. doi: 10.1016/j.ecolind.2014.11.028

Nevalainen S, Sirkiä S, Peltoniemi M, Neuvonen S (2015) **Vulnerability to pine sawfly damage decreases with with site fertility but the opposite is true with Scleroderris canker damage; results from Finnish ICP Forests and NFI data**. Ann For Sci 72:909-917. doi: 10.1007/s13595-014-0435-8

Nussbaumer A, Walder P, Etzold S, Gessler A, Benham S, Thomsen IG, Jørgensen BB, Timmermann V, Verstraeten A, Sioen G, Rautio P, Ukonmaanaho L, Skudnik M, Apuhtin V, Hug C, Burkart A, Braun S, Genau K, Wauer A, Bernhard M, Ebinger T (2016) **Patterns of mast fruiting of common beech, sessile and common oak, Norwegian spruce and Scots pine in Central and Northern Europe.** Forest Ecol Manag 363:237-251. doi:10.1016/j.foreco.2015.12.033

Pollastrini M, Feducci M, Bonal D, Fotelli M, Gessler A, Grossiord C, Guyot V, Jactel H, Nguyen D, Radoglou K, Bussotti F (2016) **Physiological significance of forest tree defoliation: Results from a survey in a mixed forest in Tuscany (central Italy).** Forest Ecol Manag 361:170-178. doi: 10.1016/j.foreco.2015.11.018

Rautio P, Ferretti M (2015) **Monitoring European forests: results for science, policy, and society.** Ann For Sci 72: 875-876. doi: 10.1007/s13595-015-0505-6

Rizzetto S, Belyazid S, Gégout J-C, Nicolas M, Alard D, Corcket E, Gaudio N, Sverdrup H, Probst A (2016) **Modelling the impact of climate change and atmospheric N deposition on French forests biodiversity.** Environ Pollut 213:1016-1027. doi: 10.1016/j.envpol.2015.12.048

Sardans J, Alonso R, Carnicer J, Fernández-Martínez M, Vivanco MG, Peñuelas J (2016) **Factors influencing the foliar elemental composition and stoichiometry in forest trees in Spain.** Perspect Plant Ecol 18:52-69. doi: 10.1016/j.ppees.2016.01.001

Suz LM, Barsoum N, Benham S, Cheffings C, Cox F, Hackett L, Jones AG, Mueller GM, Orme D, Seidling W, Van der Linde S, Bidartondo MI (2015) **Monitoring ectomycorrhizal fungi at large scales for science, forest management, fungal conservation and environmental policy.** Ann For Sci 72:877-885. doi: 10.1007/s13595-014-0447-4

Talkner U, Meiwes KJ, Potočić N, Seletković I, Cools N, De Vos B, Rautio P, Hůnová I (2015) **Phosphorus nutrition of beech (*Fagus sylvatica* L.) is decreasing in Europe.** Ann For Sci 72(7): 919-928. doi: 10.1007/s13595-015-0459-8

Tomlinson G, Buchmann N, Siegwolf R, Weber P, Thimonier A, Graf Pannatier E, Schmitt M, Schaub M, Waldner P (2015) **Can tree-ring δ15N be used as a proxy for foliar δ15N in European beech and Norway spruce?** Trees – Struct Funct 30:627-638. doi: 10.1007/s00468-015-1305-1

Verstraeten A, Verschelde P, De Vos B, Neirynck J, Cools N, Roskams P, Hens M, Louette G, Sleutel S, De Neve S (2016) **Increasing trends of dissolved organic nitrogen (DON) in temperate forests under recovery from acidification in Flanders, Belgium**. Sci Total Environ 553:107-119. doi: 10.1016/j.scitotenv.2016.02.060

Vlasáková-Matoušková L, Hůnová I (2015) **Stomatal ozone flux and visible leaf injury in native juvenile trees of Fagus sylvatica: A field study from the Jizerske hory Mts., the Czech Republic**. Environ Sci Pollut R 22:10034-10046. doi: 10.1007/s11356-015-4174-7

Waldner P, Thimonier A, Graf Pannatier E, Etzold S, Schmitt M, Marchetto A, Rautio P, Derome K, Nieminen TM, Nevalainen S, Lindroos AJ, Merilä P, Kindermann G, Neumann M, Cools N, de Vos B, Roskams P, Verstraeten A, Hansen K. Pihl Karlsson G, Dietrich HP, Raspe S, Fischer R, Lorenz M, Iost S, Granke O, Sanders TGM, Michel A, Nagel HD., Scheuschner T, Simončič P., von Wilpert K, Meesenburg H, Fleck S, Benham S, Vanguelova E, Clarke N, Ingerslev M, Vesterdal L, Gundersen P, Stupak I, Jonard M, Potočić N, Minaya M (2015) **Exceedance of critical loads and of critical limits impacts tree nutrition across Europe.** Ann For Sci 72(7):929-939. doi: 10.1007/s13595-015-0489-2

12 NATIONAL REPORTS ON THE 2015 NATIONAL CROWN CONDITION SURVEYS

Twenty-nine countries have submitted numerical results of their 2015 national crown condition surveys and 26 countries an additional written national report. All written reports have been slightly edited primarily for consistency and are presented below; the numerical results are compiled in ANNEX II. The responsibility for the national reports and numerical results remains with the National Focal Centres and not with the ICP Forests Programme Co-ordinating Centre. For contact information of the National Focal Centres, please refer to ANNEX IV-3.

Please note that in the national surveys the study design and number of plots can differ from the required 16 x 16 km grid used for the transnational analysis of tree crown condition and damage causes in Chapter 3 (Level I). Direct comparisons between the results of the national surveys of individual countries in this chapter may, therefore, be misleading. Missing values in the tables and figures in ANNEX II may indicate that data for certain years are missing or they indicate substantial differences in the samples, e.g. due to changes in the grid or the participation of a new country, as described in this chapter. For an explanation of the defoliation classes used, please refer to Table 3-1 in Chapter 3.

12.1 Andorra

The assessment of crown condition in Andorra in 2015 was conducted on 12 plots of the national 4x4 km grid. In 2015, a new plot completely composed of *Abies alba* was added. Overall, the assessment included 264 trees, 119 *Pinus sylvestris*, 137 *Pinus uncinata*, 5 *Betula pendula* and 27 *Abies alba* trees.

Results for 2015 showed an improving tendency in forest condition, as registered since 2009, with just a slow decrease in 2012. For all species, most of the trees were classified in defoliation and discoloration classes 0 and 1. Favourable climatic conditions in 2015, including high precipitation during the vegetative period could explain the good condition of the forests in terms of defoliation and discoloration.

Related to defoliation, the large majority of trees of all species were in the no defoliation class (value range from 69.8% to 100%). Only *Betula pendula* presented one dead tree (16.7%) although the significance of this result is low due to the reduced number of individuals of birch surveyed, all in the same plot.

Results for discoloration were variable depending on the species. The majority of *Pinus sylvestris* trees (69.2%) were classified as not discolorated. Individuals of *Pinus uncinata* were classified mainly in the slight discoloration class (57.6%) and in the no discoloration class (34.5%). The total of *Abies alba* trees were classified as not discolorated. Finally, the great part of *Betula pendula* individuals (83.3%) were classified as not discolorated, even this last result is not very significant due to the reduced number of birches surveyed.

The assessment of damage causes showed, as in previous years, many causal agents, like wind, snow, falling trees, fungus *Cronartium flaccidum*, rots and lightning scars, which overall affected 6.9% of the sampled trees.

12.2 Belgium

Belgium/Flanders

The large-scale survey was conducted on 71 plots of the 4x4 km grid. The main tree species in the survey are *Pinus sylvestris*, *Quercus robur*, *Pinus nigra* subsp. *laricio*, *Fagus sylvatica*, *Q. rubra,* and *Populus sp*.

Other species are pooled in subsets with 'other broadleaves' or 'other conifers'. Crown condition assessments were performed on 890 broadleaves and 721 conifers. Mean defoliation was 24.1%, and 21.5% of the trees showed more than 25% defoliation. 7.5% of the sample trees were in defoliation class 0, 71% of the trees were slightly affected. Moderate leaf loss was observed on 18.4%, and 2.1% of the trees showed severe defoliation. The mortality rate was 1%.

Q. rubra and *F. sylvatica* revealed a good condition, with 5.4% and 9.3% of the trees being damaged. Consistent with the last survey, crown condition was worse for *Populus sp*., *Q. robur* and the 'other broadleaves'. 18.5% of the *Populus sp.* were moderately to severely defoliated. The health status of *Q. robur* is problematic in several plots and 23.8% of the sample trees were rated as damaged. The highest level of defoliation was observed in the category 'other broadleaves', with a share of 35.5% in defoliation classes 2-4. *P. nigra* showed a distinctly higher rate of trees with moderate to severe defoliation compared to *P. sylvestris*. 42.7% trees were classified as being damaged compared to 12.8% of the *P. sylvestris* trees. Several infections caused damage, like *Scirrhia pini* on *Pinus nigra*, *Hymenoscyphus fraxineus* on *Fraxinus excelsior* and *Phytophthora alni* on *Alnus glutinosa.* Insect damage and mildew infections on oak were less severe compared to previous years.

Forest condition deteriorated compared to last year. Mean defoliation increased by 1.9 percentage points and the share of trees in defoliation classes 2-4 increased by 1.6 percentage points. Mean defoliation increased both in broadleaves and conifers, the share of trees being damaged only in conifers. The extent of deterioration was highest in *P. nigra*. Regarding broadleaves, there was only a significant higher defoliation in the 'other broadleaves'. Declining *Alnus glutinosa* trees in one plot are responsible for this increase.

Seed production in *Q. robur* was moderate to high in 12.5% of the trees, and these results are comparable to 2009, 2011 and 2013. In *F. sylvatica* fruiting was less remarkable.

On 27 December 2014, snowfall caused broken branches and crown break in pine forests in the northern part of Flanders. As a consequence, at least 10% of the *P. sylvestris* trees showed broken branches with a minimum diameter of 2 cm. Most of the damaged trees will survive but this event caused a significant increase in defoliation of *P. sylvestris*.

In connection with the recent ash dieback, a survey of the condition of *Fraxinus excelsior* was started in 2014, as a part of a multidisciplinary project. This survey continued in 2015, making use of the Level I grid and additional plots. A subset of 252 common sample trees in 2014-2015 revealed a remarkable deterioration of common ash. Mean defoliation increased from 28.8% to 34.3% and the proportion of trees with moderate to severe leaf loss increased from 32.1% to 47.6%.

Belgium/Wallonia

The survey in 2015 concerned 402 trees on 45 plots, on a regional systematic grid that has been adapted since 2010 to fit with the national forest inventory. It is now possible to identify trends for these 5 last years.

Since 2010 spruces showed a slight decreasing mean defoliation to reach 35% in 2014. This value remains constant in 2015; however the percentage of severely defoliated had not stopped decreasing.

Beeches improved their mean defoliation value to reach 36% in 2015. Beeches up to 140 cm were all at least moderately defoliated.

English oaks showed less mean defoliation in 2015 (29%). Sessile oaks kept better value with a mean defoliation of only 18%.

12.3 Bulgaria

The health status of forest trees in Bulgaria is systematically monitored by the long-term, large-scale monitoring programme for 30 years. In 2015, crown condition assessments were carried out in 159 sample plots on 5513 sample trees. Observations on defoliation, biotic and other stress factors were carried out in plots with the coniferous tree species *Pinus sylvestris* L., *Pinus nigra* Arn., *Picea abies* (L.) Karst. and *Abies alba* Mill., as well as the deciduous tree species *Fagus sylvatica* L., *Quercus frainetto* Ten., *Quercus petraea* (Matt.) Liebl., *Quercus cerris* L., *Quercus rubra* L., *Tilia platyphillos* Scop. and *Carpinus betulus* L. The total number of studied coniferous sample trees was 2386 and the number of deciduous trees was 3127. Approximately 74% of the monitored trees had a degree of defoliation up to 25% which coincides with the results obtained in 2014. The highest percentage of trees with an average degree of defoliation was 17.6%, determined within the interval between second and fourth classes, which is 4.2% less than the respective percentage in 2014. Compared to the study results obtained in 2014, the percentage of healthy trees has increased by 6.5%. The percentage of highly-defoliated and dead trees with third and fourth degrees has increased by 4.3%.

The observed deciduous trees were in better condition than the coniferous trees - 84.4% of the studied deciduous trees had a defoliation degree of up to 25%, which represents an increase of 4.6% in comparison with 2014. As for the coniferous tree species - 59.9% had a defoliation degree of up to 25%, which is 5.8% less than the results reported in 2014.

The health status of European beech trees (*Fagus sylvatica* L.) was very good. The variation between the different sample plots is associated with effects of an abiotic and biotic character (*Nectria* sp., *Ascodichaena rugosa*, *Fomes fomentarius*, *Orchestes fagi*, *Mikiola fagi* etc.). The increased percentage of trees with third and fourth degree (heavily-damaged and dead trees), 2.0% and 7.0% respectively, was mainly due to ice damage and to anthropogenic impact - legally and illegally cut-down.

The health status of the oak trees (*Quercus cerris* L., *Quercus frainetto* Ten., *Quercus petraea* (Matt.) Liebl. and *Quercus rubra* L.) remains at the level of previous years. The decrease in serious damages within the second and third degree was due to the lack of calamities of the main defoliators *Lymantria dispar*, *Geometridae* and *Tortricidae*. The slight increase in heavy damages in Turkey oak was caused by the main stem pathogens - *Hypoxylon mediterraneum* and *Diplodia mutila*, and in the sessile oak and Hungarian oak – by the tracheomycosis disease (*Ceratocystis roboris*).

There were no significant changes in the health status of the species *Carpinus betulus* L. and *Tilia platyphyllos* Scop.

The best condition of coniferous tree species under 60 years of age was determined in *Picea abies*, where 86.7% of the observed trees had a defoliation degree of up to 25%, followed by *Pinus sylvestris* and *Pinus nigra*. Regarding the observed stands over 60 years of age, the best condition was also determined in *Picea abies* where 88.5% of the trees had defoliation up to 25%. Compared to the results for 2014, the percentage of healthy trees of the species *Picea abies* and *Abies alba* has increased; the percentage of the fourth degree has also increased.

A higher percentage of defoliation was determined in *Pinus nigra* and *Pinus sylvestris* stands, as well as an increase in trees with fourth degree of defoliation. The worst condition, compared to other tree species, was reported in the *Pinus sylvestris* stands, where 13.6% had 3+4 defoliation degree. The resulting drought stress in pine plantations, under the dry land conditions in recent years, increased the development of the root rot pathogen *Heterobasidion annosum* and subsequent attacks by the pine shoot beetle *Tomicus piniperda*. The health status in most *Pinus nigra* sample plots was relatively good, although typical crown damages occurred caused by the fungal pathogens *Sphaeropsis sapinea*, *Dothistroma* sp. and *Lophodermium* sp.. Anthropogenic impact (illegally cut-down) was also observed.

The aforementioned biotic damages and their causes did not lead to significant changes in the condition of the observed trees. The impact of abiotic factors, mostly wet snow that fell in March in some parts of the country, as well as windthrows, windbreaks and snow breakages, was more significant. In recent years there has been a marked increase in areas affected by these factors. In 2010, a total area of 3 776 ha was affected, whereas in 2014 the area of forest damaged by abiotic disturbances had increased almost seven times (26 387 ha).

12.4 Croatia

Ninety-five sample plots (2280 trees) on the 16 x 16 km grid network were included in the survey 2015.

The percentage of trees of all species within classes 2-4 in 2015 (29.7%) was somewhat smaller than in 2014 (31.5%), and similar to year 2013 (29.1%). The percentage of broadleaves in classes 2-4 (25.3 %) was also smaller, but for conifers it was high at 55.9%, a significant increase from last year (49.7%) and year 2013 (48.3%). There were 327 conifer trees and 1953 broadleaves in the sample.

While poor crown condition of black pine is more or less a constant (69.3% this year), the deterioration of crown condition of narrow-leaved ash is very dramatic: the percentage of trees in classes 2-4 increased from 23.6% in 2013, through 49.1% in 2014 to 62.5% this year. Along with dry years, and the presence of *Stereonychus fraxini*, also the increased presence of *Hymenoschyphus fraxineus* (*Chalara fraxinea*) in the last few years seems to be a factor causing increased deterioration of ash health. Also *Abies alba* with 59.6% trees in classes 2-4 remains one of our most defoliated tree species.

The percentage of *Quercus robur* trees in classes 2-4 in the past ten years has been between 20 and 30%. This year we recorded 21.6% of moderately to severely defoliated oak trees, a reduction from last year's 29.7%.

Fagus sylvatica is still one of the tree species with lowest defoliation with 20.5% trees in the defoliation class 2-4. In the last ten years of monitoring, this percentage varied from 5.1% in 2003 to 25.5 % in year 2014.

The damage causes were this year for the first time assessed in Croatia. The most affected part of trees are leaves/needles (40.1%), followed by branches and shoots (33.7%) and stem and roots (26.3%).

The most prominent agent group is insects (18.3 %, of that defoliators 64.3%), then abiotic agents (8.7%, of that drought 50.5%), fungi (5.9%), and direct action of men (5.2%).

12.5 Cyprus

The annual assessment of crown condition was conducted on 15 Level I plots, during the period September – November 2015. The assessment covered the main forest ecosystems of Cyprus and a total of 360 trees (*Pinus brutia, Pinus nigra* and *Cedrus brevifolia)* were assessed. Defoliation, discoloration and the damaging agents were recorded.

A comparison of the results of the conducted survey with those of the previous year (2015) shows an increase of 10.9% in class 0 (not defoliated). A decrease of 10.1% in class 1 (moderately defoliated) and of 0.8% in class 2 (severely defoliated) has been observed. A slight increase of 0.3% has been observed in class 3 and 0.3% decrease has been observed in class 4.

From the total number of trees assessed (360 trees), 29.7% of them were not defoliated, 57.8% were slightly defoliated, 11.4% were moderately defoliated and 1.1% were severely defoliated.

In the case of *Pinus brutia*, 28% of the sample trees showed no defoliation, 57.7% were slightly defoliated, 13.3% were moderately defoliated and 1% were severely defoliated. For *Pinus nigra*, 41.7%

of the sample trees showed no defoliation and 58.3% showed slight defoliation. For *Cedrus brevifolia*, 33.3% of the sample trees showed no defoliation, 58.3% were slightly defoliated, 4.2% were moderately defoliated and 4.2% were severely defoliated.

From the total number of trees assessed (360 trees), 100% of them were not discolorated.

From the total number of sample trees surveyed, 35.6% showed signs of insect attacks and 12.8% showed signs of attacks by "*other agents*, *T8*" (lichens and dead branches). Also, 1.1% showed signs of both factors (insect attacks and other agent).

The major abiotic factors causing defoliation in some plots, during 2015, were the combination of climatic with edaphic conditions which resulted to secondary attacks by *Leucaspis spp*. and defoliator insects, to 1/3 of the trees.

12.6 Czech Republic

In coniferous species of the older age category (forest stands of 60 years of age and more) no pronounced changes in the trend of total defoliation were observed in 2015 compared to the preceding year. There was only a moderate increase in the total percentage of defoliation in class 3. Particularly Scots pine (*Pinus sylvestris*) contributed to this change, in which the defoliation percentage in class 3 increased from 5.7% in 2014 to 8.3% in 2015. On the contrary, in silver fir (*Abies alba*) the defoliation percentage in class 3 decreased from 2.9% in 2014 to 0.0% in 2015. The trend of defoliation in the younger age category of coniferous species (forest stands less than 59 years old) in 2015 shows an evident change only in fir compared to the preceding year, in which the defoliation percentage in class 0 increased from 22.2% in 2014 to 29.6% in 2015 at a simultaneous decrease in class 2.

The trend of total defoliation of broadleaved species in the older age category (forest stands 60-years-old and more) indicates a moderate improvement due to a decrease in the defoliation percentage in class 1 at a simultaneous increase in the percentage in class 0. In oak (*Quercus* sp.) such an improvement was reflected in a decrease in the percentage in defoliation class 2 from 63.6% in 2014 to 59.8% in 2015 at a simultaneous increase in the class 1 percentage from 34.4% in 2014 to 39.1% in 2015. In European beech (*Fagus sylvatica*) there was a pronounced increase in the defoliation percentage in class 0 from 26.4% in 2014 to 34.6% in 2015 at a simultaneous decrease in classes 1 and 2. In the category of younger broadleaved species (forest stands less than 59 years old) defoliation was clearly reduced only in beech due to an increase in the defoliation percentage in class 0 from 62.9% in 2014 to 67.1% in 2015 at a simultaneous decrease in classes 1 and 2. On the contrary, defoliation obviously increased in younger stands of silver birch (*Betula pendula*) as a result of a decrease in the defoliation percentage in class 0 from 38.3% in 2014 to 23.7% in 2015 at a simultaneous increase in class 1.

Younger coniferous trees (less than 59 years old) show lower defoliation in the long run than the stands of younger broadleaved trees. In older stands (60-years-old and more) this comparison is reverse because older coniferous trees have considerably higher defoliation than the stands of older broadleaved trees. In both age categories it is the pine that substantially contributes to a higher defoliation percentage for the group of coniferous species.

Average monthly temperatures in the period March – September always showed a positive deviation from the long-term normal. The highest deviation was recorded for average temperatures in the month of July (deviation +3.3° C) and August (deviation +4.9° C). In the summer months there were 42 tropical days in total while on 16 days the temperatures rose above 35° C. Monthly precipitation totals in the period April – September amounted to 46-86% of the normal, only in March the precipitation total reached 120% of the normal. The entire growing season can be evaluated as one of the warmest and driest seasons in the long history of recording climate characteristics. The adverse ratio of temperature to precipitation total for a major part of the growing season had negative effects on the health status of forest stands mainly at lower altitudes above sea level. The regular defoliation assessment was mostly carried out before the effects of drought on forest stands were fully manifested, and therefore the defoliation values have not been influenced by this factor significantly.

The trend of emissions of the main pollutants (particulate matter, SO_2, NO_x, CO, VOC, NH_3) has not shown any pronounced change in the last ten years while total emissions of the majority of these pollutants have decreased very moderately in the long run in spite of some fluctuations, and the emissions of particulate matter and NH_3 have been constant.

12.7 Denmark

The Danish forest condition monitoring in 2015 was carried out via the National Forest Inventory (NFI) including the remaining Level I and II plots. Monitoring showed most tree species had satisfactory health status, even though all the main species had an increase in defoliation.

As in previous years ash (*Fraxinus excelsior*) showed extensive dieback due to the invasive pathogen *Hymenoscyphus fraxineus*. Average defoliation remained at 26% for all monitored ash trees, and 36 % of the trees had at least 30% defoliation, which is a higher percentage than last year.

Norway spruce (*Picea abies*) had an increased, but still low average defoliation of 7% and almost 7% damaged trees. Sitka spruce (*Picea sitchensis*) also saw a higher defoliation of 13% in spite of the removal of the long-term monitoring plot with highest needle loss. Other conifers such as *Pinus*, *Larix* and *Abies* sp. also had slightly elevated levels of defoliation, but defoliation was only around 10% on average. In general, the health of conifers in Denmark can be considered satisfactory.

The average defoliation score of beech (*Fagus sylvatica*) increased slightly to 10%, but the frequency of damaged trees stayed at 4%. Oak (*Quercus robur* and *Q. petraea*) showed an increase in average defoliation from 13% to 17%, and the frequency of damaged trees increased to 20%. This was not unexpected considering the reports of health problems in oak in Denmark in recent years. However, based on the monitored trees there is not yet cause for a general concern over forest health in beech and oak.

Based on defoliation assessments on NFI plots and Level I & II, the results of the crown condition survey in 2015 showed that 71% of all coniferous trees and 60% of all deciduous trees were undamaged. 21% of all conifers and 30% of all deciduous trees showed warning signs of damage. The mean defoliation of all conifers was 9% in 2015, and the share of damaged trees was 7%. Mean defoliation of all broadleaves was 13%, and 11% of the trees had more than 30% defoliation.

12.8 Estonia

Forest condition in Estonia has been systematically monitored using Level I sample points since 1988. The Level I forest monitoring network was used to assess the health status of 2397 trees. 1464 Scots pines (*Pinus sylvestris*), 584 Norway spruces (*Picea abies*) and 349 deciduous species, mainly birches (*Betula pendula*) were assessed. The observation period lasted from July 13th to November 11th, 2015.

The total share of not defoliated trees, 50.7%, was 1.2% higher than in 2014. The share of not defoliated conifers, 49.7%, was lower than the share of not defoliated broadleaves, 57.0%, in 2015.

Share of trees in classes 2 to 4, moderately defoliated to dead, was 6.8% in 2015 and 6.7% in 2014. No significant change of defoliation in general was observed.

Share of conifers and broadleaves in defoliation classes 2 to 4 was 6.6% and 8.0% accordingly.

Scots pine has traditionally been and remained the most defoliated tree species in Estonia.

The share of not defoliated pines (defoliation class 0) was 49.3% in 2015, 3.2 % higher than in 2014. Share of pines in classes 2 to 4, moderately defoliated to dead, was 6.2%, slightly lower than in 2014.

However no serious long-term trend of Scots pine defoliation since 2010 could be observed. In 2010, the share of not defoliated pine trees increased from 38 % to 45% and is keeping the similar level until now.

Concerning Norway spruce some slight long-term increase of defoliation occurred. The share of not defoliated trees (defoliation class 0) was 64% in 2010 and 54.0% and 50.5% accordingly in 2014 and 2015. The share of not defoliated trees was higher, 74.7% in younger stands with the age up to 60 years and 47.8% in older stands.

Compared to 2014 there has been a significant decrease in the condition of broadleaves during 2015. The share of broadleaves in classes 2 to 4, moderately defoliated to dead, was 8.0% in 2014. This is higher than 5.7% in 2014.

The defoliation of birches (*Betula pendula*) increased about 22.3% in 2015, mainly caused by birch rust (pathogen *Melampsoridium betulinum*). The share of not defoliated silver birches was 53.9% in 2015 and 76.2% in 2014.

All trees included in the crown condition assessment on Level I plots are also regularly assessed for damage. Numerous factors determine the condition of forests. Climatic factors, disease and insect damage as well as other natural factors have an impact on tree vitality.

In 2015, 7.6% of the trees observed, had some insect damages and 39% of trees had identifiable symptoms of disease.

Visible damage symptoms recorded on Scots pine were mainly attributed to pine shoot blight (pathogen *Gremmeniella abietina*). Symptoms of shoot blight were recorded on 43% of the observed pine trees in 2015. Norway spruces mostly suffered from root rot (pathogen *Heterobasidion parviporum*) – characteristic symptoms of the disease were observed on 7.7% of sample trees.

No substantial storm damages and forest fires occurred in 2015.

12.9 France

In 2015, the forest damage monitoring in the French part of the systematic European network comprised 11 722 trees on 560 plots.

In 2015, summer was particularly hot and dry, with two heat waves in the beginning and the end of July, nevertheless most species showed little consequences of these harsh conditions: defoliation stayed the same as in 2014 for almost all broadleaved species, *Fagus sylvatica*'s defoliation even decreased. On the contrary, Fraxinus excelsior's defoliation skyrocketed due to the fungus *Chalara fraxinea* which arrived in France seven years ago. For conifers, it is quite the same, except for *Pinus pinaster*, *Picea abies* and *Pinus sylvestris*, whose defoliation slightly increased.

Death of sampled trees stayed at a relatively low level.

The number of discoloured trees was still low except for poplars, beech, wild cherry and Aleppo pine.

Damage was reported on about a quarter of the sampled trees, mainly on broad-leaved species. The most important causes of damage were mistletoe (*Viscum album*) on *Pinus sylvestris,* chestnut canker (*Cryphonectria parasitica*) and the oak buprestid (*Coroebus florentinus*) on *Quercus* spp. Abnormally small leaves were observed on different species, specially on *Quercus* spp. (mainly on evergreen and pubescent oaks).

12.10 Germany

Crown condition

In 2015, the crown condition of European beech considerably improved compared to the previous year. For all other tree species, results of the crown condition assessment 2015 are almost the same as in 2014.

Since the surveys were first taken in 1984, the share of damaged broadleaved trees as well as the mean defoliation of broadleaved tree species significantly increased. The crown condition of Norway spruce and Scots pine show no clear trend, whilst other conifers improved. There is no clear trend in the average defoliation rates across all tree species.

In summer 2015, 24 % of the forest area was assessed and classed as damaged, i.e. more than 25% crown defoliation was recorded (damage classes 2 to 4), compared to 26% in 2014. In 2014, 43% (2014: 41%) were in the warning stage. In 2015 as well as in 2014, 33% showed no defoliation. The mean crown defoliation decreased from 20.4% to 20.0%.

Picea abies: The percentage of damage classes 2 to 4 was 28% and has not changed compared the previous year. 37% (2014: 39%) of the trees were in the warning stage. The share of trees without defoliation was 35% (2014: 33%). However, mean crown defoliation increased from 20.2% to 20.6%. This increase is due to a shift to higher defoliation rates within the damage classes.

Pinus sylvestris: The share of damage classes 2 to 4 was 13% (2014: 12%). 51% (2014: 50%) were in the warning stage. 36% (2013: 38%) showed no defoliation. The mean crown defoliation increased from 16.4% to 16.9%.

Fagus sylvatica: The crown condition of European beech strongly improved compared to 2014. The share of damage classes 2 to 4 decreased from 48% to 33%, which is similar to the level of defoliation reached in 2012 and 2013. 45% (2014: 38%) of the beech area was classified in the warning stage. The share without defoliation was 22% (2014: 14%). Mean crown defoliation decreased from 27.6% to 23.3%. The crown condition in 2014 was strongly influenced by intense fruiting. In 2015, moderate or strong fruiting occurred only on a few trees and crown condition improved accordingly.

Quercus robur* & *Q. petraea: The share of damaged trees was 36%, unchanged compared to the previous year. The share of trees in the warning stage (40%), as well as the share without defoliation (24%), did not change either. Mean crown defoliation decreased from 24.7% to 24.1%.

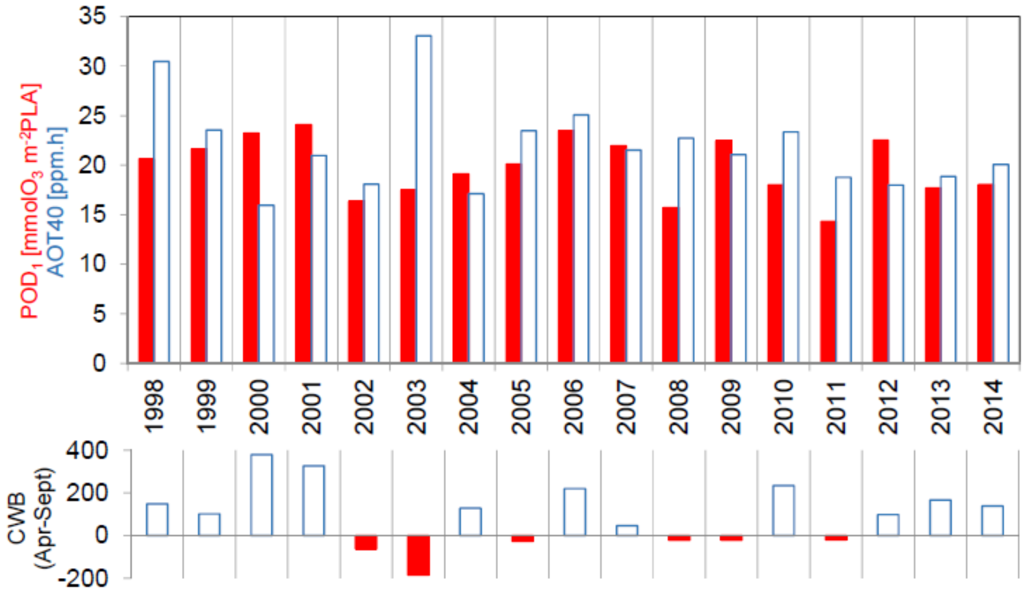
Spring and summer of 2015 were extremely warm and dry in almost all of Germany, resulting in a negative climatic water balance. In some regions drought was even more severe than in 2003. http://www.dwd.de/EN/climate_environment/climateatlas/climateatlas_node.html

This, however, is not reflected within the results of the crown condition assessment, starting in early July (in line with the ICP Forests Manual) whilst drought damage on trees only became apparent in late summer. Furthermore, the experience of the year 2003 shows that summer drought in one year may only result in poor crown condition in the following or even subsequent years.

Results of an ozone impact study

In the south-western German federal states, Rhineland-Palatinate and Saarland, the impact of tropospheric ozone was assessed using three different approaches: MPOC, AOT40 and PODy. Nine Level II sites were included in this study, of which six with co-located active O_3 measurements over the years 1998 to 2014. The critical level for AOT40 was exceeded on all sites in each year. For the beech stand in the Rhineland-Palatinate Forests (Merzalben Hortenkopf, 550 m a.s.l.) POD1 was calculated and compared with AOT40. The critical level (CL POD_1=4 mmol O3 m^{-2} PLA) was already exceeded each year by May/June, and by the end of the vegetation period it was exceeded by a factor 4 up to 7.

Similar results have been recorded for Bavarian sites for the period 2002 to 2005 (Baumgarten et al. 2009).



Phytotoxic Ozone Dose accumulated over the vegetation period (POD_1 in mmol O_3 m^{-2} PLA) compared to AOT40 (ppm.h) for the beech stand at the site Merzalben; on the bottom the climatic water balance (CWB in l m^{-2}) between April and September of the respective year is depicted (W. Werner, Trier University).

https://www.uni-trier.de/fileadmin/fb6/prof/GEB/Lehre/OzonBericht_2015_Langfassung.pdf;
http://www.wald-rlp.de/fileadmin/website/fawfseiten/fawf/downloads/WSE/2015/Bericht_klein_30_11_2015.pdf

12.11 Greece

The crown assessment survey was carried out for the year 2015 on 47 Level I plots in Greece from 13.07.2015 till 30.10.2015. The total number of trees assessed was 1113, 488 of them were trees of broadleaved species and 625 were trees of coniferous species. Comparing the survey of the year 2015 with the last survey (2014), the Level I plots were 17.5% fewer and the total trees assessed were 17.3% fewer.

The percentages of the conifer species for all defoliation classes were very similar to those of last year's survey, although the number of the assessed plots was not the same. The table below shows the results for the two consecutive years (2104 and 2015). The figures are in %.

Year	No defoliation (0)	Slight defoliation (1)	Moderate defoliation (2)	Severe defoliation (3)	Dead trees (4)
2014	43.9	29.3	18.7	6.6	1.5
2015	45.0	27.8	21.9	4.1	1.2

These figures are considered to represent a healthy tree condition (72.8% are in the No and Slight defoliation classes). The main causes assessed in the conifer species resulting in needle losses were epiphytes, insect attacks, and abiotic reasons.

The three main conifer species assessed in Greece (that means the species with the highest number of trees assessed) were *Abies cephalonica* with 213 trees, *Pinus nigra* with 100 trees and *Pinus halepensis* with 72 trees of a total of 625 conifer trees. The comparison of the health condition with the results of the previous year survey (2014) could lead to mistakes. This is due to the fact that the plots assessed in the current year survey were different. The defoliation percentages for the five classes (0, 1, 2, 3 and 4) of the *Abies cephalonica* species were found to be 34.7%, 24.9%, 28.6% 9.4% and 2.3%, respectively. That means a significantly worse tree health condition than the conifers in total. In similar tree health condition was *Abies borisii-regis*. With regard to the *Pinus nigra* species, the considerably high percentage in class 0 (63%), combined with 0 dead trees (class 4) shows a very good health condition. Finally, in the *Pinus halepensis* species the results showed a steady but moderately healthy condition. The defoliation percentages were found to be 6.9%, 50.0% and 43.1% for the 0, 1 and 2 classes respectively.

The total number of the assessed broadleaved trees in Greece for the current year (2015) was 488. A comparison with the results of the previous year survey showed a slightly better health condition. The table below shows the results for the two consecutive years 2104 and 2015. The figures are in %.

Year	No defoliation (0)	Slight defoliation (1)	Moderate defoliation (2)	Severe defoliation (3)	Dead trees (4)
2014	49.2	33.9	13.6	2.3	0.8
2015	52.1	36.6	8.0	1.8	1.4

The main broadleaved species assessed in Greece (that means the species with the highest number of trees assessed) were *Quercus frainetto* with 135 trees, *Castanea sativa* with 72 trees and *Fagus moesiaca* with 71 trees. The defoliation percentages of the *Quercus frainetto* species showed a significant improvement of its health condition. This could be attributed to the fact that insect attacks have not been observed with the same intensity as in previous years. The defoliation percentages for the five classes of *Castanea sativa* species were similar to last year's survey. But the tree condition of the *Fagus moesiaca* species was found to be very healthy with 93% in the No and Slight defoliation classes.

The main causes assessed in the broadleaved species resulting in foliage losses were insect attacks and abiotic agents.

12.12 Hungary

The forest condition survey – based on the 16x16 km grid – in 2015 included 1841 sample trees on 77 sample plots from the total of 78 permanent plots in Hungary (one of them was inaccessible). The assessments were carried out between 15th July and 15th August. 89.2% of all assessed trees were broadleaves, 10.2% were conifers.

The health condition of the Hungarian forests is in a positive state, in the recent years the share of healthy and slightly defoliated trees – despite the annual fluctuations – was near 80%.

In 2015 the share of trees without visible damage symptoms was 50.5%. The percentage of slightly defoliated trees was 25.5%, and the percentage of all trees within ICP Forests defoliation classes 2-4 (moderately damaged, severely damaged and dead) was 24%. In Hungary the dead trees remain in the sample while they are standing, but the newly (in the surveyed year) died trees can be separated. The rate of trees having died in 2015 was 0.8% of all trees. The mean defoliation level of all species was 20.5% which is higher than in 2014 (18.6%).

In the defoliation classes 2-4 the tree species suffering the most damage are *Pinus nigra* (90.9%), *Pinus sylvestris* (37.6%) and *Robinia pseudoacacia* (30.9%), (the percentages show the rate of sample trees belonging to category 2-4). *Quercus cerris* (5.4%) and other hardwoods (10.9%) had the lowest defoliation rates in classes 2-4. Defoliation rates by species generally show considerable year to year variation in these categories. The condition of the rest of the tree species represented an average level.

Discoloration can rarely be observed in the Hungarian forests, 88.8% of living sample trees did not show any discoloration.

According to the classification defined in the ICP Forests manual on crown condition the damage caused by defoliating insects had one of the highest rate, 20.9% of all damages. This damage occurred particularly on the following species: *Pinus sylvestris* (49.7%), other softwood (43.9%). The mean damage values of these trees were 14.2% and 6.8% respectively.

The rate of assessed damage caused by fungi was also 20.9%. Fungal damage was mostly assessed on stem and root (wet rot causing fungus) at 67.2%, on needle and on leaves at 15.3%. The mean damage value was 19.9%.

16% of the assessed damage was abiotic, this is higher than the previous years'. The general intensity was 17.7%. Within the abiotic damage most important identifiable causes were drought (35.9%), frost (33.5%) and wind (17.9%), while the other causes were unimportant.

12.13 Italy

The survey of Level I in 2015 took into consideration the condition of the crown of 4757 selected trees in 235 plots belonging to the EU network (16x16 km grid). The results given below relate to the distribution of frequencies of the indicators used, especially transparency - which in our case we use for the indirect assessment of defoliation, and the presence of agents and known causes attributable to both biotic and abiotic factors. For the latter, we not so much analysed the indicators but the frequencies of affected plants, and the comments made about each plant may have multiple symptoms and agents.

Defoliation data are reported according to the usual categorical system (class 0:0-10%; class 1: >10-25%; class 2: >25-60%; class 3: >60%; class 4: tree dead): most trees (71.2%) are included in the classes 1 to 4; 29.8% are included in the classes 2 to 4.

From a survey of the frequency distribution of the parameter for transparency species were divided into two age categories (<60 and ≥60 years), among the young conifers (<60 years), *Picea abies* and *Pinus sylvestris* have respectively 58.1% and 37.0% of trees in the classes 2 to 4, *Pinus pinea* has 30.0%, *Pinus nigra* has 26.6% of trees in the classes 2 to 4, but the best conditions was found on *Larix decidua* with 15.4%.

Among the old conifers (≥60 years), the species which appears to have the worst quality of foliage was *Pinus nigra* (20.9%), *Picea abies* (20.9%), and *Abies alba* (17.5%); while *Larix decidua* with 7.7% and *Pinus cembra* with 7.3% of the trees in the classes 2 to 4, were the conifers is in better condition.

Among the young broadleaves (<60 years), *Castanea sativa, Quercus pubescens* and *Ostrya carpinifolia* have respectively 80.5%, 38.1% and 32.9% of trees in the classes 2 to 4, while others have a frequency range between 21.2% (*Fagus sylvatica*) and 24.9% (*Quercus cerris*) in classes 2 to 4.

Among the old broadleaves (≥60 years) in the classes 2 to 4, *Castanea sativa* has 83.8%, *Quercus pubescens* 48.9%, *Ostrya carpinifolia* 30.0%, *Quercus ilex* 13.8%, while *Fagus sylvatica* has the lowest level of defoliation of trees in the classes 2 to 4 (8.4%).

Starting from 2005, a new methodology for a deeper assessment of damage factors (biotic and abiotic) was introduced. The main results are summarized below.

Most of the observed symptoms were attributed to insects (20.5%), subdivided into defoliators (16.4%), galls (2.4%). The following symptoms were attributed to fungi (5.1%), the most significant were attributable to “dieback and canker fungi” (2.3%). Then followed those assigned to abiotic agents, the most significant were attributable to the high temperatures recorded in summer: drought (1.9%) and “heat stroke” (1.1%).

12.14 Latvia

The forest condition survey 2015 in Latvia was carried out on 116 NFI plots. The national report of 2015 is based on data from this dataset.

In total, defoliation of 1732 trees was assessed, of which 77% were conifers and 23% broadleaves. Of all tree species, 9.1% were not defoliated, 86.5% were slightly defoliated and 4.4% moderately defoliated to dead. Comparing to 2014, the proportion of not defoliated trees has decreased by 1.5%, proportion of moderately defoliated to dead trees has decreased by 0.7% but proportion of slightly defoliated trees has increased by 2.2%. In 2015, the proportion of not defoliated broadleaves was by 2.5% higher than that of not defoliated conifers, the proportion of slightly defoliated conifers was by 2.4% higher than that of slightly defoliated broadleaves but the proportion of trees in defoliation classes 2-4 was nearly the same for broadleaves and conifers.

Mean defoliation of *Pinus sylvestris* was 20.2% (20.2 in 2014). The share of moderately damaged to dead trees constituted 5.0% (5.2% in 2014). Mean defoliation of *Picea abies* was 20.8% (17.6% in 2014). Share of moderately damaged to dead trees for spruce constituted 3.3% (3.8% in 2014). The mean defoliation level of *Betula spp*. was 19.5% (19.6% in 2014), showing a slight decrease of the defoliation level. The share of trees in defoliation classes 2-4 was 3.8% (compared to 6.3% in 2014). The mean defoliation level for *Populus tremula* was 17.0% (15.8% in 2014). The mean defoliation level was distinctly lower for younger trees (19.5% for pine, 17.3% for spruce and 18.1% for birch up to 59 years old; the respective defoliation levels for trees 60 years and older were 20.9%, 24.4% and 20.8% for pine, spruce and birch.

Visible damage symptoms were observed on 18.6% of all trees - to a larger extent than in the previous year (17.3%) but to a lesser extent than in 2013 (19.7%). The most frequently recorded damages were caused by direct action of men (34.4% of all cases; 35.1% in 2014), animals (21.4%; same in 2014), fungi (10.4%; same in 2014), abiotic factors (12.4%; 13.7% in 2014) and insects (18.9%; 17.0% in 2014), unknown damage causes were recorded for 2.5% of all cases. Proportion of trees damaged by insects continues to grow due to an increase in the population and damages by European pine sawfly, *Neodiprion sertifer*; that was reported already last year. The greatest share of trees with damage symptoms was recorded for *Picea abies* (28.9%) and the smallest for *Betula spp.* (13.5%). Percentage of damaged *Pinus sylvestris* was 18.9% from all assessed pines trees.

12.15 Lithuania

In 2015, the forest condition survey was carried out on 1060 sample plots from which 81 plots were on the transnational Level I grid and 979 plots on the National Forest Inventory grid. In total 6340 sample trees representing 19 tree species were assessed. The main tree species assessed were *Pinus sylvestris, Picea abies, Betula pendula, Betula pubescens, Populus tremula, Alnus glutinosa, Alnus incana, Fraxinus excelsior,* and *Quercus robur.*

The mean defoliation of all tree species slightly increased up to 22.9% (22.2% in 2014). 13% of all sample trees were not defoliated (class 0), 63% were slightly defoliated and 24% were assessed as moderately defoliated, severely defoliated and dead (defoliation classes 2-4).

Mean defoliation of conifers slightly increased up to 23.1% (21.7% in 2014) and slightly decreased for broadleaves up to 22.5% (22.8% in 2014).

Pinus sylvestris is a dominant tree species in Lithuanian forests and comprises about 40% of all sample trees annually. Mean defoliation of *Pinus sylvestris* reached 23.8% (23.1% in 2014) with an increasing tendency since 2008.

Populus tremula had the lowest mean defoliation and the lowest share of trees in defoliation classes 2-4 since 2006. Mean defoliation of *Populus tremula* was 18.3% (18.9% in 2014) and the proportion of trees in defoliation classes 2-4 was 10% compared with 12% in 2014.

Fraxinus excelsior condition remained the worst among all observed tree species. This tree species had the highest defoliation since year 2000. Mean defoliation increased to 41.1% (40.9% in 2014). The share of trees in defoliation classes 2-4 increased to 54% (52% in 2014).

27% of all sample trees had some kind of identifiable damage symptom. The most frequent damage was caused by abiotic agents (about 8 %) in the period of 2011 – 2015. It is closely connected with the storm that hit the South-Eastern part of Lithuania on August 8, 2010. The highest share of damage symptoms was assessed for *Fraxinus excelsior* (63%), *Populus tremula* (35%) and *Alnus incana* (34%), the least for *Betula sp.* (20%) and *Alnus glutinosa* (21%).

In general, the mean defoliation of all tree species has varied inconsiderably from 1997 to 2015 and the growing conditions of Lithuanian forests can be defined as relatively stable.

12.16 Luxembourg

In 2015 the national crown condition survey was based on a 4 x 4 km grid, which included 1200 sample trees on 51 permanent plots.

On average over all tree species, 30.5% of the forest was showing no defoliation, 32.9% were assessed as damaged (classes 2-4), and 36.6% were in the warning stage.

In 2015, 18.8% of conifers were in defoliation classes 2-4, 25.6% were slightly defoliated, and 55.6% were not defoliated. For broadleaves 40.7% were assessed as damaged (classes 2-4), 42.6% were slightly defoliated, and 16.7% showed no signs of defoliation.

12.17 Republic of Moldova

In 2015, the assessment of forest health was performed for a total of 14 280 trees (14 239 broadleaved trees and 41 coniferous trees). As a result of the negative effect of biotic and abiotic factors, the trees in the defoliation classes “none” constituted only 33.5%. The drought and adverse climatic conditions during the vegetation period affected the health of the trees in the forests of the Republic of Moldova. In 2015, weak unhealthy trees (defoliation class 1 – “slight”) constituted 40.4%, moderately unhealthy trees (defoliation class 2 – “moderate”) 24.2% and the strong unhealthy and dead trees (defoliation classes 3-4 “severe-dead”) 1.9%.

Broadleaved forests were more affected than coniferous forests, the share of broadleaved trees in the defoliation classes “slight” and “dead” (classes 1-4) was 66.5% compared to 39.0% for conifers. All monitored deciduous species (oaks, locust, beech, ash, poplar and others) framed in defoliation class 1-4 ranged from 59.0% to 89.5% and trees in defoliation class 2-4 ranged from 15.7% to 29.7%.

12.18 Norway

2015 was the third year in Norway with the new sampling design for Level I with annually one fifth of the NFI plots monitored and five year revision intervals on the plots, following the rotation of the National Forest Inventory (NFI). From 2013 we have crown condition assessments only for *Picea abies* and *Pinus sylvestris*, while damage assessments are carried out for all tree species present on the NFI plots including birch. This new design produces good estimates of average national crown condition; however estimates of regional crown condition are probably less accurate. In 2015, the mean defoliation for *Picea abies* was 15.9%, and 14.2 % for *Pinus sylvestris*. 2015 was a year with a slight increase in defoliation for both spruce and pine after four years in 2011-2014 with decreasing defoliation.

Of all the coniferous trees, 45.1 % were rated as not defoliated in 2015, which is a decrease of about 3%-points compared to the year before. 42.4% of the *Pinus sylvestris* trees were rated as not defoliated which is a decrease of about 5%-points. 47.4% of all Norway spruce trees were not defoliated, a decrease of about 1%-points compared to the year before.

With respect to crown discolouration, we observed 7% discoloured trees for *Picea abies*, a decrease of about 1%-point from 2015. For *Pinus sylvestris*, 2.8% of the assessed trees were discoloured, a decrease of about 2%-points from the year before.

The mean mortality rate for all species was 0.2% in 2015. The mortality rate was 0.2% and 0.1% for spruce and pine, respectively.

In general, the observed crown condition values result from interactions between climate, pests, pathogens, and general stress. According to the Norwegian Meteorological Institute the first half of the summer (June and July) of 2015 was cold with a temperature about 1° C lower than normal as an average for the country. The precipitation was slightly higher than normal. In sum, a cold and wet first half of the summer is good for the drought sensitive Norway spruce at dry sites, especially in the lowlands of Southeast Norway. The last half of the summer (August and September) was warm with about 2° C higher temperature than normal and about normal precipitation. The last half of the summer is normally not so crucial for growth and mortality for conifers in Norway. There are of course large climatic variations between regions in Norway, ranging from 58 to 71°N.

12.19 Poland

In 2015 the forest condition survey was carried out on 2018 plots (grid 8 km x 8 km).

Forest condition (all species total) slightly improved as compared to the previous year because of especially the broadleaved species. 11.9% of all sample trees were without any symptoms of defoliation, indicating an increase by 0.4 percent points compared to 2014. The proportion of defoliated trees (classes 2-4) decreased by 2.2 percent points to an actual level 16.7% of all trees.

The health condition of broadleaved species was slightly better than that of the coniferous species. Broadleaved species were characterized by a significantly higher proportion of healthy trees (16.2%) and a slightly higher proportion of damaged trees (18.4%) than coniferous species (9.6% and 15.8% respectively). The share of trees defoliated by more than 25% decreased by 1.4 percent points for conifers and by 3.5 percent points for broadleaves compared to 2014. In 2015, mean defoliation for all species total amounts to 21.5%, with 21.6% for conifers and 21.4% for broadleaved trees.

With regard to the three main coniferous species *Abies alba* remained the species with the lowest defoliation (19.5% trees in class 0, 15.3% trees in classes 2-4, mean defoliation amounting to 20.0%). *Pinus sylvestris* was characterized by a lower share of trees in class 0 (8.8%), little lower share of trees in classes 2-4 (15.0%) and a little higher mean defoliation (21.6%) than *Abies alba*. Otherwise *Picea abies* was characterized by a medium share of trees in class 0 (12.2%), a higher share of trees in classes 2-4 (25.1%) and higher mean defoliation (23.0%) compared to *Pinus sylvestris* and *Abies alba*.

16.2% of the assessed broadleaved trees were not defoliated. The proportion of trees with more than 25% defoliation (classes 2-4) amounted to 18.4%. As in the previous survey the highest defoliation amongst broadleaved trees was observed in *Quercus* spp. In 2015 a share of 5.2% of oak trees was without any symptoms of defoliation and 28.1% was in defoliation classes 2-4, mean defoliation amounting to 24.5%. A slightly better condition was observed for *Betula* spp. (8.9% trees without defoliation, 20.7% damage trees and mean defoliation amounting to 22.5%). *Fagus sylvatica* remained the broadleaves species with the lowest defoliation. In 2015 a share of 38.3% of beech trees was without any symptoms of defoliation, only 5.2% was in defoliation classes 2-4, mean defoliation amounting to 15.7%. *Alnus* spp. was in quite good health, but was more defoliated (18.5% trees without defoliation, 11.2% trees in classes 2-4, mean defoliation amounting to 19.7%) than *Fagus sylvatica*, but less than *Quercus* spp. and *Betula* spp.

Pinus sylvestris, *Picea abies, Abies alba* and *Alnus* sp. were almost in the same health condition compared to the previous year. Damage of *Fagus sylvatica*, *Quercus* spp. and *Betula* spp. slightly decreased.

In 2015, discolouration (classes 1-4) was observed on 0.6% of the conifers and on 0.7% of the broadleaves.

12.20 Romania

In 2015, the forest condition survey in Romania was carried out on the 16 x 16 km transnational Level I grid net, during 15th of July and 15th of September. The total number of sample trees was 5808, assessed on 242 permanent plots. From the total number of trees, 1092 were conifers (19%) and 4716 broadleaves (81%).

The mean defoliation percentage of all tree species was 15.2%. From the total number of the assessed trees, 54.2% were rated as healthy, 32.7% as slightly defoliated, 11.3% as moderately defoliated, 1.4% as severely defoliated and 0.4% were dead. The share of damaged trees (defoliation classes 2-4) was 13.1%.

For **conifers** a percentage of 9.5% of the assessed trees were classified as damaged (classes 2-4). *Picea abies* was the least affected coniferous species with a share of damaged trees of 7.8% (defoliation classes 2-4), whereas *Abies alba* had 15.5%.

For **broadleaves,** 13.9% of the trees were recorded as damaged (classes 2-4). Among the main broadleave species, *Fagus sylvatica* and *Robinia pseudoacacia* had the lowest share of damaged trees (9.8% and 11.3% respectively). For all *Quercus spp*. (*Q. petraea, Q. cerris, Q. robur,* and *Q. frainetto*) a share of 16.6% were damaged from the total number of the assessed trees. The least affected species was *Q. frainetto* (9.1%) and the most affected was *Q. petraea* (17.2%). *Q. robur* recorded the highest percent (39.0%) of damaged trees (classes 2-4), although this species is very low represented (only 77 trees were assessed).

The overall share of damaged trees (classes 2-4) decreased by 0.4 percentage points. The relative increased values of the precipitation regime registered in the south-west of Romania during 2015 led to a significant improvement of the health status of xerophyte oaks from 15.3% in 2014 to 8.8% (*Quercus frainetto*), and 12.8% (*Quercus cerris*) in 2015 respectively.

Damage symptoms were reported for 23.0% of the conifers and 33.4% of the broadleaves respectively. The most important causes of damages were attributed to defoliator and xylophage insects (49.8%) and fungi (21.3%). In general, the intensity of the visible damage symptoms for the conifers was higher than for broadleaves.

12.21 Serbia

In the region of the Republic of Serbia, ICP Forests consists of a 16 x 16 km grid with 103 sampling plots and an additional 4 x 4 grid, with 27 new plots, altogether the number of plots is 130 (not including in the assessment are AP Kosovo and Metohija). Observations at Level I were performed according to the ICP Forests Manual of Methods.

During 2015, the researchers of the NFC Serbia - Institute of Forestry with collaborators from other institutions in Serbia, have worked on all sampling points and made visual assessment of the crown condition and collected the other necessary field data.

The total number of trees assessed on all sampling points was 2910 trees, of which were 338 conifer trees and a considerably higher number, i.e. 2572, were broadleaf trees. The conifer tree species are: *Abies alba,* number of trees and percentage of individual tree species 69 (20.4%), *Picea abies* 146 (43.2%), *Pinus nigra* 67 (19.8%)*, Pinus sylvestris* 56 (16.6%). The most represented broadleaf tree species are: *Carpinus betulus,* number of trees and percentage of individual tree species 114 (4.4%) *, Fagus moesiaca* 847 (32.9%), *Quercus cerris* 503 (19.6%)*, Quercus frainetto* 380 (14.8%), *Quercus petraea* 184 (7.2%) and other species 544 (21.2%).

The results of the available data processing and the assessment of the degree of defoliation of individual conifer and broadleaf species (%) are: *Abies alba* (None 85.5, Slight 5.8, Moderate 0.0, Severe 7.2 and Dead 1.5); *Picea abies* (None 84.3, Slight 9.6, Moderate 3.4, Severe 0.0, Dead 2.7); *Pinus nigra* (None 34.3, Slight 19.4, Moderate 32.8, Severe 11.9, Dead 1.5); *Pinus sylvestris* (None 89.3, Slight 5.4, Moderate 0.0, Severe 3.6, Dead 1.8).

The degree of defoliation calculated for all conifer trees is as follows: no defoliation 75.4% trees, slight defoliation 10.1% trees, moderate 8.0% trees, severe defoliation 4.4% trees and dead 2.1% trees.

Individual tree species' defoliation (%) is: *Carpinus betulus* (None 87.7, Slight 5.3, Moderate 3.5, Severe 3.5, Dead 0.0); *Fagus moesiaca* (None 84.4, Slight 8.6, Moderate 3.9, Severe 2.8, Dead 0.2); *Quercus cerris* (None 67.8, Slight 22.1, Moderate 8.0, Severe 2.2, Dead 0.0); *Quercus frainetto* (None 83.2, Slight 12.9, Moderate 1.8, Severe 1.8, Dead 0.3); *Quercus petraea* (None 54.9, Slight 37.5, Moderate 6.0, Severe 1.1, Dead 0.5) and the rest (None 61.8, Slight 17.1, Moderate 12.9, Severe 6.4, Dead 1.8).

Degree of defoliation calculated for all broadleaf species is as follows: no defoliation 74.3% of trees, slight defoliation 15.6% of trees, moderate 6.4%, severe defoliation 3.2% trees and dead 0.5% of trees.

The data above show the presence of sample trees with moderate and severe degrees of defoliation, but this does not always signify the reduction of the vitality score caused by the effect of adverse agents (climate stress, insect pests, pathogenic fungi). This can only be a temporary phase of natural variability of crown density.

12.22 Slovakia

The 2015 national crown condition survey was carried out on 106 Level I plots on the 16x16 km grid. The assessments covered 4354 trees, 3630 of which were being assessed as dominant or co-dominant trees according to Kraft. Of the 3630 assessed trees, 34.5% were damaged (defoliation classes 2-4). The respective figures were 49.4% for conifers and 24.3% for broadleaves. Compared to the year 2014, the share of trees defoliated more than 25% increased by 0.4%. Mean defoliation for all tree species together was 24.2%, with 28.3% for conifers and 21.4% for broadleaved trees. Results show that crown condition in the Slovak Republic is worse than the European average. This is due to the worse condition of coniferous species.

Compared to the 2014 survey, improvement of crown condition (average defoliation) was observed in all broadleaves species. The mean defoliation of the main broadleaved tree species (*Fagus sylvatica, Quercus sp., Carpinus betulus)* in the years 2011-2014 was increased. In 2013 the mean defoliation of broadleaved trees was even as high as the mean defoliation of conifers, which was for the first time in the history of forest monitoring. In 2015 the mean defoliation decreased back to the level that was common before 2009.

The most severe damage has been observed in conifers *(Pinus sylvestris* and *Picea abies)*. The lowest level of defoliation shows hornbeam *(Carpinus betulus).*

From the beginning of the forest condition monitoring in 1987 until 1996 results show significant decrease of defoliation and visible forest damage. Since 1996, the share of damaged trees (25-32%) and average defoliation (22-26%) has been relatively stable (except for the above mentioned situation in the years 2011-2014 for broadleaved tree species). The recorded fluctuation of defoliation depends mostly on meteorological conditions.

As a part of crown condition survey, damage types were assessed. 24.7% of all sampling trees (4354) had some kind of damage symptoms. The most damaged tree species according to visual symptoms were oak (32%) and hornbeam (40%).

The most frequent damage was caused by harvesting and logging (9.5% of all trees), fungi (8.9%) and insects (5.5%). The most important effect on defoliation have epiphytes. 75% of trees damaged by epiphytes revealed defoliation above 25%.

12.23 Slovenia

In 2015 the Slovenian national forest health inventory was carried out on 44 systematically arranged sample plots (grid 16 x 16 km). The assessment encompassed 1051 trees, 388 coniferous and 663 broadleaved trees. The sampling scheme and the assessment method was the same as in the previous years (at each location four M6 (six-tree) plots). Report for the year 2015 includes only 1051 instead of 1056 trees. The reason is the strong sleet damage of Slovenian forests in 2014 and in two plots there wre no trees with dbh bigger than 10 cm for the replacement of the felled trees.

The mean defoliation of all tree species was estimated to be 28.1%. Compared to the 2014 survey, the situation improved for 0.1% (mean defoliation in 2014 was 28.2%). In the year 2015 mean defoliation for coniferous trees was 29.4% (in the year 2014 it was 27.6%) and for broadleaves 27.3% (year before 28.6%).

In 2015 the share of trees with more than 25% of defoliation (damaged trees) reached 37.8%. In comparison to the results of 2014, when the share of trees with more than 25% of unexplained defoliation was 38.3%, the value decreased for 0.5%.

Damaged broadleaves trees decreased from 38.4% in 2014 to 35.9% in 2015. Especially significant is the change of damaged trees for coniferous where the share of damaged trees increased from 38.8% in 2014 to 41.0% in 2015.

In the year 2014 the share of damaged coniferous was just slightly greater than the share of damaged broadleaves trees. But in the year 2015 the share of damaged coniferous is significantly higher than the share of damaged broadleaves.

In general, the mean defoliation of all tree species has slightly increased since 1991. In comparison to the year 2010 the mean defoliation deteriorated in year 2011, improved in 2012 and again deteriorated in 2013. The biggest change in the mean defoliation can be seen in the year 2014 due to the sleet damage in February 2014. In 2015 the defoliation of broadleaves decreased, but the defoliation of coniferous is even higher. The main reason is probably the bark beetle outbreak in summer of 2015.

12.24 Sweden

An annual monitoring of the most important sources of forest damage is carried out by the Swedish National Forest Inventory (NFI). Although the Swedish NFI is an objective and uniform inventory including data about forest damage in Swedish forests at national and regional scales, less common or less widespread occurrences of forests pests and pathogens are difficult to survey solely through large-scale monitoring programmes. Complementary target tailored forest damage inventories (TFDI) have therefor been introduced. TDFIs are developed to give a rapid response to requested information on specific damage outbreaks. The TDFIs are carried out in limited and concentrated samples, with flexible but robust methods and design.

The national results are based on assessment of the main tree species Norway spruce (*Picea abies*) and Scots pine (*Pinus sylvestris*) in the National Forest Inventory (NFI), and concern, as previously, only forest of thinning age or older. In total, 8032 trees on 4097 sample plots were assessed. The Swedish NFI is carried out on permanent as well as on temporary sample plots. The permanent sample plots, which represent about 60 percent of the total sample, are remeasured every 5th year.

The proportion of trees with more than 25 % defoliation is for Norway spruce 25.4% and for Scots pine 14.7%. A minor increase in defoliation for Norway spruce in central and southern Sweden is seen during the last ten years. While a slight improvement is seen in Norway spruce in northern Sweden during recent years. In all of Sweden, defoliation in Scots pine has increased during the last seven years. There are some large temporal changes seen in defoliation levels at regional level however the majority of changes during recent years are minor.

A few minor storms affected southern Sweden in 2015. In total about 5–6 million m^3 forest were wind felled. There are still wind-felled trees in small groups found spread over a large area in central Sweden. In October 2015 an estimated volume of more than 0.5 million m^3 of wind-felled spruce trees were still available for breeding by bark beetles. Also 0.75 million of wind-felled spruce trees were found utilized in 2015 by bark beetles, mainly *Ips typographus* and *Polygraphus sp.* An increased damage to the growing forest is also seen. Approximately 0.4 million m^3 of spruce trees were killed by bark beetles. The bark beetle populations have increased and it is likely that this will lead to a further increase in damage to the growing forest.

The decline in Ash (*Fraxinus excelsior*) is continuing in southern Sweden. Severe problems remain with Dutch elm disease **(**(*Ophiostoma novo-ulmi*). In northern Sweden problems with resin top disease (*Cronartium flaccidum*) still occur in young pine stands. In the same area during the last years damage by pine twisting rust (*Melampsora pinitorqua*) has also increased. Overall however the most important biotic damage problems are, as previously, due to pine weevil (Hylobius abietis) (in young forest plantations), browsing by ungulates - mainly elk (in young forest), and root rot caused by *Heterobasidion annosum*.

12.25 Switzerland

In 2015, the defoliation decreased again after it had been increasing from 2013 to 2014. The proportion of "significantly damaged trees[1]" between 30 % and 100% (class 2-4), decreased from 30.5% in 2014 to 24.7% in 2015 thus being also lower than the values from 2012 to 2013. The basis for this data is the crown assessment for a total of 1051 trees in 2015. The percentage observed in 2015 is still a bit higher than the most recent period with rather low defoliation (2005 to 2010), where the average of significantly damaged trees amounted to 21% of all trees assessed. The value for 2015 is, however, approaching the long-term average of the last twenty years, which is 23.3%. Whilst the proportion of slightly defoliated trees (class 1) did not change clearly between 2014 and 2015, the moderately defoliated ones (class 2) dropped from 19.5% to 13.2%. Moreover, the proportion of not defoliated trees increased between 2014 (18.2%) and 2015 (22.6%).

The trends in 2015 fit into previous observations that there are in general strong high-frequency variations that can be seen since the end of the 90s. Thus, after the significant increase in defoliation observed until the mid ‘90s, no clear long-term trend is visible since about 2000. The heavy increases in defoliation and the subsequent recovery coincide often with climatic events. The storm Lothar was responsible for the maximum in 2000 and the dry and hot summer of 2003 for the second peak. However, increases in defoliation from 2009 to 2012 cannot be explained completely by climatic events and also the 2014 increase and the 2015 decrease is not directly attributable to meteorological extremes.

We, however, observed a tendency for insect damage to more strongly contributing to defoliation. This relationship is mainly visible in deciduous trees, where the beech leaf miner (*Rhynchaenus fagi)* is likely to have the greatest influence. Still the defoliation trend for deciduous trees followed that of all trees species in 2015 and decreased from 2014 (28% class 2-4) to 2015 (26.2%). The increased frequency of mast years might contribute to the strong year-to-year variations.

After a short relief in 2012, the ash dieback that started in Switzerland in 2008, caused another increase in defoliation in 2015 being comparable to 2013. A third of the ash trees are severely affected but there is also a tendency that new replacement sprouts allow trees to produce relatively dense crowns.

12.26 Turkey

Monitoring studies have been conducted on a grid of 16x16 km and crown condition of 13 665 trees in 591 Level I sample plots have been evaluated in 2015. Average needle/leaf loss ratio of all evaluated trees is 15.6%. The ratio of healthy trees (class 0-1) is 95.6% and the remaining 9.5% had a loss ratio of greater than 25 percent. Annual average needle/leaf loss had slightly increased in comparison to last year.

The average defoliation ratio of broadleaved species is 16.0% percent. Common tree species with highest defoliation ratios are *Quercus pubescens* (22.6%), *Alnus glutinosa* (24.3%), *Castanea sativa* (20.0%) and *Quercus petraea* (19.5%). The same species had the greatest needle/leaf loss in the last two years. Among the less common broadleaved species (each of which are presented by less than 20 individuals), *Fraxinus ornus, Ceratonia siliqua, Juglans regia, Ostrya carpinifolia, Pistacia lentiscus* ve *Prunus avium* have a 25% or greater defoliation ratio. While 89.2% of all broadleaved trees showed no or slight defoliation (class 0-1), 10.8% of them were defoliated by more than 25% (class 2-4).

[1] Trees showing unexplained defoliation subtracting the percentage of defoliation due to known causes such as insect or frost damage.

The average defoliation ratio of coniferous species is 15.4%. 91.4% of all evaluated coniferous trees have a needle loss of less than 25% (class 0-1), and the remaining 8.6% of them have over 25% needle loss (class 2-4). *Pinus pinaster, Pinus brutia, Abies cilicica,* Junipers (*Juniperus foetidissima, J. excelsa, J. oxycedrus, J. communis*) have the highest needle loss among common conifers with defoliation ratios between 18.4% and 16.2%. As for pine species, defoliation ratios of *P. brutia*, *P. sylvestris* and *P. nigra* are 17.6%, 15.0% and 12.5%, respectively. In addition, the greatest needle loss was observed in *P. pinaster* (24.6%), which is a less common species and represented by only 14 sample trees in this monitoring study.

Among the biotic causes of damage, *Rhynchaenus fagi, Lophodermium pinastri, Cinara cedri, Cryphonectria parasitica* and *Tomicus spp* are the most pronounced. The number of trees affected by *Thaumetopoea* spp. declined by 7.5% in comparison to last year. As in previous years, mistletoe (*Viscum alba*) is also among the leading damaging agents.

12.27 Ukraine

The field survey on Level I forest monitoring plots was carried out by specialists of the State Forest Management Enterprises (SFME's) under the methodological guidance experts from the Ukrainian Research Institute of Forestry and Forest Melioration (URIFFM) and experts from Regional Forest Administrations (RFA). Responsibility for QA/QC of the forest monitoring data is placed to RFA and URIFFM, experts from URIFFM are responsible for maintaining the national forest monitoring database.

In 2015, 31 978 sample trees were assessed on 1 341 permanent forest monitoring plots in 24 administrative regions of Ukraine (observations were not carried out in Crimea, and partly in the Donetsk and Lugansk regions). The average defoliation of conifers was 11.7 % and of broadleaved trees it was 12.0 %.

Generally the tree crown condition is satisfactory: the part of healthy (not defoliated) trees amounts to 62.5%. Compared to the previous results there is some worsening of crown condition in 2015: for the total sample the percentage of healthy trees slightly decreased (62.5 against 65.1%), and respectively the part of slightly defoliated tress increased (from 28.3 to 30.4%). The part of "damaged trees" (with defoliation over 25%) also increased from 6% to 7.1%.

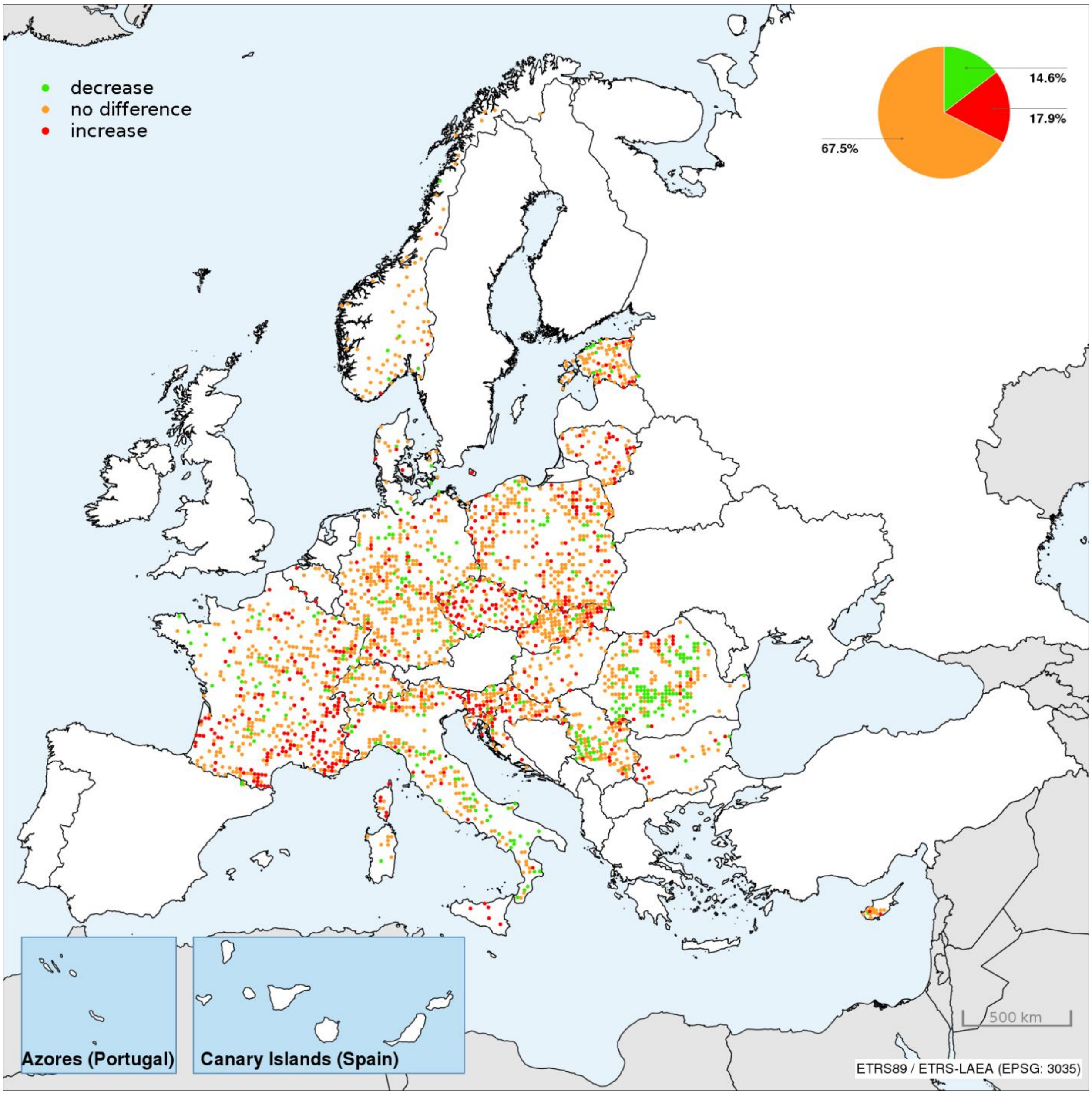
For broadleaved the part of healthy trees is 60.9%, and respectively the part of defoliated trees is 39.1%, from those the part of damaged trees (with defoliation over 25%) is 6.3%. For conifers the part of healthy trees is 64.6% and the part of damaged trees (with defoliation of more then 25%) amounts to 7.9%.

For the sample of common sample trees (CSTs) (31 678 trees) average defoliation slightly increased – from 11.2% to 11.8% compared to the previous year.

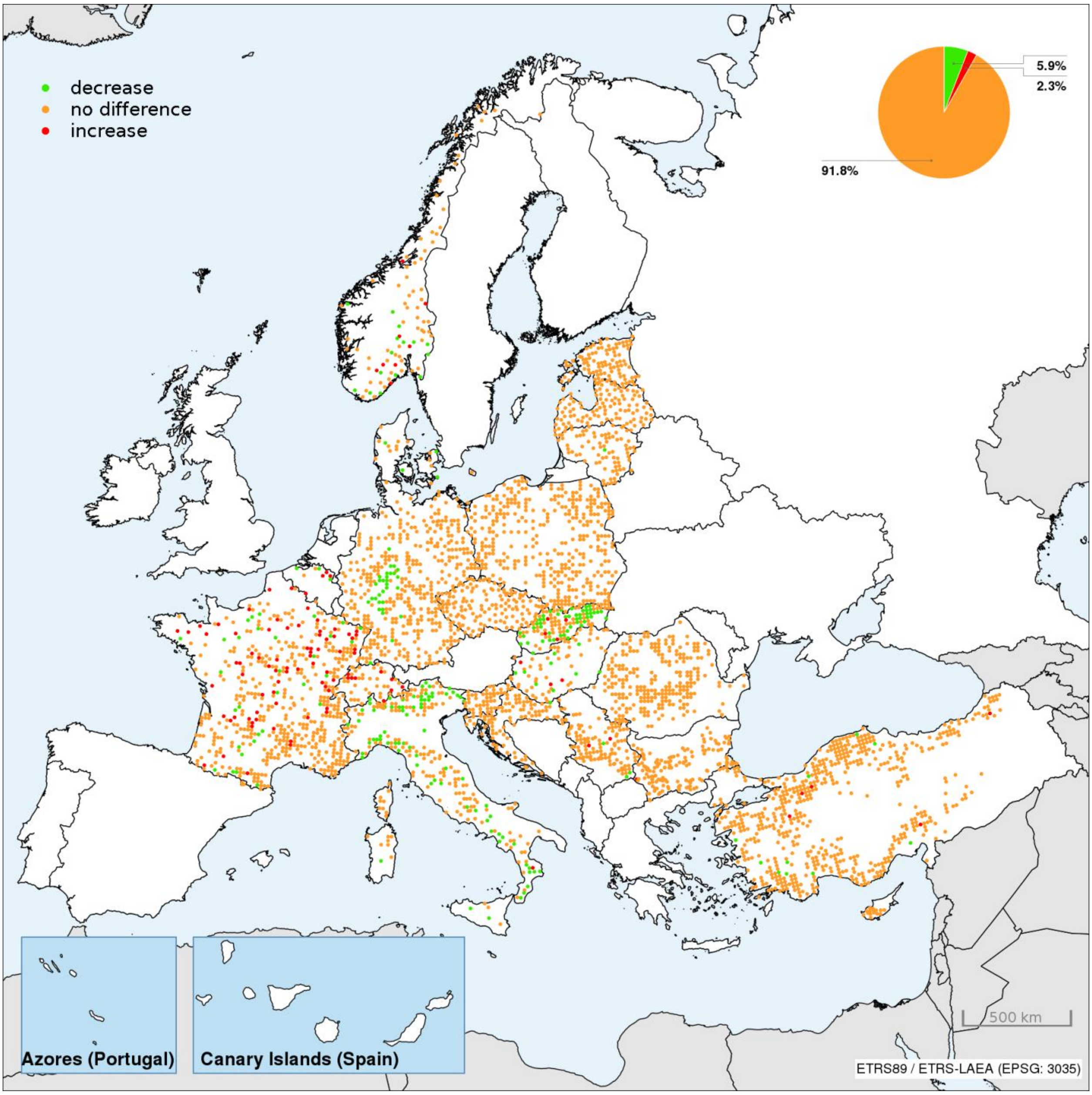
In the current year the lowest average defoliation have *Pinus sylvestris* trees (10.5%), middle values – *Quercus robur (12.3%), Fraxinus excelsior* (11.1%) and the highest average defoliation have trees of *Fagus sylvatica (*13.2%), *Abies alba* (13.3%), and *Picea abies* (14.9%).

ANNEX

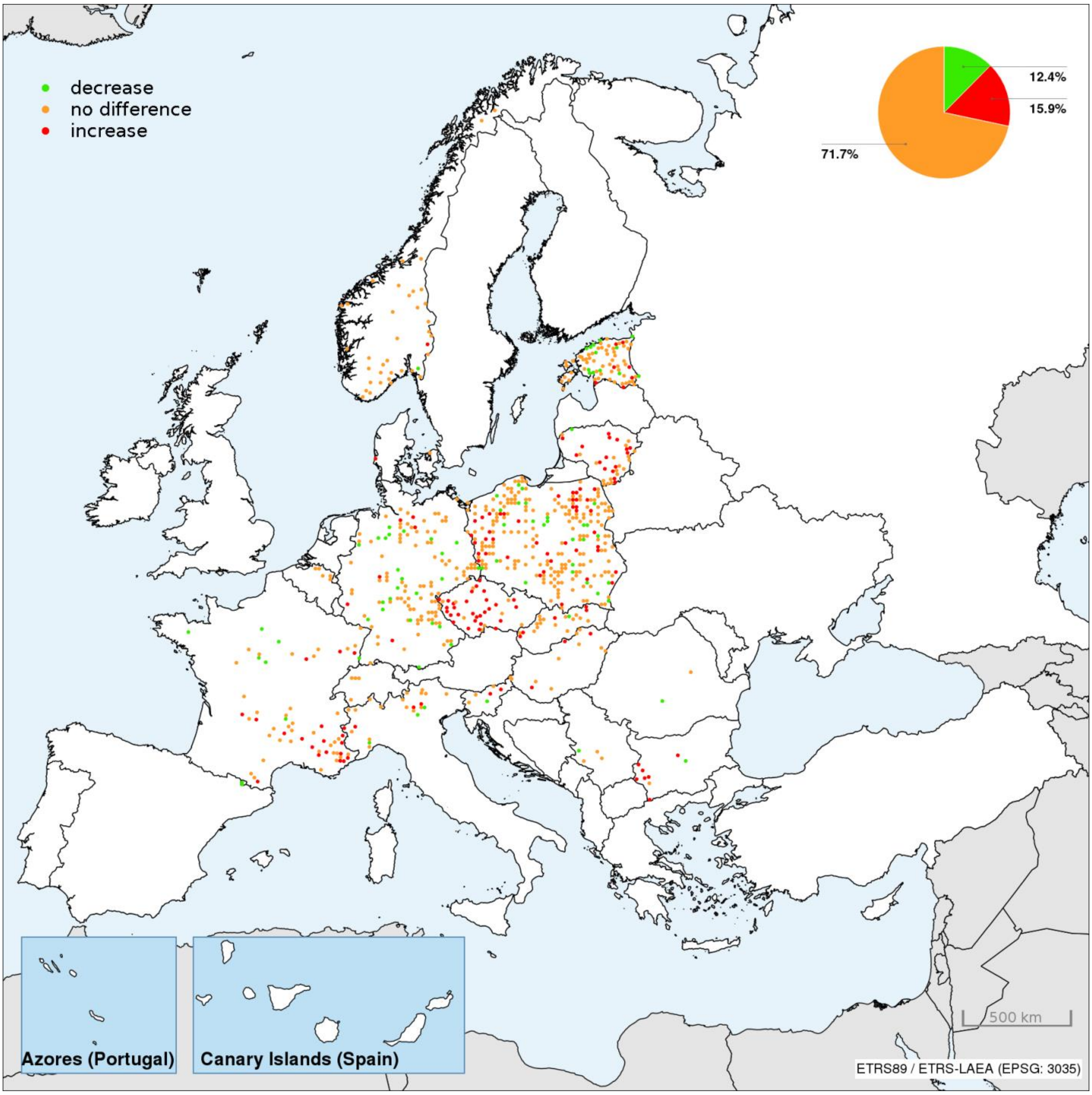
ANNEX I
TREE CROWN CONDITION AND DAMAGE CAUSES – ADDITIONAL MAPS



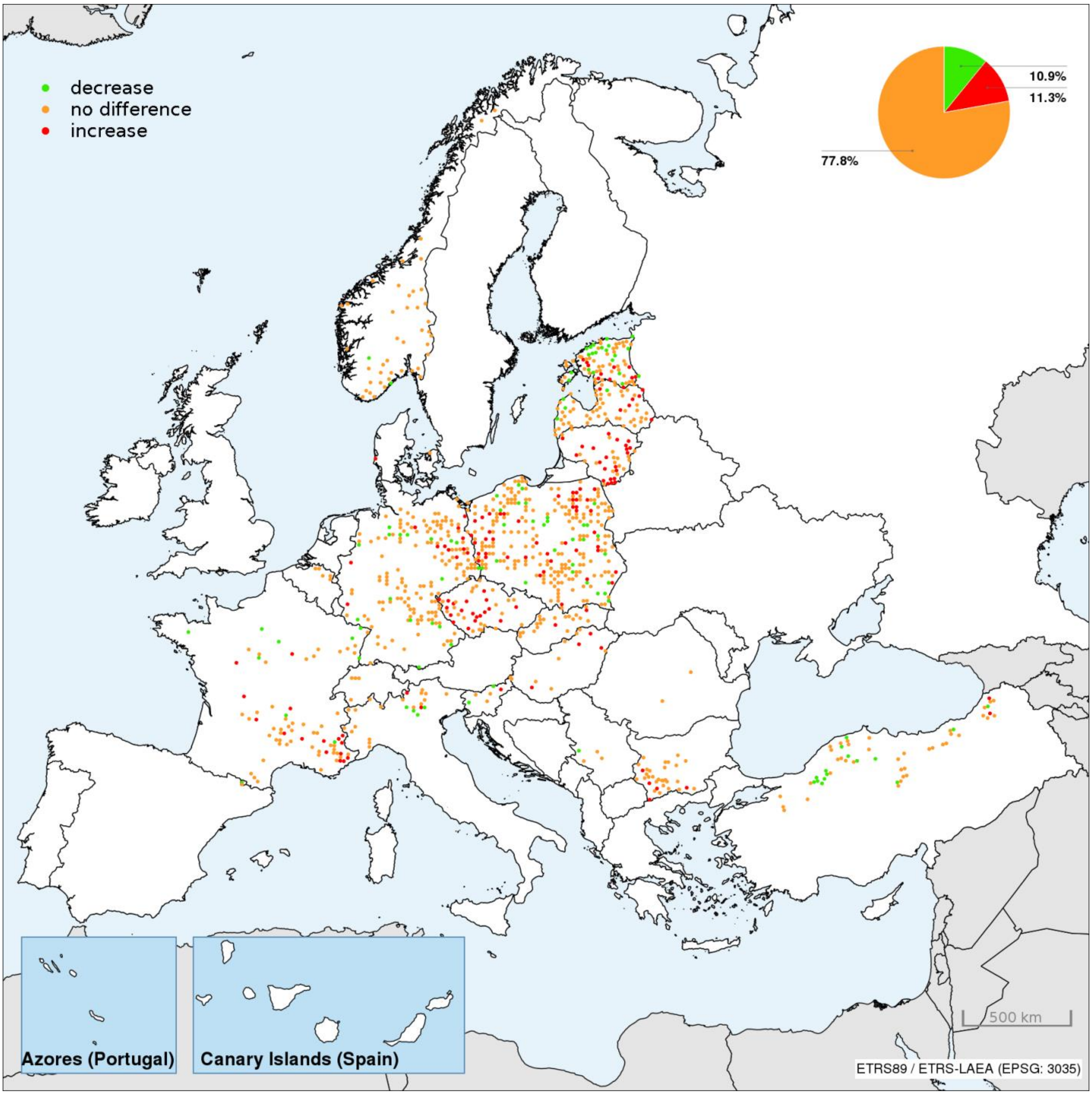
Annex I-1. Trends in mean plot defoliation (Mann-Kendall test) of all species between 2002 and 2015 with a minimum assessment length of 10 years.



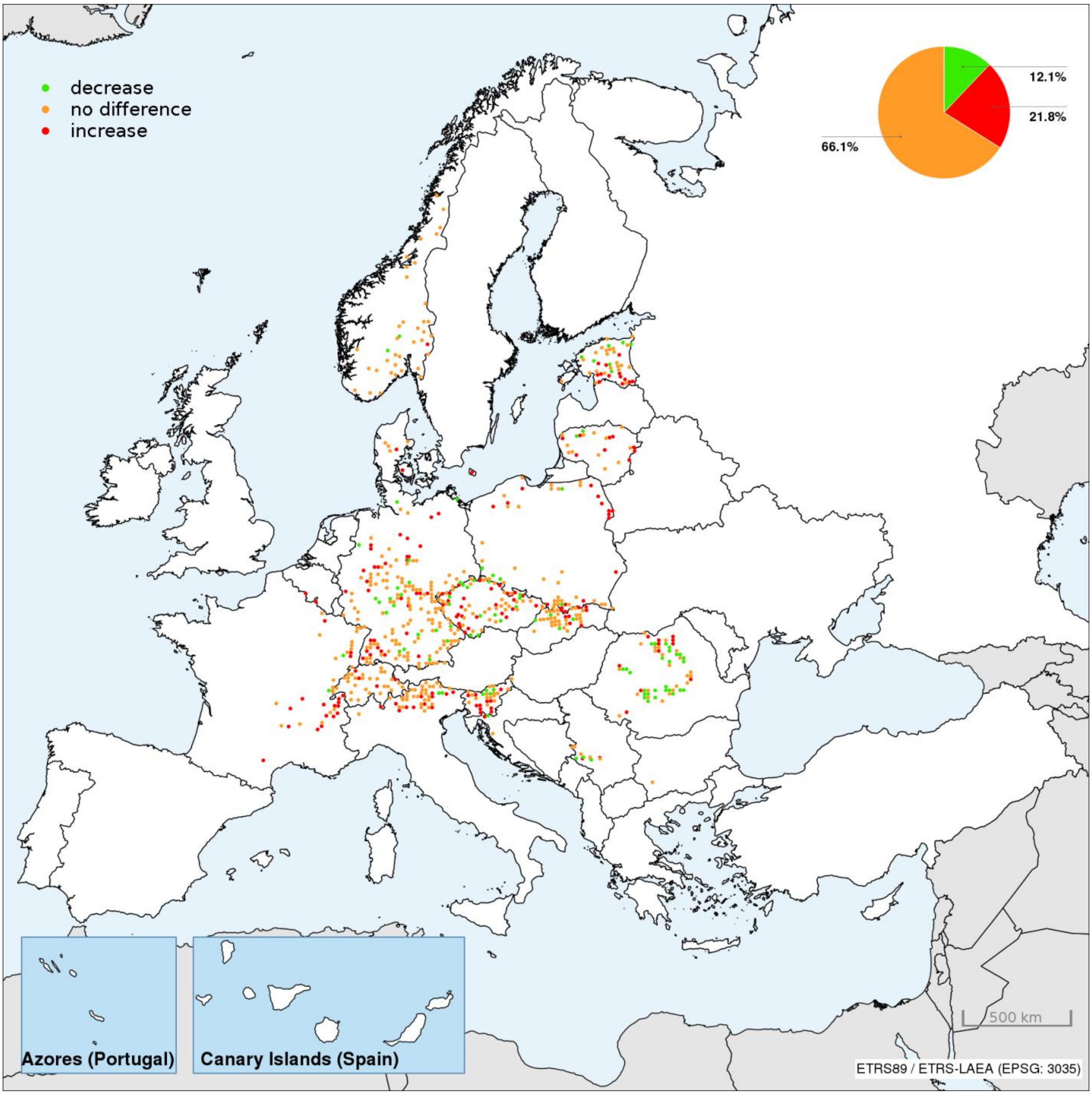
Annex I-2. Trends in mean plot defoliation (Mann-Kendall test) of all species between 2006 and 2015 with a minimum assessment length of 5 years.



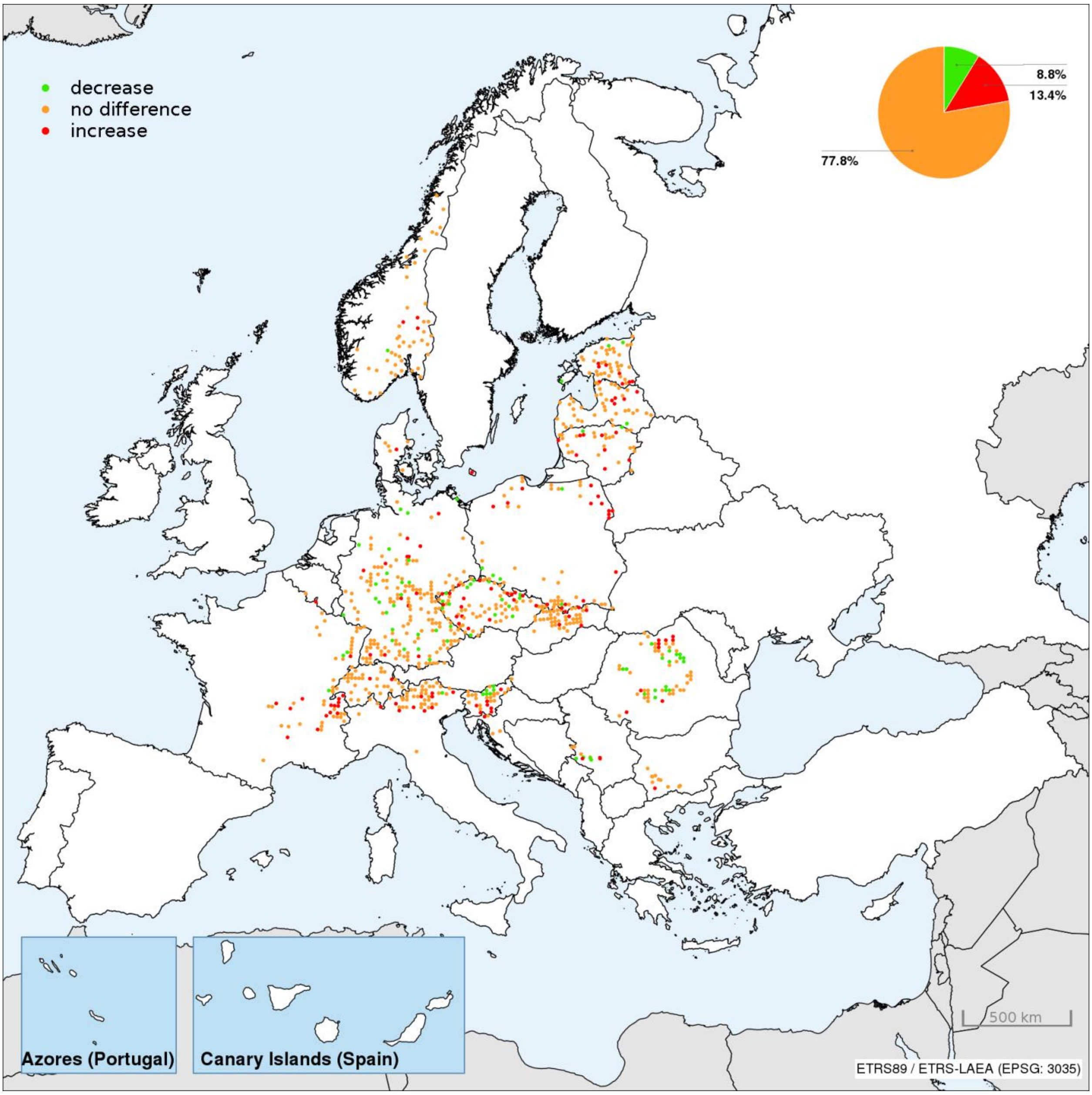
Annex I-3. Trends in mean plot defoliation (Mann-Kendall test) of Scots pine between 2002 and 2015 with a minimum assessment length of 10 years.



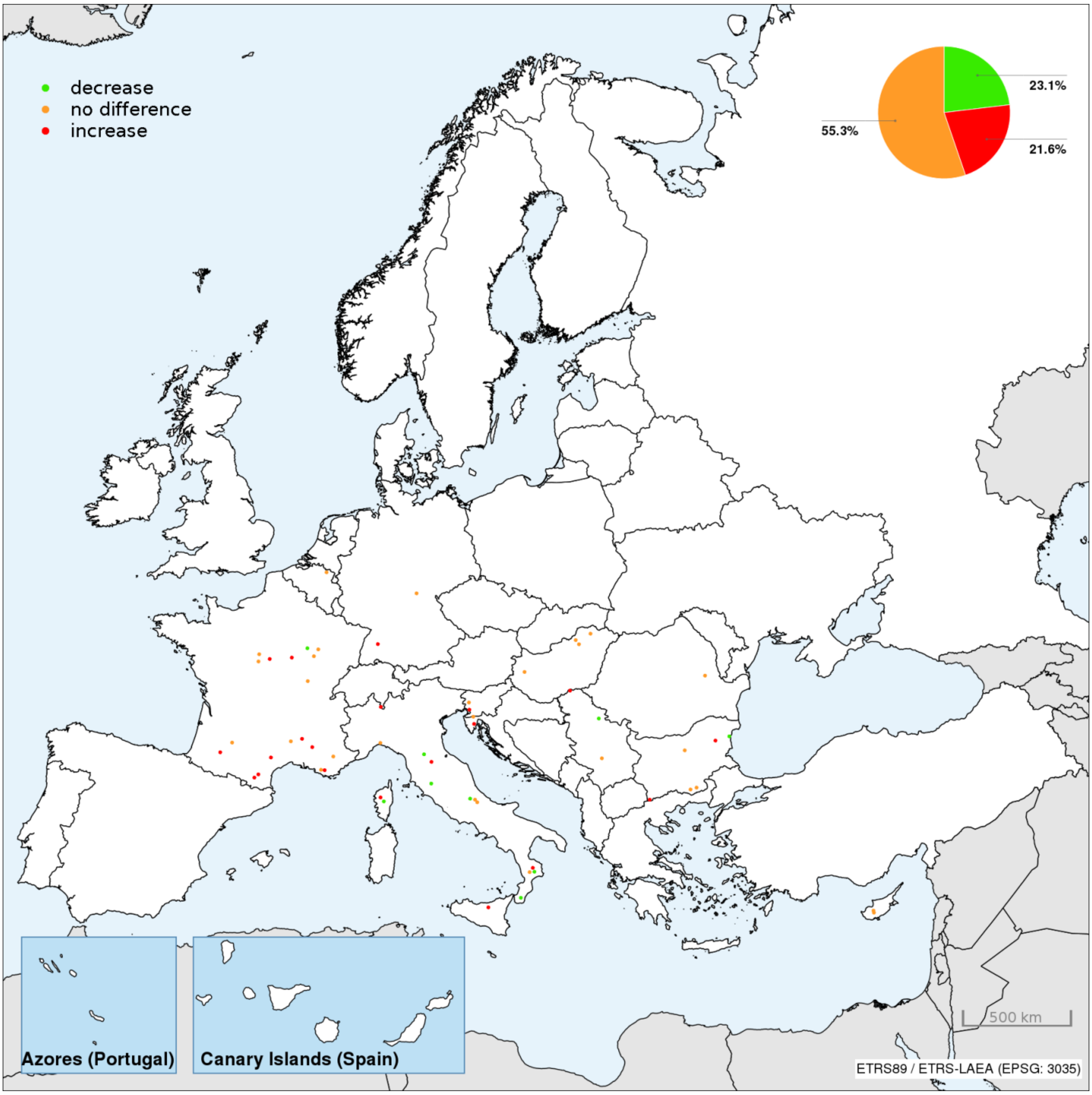
Annex I-4. Trends in mean plot defoliation (Mann-Kendall test) of Scots pine between 2006 and 2015 with a minimum assessment length of 5 years.



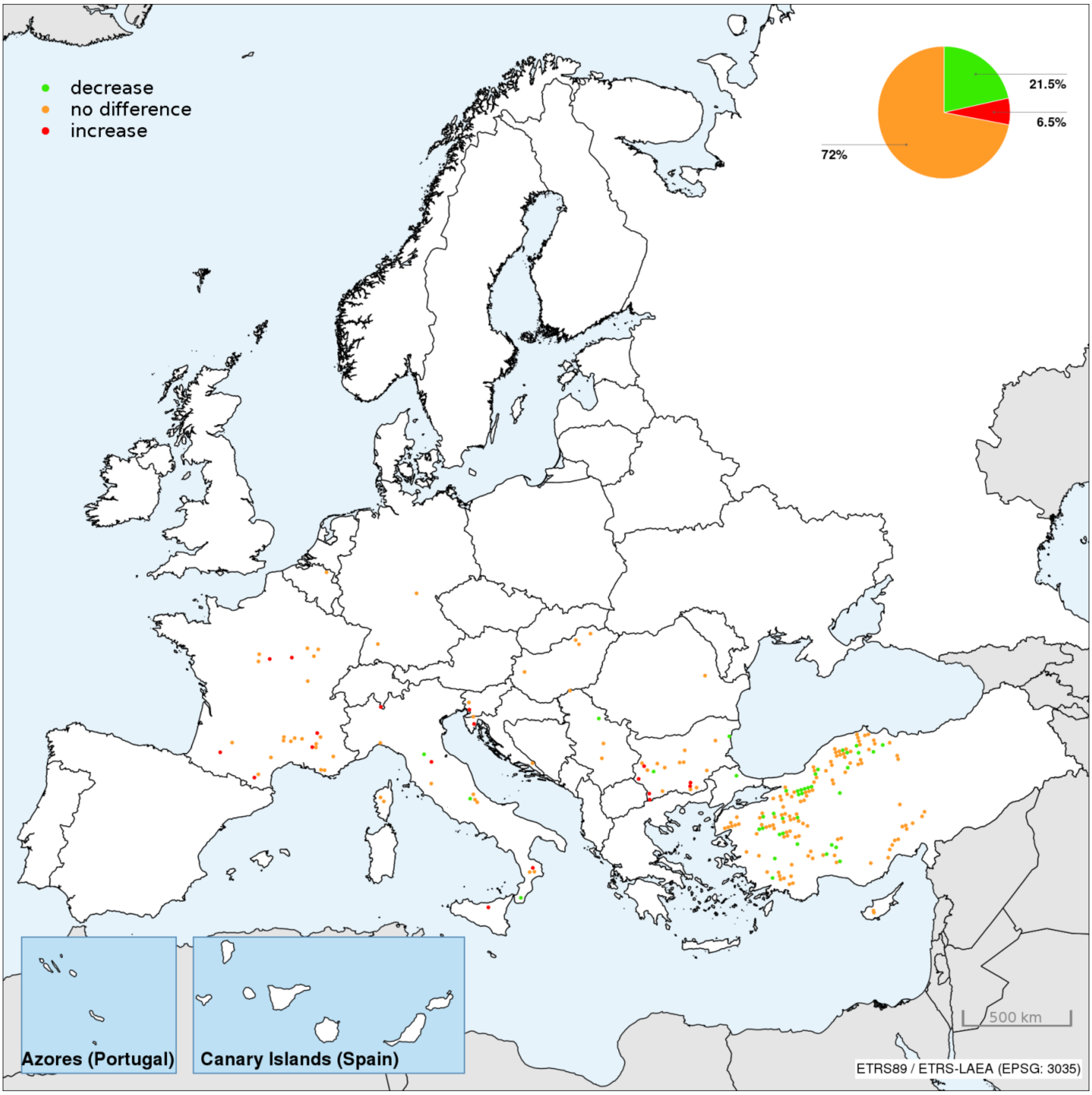
Annex I-5. Trends in mean plot defoliation (Mann-Kendall test) of Norway spruce between 2002 and 2015 with a minimum assessment length of 10 years.



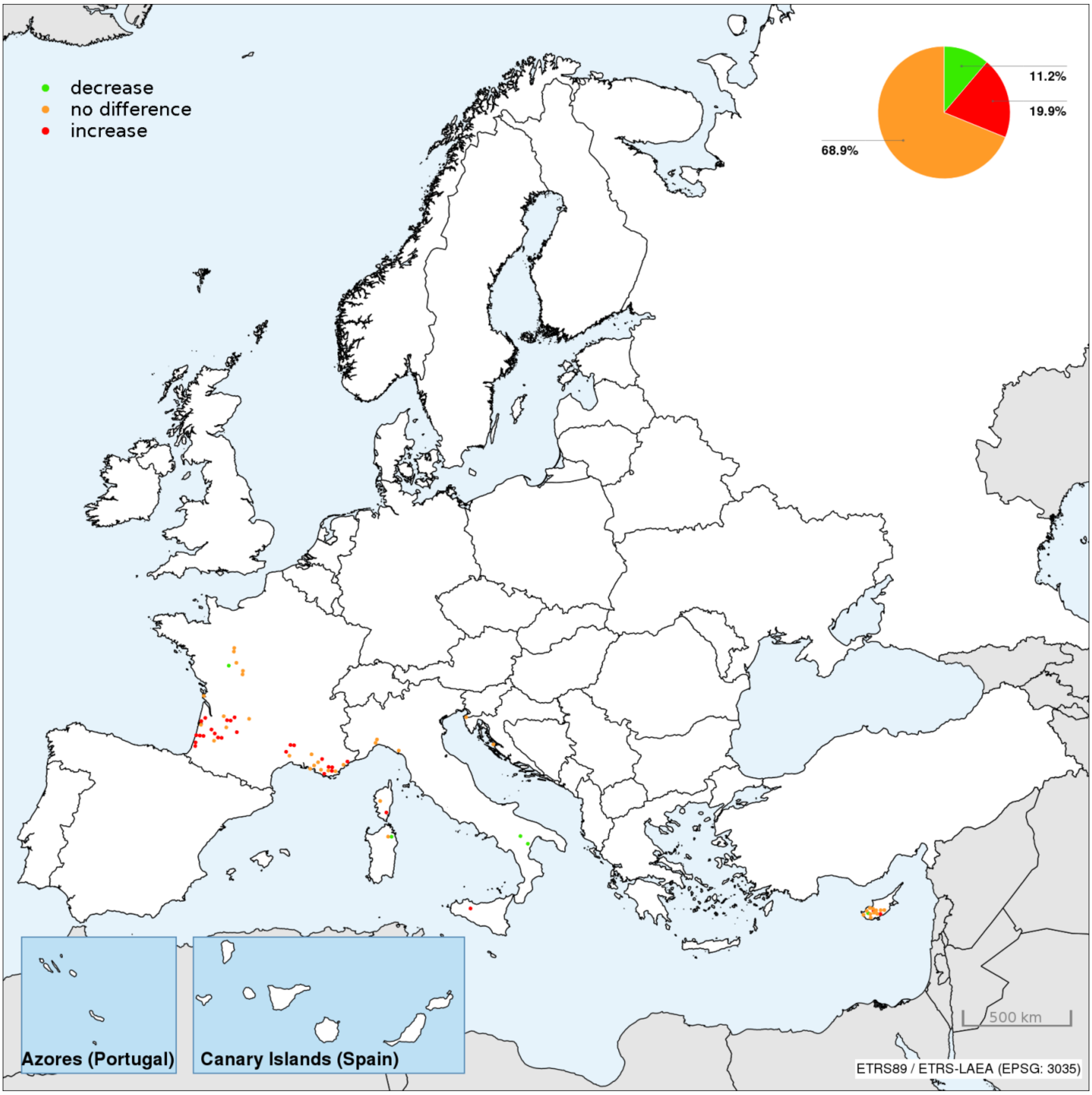
Annex I-6. Trends in mean plot defoliation (Mann-Kendall test) of Norway spruce between 2006 and 2015 with a minimum assessment length of 5 years.



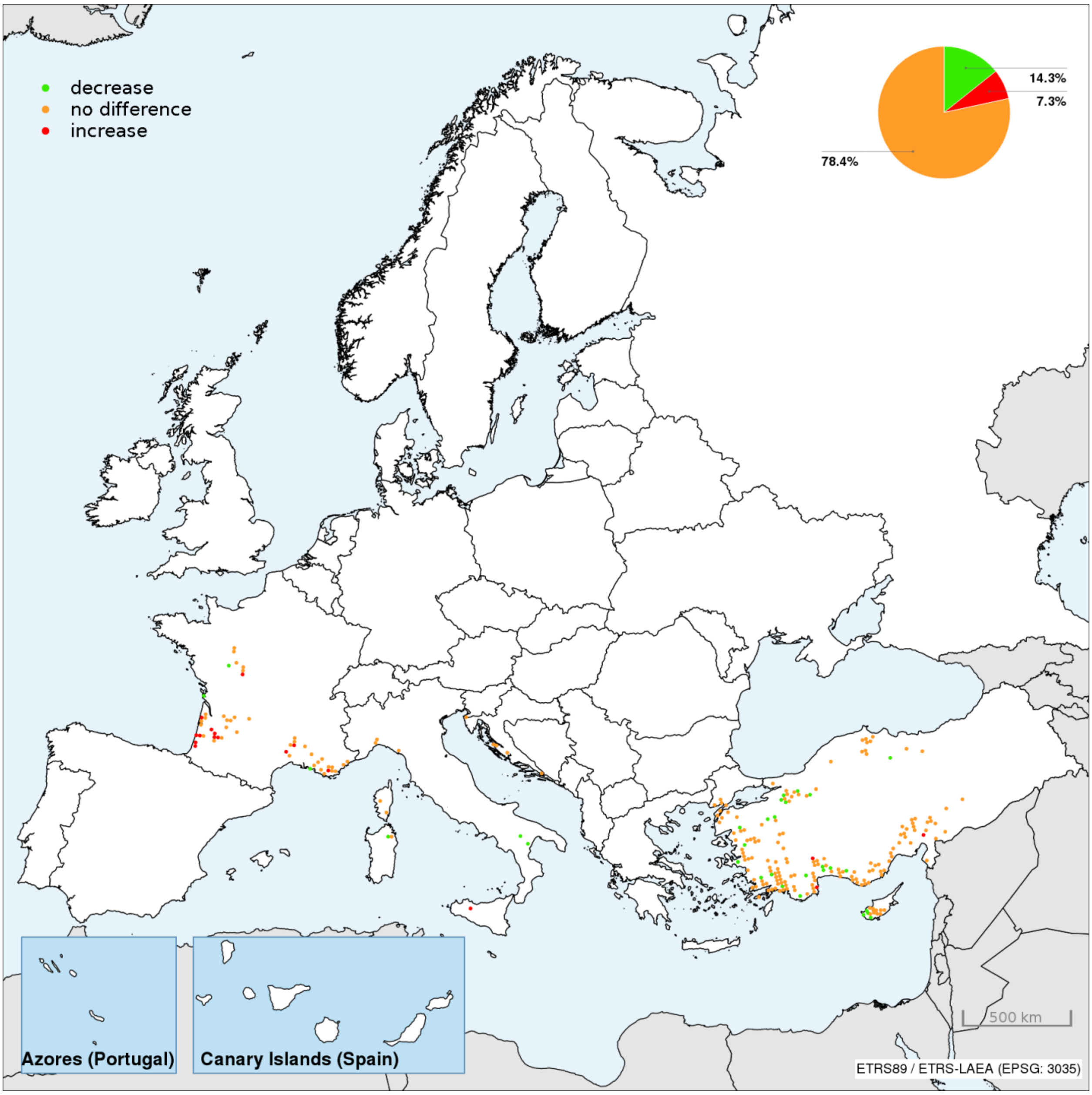
Annex I-7. Trends in mean plot defoliation (Mann-Kendall test) of Austrian pine between 2002 and 2015 with a minimum assessment length of 10 years.



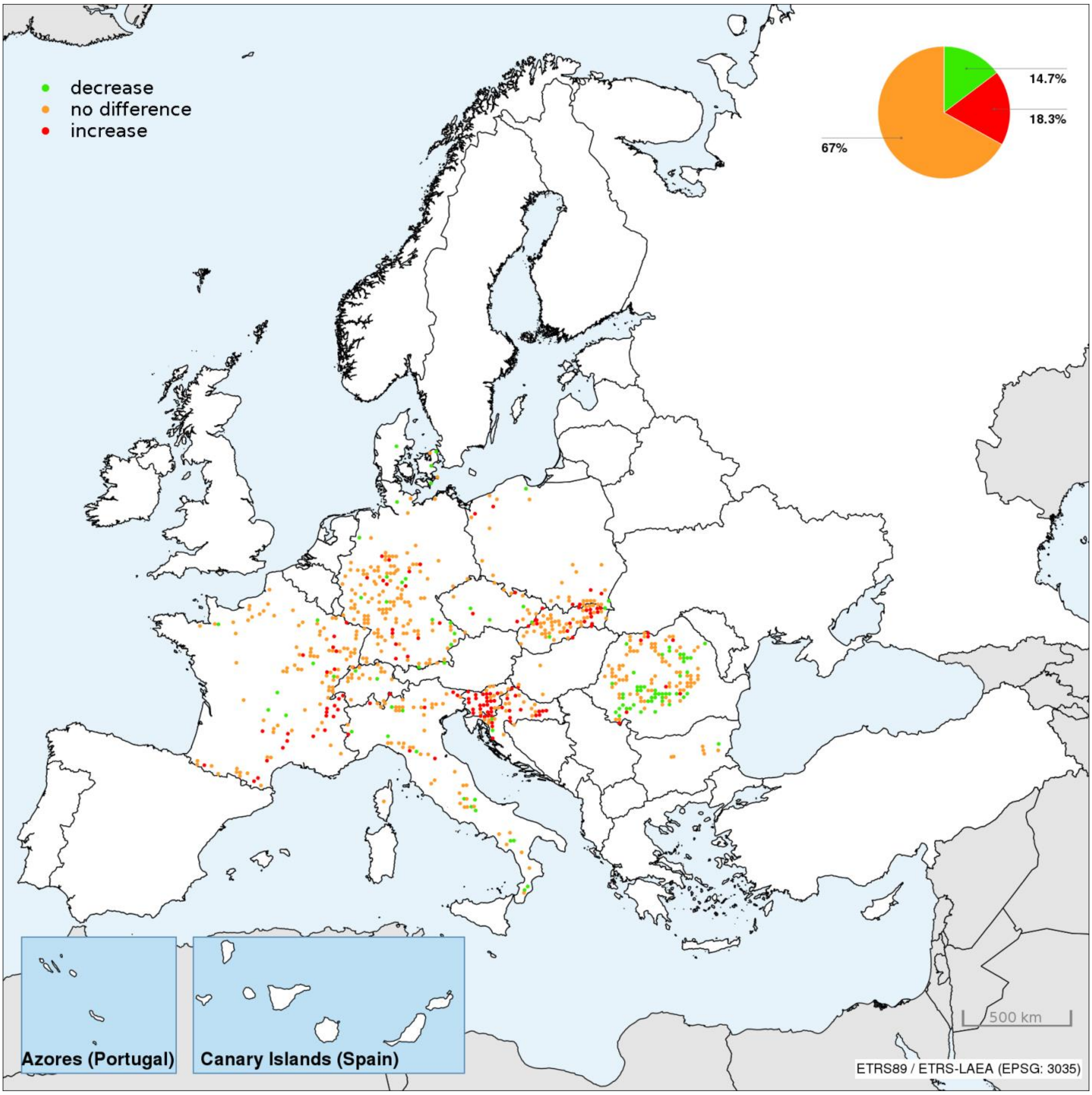
Annex I-8. Trends in mean plot defoliation (Mann-Kendall test) of Austrian pine between 2006 and 2015 with a minimum assessment length of 5 years.



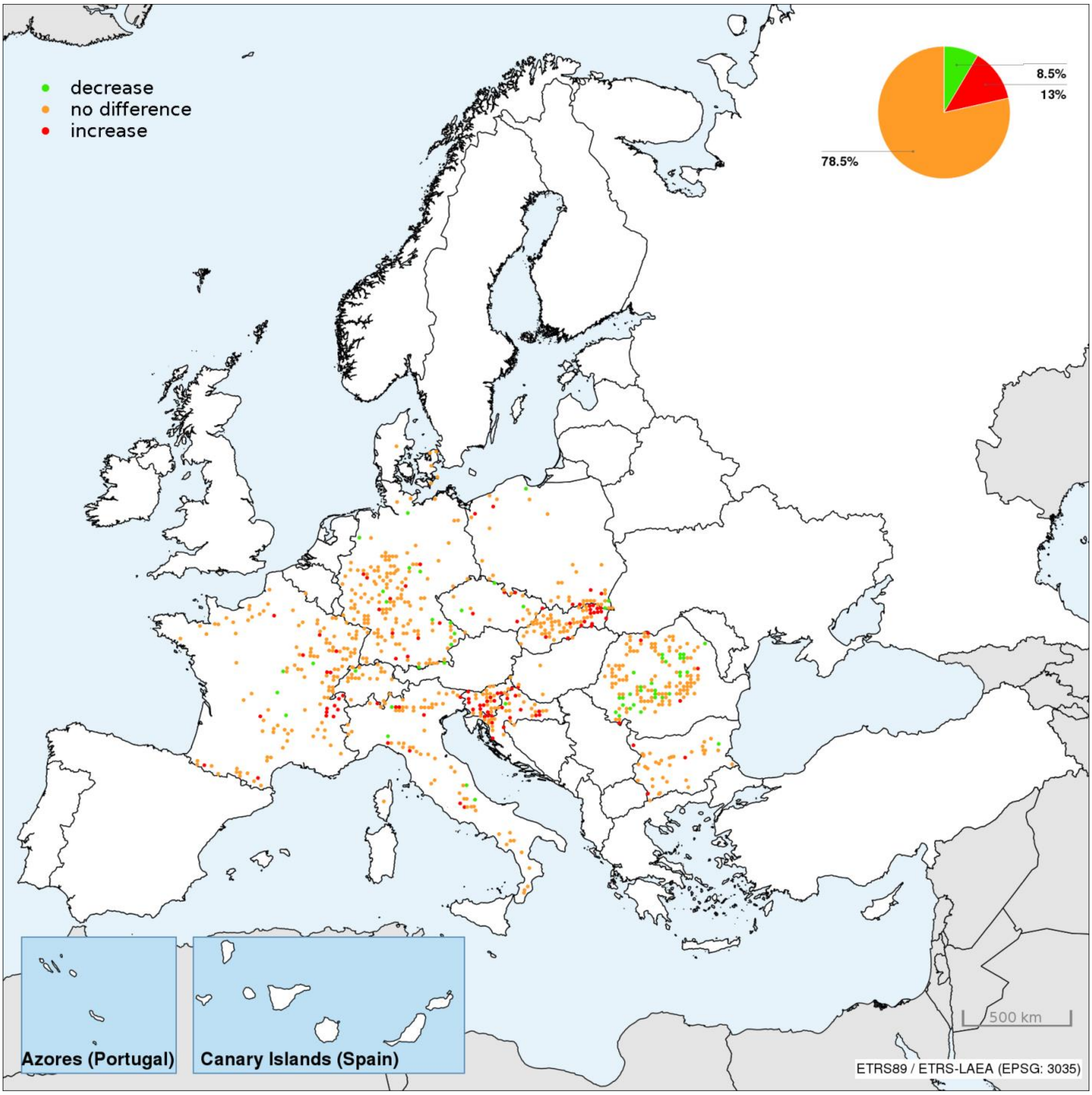
Annex I-9. Trends in mean plot defoliation (Mann-Kendall test) of Mediterranean lowland pines (*Pinus brutia*, *P. halepensis*, *P. pinaster*, *P. pinea*) between 2002 and 2015 with a minimum assessment length of 10 years.



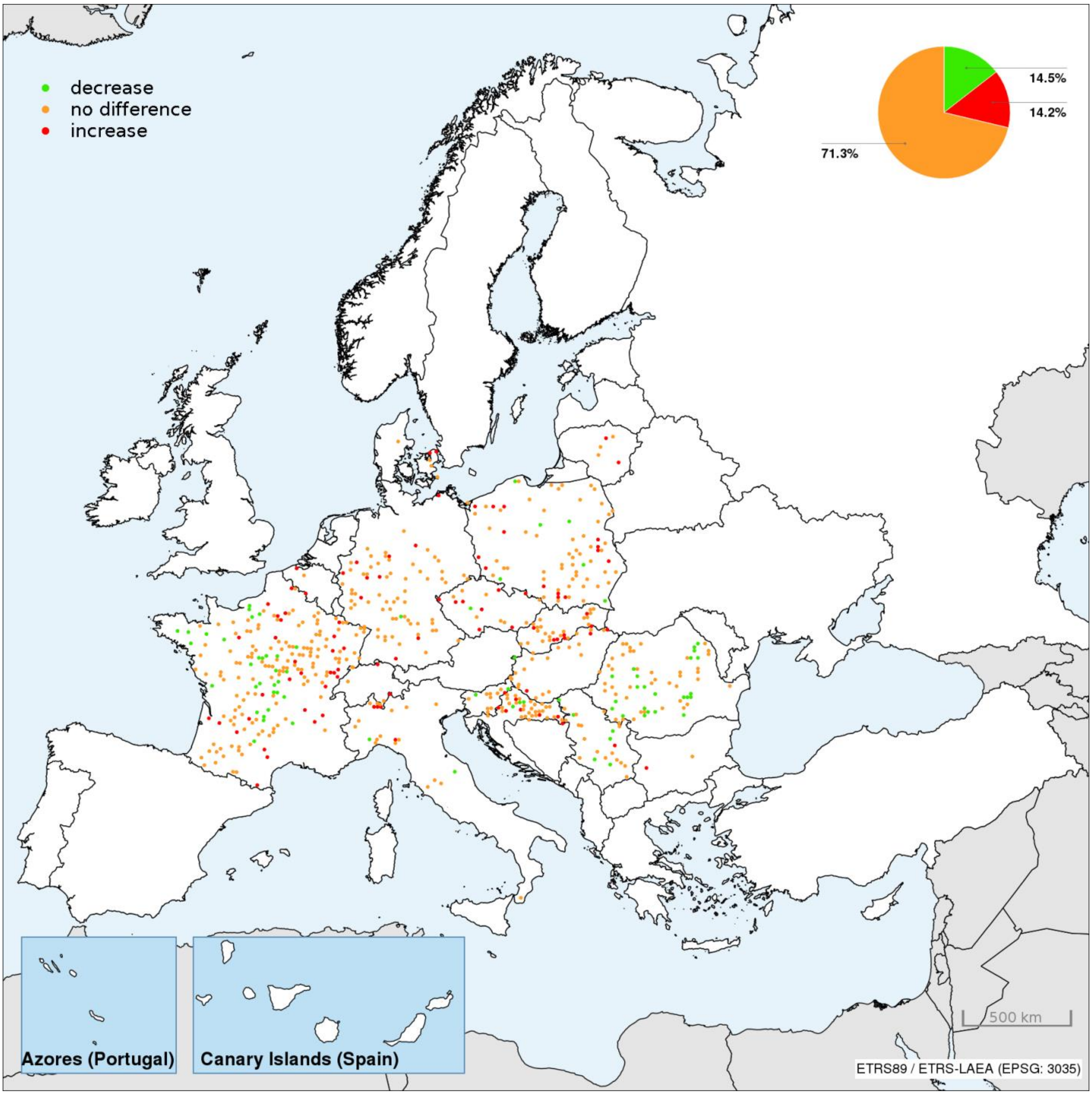
Annex I-10. Trends in mean plot defoliation (Mann-Kendall test) of Mediterranean lowland pines (*Pinus brutia*, *P. halepensis*, *P. pinaster*, *P. pinea*) between 2006 and 2015 with a minimum assessment length of 5 years.



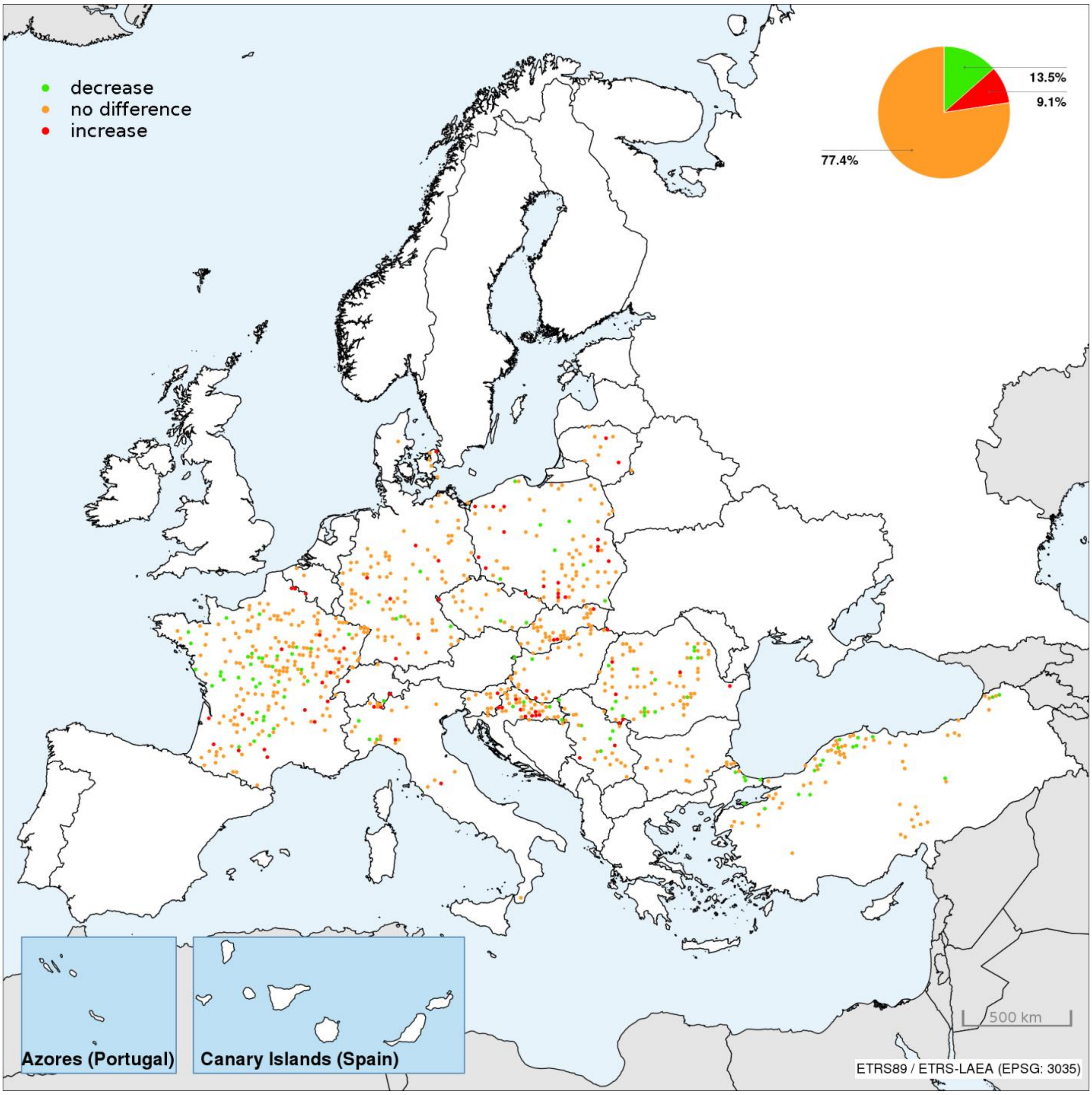
Annex I-11. Trends in mean plot defoliation (Mann-Kendall test) of common beech between 2002 and 2015 with a minimum assessment length of 10 years.



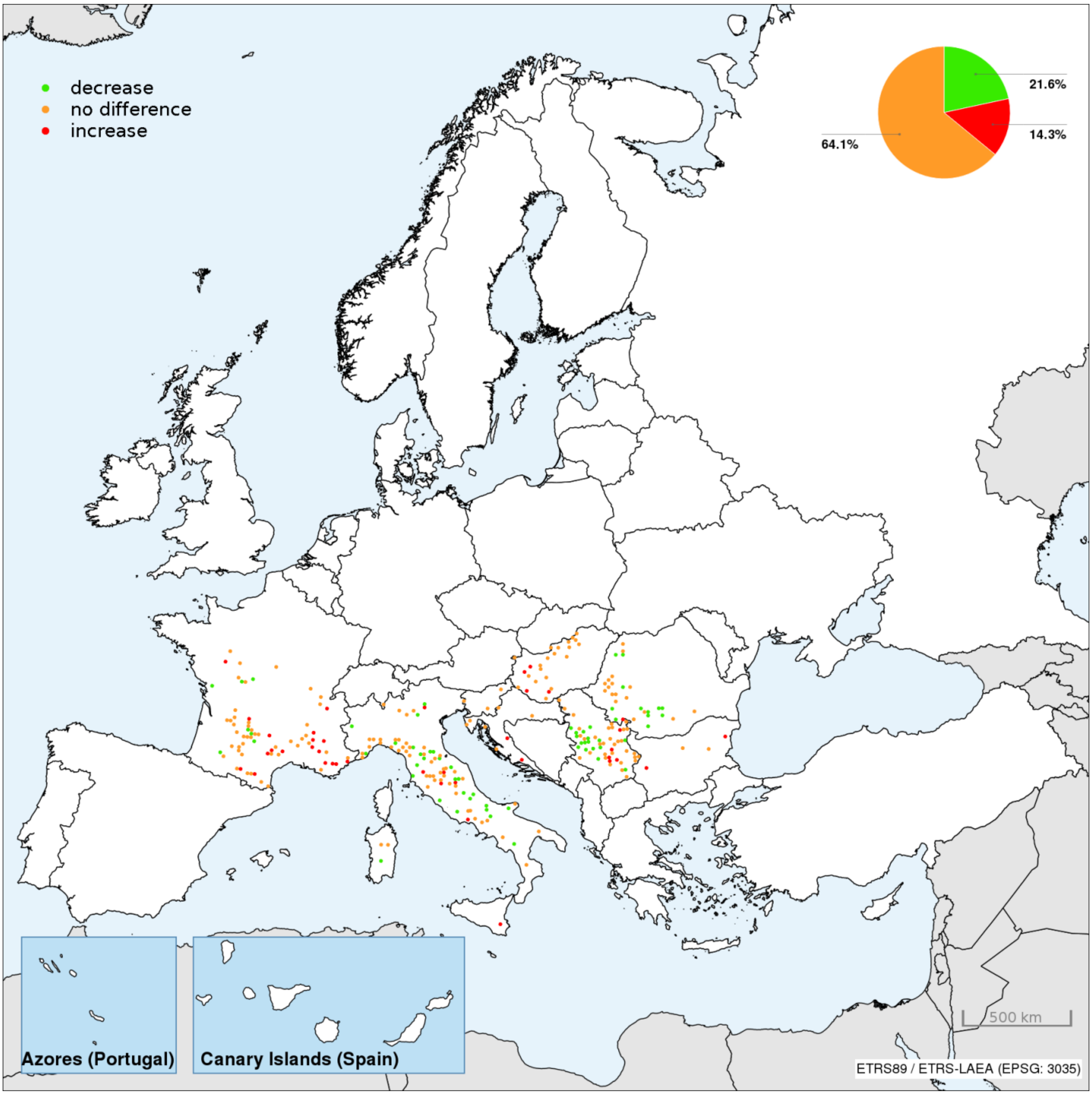
Annex I-12. Trends in mean plot defoliation (Mann-Kendall test) of common beech between 2006 and 2015 with a minimum assessment length of 5 years.



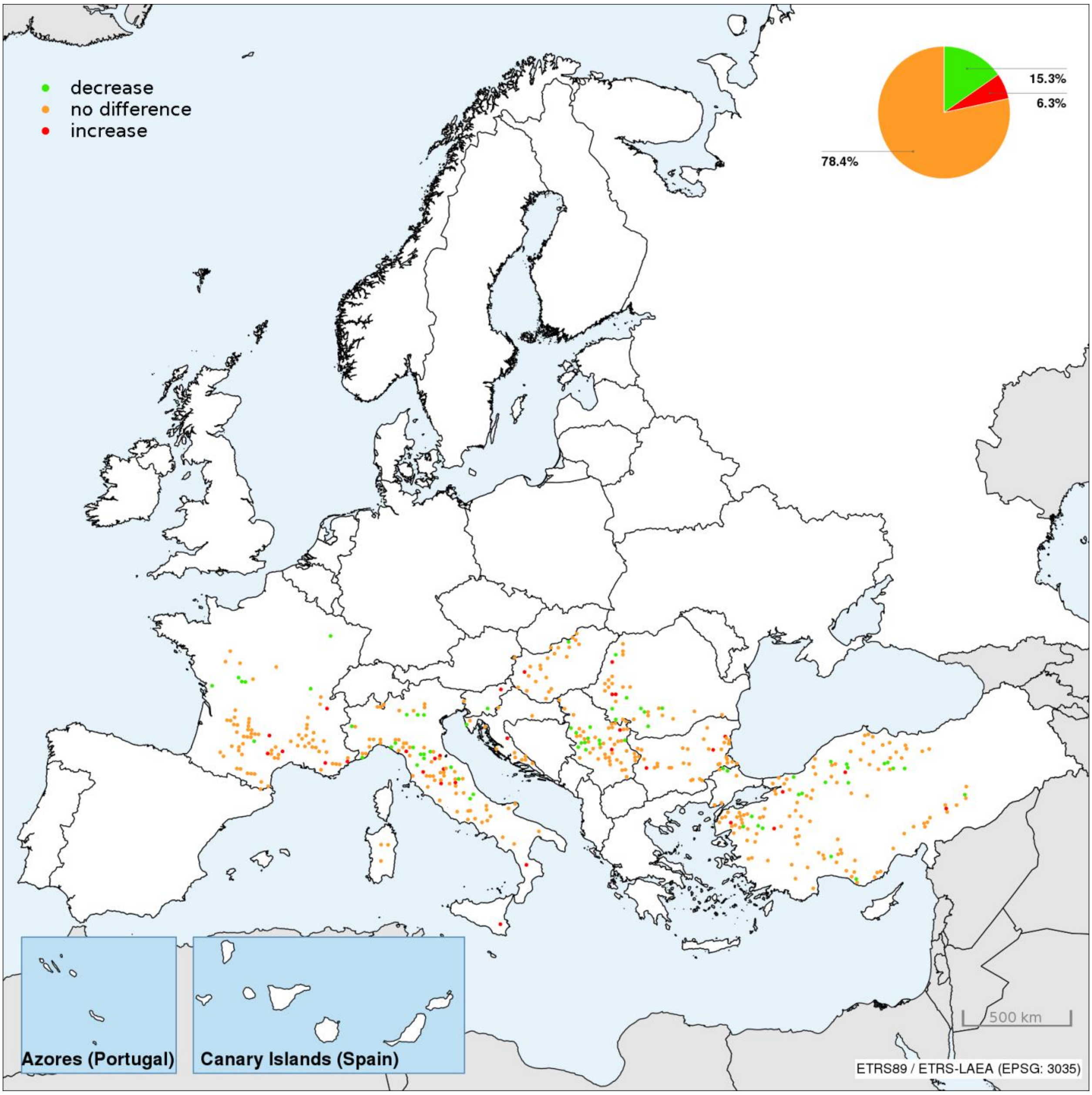
Annex I-13. Trends in mean plot defoliation (Mann-Kendall test) of deciduous temperate oaks (*Quercus robur* and *Q. petraea*) between 2002 and 2015 with a minimum assessment length of 10 years.



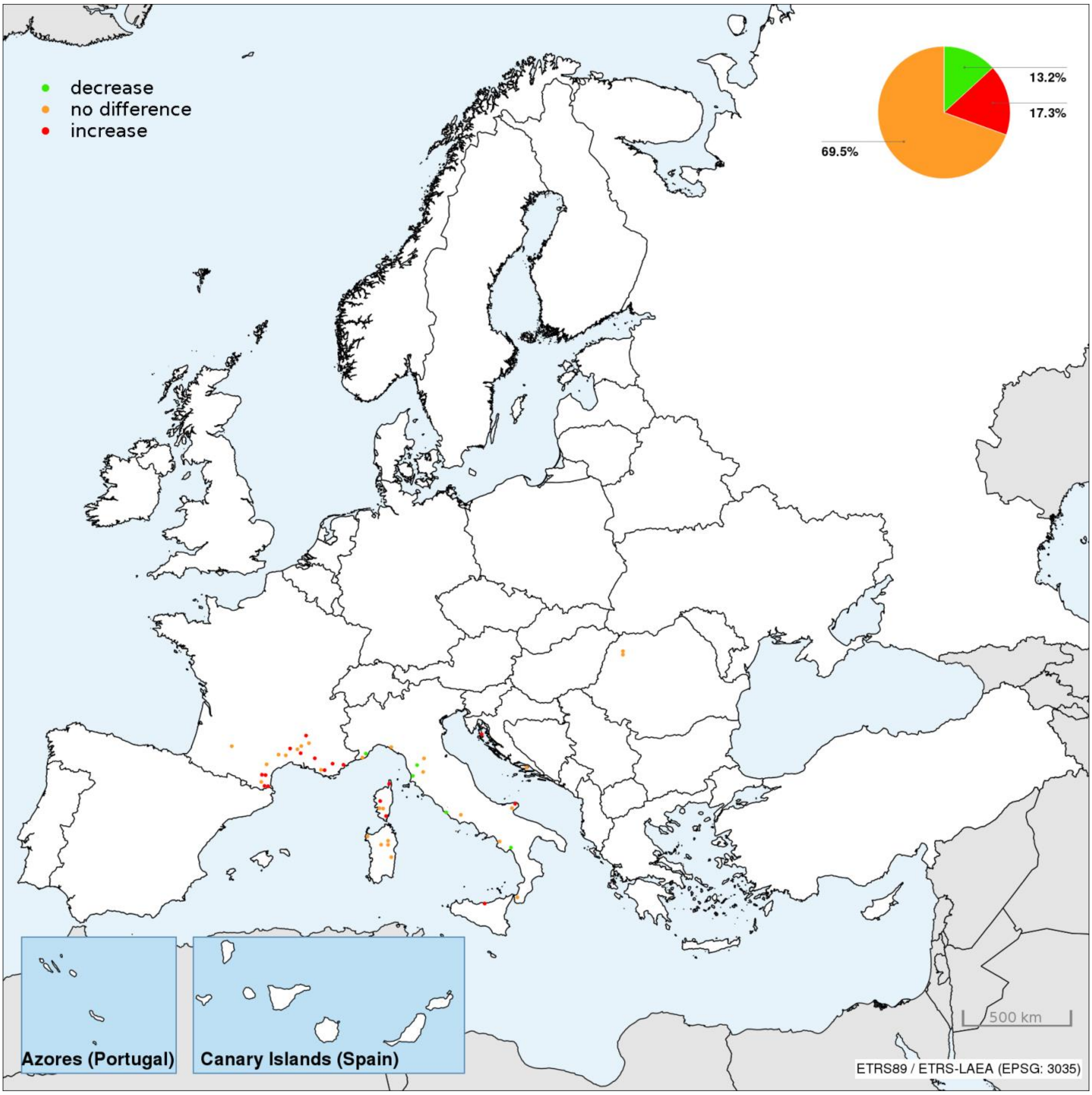
Annex I-14. Trends in mean plot defoliation (Mann-Kendall test) of deciduous temperate oaks (*Quercus robur* and *Q. petraea*) between 2006 and 2015 with a minimum assessment length of 5 years.



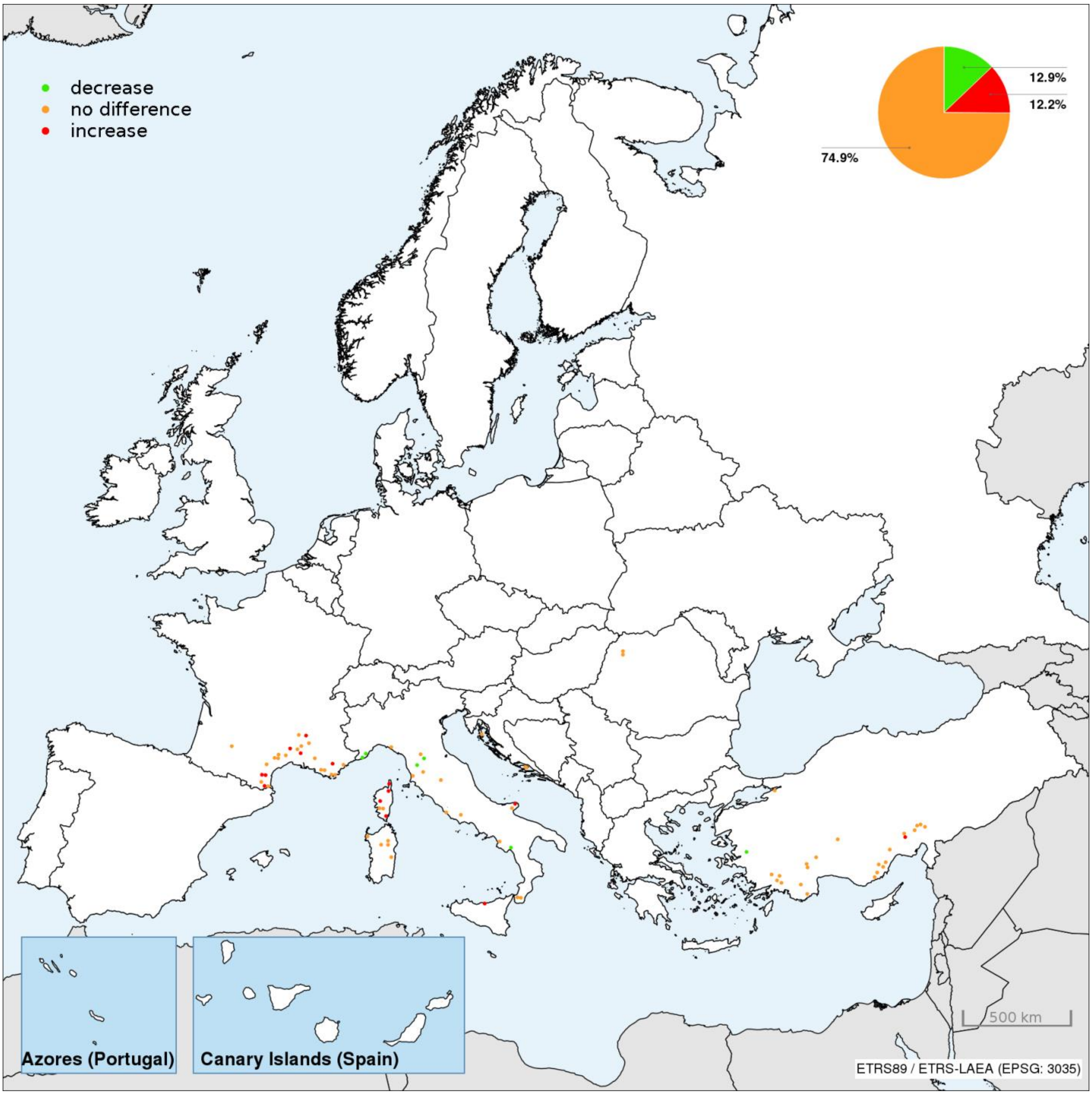
Annex I-15. Trends in mean plot defoliation (Mann-Kendall test) of deciduous (sub-) Mediterranean oaks (*Quercus cerris*, *Q. frainetto*, *Q. pubescens*, *Q. pyrenaica*) between 2002 and 2015 with a minimum assessment length of 10 years.



Annex I-16. Trends in mean plot defoliation (Mann-Kendall test) of deciduous (sub-) Mediterranean oaks (*Quercus cerris*, *Q. frainetto*, *Q. pubescens*, *Q. pyrenaica*) between 2006 and 2015 with a minimum assessment length of 5 years.



Annex I-17. Trends in mean plot defoliation (Mann-Kendall test) of evergreen oaks (*Quercus coccifera*, *Q ilex, Q. rotundifolia*, *Q. suber*) between 2002 and 2015 with a minimum assessment length of 10 years.



Annex I-18. Trends in mean plot defoliation (Mann-Kendall test) of evergreen oaks (*Quercus coccifera*, *Q. ilex*, *Q. rotundifolia*, *Q. suber*) between 2006 and 2015 with a minimum assessment length of 5 years.

ANNEX II
RESULTS OF THE NATIONAL CROWN CONDITION SURVEYS

Annex II-1 | Information on the monitoring design in the countries participating in ICP Forests

Participating countries	Total area (1000 ha)	Forest area (1000 ha)	Coniferous forest (1000 ha)	Broadleaf forest (1000 ha)	Area surveyed (1000 ha)	Grid size (km x km)	No. of sample plots	No. of sample trees
Albania	No data available for 2015							
Andorra	46	17	15	2	17	4 x 4	12	289
Austria	No data available for 2015							
Belarus	No data available for 2015							
Belgium-Flanders	1 351	146	N/A	N/A	146	4 x 4	71	1 611
Belgium-Wallonia	1 684	554	224	260	N/A	N/A	45	402
Bulgaria	11 100	4 202	1 261	2 917	4 202	varying	159	5 513
Croatia	5 654	2 061	321	1 740	N/A	16 x 16	95	2 280
Cyprus	925	297	171	0	137	16 x 16	15	361
Czech Republic	7 887	2 666	1 956	710	2 666	N/A	136	5 218
Denmark	4 310	586	289	263	N/A	N/A	379	2 003
Estonia	4 510	2 274	1 139	1 135	2 274	16 x 16	97	2 397
Finland	No data available for 2015							
France	55 150	15 549	3 080	9 769	N/A	16 x 16	567	8 871
Germany	35 721	11 419	5 900	4 728	10 628	16 x 16	424	10 209
Greece	13 196	6 513	1 430	1 930	1 459	16 x 16	47	1 113
Hungary	9 300	1 939	209	1 730	1 939	16 x 16	77	1 841
Ireland	No data available for 2015							
Italy	30 128	8 675	1 735	6 940	N/A	16 x 16	235	4 757
Latvia	6 459	3 162	1 454	1 711	3 162	16 x 16	116	1 732
Lithuania	6 529	2 180	1 150	906	2 056	4x4/16x16	1 060	6 340
Luxembourg	259	91	27	59	86	4 x 4	51	1 200
FYR of Macedonia	No data available for 2015							
Rep. of Moldova	3 384	N/A	8	367	375	N/A	N/A	14 239
Montenegro	1 381	827	207	620	827	16 x 16	49	1 176
Netherlands	No data available for 2015							
Norway	32 376	12 000	6 800	5 200	12 000	N/A	1 664	9 153
Poland	31 268	9 177	6 350	2 827	9 177	8 x 8	2 018	40 360
Portugal	No data available for 2015							
Romania	23 839	6 233	1 873	4 360	6 233	16 x 16	242	5 808
Russian Fed.	No data available for 2015							
Serbia	8 836	2 360	179	2 181	1 868	16x16/4x4	130	2 910
Slovakia	4 904	2 014	768	1 246	2 014	16 x 16	106	3 630
Slovenia	2 027	1 248	N/A	N/A	1 248	16 x 16	44	1 051
Spain	No data available in 2015							
Sweden	47 496	28 064	14 762	1 265	17 357	varying	4 097	8 032
Switzerland	4 129	1 279	778	501	N/A	N/A	47	1 051
Turkey	77 846	21 537	13 158	8 379	9 057	16 x 16	591	13 665
Ukraine	60 350	9 400	2 756	3 285	5 790	16 x 16	1 341	31 978
United Kingdom	No data available for 2015							
TOTAL	492 045	156 470	66 127	65 031			13915	189 190

Annex II-2 | Tree defoliation of all species in 2015

Participating countries	Area surveyed (1000 ha)	No. of sample trees	0 none (%)	1 slight (%)	2 moderate (%)	3+4 severe and dead (%)	2+3+4 moderate to dead (%)
Albania	No data available for 2015						
Andorra	17	289	77.9	17.6	3.8	0.7	4.5
Austria	No data available for 2015						
Belarus	No data available for 2015						
Belgium-Flanders	146	1 611	7.5	71.0	18.4	3.1	21.5
Belgium-Wallonia	N/A	402	11.7	42.7	40.4	5.7	46.1
Bulgaria	4 202	5 513	33.7	40.1	17.6	8.6	26.2
Croatia	N/A	2 280	32.0	38.3	24.6	5.2	29.7
Cyprus	137	361	29.7	57.8	11.4	1.1	12.5
Czech Republic	2 666	5 281	15.8	32.2	48.9	3.1	52.0
Denmark	N/A	2 003	66.9	24.4	7.3	1.4	8.7
Estonia	2 274	2 397	50.8	42.5	5.5	1.2	6.7
Finland	No data available for 2015						
France	N/A	8 871	21.0	35.0	39.8	3.6	43.4
Germany	10 628	10 209	33.2	43.1	22.1	1.7	23.8
Greece	1 459	1 841	48.1	31.7	15.8	4.4	20.2
Hungary	1 939		50.5	25.5	16.2	7.8	24.0
Ireland	No data available for 2015						
Italy	N/A	4 757	28.8	41.4	24.6	5.2	29.8
Latvia	3 162	1 732	9.1	86.5	4.3	0.1	4.4
Lithuania	2 056	6 340	13.4	62.8	22.0	1.8	23.8
Luxembourg	86	1200	29.9	37.4	30.3	2.3	32.6
FYR of Macedonia	No data available for 2015						
Rep. of Moldova	375	14 239	33.6	40.3	24.2	1.9	26.1
Montenegro	827	1 176	31.9	42.7	21.1	4.3	25.4
Netherlands	No data available for 2015						
Norway	12 000	9 153	45.1	38.4	14.1	2.4	16.5
Poland	9 177	40 360	12.0	71.4	15.4	1.3	16.7
Portugal	No data available for 2015						
Romania	6 233	5 808	54.2	32.7	11.3	1.8	13.1
Russian Federation	No data available for 2015						
Serbia	1 868	2 910	74.4	14.9	6.6	4.1	10.7
Slovakia	2 014	3 630	15.0	50.5	33.6	0.9	34.5
Slovenia	1 248	1 051	17.5	44.7	30.8	6.9	37.8
Spain	No data available for 2015						
Sweden	17 357	8 032	47.4	32.8	17.3	2.5	19.8
Switzerland	N/A	1 051	22.6	52.7	13.2	11.6	24.8
Turkey	9 057	13 665	44.1	44.7	8.1	1.3	9.5
Ukraine	5 790	31 978	62.5	30.4	6.6	0.5	7.1
United Kingdom	No data available for 2015						

Cyprus, Norway, Sweden: only conifers assessed.

Note that some differences in the level of defoliation between participating countries 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-3 | Tree defoliation of conifers in 2015

Participating countries	Coniferous Forest (1000 ha)	No. of sample trees	0 None (%)	1 Slight (%)	2 Moderate (%)	3+4 severe and dead (%)	2+3+4 moderate to dead (%)
Albania	No data available for 2015						
Andorra	15	283	77.7	18.0	3.9	0.4	4.3
Austria	No data available for 2015						
Belarus	No data available for 2015						
Belgium-Flanders	N/A	721	5.3	74.9	19.3	0.5	19.8
Belgium-Wallonia	224	194	7.0	36.0	57.0	1.0	58.0
Bulgaria	1 261	2 386	21.0	38.9	30.5	9.6	40.1
Croatia	321	327	19.9	24.2	45.3	10.7	56.0
Cyprus	171	360	29.7	57.8	11.4	1.1	12.5
Czech Republic	1 956	3 995	13.8	28.4	54.4	3.4	57.8
Denmark	289	1 083	71.3	21.3	6.4	1.0	7.4
Estonia	1 139	2 048	49.7	43.8	5.2	1.3	6.5
Finland	No data available for 2015						
France	3 080	3 515	30.0	32.0	35.0	3.0	38.0
Germany	5 900	6 157	36.2	43.6	18.8	1.4	20.3
Greece	1 430	625	45.0	27.8	21.9	5.3	27.2
Hungary	209		33.3	20.2	27.8	18.7	46.5
Ireland	No data available for 2015						
Italy	1 735	1 184	38.5	38.9	19.3	3.3	22.6
Latvia	1 454	1 333	8.6	87.1	4.3	0.1	4.4
Lithuania	1 150	3 795	11.1	63.9	23.9	1.1	25.0
Luxembourg	27	426	55.4	25.7	17.0	1.7	18.7
FYR of Macedonia	No data available for 2015						
Rep. of Moldova	Only broadleaves assessed						
Montenegro	207	288	36.8	37.2	16.0	10.1	26.1
Netherlands	No data available for 2015						
Norway	6 800	9 153	45.1	38.4	14.1	2.4	16.5
Poland	6 350	26 057	9.6	74.7	14.6	1.2	15.7
Portugal	No data available for 2015						
Romania	1 873	1 092	65.2	8.4	6.9	1.1	8.0
Russian Fed.	No data available for 2015						
Serbia	179	338	75.4	10.1	8.0	6.5	14.5
Slovakia	768	1 467	6.3	44.3	47.7	1.7	49.4
Slovenia	N/A	388	18.0	41.0	33.3	7.7	41.0
Spain	No data available in 2015						
Sweden	14 762	8032	47.4	32.8	17.3	2.5	19.8
Switzerland	778	748	23.8	52.3	15.7	8.3	24.0
Turkey	13 158	8 457	42.7	48.7	7.8	0.9	8.6
Ukraine	2 756	13 816	64.6	27.5	7.5	0.4	7.9
United Kingdom	No data available for 2015						

Note that some differences in the level of defoliation between participating countries 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-4 | Tree defoliation of broadleaves in 2015

Participating countries	Broadleaf forest (1000 ha)	No. of sample trees	0 None (%)	1 Slight (%)	2 Moderate (%)	3+4 severe and dead (%)	2+3+4 moderate to dead (%)
Albania	No data available for 2015						
Andorra	2	5	83.3	0.0	0.0	16.7	16.7
Austria	No data available for 2015						
Belarus	No data available for 2015						
Belgium-Flanders	N/A	890	9.3	67.9	17.6	5.2	22.8
Belgium-Wallonia	260	208	16.0	49.0	25.0	10.0	35.0
Bulgaria	2 917	3 127	43.4	41.0	7.8	7.9	15.6
Croatia	1 740	1 953	34.0	40.7	21.1	4.4	25.3
Cyprus	Only conifers assessed						
Czech Republic	710	1 223	22.7	44.6	30.7	2.0	32.7
Denmark	263	908	60.1	29.1	8.9	1.9	10.8
Estonia	1 135	349	57.1	35.0	7.2	0.8	8.0
Finland	No data available for 2015						
France	9 769	5 266	15.0	37.0	43.0	4.0	47.0
Germany	4 728	4 052	28.7	42.2	26.9	2.1	29.0
Greece	1 930	488	52.1	36.6	8.0	3.3	11.3
Hungary	1 730	1 643	52.5	26.1	14.8	6.6	21.4
Ireland	No data available for 2015						
Italy	6 940	3 573	25.6	42.3	26.3	5.8	32.1
Latvia	1 711	399	11.1	84.7	4.2	0.0	4.2
Lithuania	906	2 545	17.0	61.1	19.1	2.8	21.9
Luxembourg	59	774	15.9	43.8	37.6	2.7	40.3
FYR of Macedonia	No data available for 2015						
Rep. of Moldova	367	14 201	33.5	40.4	24.2	1.9	26.1
Montenegro	620	888	30.3	44.5	22.8	2.5	25.2
Netherlands	No data available for 2015						
Norway	Only conifers assessed						
Poland	2 827	14 303	16.2	65.5	16.8	1.6	18.4
Portugal	No data available for 2015						
Romania	4 360	4 716	51.7	34.4	12.0	1.9	13.9
Russian Fed.	No data available for 2015						
Serbia	2 181	2 572	74.3	15.6	6.4	3.7	10.1
Slovakia	1 246	2 163	20.9	54.8	23.9	0.4	24.3
Slovenia	N/A	663	17.2	46.9	29.4	6.5	35.9
Spain	No data available for 2015						
Sweden	Only conifers assessed						
Switzerland	501	303	20.0	53.6	8.0	18.4	26.4
Turkey	8 379	5 208	46.3	43.0	8.8	2.0	10.8
Ukraine	3 285	18 162	60.9	32.8	5.8	0.5	6.3
United Kingdom	No data available for 2015						

Note that some differences in the level of defoliation between participating countries 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-5 | Percentage of moderately to severely defoliated trees between 2005 and 2015 – All species

Participating countries	All species Defoliation classes 2–4											Change % points
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2014/15
Albania		11.1							21.0			**N/A**
Andorra		23.0	47.2	15.3	6.8	15.3	8.3	5.6	3.4	5.3	4.5	**-0.8**
Austria	14.8	15.0				14.2						**N/A**
Belarus	9.0	7.9	8.1	8.0	8.4	7.4	6.1					**N/A**
Belgium	19.9	17.9	16.4	14.5	20.2	22.1	23.5	28.2	27.6	27.5	26.4	**-1.1**
Bulgaria	35.0	37.4	29.7	31.9	21.1	23.8	21.6	32.3	33.5	26.0	26.2	**+0.2**
Croatia	27.1	24.9	25.1	23.9	26.3	27.9	25.2	28.5	29.1	31.5	29.7	**-1.8**
Cyprus	10.8	20.8	16.7	47.0	36.2	19.2	16.4	10.6	8.9	13.3	12.5	**-0.8**
Czech Republic	57.1	56.2	57.1	56.7	56.8	54.2	52.7	50.3	51.7		52.0	**N/A**
Denmark	9.4	7.6	6.1	9.1	5.5	9.3	10.0	7.3	4.9	7.0	8.7	**+1.7**
Estonia	5.4	6.2	6.8	9.0	7.2	8.1	8.1	7.8	8.0	6.7	6.7	**0.0**
Finland	8.8	9.7	10.5	10.2	9.1	10.5	10.6	14.3				**N/A**
France	34.2	35.6	35.4	32.4	33.5	34.6	39.9	41.4	40.1	42.8	43.4	**+0.6**
Germany	28.5	27.9	24.8	25.7	26.5	23.2	28.0	24.6	22.7	26.2	23.8	**-2.4**
Greece	16.3				24.3	23.8				24.8	20.2	**-4.6**
Hungary	21.0	19.2	20.7		18.4	21.8	18.9	20.2	22.4		24.0	**N/A**
Ireland	16.2	7.4	6.0	10.0	12.5	17.5		1.0				**N/A**
Italy	32.9	30.5	35.7	32.8	35.8	29.8	31.3	35.7	33.7	30.8	29.8	**-1.0**
Latvia	13.1	13.4	15.0	15.3	13.8	13.4	14.0	9.2	6.4	5.1	4.4	**-0.7**
Lithuania	11.0	12.0	12.3	19.6	17.7	21.3	15.4	24.5	19.7	21.7	23.8	**+2.1**
Luxembourg									33.2		32.6	**N/A**
FYR of Macedonia			23.0									**N/A**
Rep. of Moldova	26.5	27.6	32.5	33.6	25.2	22.5	18.4	25.6		19.9	26.1	**+6.2**
Montenegro									22.7		25.4	**N/A**
Netherlands	30.2	19.5			18.2	21.6						**N/A**
Norway	21.6	23.3	26.2	22.7	21.0	18.9	20.9	18.8	17.7	15.9	16.5	**+0.6**
Poland	30.7	20.1	20.2	18.0	17.7	20.7	24.0	23.4	18.8	18.9	16.7	**-2.2**
Portugal	24.3											**N/A**
Romania	8.1	8.6	23.2		18.9	17.8	13.9	13.9	13.6	13.5	13.1	**-0.4**
Russian Fed.					6.2	4.4	8.3					**N/A**
Serbia	16.4	11.3	15.4	11.5	10.3	10.8	7.6	10.3	14.7	12.4	10.7	**-1.7**
Slovakia	22.9	28.1	25.6	29.3	32.1	38.6	34.7	37.9	43.4		34.5	**N/A**
Slovenia	30.6	29.4	35.8	36.9	35.5	31.8	31.4	29.1	30.9	38.3	37.8	**-0.5**
Spain	21.3	21.5	17.6	15.6	17.7	14.6	11.8	17.5	16.6	14.9		**N/A**
Sweden	18.4	19.4	17.9	17.3	15.1	19.2	18.9	15.9	19.9		19.8	**N/A**
Switzerland	28.1	22.6	22.4	19.0	18.3	22.2	30.9	31.3	26.0	30.6	24.8	**-5.8**
Turkey				24.6	18.7	16.8	13.6	12.4	10.2	11.0	9.5	**-1.5**
Ukraine	8.7	6.6	7.1	8.2	6.8	5.8	6.8	7.5	7.1	6.0	7.1	**+1.1**
United Kingdom	24.8	25.9	26.0			48.5						**N/A**

Note that some differences in the level of defoliation between participating countries may be at least partly due to differences in standards used. This restriction, however, does not affect the reliability of the trends over time.

Austria: from 2003 on results are based on the 16 x 16 km transnational grid net and must not be compared with previous years. *Poland*, *Belgium-Wallonia*: change of grid net since 2006 and 2010, resp. *Russian Federation:* north-western and Central European parts only. *Ukraine*: change of grid net in 2005. *Hungary, Romania*: comparisons not possible due to changing survey designs. *Norway*: new sampling design since 2013.

Annex II-6 | Percentage of moderately to severely defoliated trees between 2005 and 2015 – Conifers

Participating countries					**Conifers Defoliation classes 2–4**							**Change % points**
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2014/15**
Albania		13.6							21.0			**N/A**
Andorra		23.0	47.2	15.3	6.8	15.3	8.3	5.6	3.1	5.4	4.3	**-1.1**
Austria	15.1	14.5				14.5						**N/A**
Belarus	8.4	7.5	8.1	8.1	8.3	7.7	5.8					**N/A**
Belgium	16.8	15.8	13.9	13.2	13.6	16.2	15.2	20.3	19.7	22.8	27.9	**+5.1**
Bulgaria	45.4	47.6	37.4	45.6	33.0	31.1	33.3	35.1	40.8	34.1	40.1	**+6.0**
Croatia	79.5	71.7	61.1	59.1	66.5	56.9	45.1	54.7	48.3	49.7	56.0	**+6.3**
Cyprus	10.8	20.8	16.7	46.9	36.2	19.2	16.4	10.6	8.9	13.3	12.5	**-0.8**
Czech Republic	62.7	62.3	62.9	62.8	63.1	60.1	58.9	56.9	59.2		57.8	**N/A**
Denmark	5.5	1.7	3.1	9.9	1.0	5.4	5.7	4.6	2.8	5.3	7.4	**+2.1**
Estonia	5.6	6.0	6.7	9.3	7.5	9.0	8.7	6.6	8.5	6.9	6.5	**-0.4**
Finland	9.2	9.6	10.4	10.1	9.9	10.6	11.7	14.6				**N/A**
France	20.8	23.6	24.1	25.1	26.8	27.4	31.9	32.2	33.7	36.6	38.0	**+1.4**
Germany	24.9	22.7	20.2	24.1	20.3	19.2	20.3	19.3	18.1	19.7	20.3	**+0.6**
Greece	15.0				26.3	23.7				26.7	27.2	**+0.5**
Hungary	22.0	20.8	22.3		27.1	35.1	28.7	23.1	23.5		46.5	**N/A**
Ireland	16.2	7.4	6.2	10.0	12.5	17.5		1.0				**N/A**
Italy	22.8	19.5	22.7	24.0	31.6	29.1	32.2	31.8	24.2	24.0	22.6	**-1.4**
Latvia	13.2	15.2	16.2	16.7	14.8	15.0	16.0	7.9	6.9	4.8	4.4	**-0.4**
Lithuania	9.3	9.5	10.2	19.1	17.4	19.8	16.3	26.9	23.1	21.1	25.0	**+3.9**
Luxembourg									17.5	93.3*	18.7	**-74.6***
FYR of Macedonia												**N/A**
Rep. of Moldova	38.0	38.6	34.3			33.3	32.1	44.3		29.4		**N/A**
Montenegro									22.6		26.1	**N/A**
Netherlands	17.9	15.3			14.1	18.9						**N/A**
Norway	19.7	20.2	23.0	19.2	17.9	16.4	17.3	16.1	17.7	15.9	16.5	**+0.6**
Poland	29.6	21.1	20.9	17.5	17.2	20.3	24.2	22.3	17.8	17.2	15.7	**-1.5**
Portugal	17.1											**N/A**
Romania	4.7	5.2	21.8		21.7	16.1	15.9	14.9	13.9	13.7	8.0	**-5.7**
Russian Fed.					7.3	5.1	10.6					**N/A**
Serbia	21.3	12.6	13.3	13.0	12.6	12.0	11.1	11.0	13.0	14.6	14.5	**-0.1**
Slovakia	35.3	42.4	37.5	41.1	42.7	46.8	46.6	43.5	43.3		49.4	**N/A**
Slovenia	33.8	32.1	36.0	40.7	38.8	37.8	33.6	31.3	31.3	38.1	41.0	**+2.9**
Spain	19.4	18.7	15.8	12.9	14.9	13.1	10.4	11.4	12.6	11.4		**N/A**
Sweden	19.6	20.1	17.9	17.3	15.1	19.2	18.9	15.9	19.9	18.8	19.8	**+1.0**
Switzerland	28.2	22.5	20.7	18.7	18.8	20.9	31.5	30.6	23.3	31.7	24.0	**-7.7**
Turkey			8.1	16.2	16.0	14.5	11.6	9.9	6.9	7.2	8.6	**+1.4**
Ukraine	8.1	6.9	7.1	7.1	6.3	5.6	6.8	7.5	7.5	6.8	7.9	**+1.1**
United Kingdom	22.2	23.3	16.1			38.6						**N/A**

** In Luxembourg only 3.5% of the conifers assessed in 2015 were assessed in 2014.*

Note that some differences in the level of defoliation between participating countries may be at least partly due to differences in standards used. This restriction, however, does not affect the reliability of the trends over time.

Austria: from 2003 on results are based on the 16 x 16 km transnational grid net and must not be compared with previous years. *Poland, Belgium-Wallonia*: change of grid net since 2006 and 2010, resp. *Russian Federation:* north-western and Central European parts only. *Ukraine*: change of grid net in 2005. *Hungary, Romania*: comparisons not possible due to changing survey designs. *Norway*: new sampling design since 2013.

Annex II-7 | Percentage of moderately to severely defoliated trees between 2005 and 2015 – Broadleaves

Participating countries	Broadleaves Defoliation classes 2–4											Change % points
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2013/14
Albania		8.5							19.0			**N/A**
Andorra									20.0	20.0	16.7	**-3.3**
Austria	12.9	20.1				10.5						**N/A**
Belarus	10.6	8.9	8.2	7.6	8.7	6.9	6.4					**N/A**
Belgium	21.4	18.8	17.5	15.3	23.4	24.6	26.7	32.9	29.4	31.4	25.1	**-6.3**
Bulgaria	23.1	36.4	21.1	17.8	12.2	18.2	12.8	29.8	28.0	20.0	15.6	**-4.4**
Croatia	19.2	18.2	20.0	19.1	20.7	21.9	21.5	23.7	25.7	28.1	25.3	**-2.8**
Cyprus												**N/A**
Czech Republic	32.0	31.2	33.5	32.2	32.9	32.2	31.2	28.4	25.7		32.7	**N/A**
Denmark	14.4	14.8	10.3	8.0	10.0	12.1	12.8	10.9	7.9	9.0	10.8	**+1.8**
Estonia	3.4	8.6	7.6	3.4	3.5	2.5	3.0	14.9	5.3	5.7	8.0	**+2.3**
Finland	7.2	10.3	10.9	10.6	4.7	9.2	6.0	12.8				**N/A**
France	41.3	42.0	41.6	36.5	37.1	38.7	44.3	45.9	43.6	46.1	47.0	**+0.9**
Germany	35.8	37.2	32.8	28.4	36.1	29.4	38.0	32.5	29.8	36.1	29.0	**-7.1**
Greece	17.9				5.2	23.9				16.7	11.3	**-5.4**
Hungary	20.9	19.0	20.6		17.1	19.7	17.3	19.9	22.3		21.4	**N/A**
Ireland												**N/A**
Italy	36.5	35.2	40.4	35.8	36.8	30.1	32.7	37.2	37.1	33.4	32.1	**-1.3**
Latvia	12.9	8.5	11.8	11.5	11.6	9.4	8.8	12.9	4.4	6.1	4.2	**-1.9**
Lithuania	15.4	16.6	17.7	20.3	18.4	23.7	13.8	21.0	14.7	22.5	21.9	**-0.6**
Luxembourg									42.4	*34.6	40.3	***+5.7**
FYR of Macedonia												**N/A**
Rep. of Moldova	26.4	27.6	32.5	33.6	25.2	22.4	18.4	25.6		19.9	26.1	**+6.2**
Montenegro									22.8		25.2	**N/A**
Netherlands	53.1	26.2			25.6	26.6						**N/A**
Norway	27.6	33.2	36.3	33.8	31.0	26.8	32.3	27.3				**N/A**
Poland	34.1	18.0	18.9	19.1	18.5	21.5	23.5	25.5	20.7	21.9	18.4	**-3.5**
Portugal	27.0											**N/A**
Romania	9.3	9.9	23.5		18.3	18.0	13.4	13.6	13.6	13.0	13.9	**+0.9**
Russian Fed.					4.4	3.2	4.3					**N/A**
Serbia	15.7	11.0	15.7	11.3	9.9	10.7	7.2	10.2	14.9	12.1	10.1	**-2.0**
Slovakia	13.6	17.0	16.6	20.8	24.5	32.9	26.4	33.9	43.5	43.5	24.3	**-19.2**
Slovenia	28.5	27.6	35.7	34.6	33.3	28.1	30.0	27.7	30.6	38.4	35.9	**-2.5**
Spain	23.3	24.4	19.5	18.4	20.7	16.1	13.2	23.6	20.7	18.4		**N/A**
Sweden	9.2	10.8										**N/A**
Switzerland	27.9	22.6	26.1	19.6	17.4	25.2	29.6	33.3	31.5	28.0	26.4	**-1.6**
Turkey				38.3	23.4	21.2	17.2	16.8	15.7	17.2	10.8	**-6.4**
Ukraine	9.2	6.2	7.1	9.1	7.2	6.4	6.7	7.5	7.0	5.5	6.3	**+0.8**
United Kingdom	28.2	29.2	35.3			56.1						**N/A**

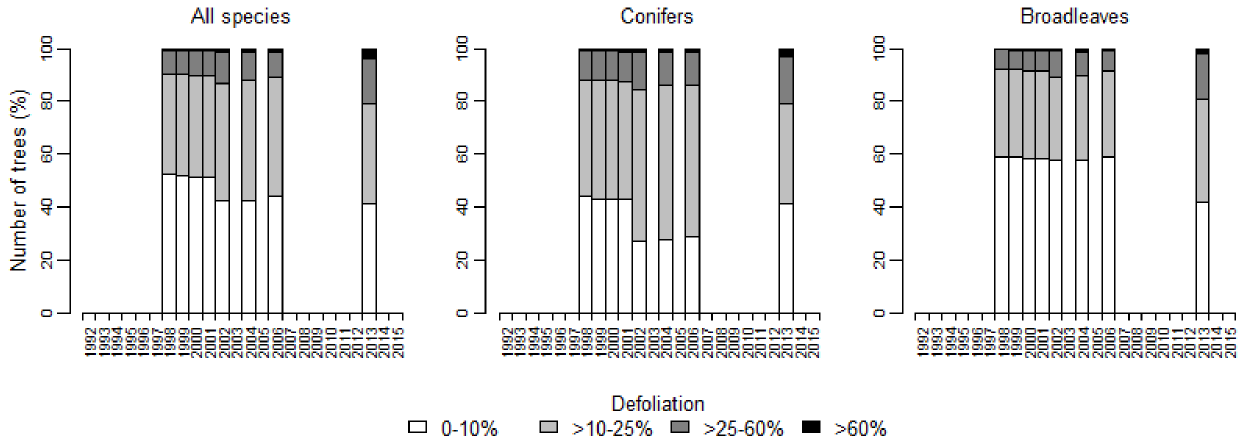
** In Luxembourg only 10.1% of the broadleaves assessed in 2015 were assessed in 2014.*

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

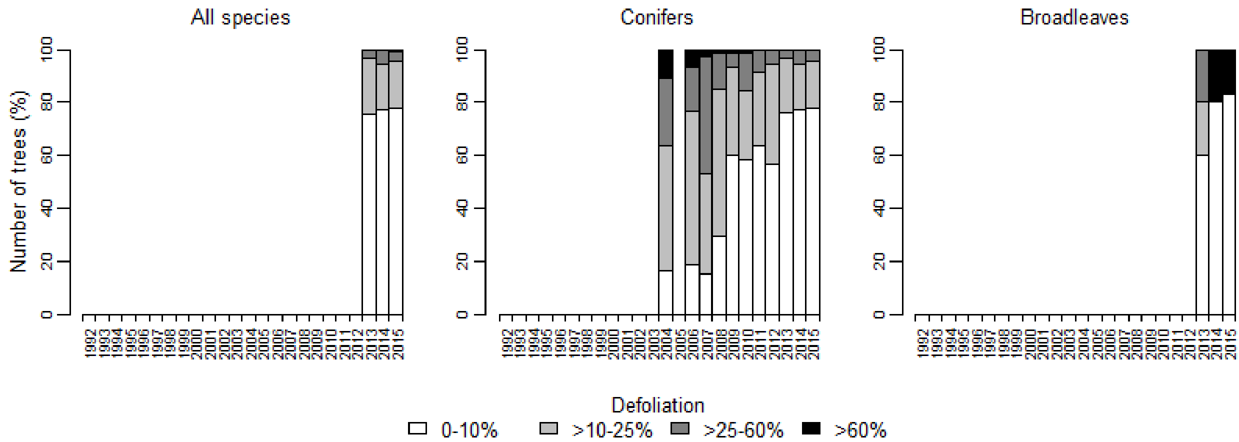
Austria: from 2003 on results are based on the 16 x 16 km transnational grid net and must not be compared with previous years. *Poland, Belgium-Wallonia*: change of grid net since 2006 and 2010, resp. *Russian Federation:* north-western and Central European parts only. *Ukraine*: change of grid net in 2005. *Hungary, Romania*: comparisons not possible due to changing survey designs. *Norway*: new sampling design since 2013.

Annex II-8 | Change of tree defoliation over time (1991–2015) per country

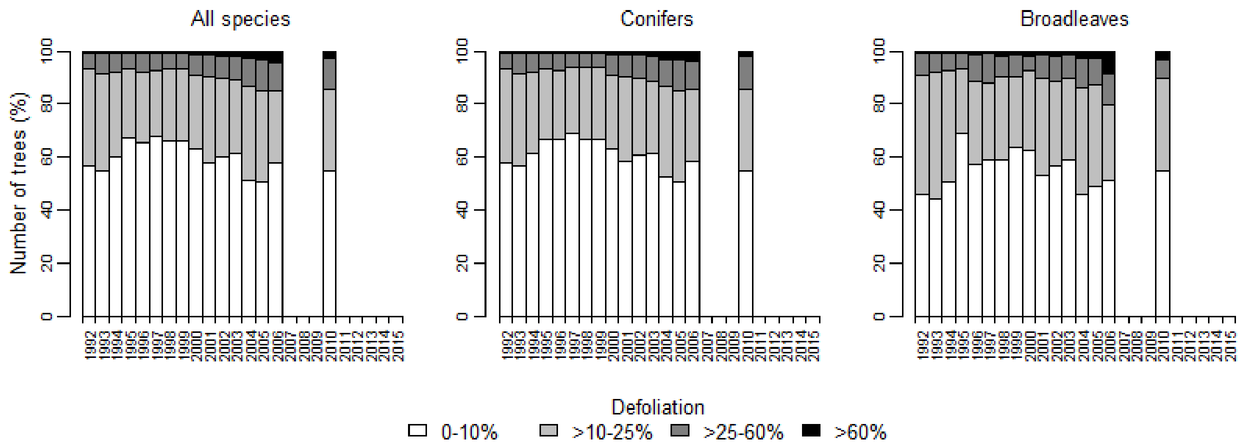
ALBANIA



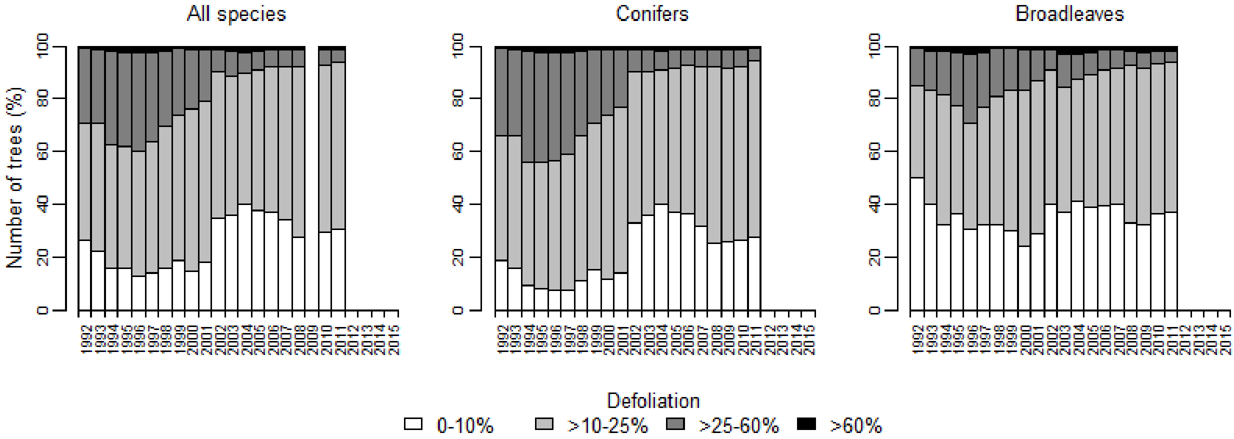
ANDORRA



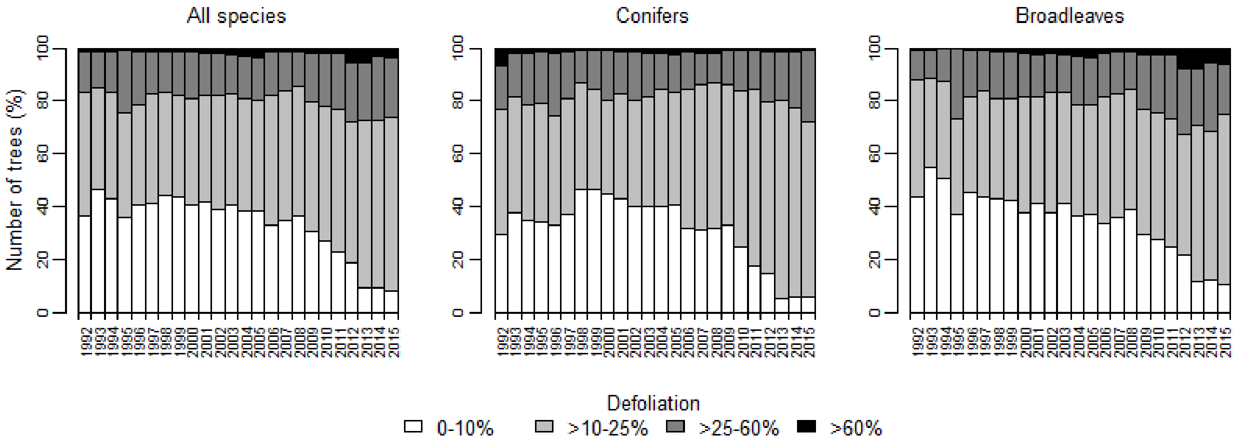
AUSTRIA



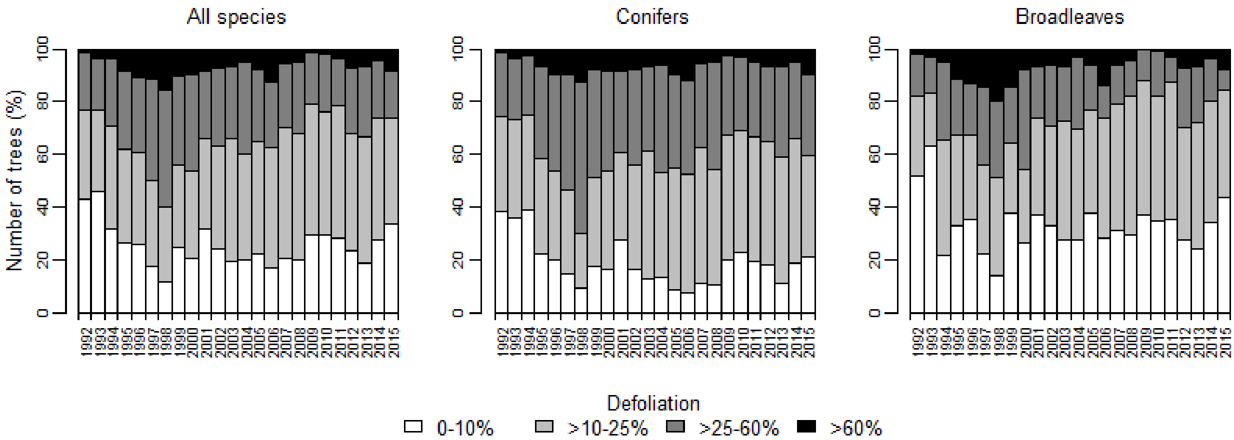
BELARUS



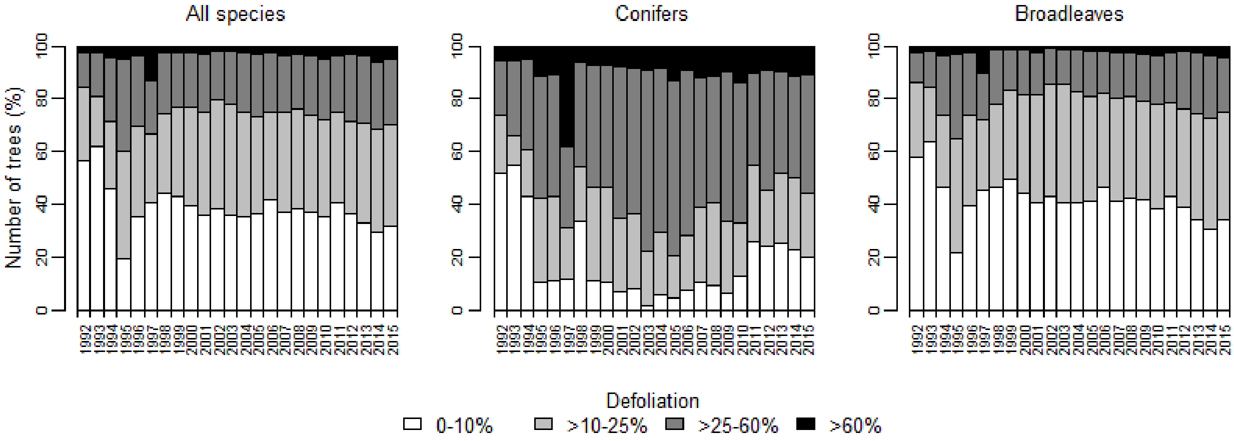
BELGIUM



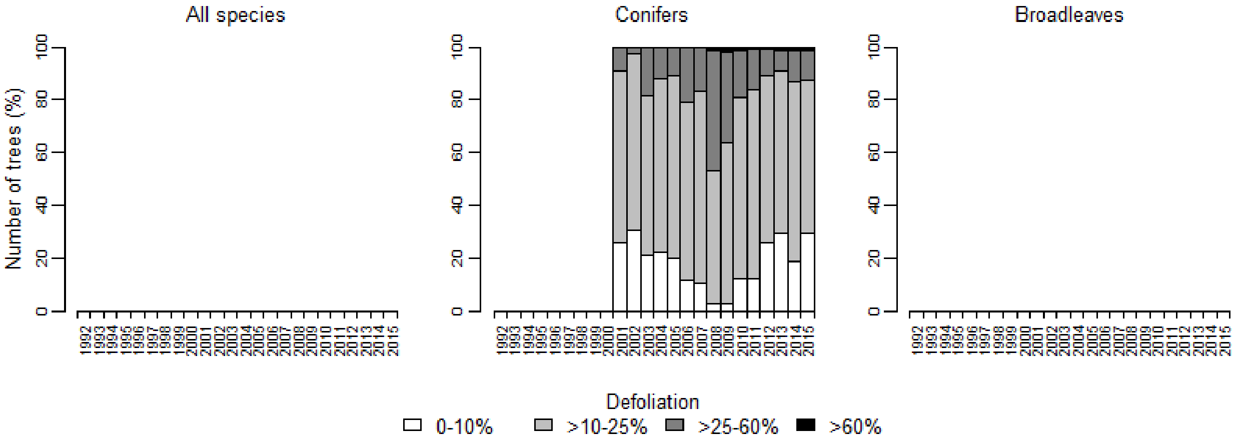
BULGARIA



CROATIA



CYPRUS



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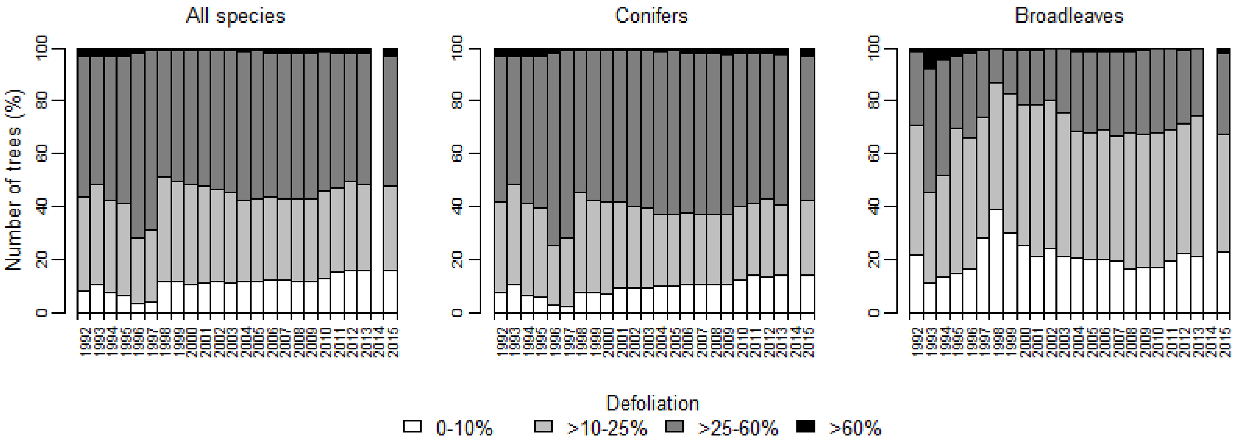

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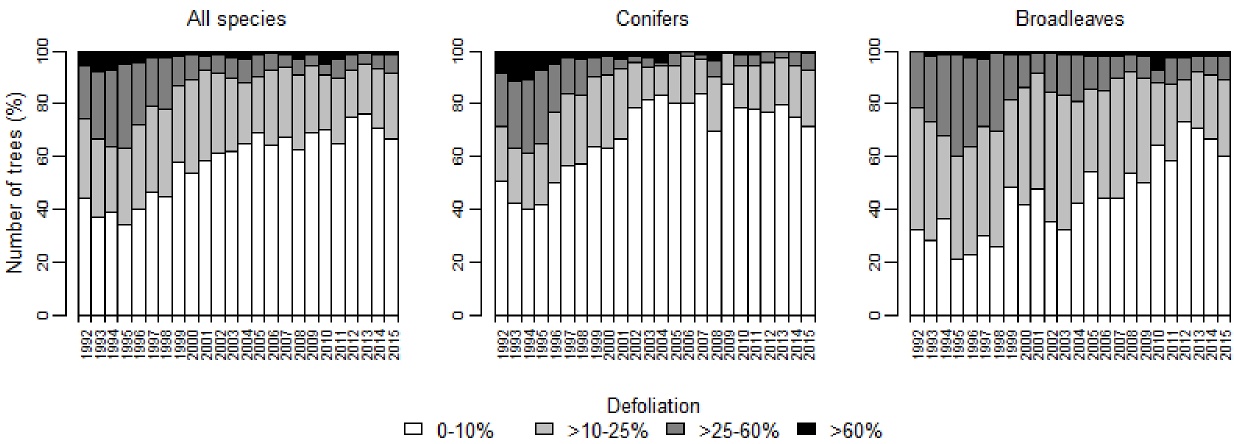

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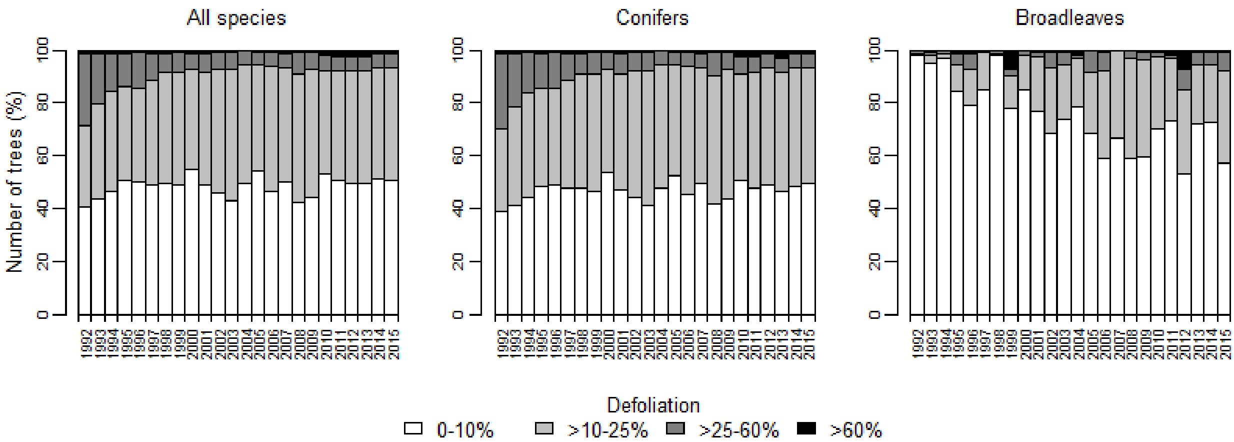

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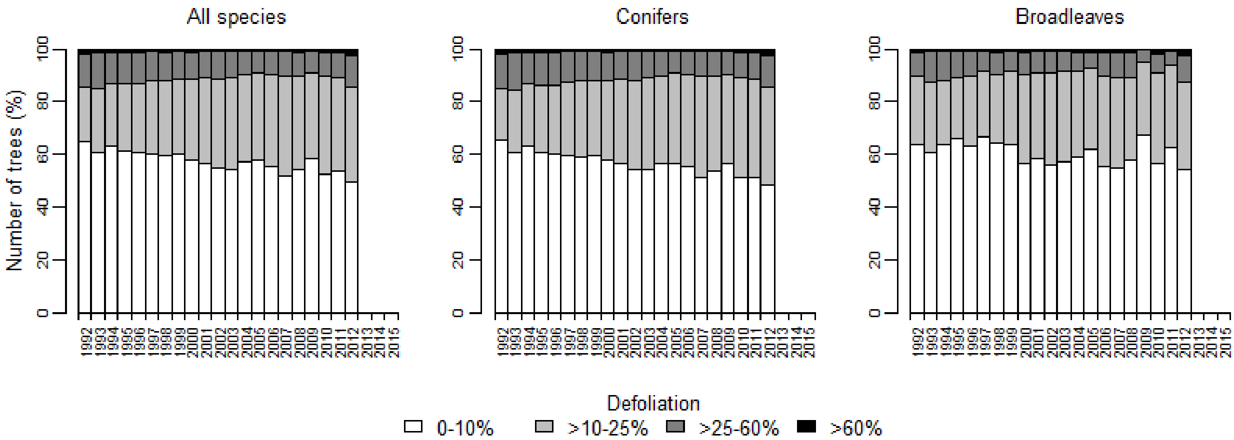

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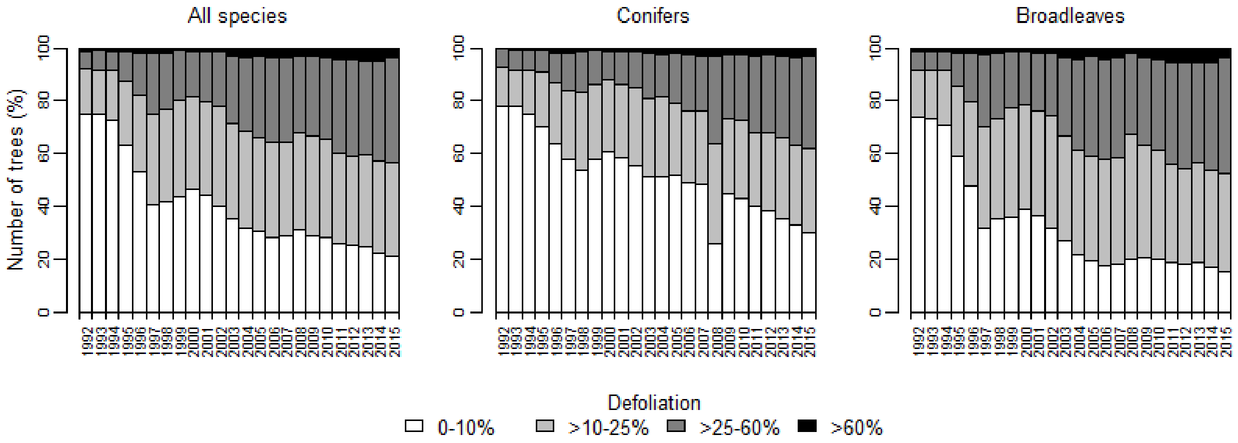

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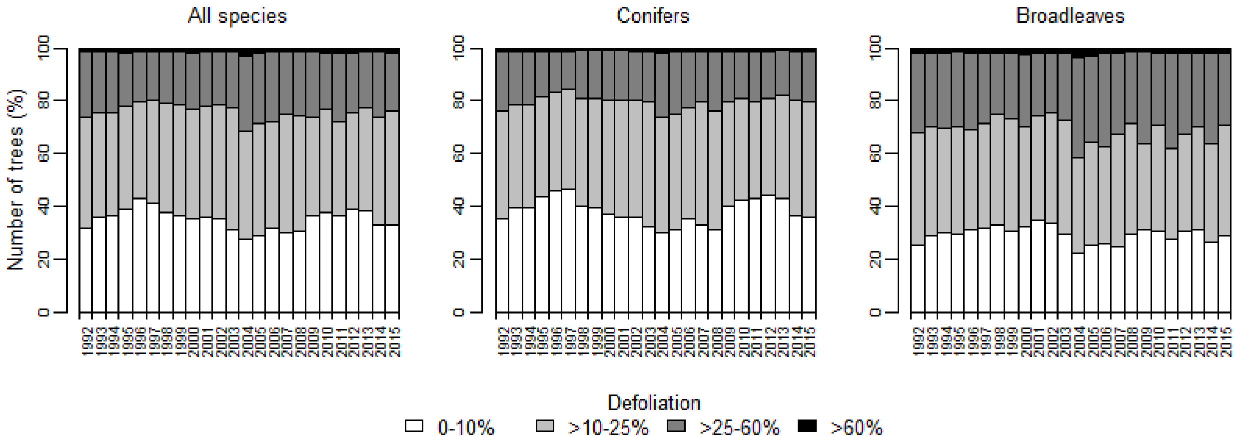

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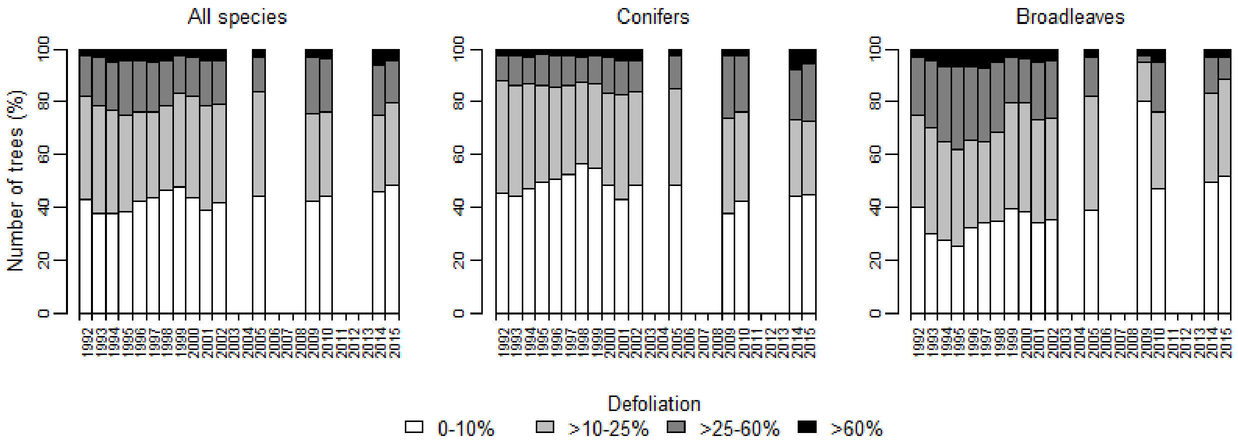
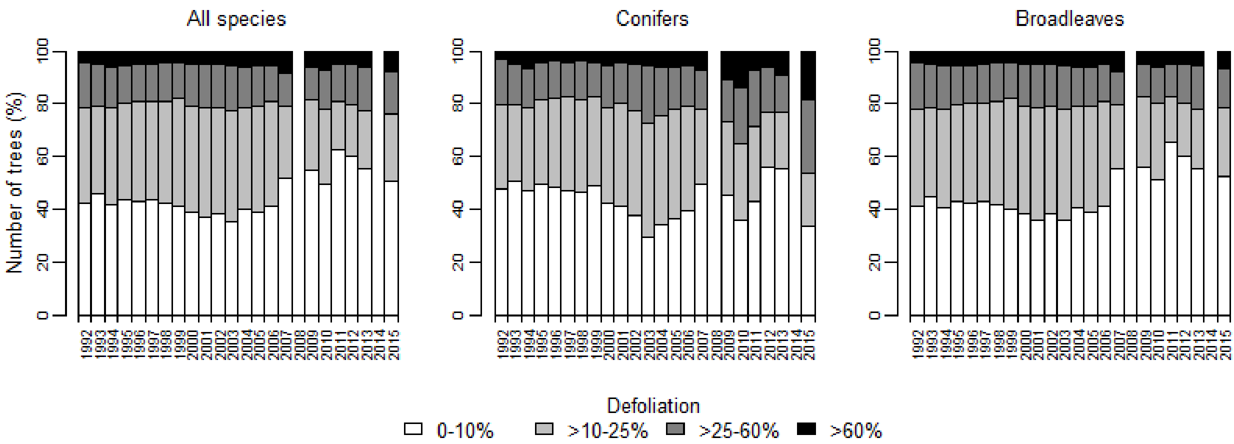


HUNGARY



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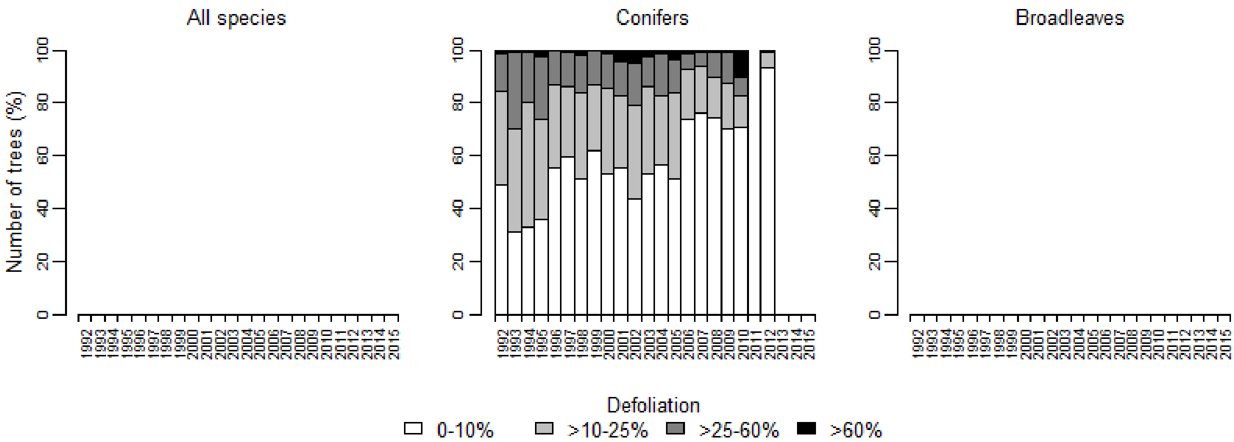

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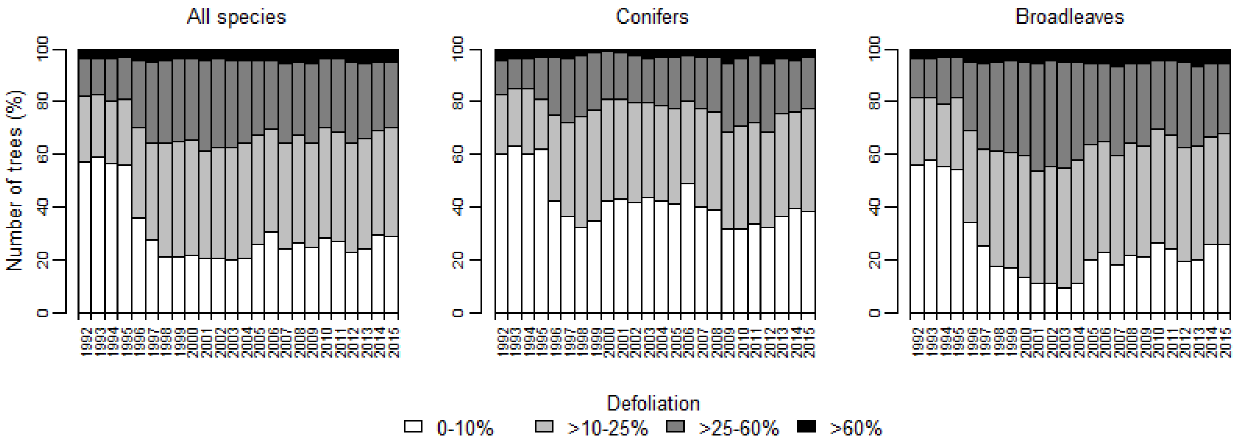

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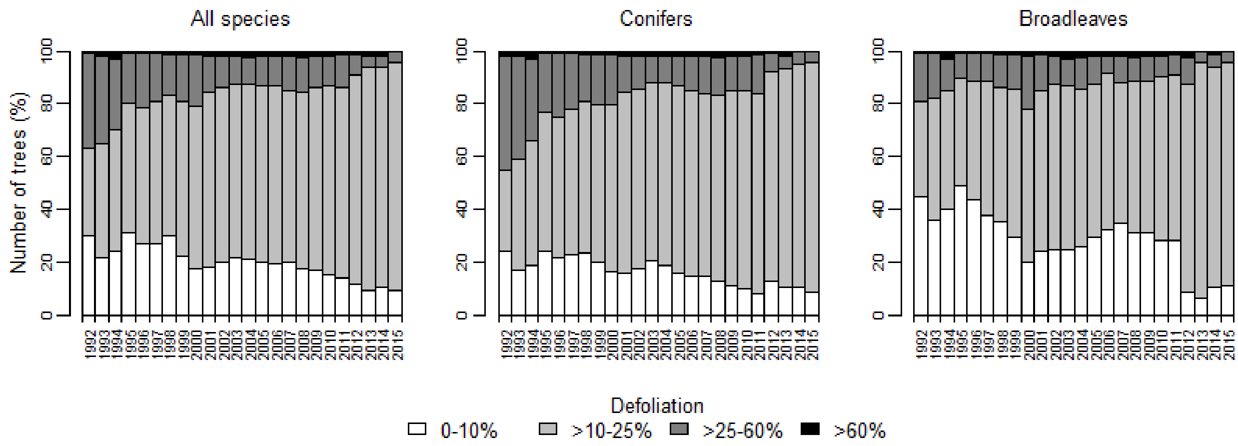
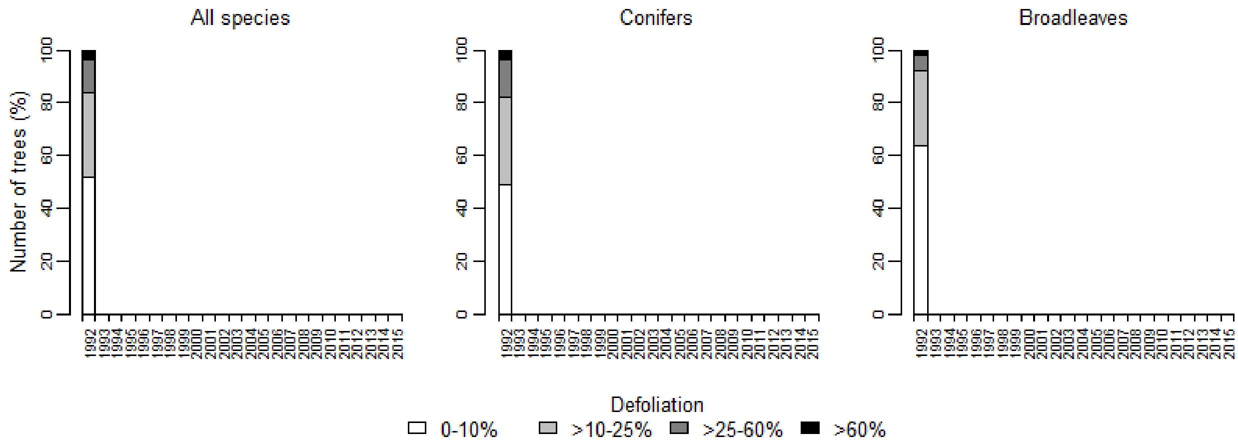


LIECHTENSTEIN



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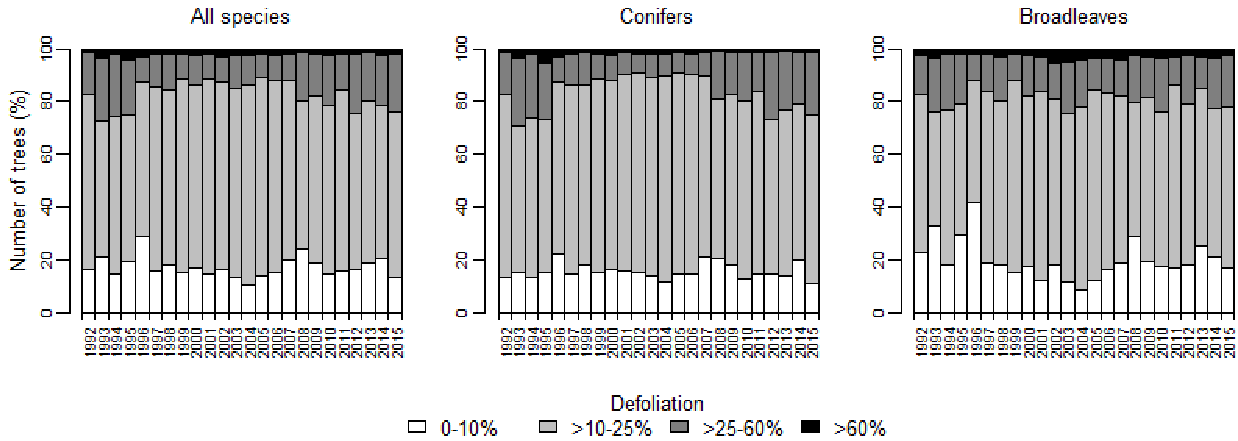
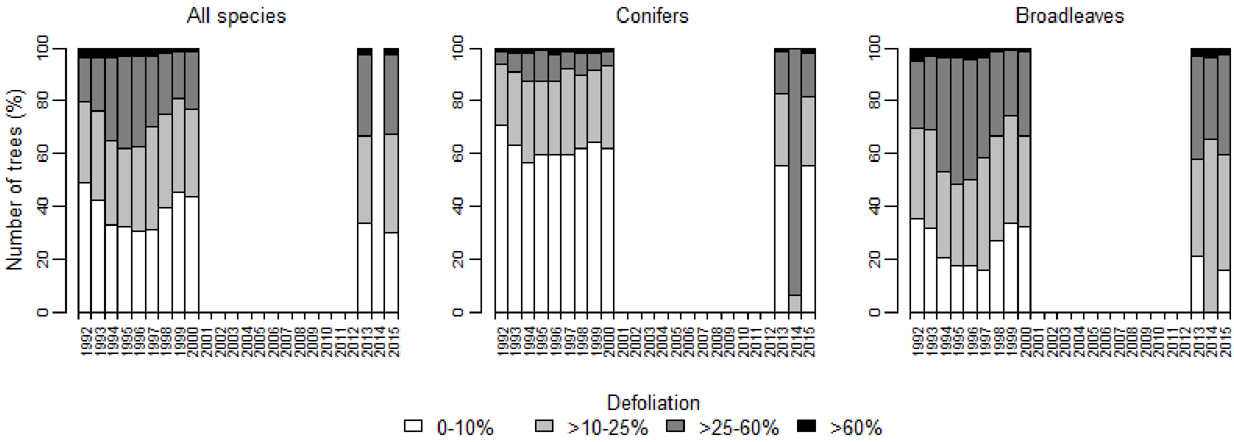


LUXEMBOURG



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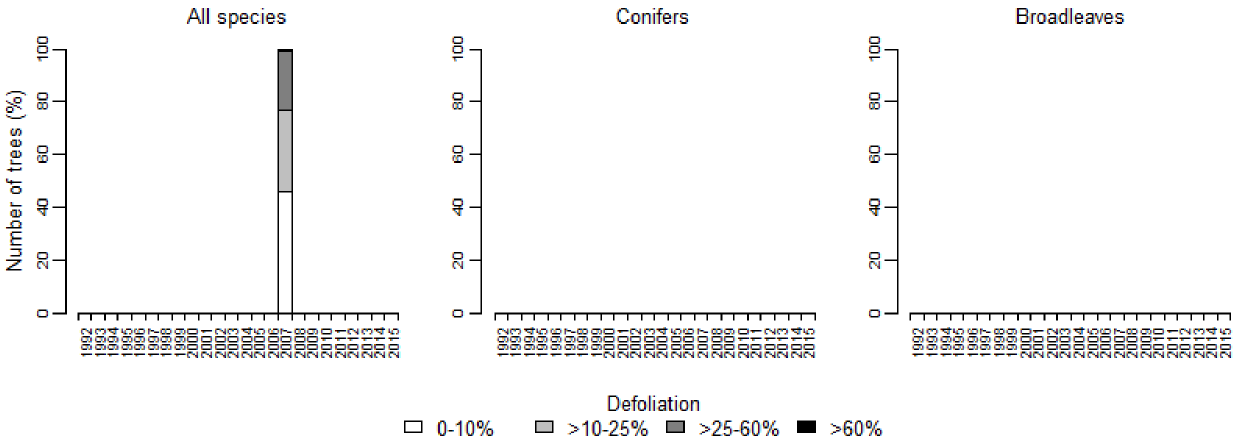
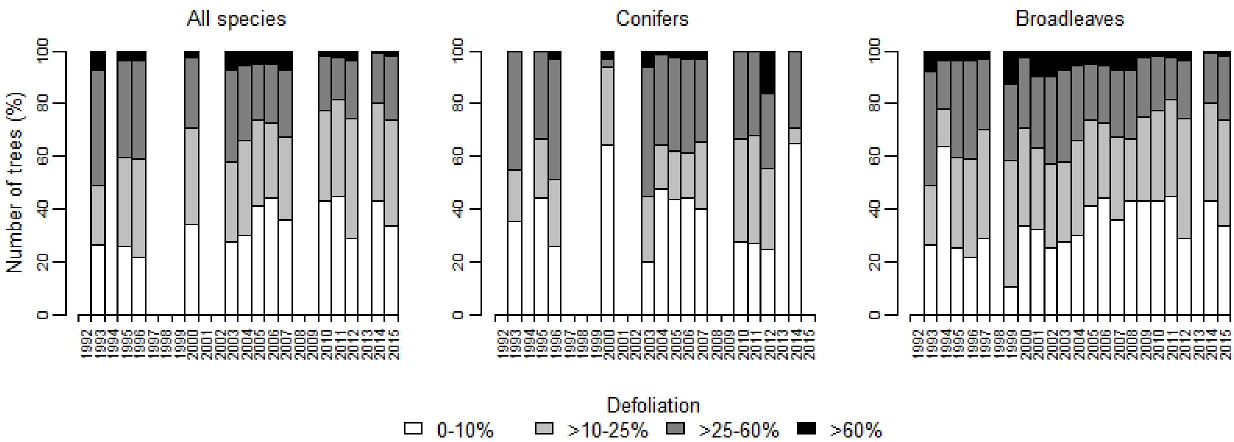
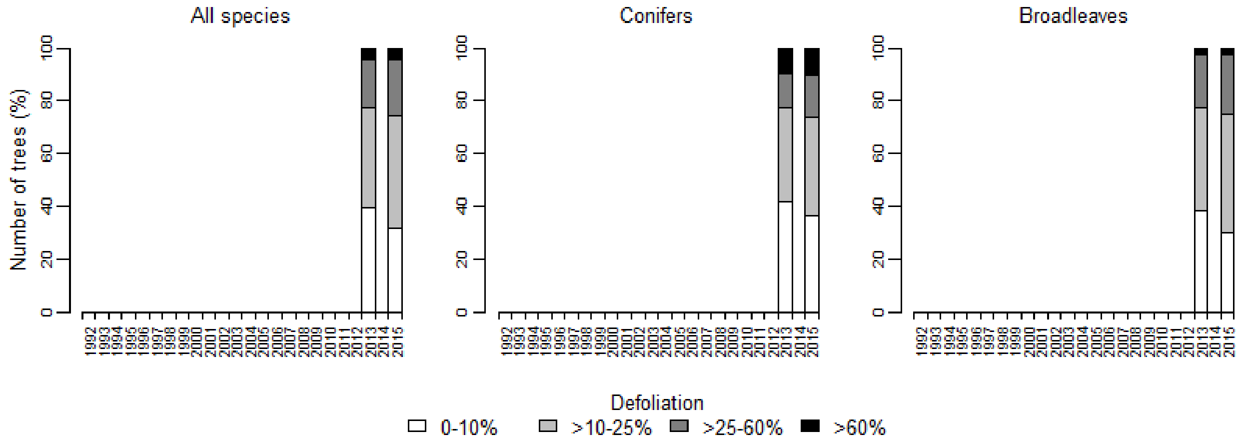


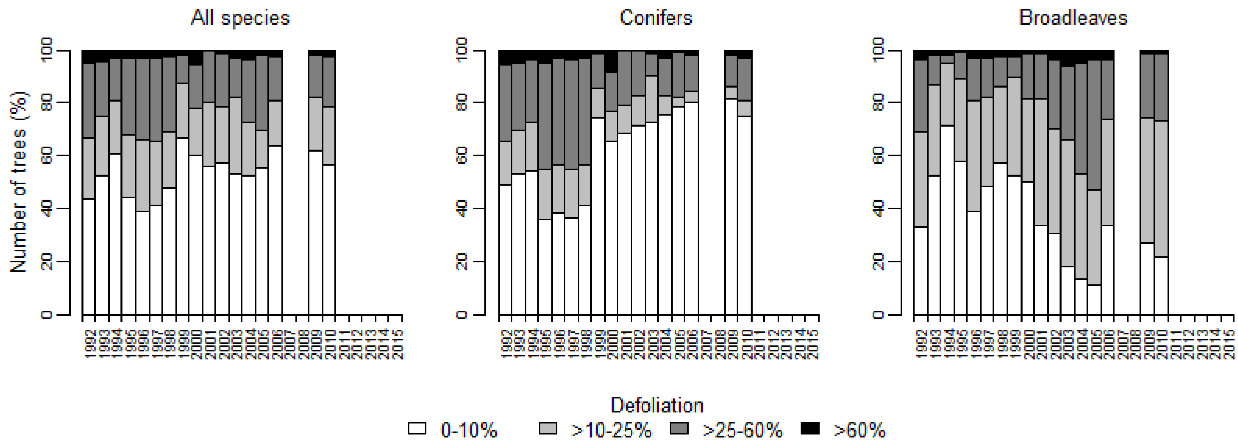
REPUBLIC OF MOLDOVA



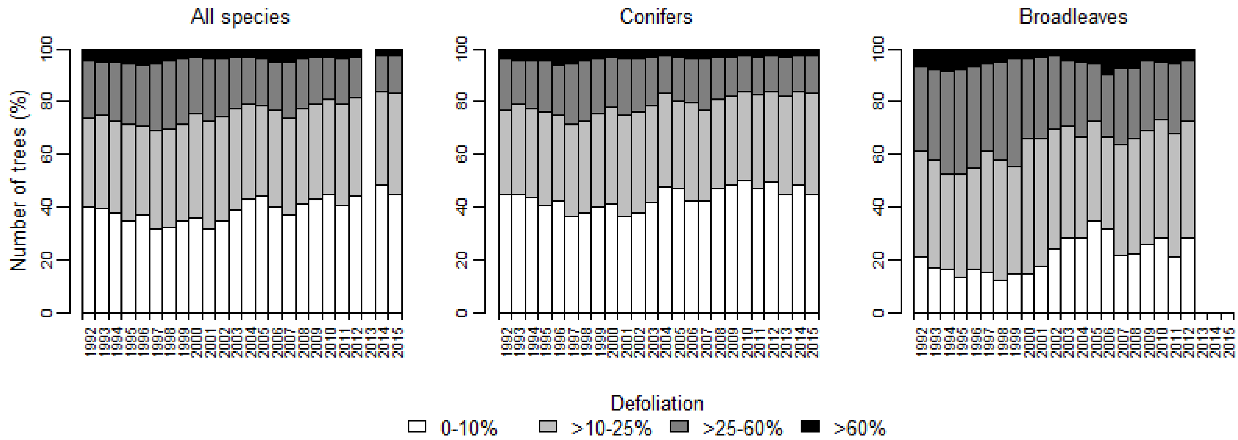
MONTENEGRO



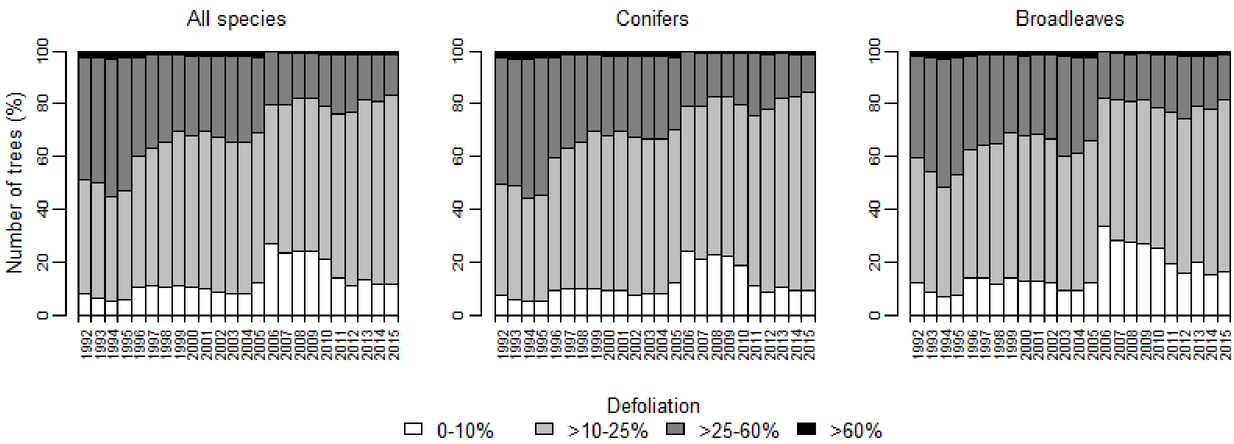
THE NETHERLANDS



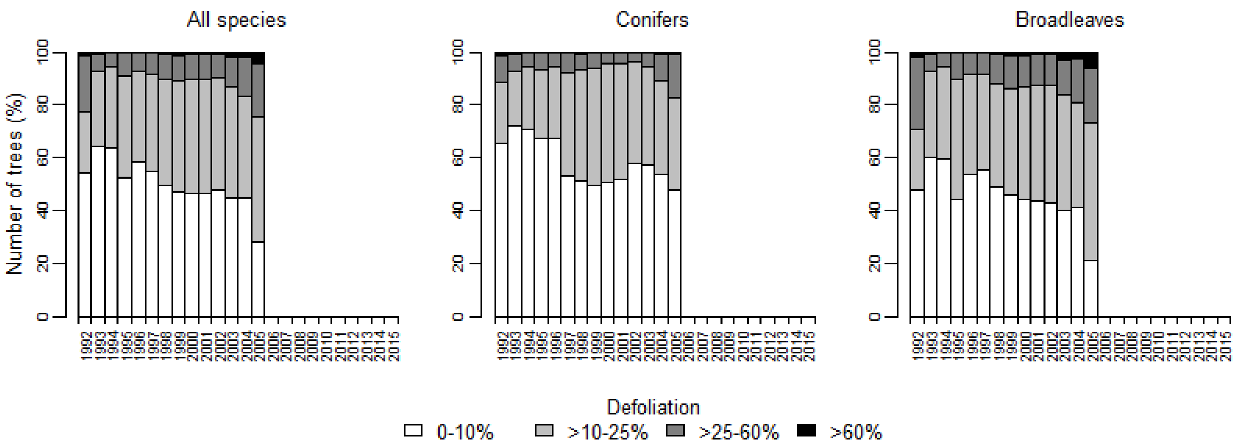
NORWAY



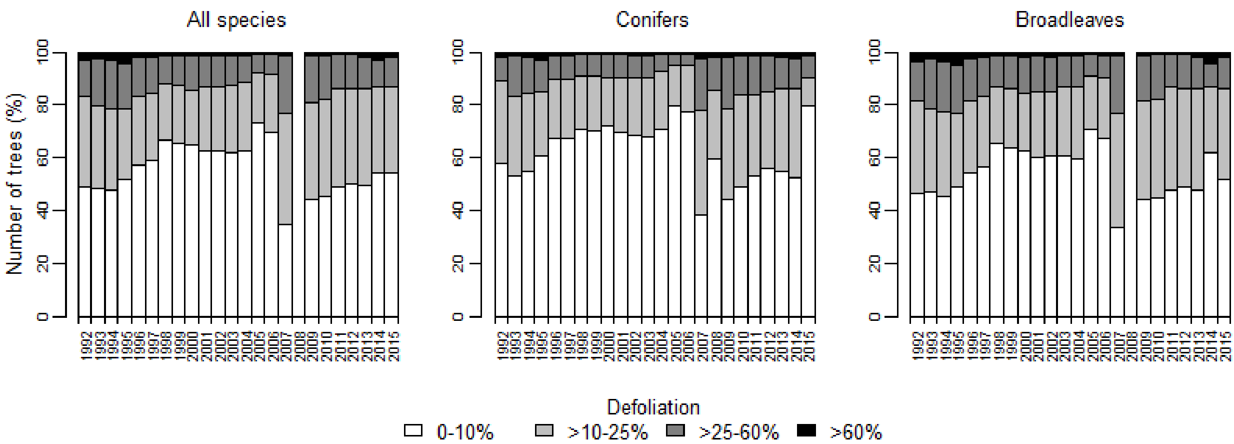
POLAND



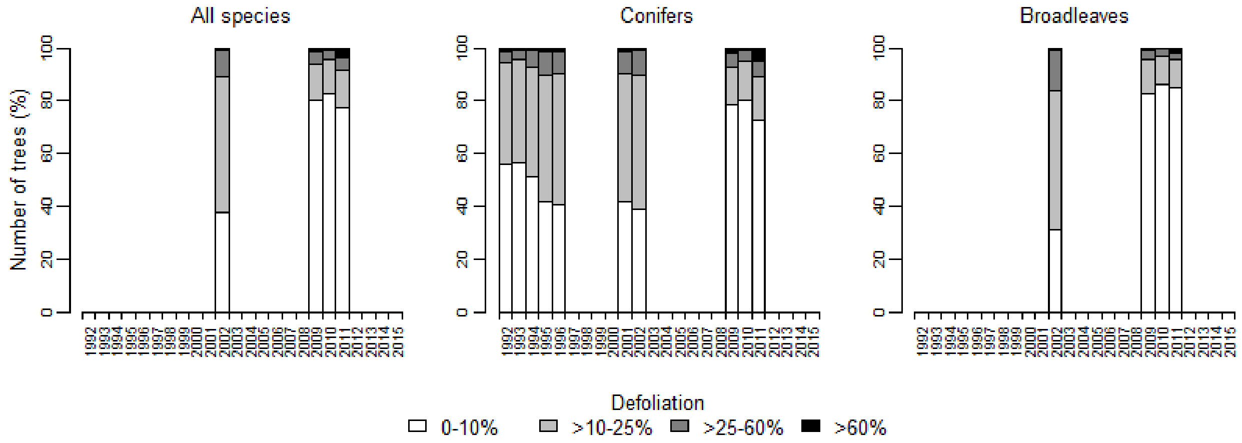
PORTUGAL



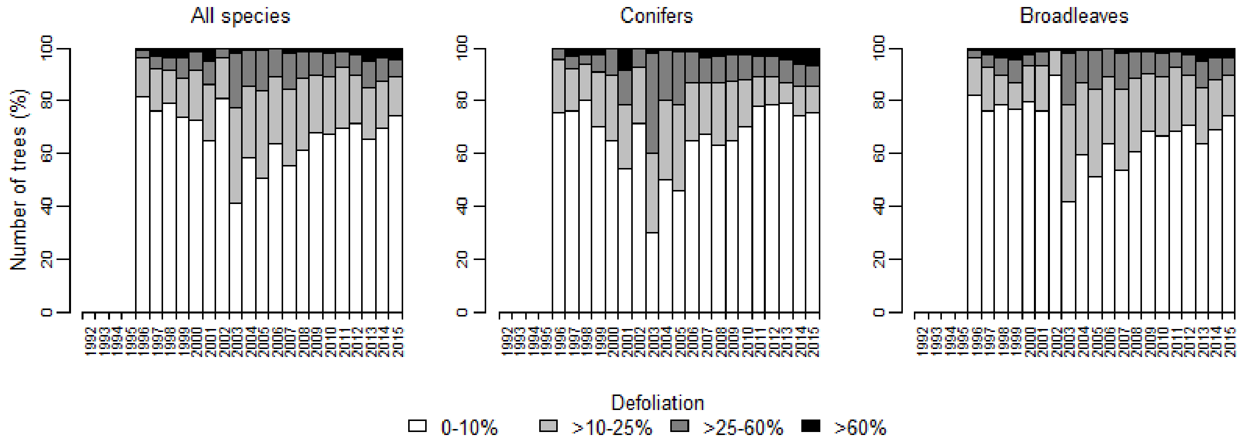
ROMANIA



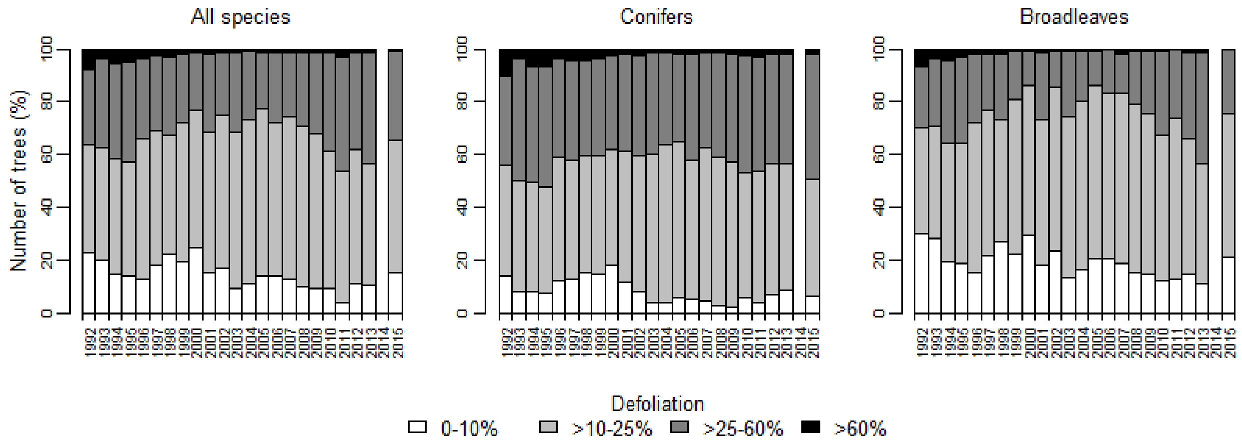
RUSSIAN FEDERATION



SERBIA



SLOVAKIA



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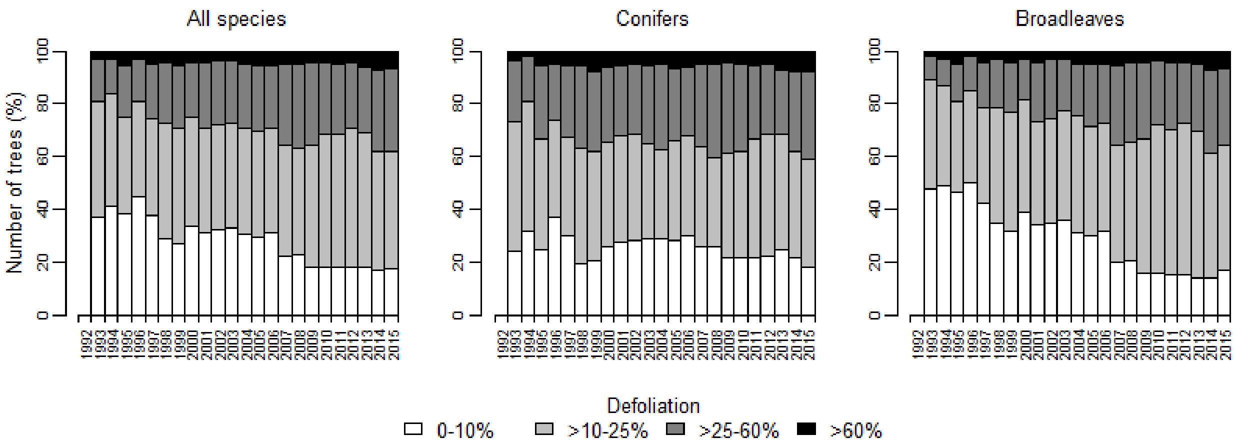
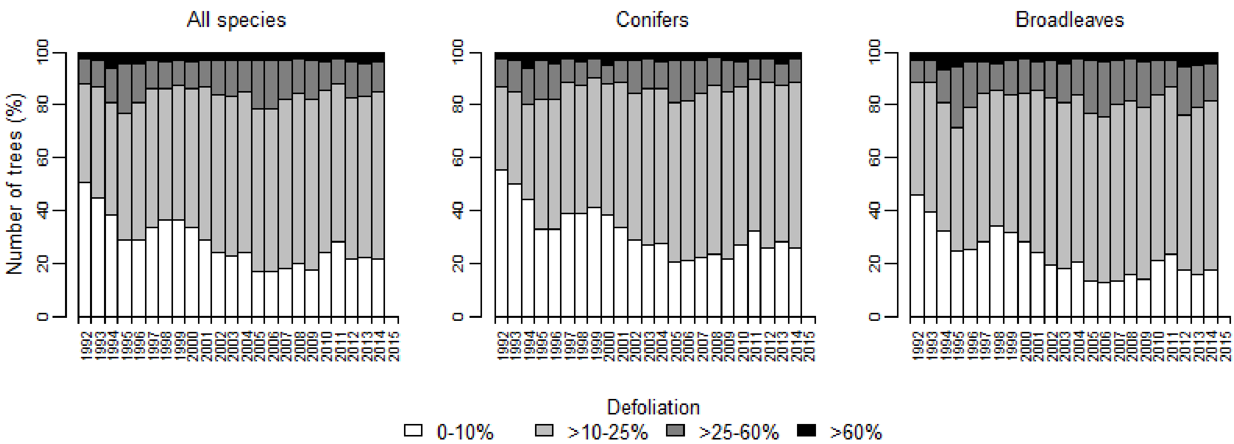
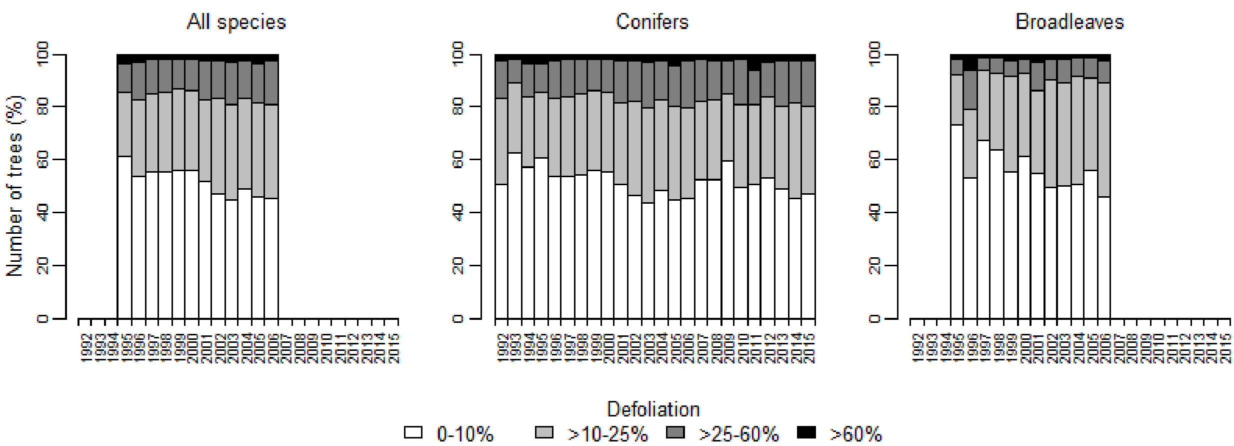


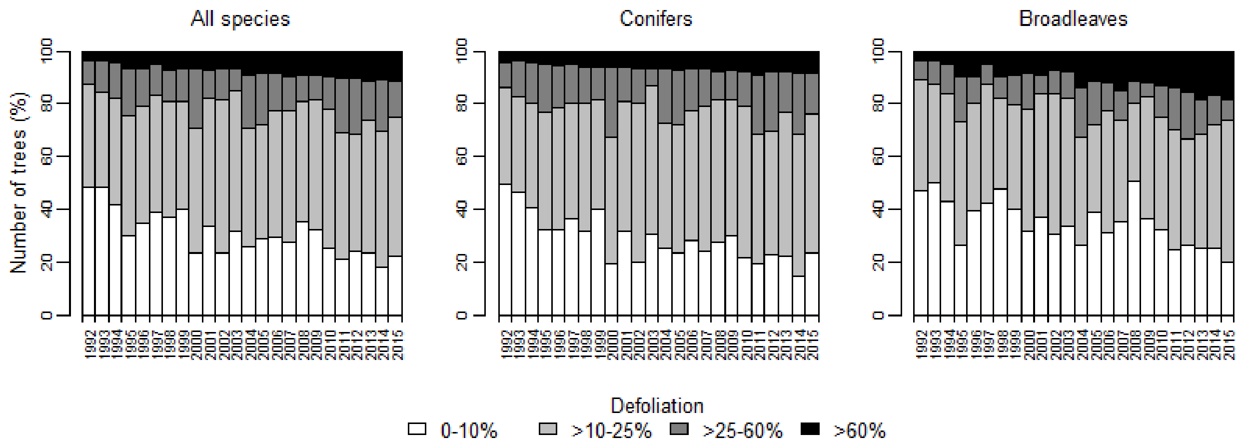
SPAIN



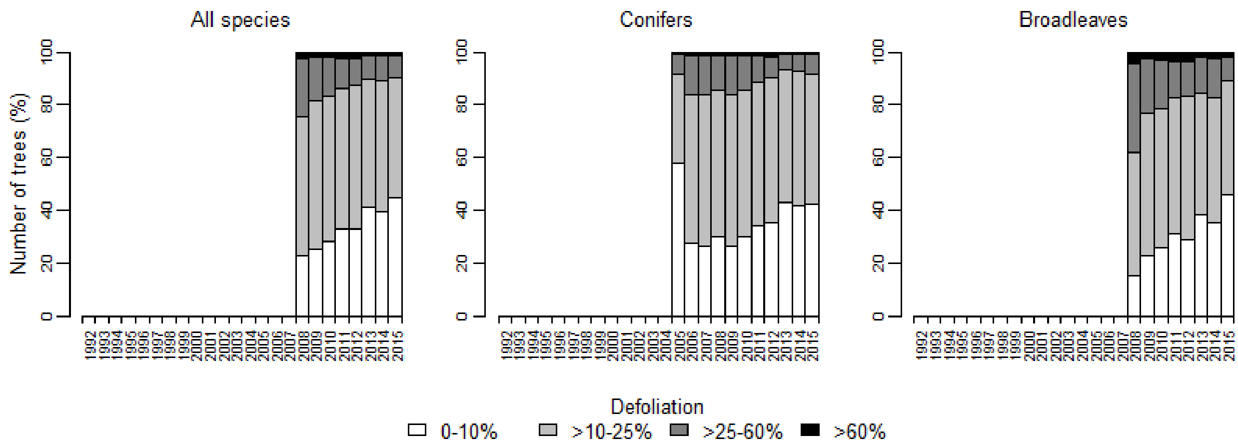
SWEDEN



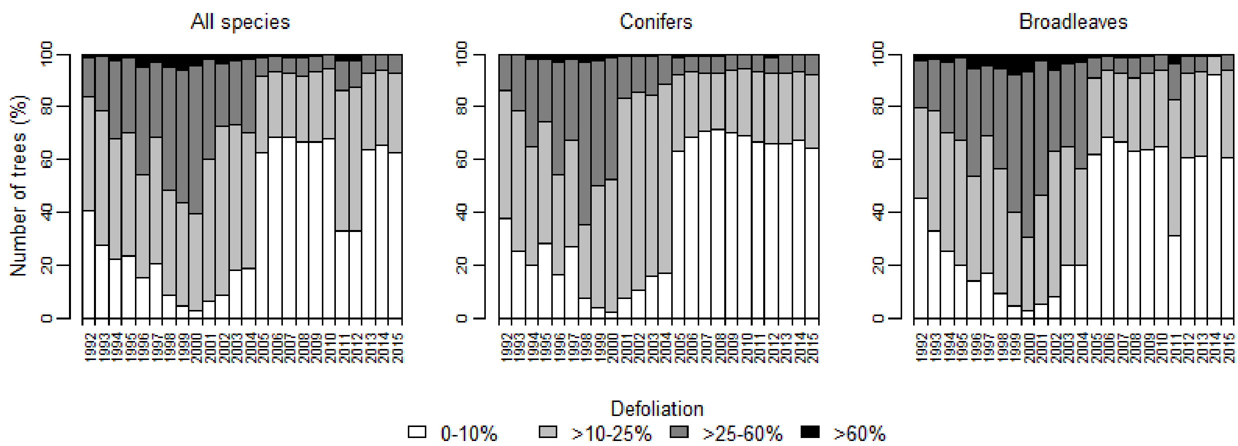
SWITZERLAND



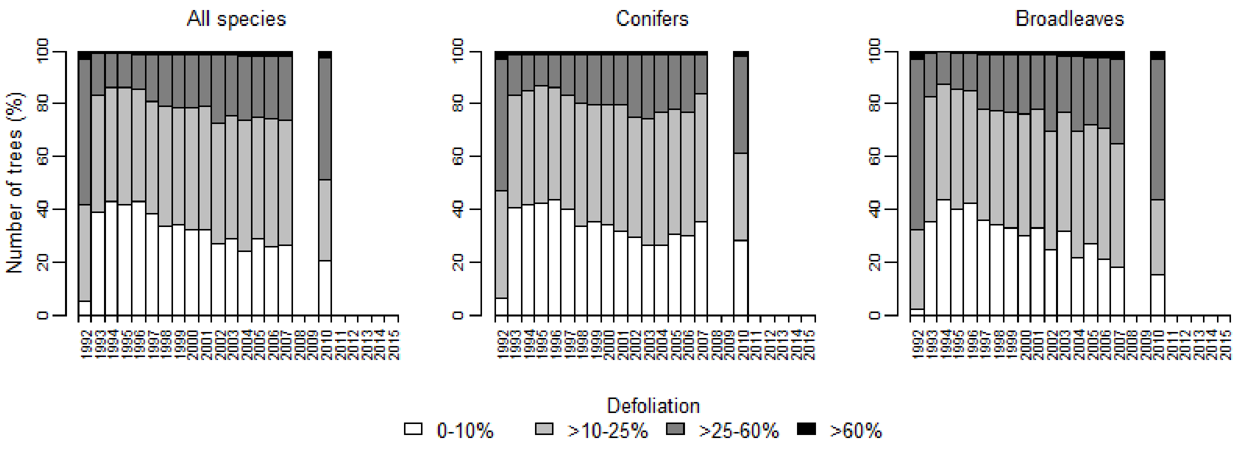
TURKEY



UKRAINE



UNITED KINGDOM



ANNEX III
LIST OF WOODY SPECIES (CHAPTER 5)

Taxon	N. of records	Taxon	N. of records
Picea abies	2069	*Quercus pyrenaica*	142
Fagus sylvatica	1812	*Euonymus europaeus*	134
Rubus idaeus	1310	*Alnus glutinosa*	130
Betula pendula	982	*Lavandula stoechas*	130
Fraxinus excelsior	920	*Phillyrea latifolia*	130
Corylus avellana	919	*Genista scorpius*	124
Rubus sp.	885	*Prunus serotina*	121
Carpinus betulus	784	*Pinus pinaster*	112
Pinus sylvestris	679	*Quercus rubra*	110
Vaccinium myrtillus	626	*Quercus coccifera*	108
Salix caprea	580	*Viburnum lantana*	107
Quercus robur	566	*Pinus nigra*	105
Prunus spinosa	560	*Cytisus scoparius*	104
Rubus fruticosus group	504	*Lithodora diffusa*	103
Crataegus monogyna	500	*Fraxinus ornus*	99
Populus tremula	473	*Pinus pinea*	94
Sorbus aucuparia	455	*Smilax aspera*	92
Acer campestre	444	*Robinia pseudacacia*	91
Frangula alnus	430	*Cistus albidus*	90
Acer pseudoplatanus	426	*Spartium junceum*	90
Hedera helix	377	*Castanea sativa*	89
Quercus ilex	376	*Quercus suber*	89
Rubus caesius	373	*Lonicera xylosteum*	88
Rubus ulmifolius	349	*Anthyllis cytisoides*	84
Rosa canina	328	*Ilex aquifolium*	84
Cistus incanus	296	*Ulex gallii*	83
Quercus petraea	278	*Quercus sp.*	82
Quercus cerris	273	*Pinus cembra*	81
Thymus vulgaris	265	*Crataegus sp.*	80
Rosmarinus officinalis	250	*Cistus ladanifer*	79
Rubus fruticosus	246	*Sorbus aria*	79
Prunus avium	242	*Ligustrum vulgare*	76
Cornus sanguinea	227	*Rubus hirtus*	76
Pinus halepensis	216	*Lavandula latifolia*	75
Ulex parviflorus	212	*Erica arborea*	74
Larix decidua	209	*Quercus frainetto*	73
Juniperus communis	203	*Alnus incana*	72
Abies alba	197	*Halimium lasianthum*	71
Acer platanoides	183	*Helianthemum apenninum*	71
Helianthemum marifolium	182	*Myrtus communis*	71
Clematis vitalba	180	*Lonicera periclymenum*	70
Sambucus nigra	177	*Arctostaphylos uva-ursi*	68
Cistus salvifolius	174	*Cornus mas*	68
Tilia cordata	165	*Genista hispanica*	66
Rosa sp.	159	*Pinus radiata*	66
Calluna vulgaris	158	*Rhamnus lycioides*	66
Vaccinium vitis-idaea	150	*Ulmus glabra*	62
Pistacia lentiscus	146	*Rhamnus alaternus*	61
Juniperus oxycedrus	144	*Rubus nessensis*	56
Thymus sp.	55	*Cistus crispus*	19

Taxon	N. of records	Taxon	N. of records
Erica herbacea	51	*Helianthemum lavandulifolium*	19
Salix myrsinifolia	49	*Populus sp.*	19
Sambucus racemosa	49	*Rhamnus alpinus*	19
Quercus alnifolia	48	*Sambucus ebulus*	19
Salix alba	48	*Coronilla emerus*	18
Thymus mastichina	48	*Fraxinus pennsylvanica*	18
Viburnum opulus	48	*Pseudotsuga menziesii*	18
Abies sp.	47	*Pyrus communis*	18
Salix cinerea	47	*Acer opalus*	17
Rosa elliptica	46	*Anthyllis hermanniae*	17
Phillyrea angustifolia	45	*Dorycnium pentaphyllum*	17
Fumana ericoides	44	*Erica cinerea*	17
Ribes rubrum	44	*Juniperus phoenicea*	17
Cistus clusii	42	*Pistacia terebinthus*	17
Ostrya carpinifolia	42	*Chamaerops humilis*	16
Humulus lupulus	40	*Cytisus striatus*	16
Ononis minutissima	39	*Salix purpurea*	16
Sorbus torminalis	39	*Thymus longicaulis*	16
Salix atrocinerea	38	*Cistus laurifolius*	15
Tilia platyphyllos	38	*Cytisus sessilifolius*	15
Genista tinctoria	37	*Clematis flammula*	14
Salix sp.	37	*Cotoneaster sp.*	14
Arbutus unedo	36	*Malus sylvestris*	14
Jasminum nudiflorum	35	*Tilia sp.*	14
Picea pungens	35	*Crataegus laevigata*	13
Helianthemum nummularium	32	*Euonymus verrucosus*	13
Helianthemum sp.	32	*Genista germanica*	13
Ulmus minor	32	*Morus alba*	12
Prunus padus	30	*Prunus sp.*	12
Quercus pubescens	30	*Quercus dalechampii*	12
Alnus viridis	29	*Rhamnus catharticus*	12
Ulmus laevis	29	*Daphne mezereum*	11
Erica vagans	27	*Pinus uncinata*	11
Ulex sp.	27	*Scutellaria cypria*	11
Malus sp.	26	*Acer sp.*	10
Populus alba	26	*Mespilus germanica*	10
Halimium halimifolium	25	*Populus x canadensis*	10
Pyrus pyraster	25	*Thymus serpyllum*	10
Salix aurita	25	*Vitis vinifera*	10
Berberis cretica	24	*Amelanchier sp.*	9
Rhododendron ferrugineum	23	*Cotoneaster integerrimus*	9
Acer negundo	22	*Daboecia cantabrica*	9
Lonicera implexa	22	*Erica multiflora*	9
Salix fragilis	22	*Juglans regia*	9
Vaccinium uliginosum	22	*Polygala chamaebuxus*	9
Berberis vulgaris	21	*Sorbus mougeotii*	9
Betula pubescens	21	*Eucalyptus camaldulensis*	8
Coronilla juncea	21	*Laburnum alpinum*	8
Genista sp.	20	*Malus domestica*	8
Helianthemum cinereum	20	*Ulmus procera*	8
Olea europaea	20	*Ailanthus altissima*	7
Ruscus aculeatus	20	*Amorpha fruticosa*	7
Aesculus hippocastanum	19	*Cytisus sp.*	7
Mahonia aquifolium	7	*Taxus baccata*	2

Taxon	N. of records	Taxon	N. of records
Pyrus syriaca	7	*Ulex minor*	2
Ribes uva-crispa	7	*Alyssum bertolonii*	1
Spiraea x vanhouttei	7	*Arthrocnemum macrostachyum*	1
Cotoneaster nebrodensis	6	*Calluna sp.*	1
Genista hirsuta	6	*Celtis australis*	1
Genista pilosa	6	*Cornus sp.*	1
Globularia alypum	6	*Coronilla valentina*	1
Lithodora fruticosa	6	*Cytisus emeriflorus*	1
Philadelphus sp.	6	*Cytisus patens*	1
Prunus mahaleb	6	*Dorycnium hirsutum*	1
Quercus faginea	6	*Fumana sp.*	1
Rosa sempervirens	6	*Laburnum anagyroides*	1
Solanum dulcamara	6	*Lavandula angustifolia*	1
Ulex europaeus	6	*Lonicera nigra*	1
Acer tataricum	5	*Lonicera sp.*	1
Buxus sempervirens	5	*Ononis natrix*	1
Cytisus villosus	5	*Phillyrea sp.*	1
Erica sp.	5	*Pyrus amygdaliformis*	1
Juniperus sabina	5	*Ruta chalepensis*	1
Juniperus thurifera	5	*Salix elaeagnos*	1
Osyris quadripartita	5	*Salix viminalis*	1
Populus nigra	5	*Sophora japonica*	1
Prunus domestica	5	*Sorbus domestica*	1
Acer hyrcanum	4	*Symphoricarpos albus*	1
Buddleja davidii	4	*Tilia tomentosa*	1
Crataegus macrocarpa	4	*Vaccinium sp.*	1
Daphne gnidium	4		
Larix sp.	4		
Lithodora sp.	4		
Lonicera alpigena	4		
Populus x canescens	4		
Ruta graveolens	4		
Acacia dealbata	3		
Alnus sp.	3		
Amelanchier ovalis	3		
Daphne laureola	3		
Genista anglica	3		
Juniperus sp.	3		
Polygala sp.	3		
Ribes nigrum	3		
Amelanchier spicata	2		
Chamaecytisus austriacus	2		
Ephedra distachya	2		
Ononis fruticosa	2		
Pinus mugo	2		
Ribes petraeum	2		
Rosa rugosa	2		
Rubus corylifolius group	2		
Salix reticulata	2		
Satureja montana	2		
Sorbus sp.	2		

ANNEX IV
CONTACTS

Annex IV-1 | UNECE and ICP Forests

UNECE – LRTAP Convention	United Nations Economic Commission for Europe LRTAP Convention Secretariat Palais des Nations, 8-14, avenue de la Paix 1211 Geneva 10, SWITZERLAND Phone: +41 22 917 23 58/Fax: +41 22 917 06 21 Email: krzysztof.olendrzynski@unece.org Mr Krzysztof Olendrzynski
ICP Forests Lead Country	Federal Ministry of Food and Agriculture - Ref. 535 Postfach 14 02 70 53107 Bonn, GERMANY Phone: +49 228 99 529-41 30/Fax: +49 228-99 529 42 62 Email: sigrid.strich@bmel.bund.de, 535@bmel.bund.de Ms Sigrid Strich
ICP Forests Chairperson	Universität Hamburg, Zentrum Holzwirtschaft Leuschnerstr. 91 21031 Hamburg, GERMANY Phone: +49 40 739 62 101/Fax: +49 40 739 62 199 Email: michael.koehl@uni-hamburg.de Mr Michael Köhl, Chairman of ICP Forests
ICP Forests Programme Co-ordinating Centre (PCC)	Thünen Institute of Forest Ecosystems Alfred-Möller-Str. 1, Haus 41/42 16225 Eberswalde, GERMANY Phone: +49 3334 3820-338 /Fax: +49 3334 3820-354 Email: walter.seidling@thuenen.de http://icp-forests.net Mr Walter Seidling, Head of PCC

Annex IV-2 | Expert panels, working groups, and other coordinating institutions

Expert Panel on Soil and Soil Solution	Mr Bruno De Vos, Chair Research Institute for Nature and Forest (INBO) Environment & Climate Unit Gaverstraat 4 9500 Geraardsbergen, BELGIUM Phone: +32 54 43 71 20/Fax: +32 54 43 61 60 Email: bruno.devos@inbo.be Ms Nathalie Cools, Co-chair Research Institute for Nature and Forest (INBO) Gaverstraat 4 9500 Geraardsbergen, BELGIUM Phone: + 32 54 43 61 75/Fax: +32 54 43 61 60 Email: nathalie.cools@inbo.be

Ms Tiina Nieminen, Co-chair
Natural Resources Institute Finland (LUKE)
Jokiniemenkuja 1
01370 Vantaa, FINLAND
Phone: +358 10 211 5457/Fax: +358 10 211 2103
Email: tiina.m.nieminen@luke.fi

Expert Panel on Foliar Analysis and Litterfall

Mr Pasi Rautio, Chair
Natural Resources Institute Finland (LUKE)
PO Box 16, Eteläranta 55
96301, Rovaniemi, FINLAND
Phone: +358 50 391 4045/Fax: +358 10 211 4401
Email: pasi.rautio@luke.fi

Ms Liisa Ukonmaanaho, Co-chair Litterfall
Natural Resources Institute Finland (LUKE)
Jokiniemenkuja 1
01370 Vantaa, FINLAND
Phone: +358 10 211 5115/Fax: +358 10 211 2103
Email: liisa.Ukonmaanaho@luke.fi

Expert Panel on Forest Growth

Mr Tom Levanič, Chair
Slovenian Forestry Institute (SFI)
Večna pot 2
1000 Ljubljana, SLOVENIA
Phone: +386 1200 78 44
Email: tom.levanic@gozdis.si

Mr Vivian Kvist Johannsen, Co-chair
University of Copenhagen
Department of Geosciences and Natural Resource Management
Rolighedsvej 23
1958 Frederiksberg C, DENMARK
Phone: +453 53 316 99
Email: vkj@ign.ku.dk

Expert Panel on Deposition

Ms Karin Hansen, Chair
Swedish Environmental Research Institute (IVL)
Natural Resources & Environmental Research Effects
Box 210 60
100 31 Stockholm, SWEDEN
Phone: +46 859 85 64 25(direct) and +46 859 85 63 00
Fax: +46 859 85 63 90
Email: karin.hansen@ivl.se

Mr Daniel Žlindra, Co-chair
Slovenian Forestry Institute (SFI)
Gozdarski Inštitut Slovenije GIS
Večna pot 2
1000 Ljubljana, SLOVENIA
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