ICP Forests

Forest Condition in Europe

2012 Technical Report of ICP Forests

2012

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

Forest Condition
In Europe

2012 Technical Report of ICP Forests

Work Report of the:

Thünen Institute for World Forestry

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Forest Condition in Europe

2012 Technical Report of ICP Forests

Martin Lorenz, Georg Becher (eds.)

Work report of the Institute for World Forestry 2012/1

Hamburg, December 2012

United Nations Economic Commission for Europe (UNECE)
Convention on Long-Range Transboundary Air Pollution CLRTAP
International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests)
www.icp-forests.net

Citation

Lorenz, M., Becher, G. (eds.). 2012: Forest Condition in Europe, 2012 Technical Report of ICP Forests. Work Report of the Thünen Institute for World Forestry 2012/1. ICP Forests, Hamburg, 2012.

Acknowledgements

30 countries supported the preparation of the present report by submission of data and by providing comments and corrections to the text. A complete list of the national and international institutions participating in or cooperating with ICP Forests is provided in the Annex. Ms U. Carstens carried out technical and administrative work.

Cover photos: Román Clavijo Garcia (big photo), Anna Kowalska (small photo)

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Summary

Of the 42 countries participating in ICP Forests, 29 countries reported for the year 2011 large-scale (Level I) monitoring data from about 15,000 plots and forest ecosystem related (Level II) monitoring data from about 700 plots. The data analysis focused on the impact of air pollution on forest soils, tree nutrition, and tree crown condition. In this respect emphasis was laid on the assessment of future risks of air pollution damage to the forests in Europe. Also considered was the impact of factors other than air pollution such as pests and diseases.

Mean annual throughfall and bulk deposition of S and N was calculated for 289 and 357 Level II plots, respectively. S deposition is highest in central Europe, ranging from the North Sea coast via central Germany to Poland, the Czech Republic, and the Slovak Republic. High S deposition along the coast mostly occurs with high Cl deposition indicating that S deposition originates from sea salt. The fact that throughfall is higher than bulk deposition confirms that the canopy filters sulphur from the air. Similar to S deposition, N deposition is highest in central Europe but extends further west to France, the United Kingdom, and Ireland, as well as further south to Switzerland. On about half of the investigated sites there is a statistically significant decrease in S and N deposition between 2000 and 2010.

For assessing effects of N deposition on the nutrition of trees, the exceedances of harmful pollutant concentrations (critical limits) in the soil were calculated. Up to 251 Level II plots were included in the study depending on data availability. Deposition data included throughfall and bulk deposition. Soil solution was sampled using lysimeters in the same intervals as deposition. For different soil depths annual mean concentrations and their exceedances of critical limits published in the scientific literature were assessed. Results show a clear relation between N deposition and the occurrence of high nitrate concentrations below the rooting zone indicating N saturation at the particular sites. Nutrient imbalances related to high nitrate concentrations could be substantiated. Mg deficiencies occur more frequently on coniferous plots with exceedances of critical limits for nitrate in the soil solution. Also for beech trees the percentage of plots with low Mg amounts is higher on plots with critical limit exceedances. For spruce, pine, beech and oak there is a tendency towards less optimal Mg/N ratios with increasing exceedances of critical limits for nitrate in the soil solution. The share of trees with light green to yellow discolouration is higher when critical limits for nutrient imbalances are exceeded. The share of trees showing insect damage is related to the exceedance of critical levels for the BC/Al ratio.

Crown condition is the most widely applied indicator for forest health and vitality in Europe. Mean defoliation of 135,388 sample trees on 6,807 transnational Level I plots was 19.5%. Of all trees assessed a share of 20.0% was scored as damaged, i. e. had a defoliation of more than 25%. Of the main species groups, deciduous temperate oak species had by far the highest mean defoliation (24.4%), followed by deciduous Sub-Mediterranean oak species (22.0%), and evergreen oak species (21.2%). A mean defoliation of 20.7% was assessed for *Fagus sylvatica*. Coniferous species had lower defoliation, with Mediterranean lowland pine species showing 20.4%, followed by *Picea abies* (18.6%), *Pinus sylvestris* (18.1%). These figures are not comparable to those of previous reports because of fluctuations in the plot sample, mainly due to changes in the participation of countries. Therefore, the long-term development of defoliation was calculated from the monitoring results of those countries which have been submitting data since 1992 every year without interruption. While defoliation of *Scots pine* and

Norway spruce decreased, defoliation of *Fagus sylvatica* and the oak species groups increased since 1992.

In addition to defoliation, crown condition assessments comprise discolouration as well as damage caused by biotic and abiotic factors. Among the different damage factors, insects and fungi are the most frequent ones.

1. Introduction

Forest condition in Europe has been monitored since 1986 by the International Co-operative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) in the framework of the Convention on Long-range Transboundary Air Pollution (CLRTAP) under the United Nations Economic Commission for Europe (UNECE). The number of countries participating in ICP Forests has meanwhile grown to 42 including Canada and the United States of America, rendering ICP Forests one of the largest biomonitoring networks of the world. ICP Forests has been chaired by Germany from the beginning on. The Institute for World Forestry of the Johann Heinrich von Thünen-Institute (TI) hosts the Programme Coordinating Centre (PCC) of ICP Forests. The work of ICP Forests was frequently co-financed by the European Commission (EC) or even conducted in close cooperation with it.

Aimed mainly at the assessment of effects of air pollution on forests, ICP Forests provides scientific information to CLRTAP as a basis of legally binding protocols on air pollution abatement policies. For this purpose ICP Forests developed a harmonised monitoring approach comprising a large-scale forest monitoring (Level I) as well as a forest ecosystem forest monitoring (Level II) approach laid down in the ICP Forests Manual. The participating countries submit their monitoring data to PCC for validation, storage, and analysis.

While ICP Forests - in line with its obligations under CLRTAP - focuses on air pollution effects, its monitoring approach was extended towards assessments of forest information related to carbon budgets, climate change, and biodiversity. This was accomplished in close cooperation with the EC LIFE project "FutMon" in the years 2009 to 2011. ICP Forests delivers also information to processes of international environmental politics other than CLRTAP. This holds true in particular for the provision of information on several indicators for sustainable forest management laid down by Forest Europe (FE).

The present report describes the results of the latest analyses of the ICP Forests large-scale (Level I) and forest ecosystem related (Level II) monitoring data. It is structured as follows:

Chapter 2 describes the Level I and Level II monitoring systems. Chapter 3 presents results of the 2011 crown condition survey including assessments of different damage causes. In Chapter 4 the spatial and temporal variation of sulphur and nitrogen deposition are described. Chapters 5 focus on the risks posed to forests by air pollution and climate change. Chapter 6 consists of national reports by the participating countries, focussing on crown condition in 2011 as well as its development and its causes. Maps, graphs and tables concerning the transnational and the national results are presented in the Annexes.

2. The monitoring system

2.1.Background

Martin Lorenz, Oliver Granke[1]

Forest monitoring in Europe has been conducted for 27 years according to harmonised methods and standards by the International Cooperative Programme on Assessment and Monitoring of Air Pollution effects on Forests (ICP Forests) of the Convention on Long-range Transboundary Air Pollution (CLRTAP) under the United Nations Economic Commission for Europe (UNECE). The monitoring results meet the scientific information needs of CLRTAP for clean air policies under UNECE. According to its strategy for the years 2007 to 2015, ICP Forests pursues the following two main objectives:

1. To provide a periodic overview of the spatial and temporal variation of forest condition in relation to anthropogenic and natural stress factors (in particular air pollution) by means of European-wide (transnational) and national large-scale representative monitoring on a systematic network (monitoring intensity Level I).
2. To gain a better understanding of cause-effect relationships between the condition of forest ecosystems and anthropogenic as well as natural stress factors (in particular air pollution) by means of intensive monitoring on a number of permanent observation selected in most important forest ecosystems in Europe (monitoring intensity Level II).

The complete methods of forest monitoring by ICP Forests are described in detail in the "Manual on methods and criteria for harmonised sampling, assessment, monitoring and analysis of the effects of air pollution on forests" (ICP Forests 2010). For many years forest monitoring according to the ICP Forests Manual was conducted jointly by ICP Forests and the European Commission (EC) based on EU - cofinancing under relevant Council and Commission Regulations. The monitoring results are also delivered to processes and bodies of international forest and environmental policies other than CLRTAP, such as Forest Europe (FE), the Convention on Biological Diversity (CBD), the UN-FAO Forest Resources Assessment (FRA), and EUROSTAT of EC. In order to better meet the new information needs with respect to carbon budgets, climate change, and biodiversity, the forest monitoring system was further developed in the years 2009 to 2011 within the project "Further Development and Implementation of an EU-level Forest Monitoring System" (FutMon) under EU-cofinancing. The following chapters describe briefly the selection of sample plots and the surveys on the revised Level I and Level II monitoring networks.

2.2 Large-scale forest monitoring (Level I)

The large-scale forest monitoring grid consists of more than 7500 plots. The selection of Level I plots is within the responsibility of the participating countries, but the density of the plots should resemble that of the previous 16 x 16 km grid. For this reason, the number of plots in each country should be equal to the forest area of the country (in km^2) divided by 256.

[1] See addresses in Annex III-4

By the end of FutMon in June 2011, 58% of the Level I plots in the EU-Member States were coincident with NFI plots. No coincidence with NFI plots was given for 29% of the plots. It is expected, however, that a number of countries will merge these plots with NFI plots at a later date. For the remaining plots no information was made available (Fig. 2.2-1).

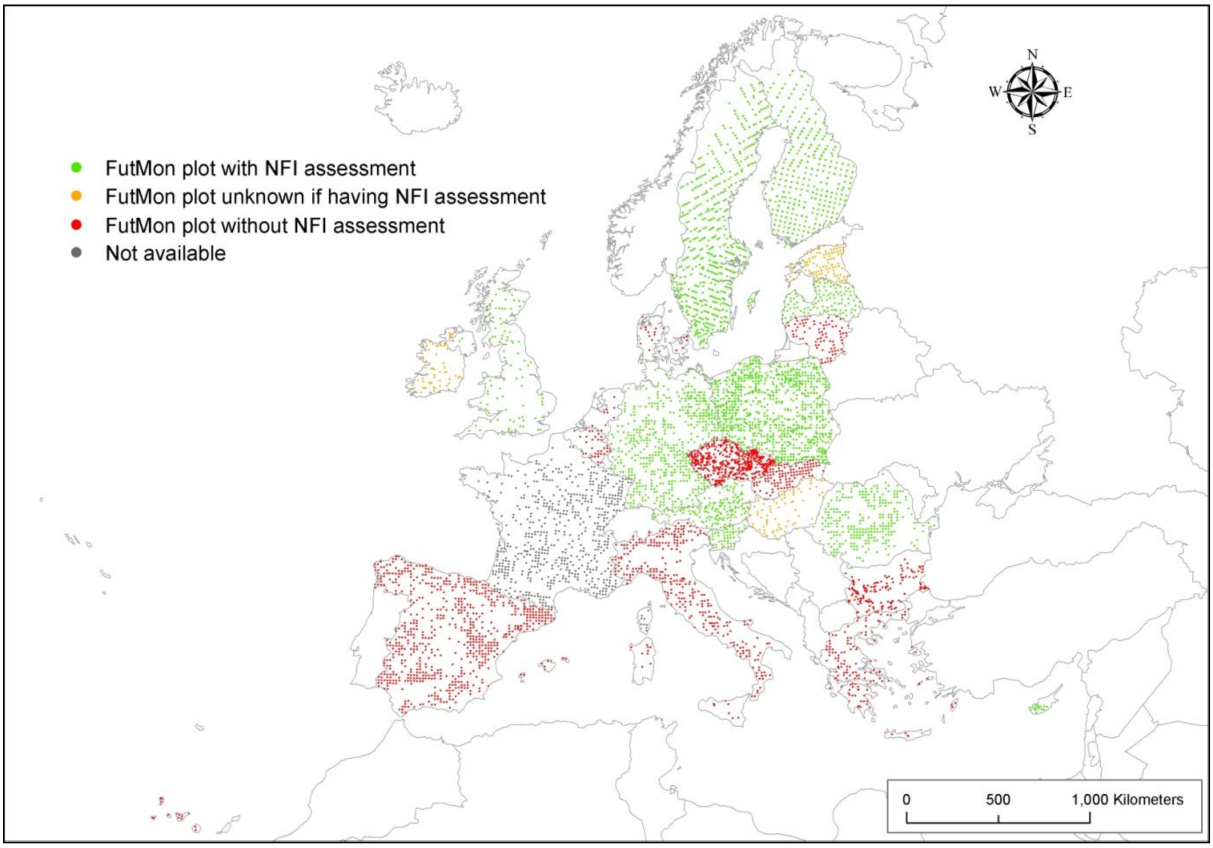

Figure 2.2-1: Spatial distribution of the large-scale plots under FutMon. Green colour implies a coincidence with NFI plots.

On most of the Level I plots tree crown condition is assessed every year. In 1995, element contents in needles and leaves were assessed on about 1500 plots and a forest soil condition survey was carried out on about 3500 plots. The Level I soil condition survey was repeated on about 5300 plots in 2005 and 2006 and the species diversity of forest ground vegetation was assessed on about 3400 plots in 2006 under the Forest Focus Regulation of EC within the BioSoil project (Fig. 2.2-2).

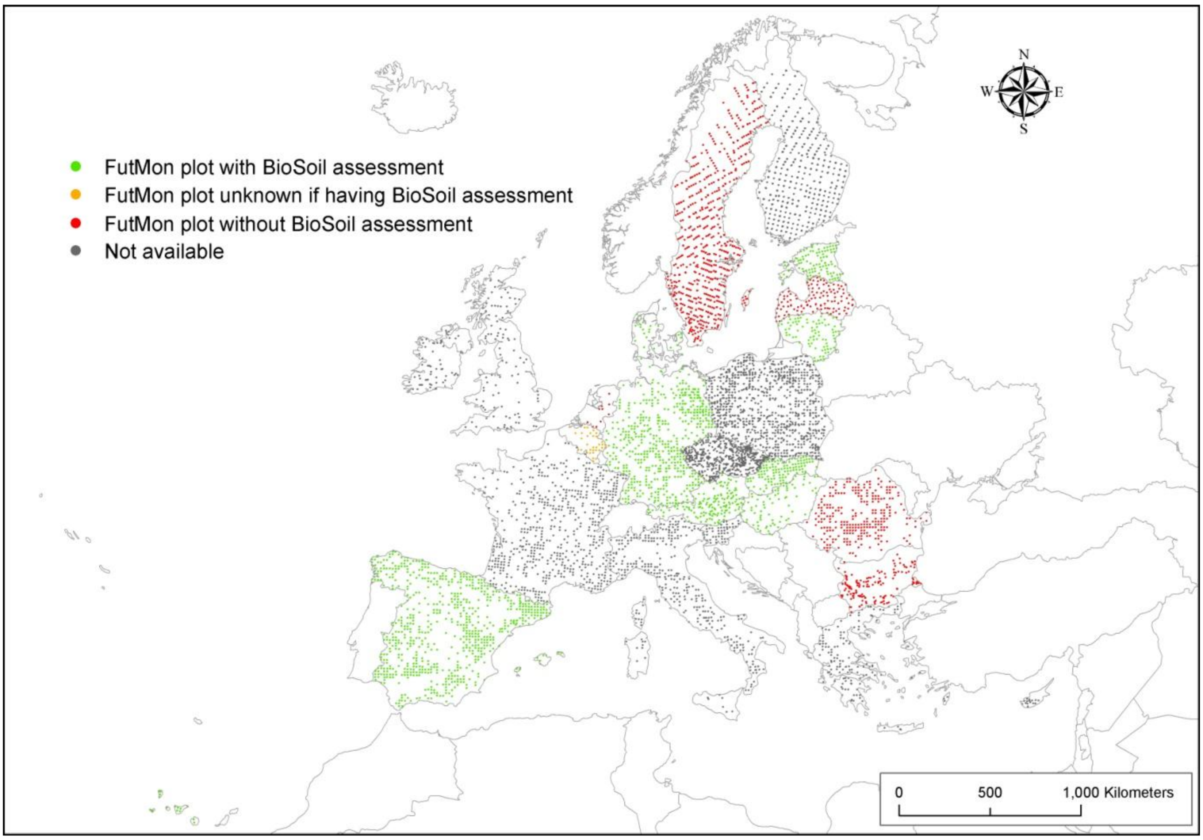

Figure 2.2-2: Spatial distribution of the large-scale plots under FutMon. Green colour implies inclusion in the BioSoil project under the Forest Focus Regulation of EC.

2.3 Forest ecosystem monitoring (Level II)

The number of forest ecosystem monitoring (Level II) plots in the data base is 938 including plots with different assessment intensities and a number of abandoned plots as well. On the plots up to 17 surveys are conducted (Tab. 2.3.-1). Of these surveys many are not conducted continuously or annually, but are due only every few years. The complete set of surveys, however, is carried out on only about 100 Level II "core plots". The map in Fig. 2.3-1 shows those plots on which crown condition was assessed in 2009, coming close to the total of all Level II plots assessed in 2009. Moreover, the map indicates the locations of Level II plots of previous years.

Table 2.3-1: Surveys and assessment frequencies in 2010

Survey	Data submitted for 2010	Assessment frequency
Crown condition	565	Annually
Foliar chemistry	115	Every two years
Soil condition	60	Every ten years
Soil solution chemistry	206	Continuously
Tree growth	100	Every five years
Deposition	311	Continuously
Ambient air quality (active)	164	Continuously
Ambient air quality (passive)	211	Continuously
Ozone induced injury	124	Annually
Meteorology	249	Continuously
Phenology	131	Several times per year
Ground vegetation	254	Every five years
Litterfall	172	Continuously
Nutrient budget of ground vegetation	92	Once
Leaf Area Index	145	Once
Soil Water	44	Once
Extended Tree Vitality	117	Annually/ Continuously

Figure 2.3-1: Level II plots with crown condition assessments in 2009. Also shown are plots with other surveys and of previous years.

2.4. References

ICP Forests (2010) Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests. UNECE, ICP Forests, Hamburg. ISBN: 978-3-926301-03-1, [http://www.icp-forests.org/Manual.htm]

3. Tree crown condition and damage causes

Georg Becher, Martin Lorenz, Stefan Meining, Richard Fischer[1]

3.1. Large scale tree crown condition

3.1.1. Methods of the 2011 survey

The annual transnational tree condition survey was conducted on 6 807 plots in 28 countries including 19 EU-Member States (Tab. 3.1.1-1). The assessment was carried out under national responsibilities according to harmonized methods laid down in ICP Forests. Prior to the evaluation all data were checked for consistency by the participating countries and submitted online to the Programme Coordinating Centre at the Institute for World Forestry in Hamburg, Germany.

Table 3.1.1-1: Number of sample plots assessed for crown condition from 1999 to 2011

Country	Number of plots assessed												
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Austria	130	130	130	133	131	136	136	135				135	
Belgium	30	29	29	29	29	29	29	27	27	26	26	9	9
Bulgaria	114	108	108	98	105	103	102	97	104	98	159	159	159
Cyprus			15	15	15	15	15	15	15	15	15	15	15
Czech Rep.	139	139	139	140	140	140	138	136	132	136	133	132	136
Denmark	23	21	21	20	20	20	22	22	19	19	16	17	18
Estonia	91	90	89	92	93	92	92	92	93	92	92	97	98
Finland	457	453	454	457	453	594	605	606	593	475	886	932	717
France	544	516	519	518	515	511	509	498	504	508	500	532	544
Germany	433	444	446	447	447	451	451	423	420	423	412	411	404
Greece	93	93	92	91			87				97	98	
Hungary	62	63	63	62	62	73	73	73	72	72	73	71	72
Ireland	20	20	20	20	19	19	18	21	30	31	32	29	
Italy	239	255	265	258	247	255	238	251	238	236	252	253	253
Latvia	98	94	97	97	95	95	92	93	93	92	207	207	203
Lithuania	67	67	66	66	64	63	62	62	62	70	72	75	77
Luxembourg	4	4		4	4	4	4	4	4	4			
Netherlands	11	11	11	11	11	11	11	11			11	11	
Poland	431	431	431	433	433	433	432	376	458	453	376	374	367
Portugal*	149	149	150	151	142	139	125	124					
Romania	238	235	232	231	231	226	229	228	218		227	239	242
Slovak Rep.	110	111	110	110	108	108	108	107	107	108	108	108	109
Slovenia	41	41	41	39	41	42	44	45	44		44	44	44
Spain**	611	620	620	620	620	620	620	620	620	620	620	620	620
Sweden	764	769	770	769	776	775	784	790			857	830	640
United Kingdom	85	89	86	86	86	85	84	82	32			76	
EU	4.984	4.982	5.004	4.997	4.887	5.039	5.110	4.938	3.885	3.478	5.215	5.474	4.727
Andorra						3		3	3	3	3	3	3
Belarus	408	408	408	407	406	406	403	398	400	400	409	410	416
Croatia	84	83	81	80	78	84	85	88	83	84	83	83	92
Moldova	10	10	10										
Montenegro												49	49
Norway	381	382	408	414	411	442	460	463	476	481	487	491	496
Russian Fed.											365	288	295
Serbia					103	130	129	127	125	123	122	121	119
Switzerland	49	49	49	49	48	48	48	48	48	48	48	48	47
Turkey									43	396	560	554	563
Total Europe	5.916	5.914	5.960	5.947	5.933	6.152	6.235	6.065	5.063	5.013	7.292	7.521	6.807

* including Azores, **including Canares

[1] See addresses in Annex III-4

Similar to the previous Forest Condition Report, data on forest damage causes collected in 2011 are analysed and detailed results presented in Chapter 3.2.

The spatial distribution of the plots assessed in 2011 is shown in Fig. 3.1.1-1.For certain analyses of defoliation, the Level I plots are stratified according to the European Forest Types (EFT). The system of EFT was developed in 2006 by the European Environment Agency (EEA) of the European Union in cooperation with experts from some European countries co-ordinated by the Italian Academy of Forest Sciences. After improvements and refinements based on experts' knowledge and information gained from NFIs plots, forest maps and forest management plans, the classification of European forests into forest types became operational. The system of the European Forest Types consists of 14 categories, representing groups of ecologically distinct forest communities dominated by specific assemblages of trees. The classification is conceived to categorize stocked forest land, with the help of classification keys mainly based on forest dominant tree species (Tab. 3.1.1-2).

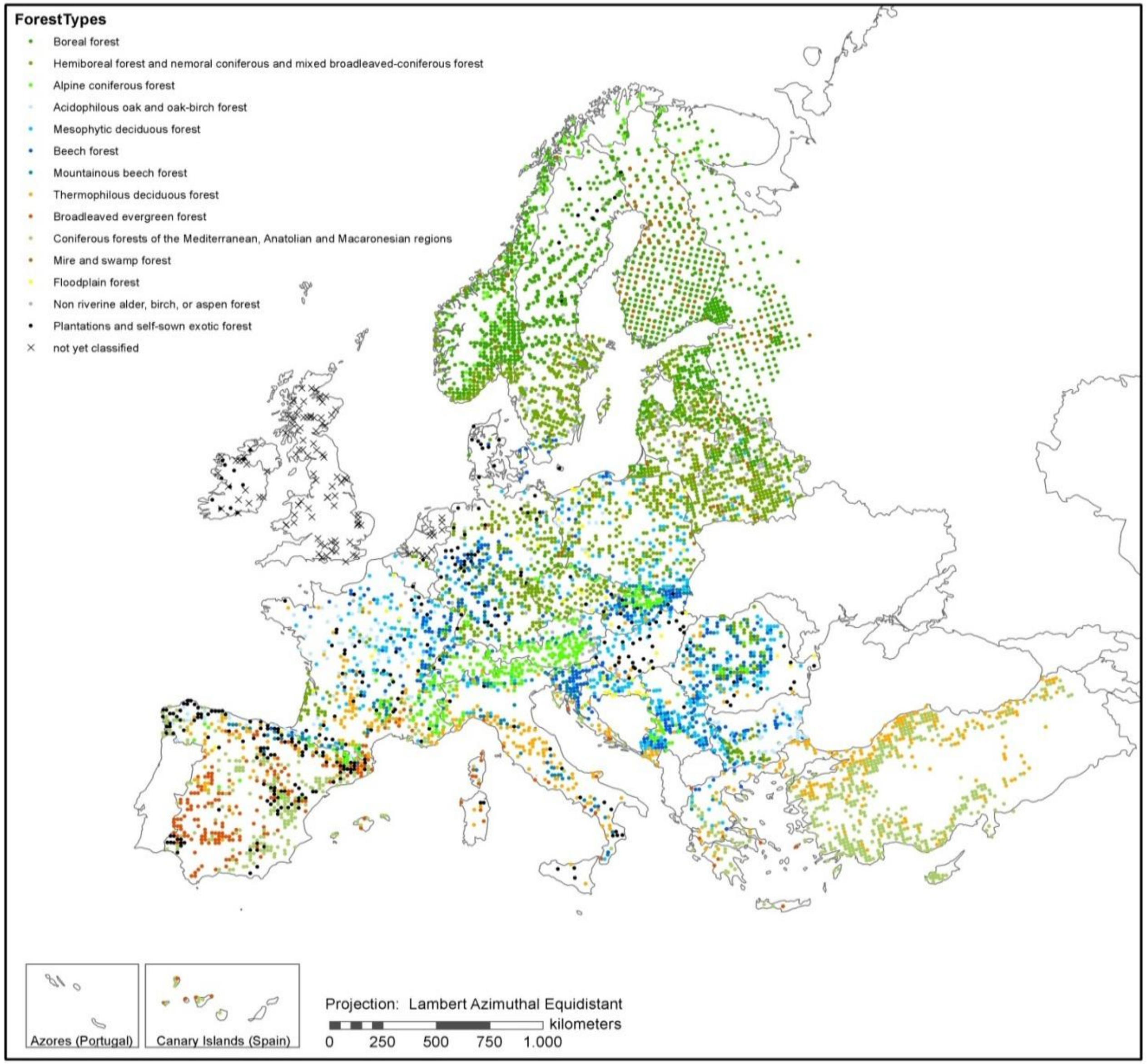

Figure 3.1.1-1: Plots according to European Forests Types (2011).

Table 3.1.1-2: Description of the European Forest Types (EFT).

Forest type category	Main characteristics
1. Boreal forest	Extensive boreal, species-poor forests, dominated by Picea abies and Pinus sylvestris. Deciduous trees including birches (Betula spp.), aspen (Populus tremula), rowan (Sorbus aucuparia) and willows (Salix spp.) tend to occur as early colonisers.
2. Hemiboreal and nemoral coniferous and mixed broad-leaved-coniferous forest	Latitudinal mixed forests located in between the boreal and nemoral (or temperate) forest zones with similar characteristics to EFT 1, but a slightly higher tree species diversity, including also temperate deciduous trees like Tilia cordata, Fraxinus excelsior, Ulmus glabra and Quercus robur. Includes also: pure and mixed forests in the nemoral forest zone dominated by coniferous species native within the borders of individual FOREST EUROPE member states like Pinus sylvestris, pines of the Pinus nigra group, Pinus pinaster, Picea abies, Abies alba.
3. Alpine forest	High-altitude forest belts of central and southern European mountain ranges, covered by Picea abies, Abies alba, Pinus sylvestris, Pinus nigra, Larix decidua, Pinus cembra and Pinus mugo. Includes also the mountain forest dominated by birch of the boreal region.
4. Acidophilous oak and oakbirch forest	Scattered occurrence associated with less fertile soils of the nemoral forest zone; the tree species composition is poor and dominated by acidophilous oaks (Q. robur, Q. petraea) and birch (Betula pendula).
5. Mesophytic deciduous forest	Related to medium rich soils of the nemoral forest zone; forest composition is mixed and made up of a relativelylarge number of broadleaved deciduous trees: Carpinus betulus, Quercus petraea, Quercus robur, Fraxinus, Acerand Tilia cordata.
6. Beech forest	Widely distributed lowland to submountainous beech forest. Beech, Fagus sylvatica and F. orientalis (Balkan) dominate, locally important is Betula pendula.
7. Mountainous beech forest	Mixed broadleaved deciduous and coniferous vegetation belt in the main European mountain ranges. Speciescomposition differs from EFT 6, including Picea abies, Abies alba, Betula pendula and mesophytic deciduous tree species. Includes also mountain fir dominated stands.
8. Thermophilous deciduous forest	Deciduous and semi-deciduous forests mainly of the Mediterranean region dominated by thermophilous species, mainly of Quercus; Acer, Ostrya, Fraxinus, Carpinus species are frequent as associated secondary trees. Includes also Castanea sativa dominated forest.
9. Broadleaved evergreen forest	Broadleaved evergreen forests of the Mediterranean and Macaronesian regions dominated by sclerophyllous or lauriphyllous trees, mainly Quercus species.
10. Coniferous forests of the Mediterranean, Anatolian and Macaronesian regions	Varied group of coniferous forests in Mediterranean, Anatolian and Macaronesian regions, from the coast to high mountains. Dry and often poorly-developed soils limit tree growth. Several tree species, including a number of endemics, of Pinus, Abies and Juniperus species.
11. Mire and swamp forest	Wetland forests on peaty soils widely distributed in the boreal region. Water and nutrient regimes determine the dominant tree species: Pinus sylvestris, Picea abies or Alnus glutinosa.
12. Floodplain forest	Riparian and riverine species-rich forests characterised by different assemblages of species of Alnus, Betula, Populus, Salix, Fraxinus, Ulmus.
13. Non-riverine alder, birch or aspen forest	Pioneer forests dominated by Alnus, Betula or Populus.
14. Introduced tree species Forest	Forests dominated by introduced trees above categories. Introduced tree species can be identified at regional (recommended) or national level.

Defoliation: scientific background for its assessment and analysis

Defoliation reflects a variety of natural and human induced environmental influences. It would therefore be inappropriate to attribute it to a single factor such as air pollution without additional evidence. As the true influence of site conditions and the share of tolerable defoliation cannot be quantified precisely, damaged trees cannot be distinguished from healthy ones only by means of a certain defoliation threshold. Consequently, the 25% threshold for defoliation does not necessarily identify trees damaged in a physiological sense. Some differences in the level of damage across national borders may be at least partly due to differences in standards used. This restriction, however, does not affect the reliability of trends over time.

Natural factors strongly influence crown condition. As also stated by many participating countries, air pollution is thought to interact with natural stressors as a predisposing or accompanying factor, particularly in areas where deposition may exceed critical loads for acidification (CHAPPELKA and FREER-SMITH, 1995, CRONAN and GRIGAL, 1995, FREER-SMITH, 1998).

It has been suggested that the severity of forest damage has been underestimated as a result of the replacement of dead trees by living trees in the course of regular forest management activities. However, detailed statistical analyses of the results of 10 monitoring years have revealed that the number of dead trees has remained so small that their replacement has not influenced the results notably (LORENZ et al., 1994).

Classification of defoliation data

The results of the evaluations of the crown condition data are presented in terms of mean plot defoliation or the percentages of the trees falling into 5%-defoliation steps. In previous presentations of survey results, partly the traditional classification of both defoliation and discolouration had been applied, although it is considered arbitrary by some countries. This classification (Tab. 3.1.1-3) is a practical convention, as real physiological thresholds cannot be defined.

Table 3.1.1-3: Defoliation and discolouration classes according to UNECE and EU classification

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
Discolouration class	**foliage discoloured**	**degree of discolouration**
0	up to 10 %	none
1	> 10 - 25 %	slight
2	> 25 - 60 %	moderate
3	> 60 %	severe
4		dead

In order to discount background perturbations which might be considered minor, a defoliation of >10-25% is considered a warning stage, and a defoliation > 25% is taken as a threshold for damage. Therefore, in the present report a distinction has sometimes only been made between defoliation classes 0 and 1 (0-25% defoliation) on the one hand, and classes 2, 3 and 4 (defoliation > 25%) on the other hand.

Classically, trees in classes 2, 3 and 4 are referred to as "damaged", as they represent trees with considerable defoliation. In the same way, the sample points are referred to as "damaged" if the mean defoliation of their trees (expressed as percentages) falls into class 2 or higher. Otherwise the sample point is considered as "undamaged". The most important results have been tabulated separately for all countries participated (called "all plots") and for the participating EU-Member States.

3.1.2. Results of the transnational crown condition survey in 2011

On each sampling point sample trees were selected according to national procedures and assessed for defoliation. According to Tab. 3.1.2-1 the defoliation assessment was carried out in 28 countries including 135 388 trees. The figures in Tab. 3.1.2-1 are not necessarily identical with those published in the reports of the past years since in case of a restructure of the national observation networks a resubmission of older data is possible.

Table 3.1.2-1: Number of sample trees from 1999 to 2011 according to the current data base

Country	Number of sample trees												
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Austria	3.535	3.506	3.451	3.503	3.470	3.586	3.528	3.425				3.087	
Belgium	696	686	682	684	684	681	676	618	616	599	599	216	230
Bulgaria	4.344	4.197	4.174	3.720	3.836	3.629	3.592	3.510	3.569	3.304	5.560	5.569	5.583
Cyprus			360	360	360	360	361	360	360	360	362	360	360
Czech Rep.	3.475	3.475	3.475	3.500	3.500	3.500	3.450	3.425	3.300	3.400	3.325	3.300	3.400
Denmark	552	504	504	480	480	480	528	527	442	452	384	408	432
Estonia	2.184	2.160	2.136	2.169	2.228	2.201	2.167	2.191	2.209	2.196	2.202	2.348	2.372
Finland	8.662	8.576	8.579	8.593	8.482	11.210	11.498	11.489	11.199	8.812	7.182	7.946	4.217
France	10.883	10.317	10.373	10.355	10.298	10.219	10.129	9.950	10.074	10.138	9.949	10.584	11.111
Germany	13.466	13.722	13.478	13.534	13.572	13.741	13.630	10.327	10.241	10.347	10.088	10.063	9.635
Greece	2.192	2.192	2.168	2.144			2.054				2.289	2.311	
Hungary	1.470	1.488	1.469	1.446	1.446	1.710	1.662	1.674	1.650	1.661	1.668	1.626	1.702
Ireland	417	420	420	424	403	400	382	445	646	679	717	641	
Italy	6.710	7.128	7.350	7.165	6.866	7.109	6.548	6.936	6.636	6.579	6.794	8.338	8.454
Latvia	2.348	2.256	2.325	2.340	2.293	2.290	2.263	2.242	2.228	2.184	3.911	3.888	3.778
Lithuania	1.613	1.609	1.597	1.583	1.560	1.487	1.512	1.505	1.507	1.688	1.734	1.814	1.846
Luxembourg	96	96		96	96	96	97	96	96	96			
Netherlands	225	218	231	232	231	232	232	230			247	227	
Poland	8.620	8.620	8.620	8.660	8.660	8.660	8.640	7.520	9.160	9.036	7.520	7.482	7.342
Portugal	4.470	4.470	4.500	4.530	4.260	4.170	3.749	3.719					
Romania	5.712	5.640	5.568	5.544	5.544	5.424	5.496	5.472	5.232		5.448	5.736	5.808
Slovak Rep.	5.063	5.157	5.054	5.076	5.116	5.058	5.033	4.808	4.904	4.956	4.944	4.831	5.218
Slovenia	984	984	984	936	983	1.006	1.056	1.069	1.056		1.056	1.052	1.057
Spain	14.664	14.880	14.880	14.880	14.880	14.880	14.880	14.880	14.880	14.880	14.880	14.880	14.880
Sweden	11.135	11.361	11.283	11.278	11.321	11.255	11.422	11.186			2.591	2.742	2.057
United Kingdom	2.039	2.136	2.064	2.064	2.064	2.040	2.016	1.968	768			1.803	
EU	115.555	115.798	115.725	115.296	112.633	115.424	116.601	109.572	90.773	81.367	93.450	101.252	89.482
Andorra						72		74	72	72	73	72	72
Belarus	9.745	9.763	9.761	9.723	9.716	9.682	9.484	9.373	9.424	9.438	9.615	9.617	9.583
Croatia	2.015	1.991	1.941	1.910	1.869	2.009	2.046	2.109	2.013	2.015	1.991	1.992	2.208
Moldova	259	234	234										
Montenegro												1.176	1.176
Norway	4.052	4.051	4.304	4.444	4.547	5.014	5.319	5.525	5.824	6.085	6.014	6.330	6.463
Russian Fed.											11.016	8.958	9.275
Serbia					2.274	2.915	2.995	2.902	2.860	2.788	2.751	2.786	2.742
Switzerland	857	855	834	827	806	748	807	812	790	773	801	795	1.105
Turkey									941	9.291	13.156	12.974	13.282
Total Europe	132.483	132.692	132.799	132.200	131.845	135.864	137.252	130.367	112.697	111.829	138.867	145.952	135.388

* including Azores, ** including Canares

The main results summarized in Tab. 3.1.2-2 show that the mean defoliation of all trees assessed in Europe was 19.5%. Broadleaved trees showed a higher mean defoliation (20.4%) than conifers (18.7%). With a share of 24.4% the deciduous temperate oak is the most damaged species group followed by the Mediterranean oak (24.2%) and *Fagus sylvatica* (20.7%). The spatial distribution of the two species groups depicted in Annex I-1 shows that in 2011 61.3% of the plots were dominated by coniferous and 38.7% by broadleaved trees.

The maps in Annex I-2 and Annex I-3 indicate that defoliation is highest on plots located in central and southern Europe. The largest shares (58.0%) are plots with mean defoliation ranging from 11 to 25%. The percentage of trees damaged i.e. trees defoliated by 25% and more is relatively low in northern Europe, whereas clusters of severely damaged trees are found in some parts of Czech Republic and France (Annex I-2).

Table 3.1.2-2: Percentages of trees in defoliation classes and mean defoliation for broadleaves, conifers and all species

		Percentage of trees in defoliation class							Defoliation		
	Species type		>10-25	0-25	>25-60	>60	dead	>25	mean	median	No of trees
EU	broadleaves	27.6	46.6	74.1	22.6	2.3	0.9	25.9	22.2	20	43 515
	conifers	30.8	46.7	77.5	20.3	1.4	0.8	22.5	20.4	15	44 855
	all species	29.2	46.6	75.8	21.4	1.9	0.9	24.2	21.3	20	88 370
Total Europe	*Fagus sylvatica*	34.6	39.8	74.4	23.4	1.8	0.5	25.6	20.7	20	11 764
	Deciduous temperate oak	20.7	47.2	68.0	28.9	1.8	1.4	32.0	24.4	20	9 025
	Deciduous (sub-) mediterranean oak	26.7	49.2	75.8	20.8	2.5	0.9	24.2	22.0	20	8 256
	Evergreen oak	20.7	61.5	82.3	14.9	2.1	0.7	17.7	21.2	15	4 744
	broadleaves	34.2	43.7	77.9	19.1	2.1	1.0	22.1	20.4	15	62 221
	Pinus sylvestris	35.1	49.1	84.3	14.0	0.9	0.9	15.7	18.1	15	31 010
	Picea abies	43.3	34.0	77.3	19.7	1.7	1.3	22.7	18.6	15	18 901
	Mediterranean lowland pines	24.6	59.2	83.8	13.7	0.9	1.6	16.2	20.4	15	8 847
	conifers	36.3	45.5	81.8	15.9	1.2	1.0	18.2	18.7	15	71 440
	all species	35.3	44.7	80.0	17.4	1.6	1.0	20.0	19.5	15	133 661

For the 5% defoliation classes including dead trees a frequency distribution was calculated. Fig. 3.1.2-1 indicates that about 20% of all species were defoliated by 15%. More conifers than broadleaves fell in 2011 in defoliation classes of up to 20%, whereas deciduous trees are more frequently represented in defoliation classes above 20%.

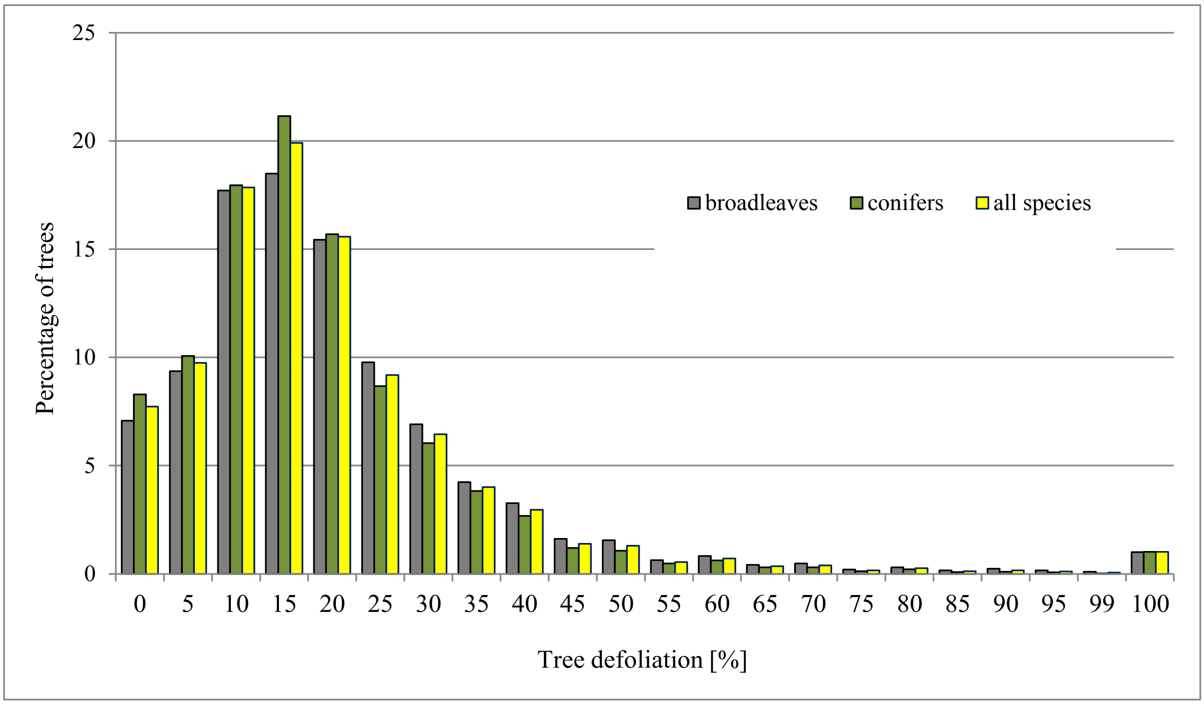

Figure 3.1.2-1: Relative frequency distribution of all trees assessed in 2011 in 5% defoliation steps

For the first time crown condition data were evaluated according to the European Forest Types (EFT) described in Tab. 3.1.1-2 of this report. Similar to other evaluations mean defoliation and the share of trees in damage categories were calculated in each of the 14 forest types. As indicated in Tab. 3.1.2-3 the highest mean defoliation was found in the broadleaved evergreen forests (24.2%), corresponding with the highest share of trees defoliated by 25% and more. The values of mean defoliation of the most forest types vary between 19 and 21%. The healthiest trees in terms of mean defoliation are in boreal forests with mean defoliation of 14.4% and the percentage of healthy trees of roughly 57%.

Table 3.1.2-3: Percentages of trees in defoliation classes and mean defoliation according to European Forest Types (EFT)

Forest type		Percentage of trees in defoliation class							mean defoliation
Code	Name	0-10	>10-25	0-25	>25-60	>60	dead	>25	
1	Boreal forest	56.8	32.4	89.2	7.8	1.3	1.7	10.8	14.4
2	Hemiboreal forest and nemoral coniferous and mixed broadleaved-coniferous forest	31.6	49.8	81.4	17.4	0.9	0.3	18.6	18.6
3	Alpine coniferous forest	29.5	40.7	70.2	26.8	2.2	0.9	29.8	22.6
4	Acidophilous oak and oak-birch forest	17.9	65.8	83.8	13.6	0.8	1.9	16.2	21.6
5	Mesophytic deciduous forest	31.8	41.2	73.0	23.7	2.2	1.1	27.0	21.6
6	Beech forest	37.5	40.1	77.6	20.3	1.5	0.6	22.4	19.4
7	Mountainous beech forest	30.6	42.5	73.1	24.1	2.4	0.4	26.9	21.8
8	Thermophilous deciduous forest	28.3	49.3	77.6	19.0	2.2	1.2	22.4	21.7
9	Broadleaved evergreen forest	24.2	43.2	67.4	28.8	3.4	0.5	32.6	24.2
10	Coniferous forests of the Mediterranean, Anatolian and Macaronesian regions	30.5	57.2	87.7	10.4	0.8	1.2	12.3	18.5
11	Mire and swamp forest	45.7	40.1	85.8	12.4	1.0	0.9	14.2	16.4
12	Floodplain forest	31.3	44.2	75.5	20.9	2.2	1.5	24.5	21.4
13	Non riverine alder, birch, or aspen forest	36.0	55.2	91.3	7.3	0.9	0.5	8.7	16.3
14	Plantations and self-sown exotic forest	42.2	39.7	81.9	14.0	1.2	2.8	18.1	19.4

In view of the species richness (about 130) recorded within the transnational forest monitoring only the most abundant species could be evaluated. For other, also important but less abundant species the following groups were created and evaluated in this report:

- **Deciduous temperate oak:** (*Quercus robur* and *Q. petraea*) accounting together for 6.7% of the assessed trees,
- **Mediterranean lowland pines:** (*Pinus brutia, P. pinaster, P. halepensis* and *P. pinea*) accounting together for 6.1% of the assessed trees,
- **Deciduous (sub-) temperate oak:** (*Quercus frainetto, Q. pubescens, Q. pyrenaica* and *Q. cerris*) accounting together for 5.5% of the assessed trees,
- **Evergreen oak:** (*Quercus coccifera, Q. ilex, Q. rotundifolia* and *Q. suber*) accounting together for 3.9% of the assessed trees.

For all evaluations of related to a particular tree species a criterion had to be set up to decide if a given plot represents this species or not. This criterion was that the number of trees of the particular species had to be three or more per plot. The mean plot defoliation for the particular species was then calculated as the mean defoliation of the trees of the species on that plot based on sample size N ≥ 3.

In Fig. 3.1.2-2 to 3.1.2-8 mean plot defoliation for *Pinus sylvestris, Picea abies, Fagus sylvatica* and the four species groups **Deciduous temperate oak, Mediterranean lowland pines, Deciduous (sub-) temperate oak and Evergreen oak** (see above) is mapped. The spatial distribution of these species and species groups will be described in relation to Tab. 3.1.2-2. According to this table the highest level of mean defoliation had deciduous temperate oaks (24.4%). For the evergreen oaks a mean defoliation of 21.2% (Tab. 3.1.2-2) was calculated but the majority of the plots namely 71.1% have a mean defoliation lying between 11 and 25% (Fig. 3.1.2-8).

The mean defoliation value of *Pinus sylvestris* is relatively low (18.1%). The spatial distribution of plots defoliated by 26 to 40% shows clusters in central Europe, whereas healthy plots (0-10% defoliation) can mostly be found in Scandinavia, (Fig. 3.1.2-2).

Similar to *Pinus sylvestris* heavily damaged *Picea abies* plots are concentrated in central Europe. The distribution of healthy plots resembles that of *Pinus sylvestris* (Fig. 3.1.2-3).

Clustered occurrence of severely damaged *Fagus sylvatica* plots is in Germany (Fig. 3.1.2-5)

In the group of deciduous (sub-) Mediterranean oaks the most affected plots are in southern Europe. The share of plots in this species group showing negligible signs of crown transparency is less than 14 % (Fig. 3.1.2-7).

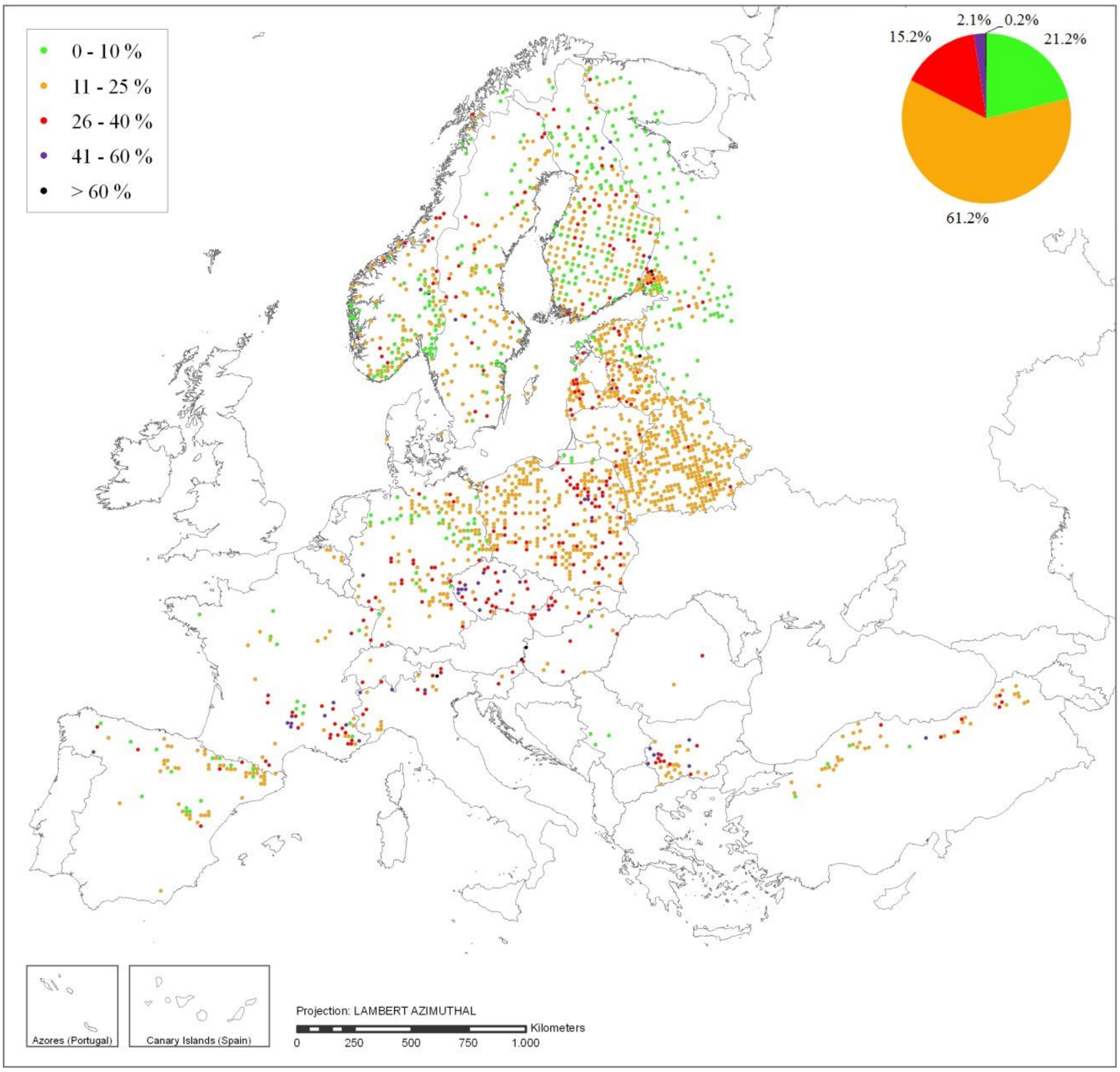

Figure 3.1.2-2: Mean plot defoliation for *Pinus sylvestris* (2011)

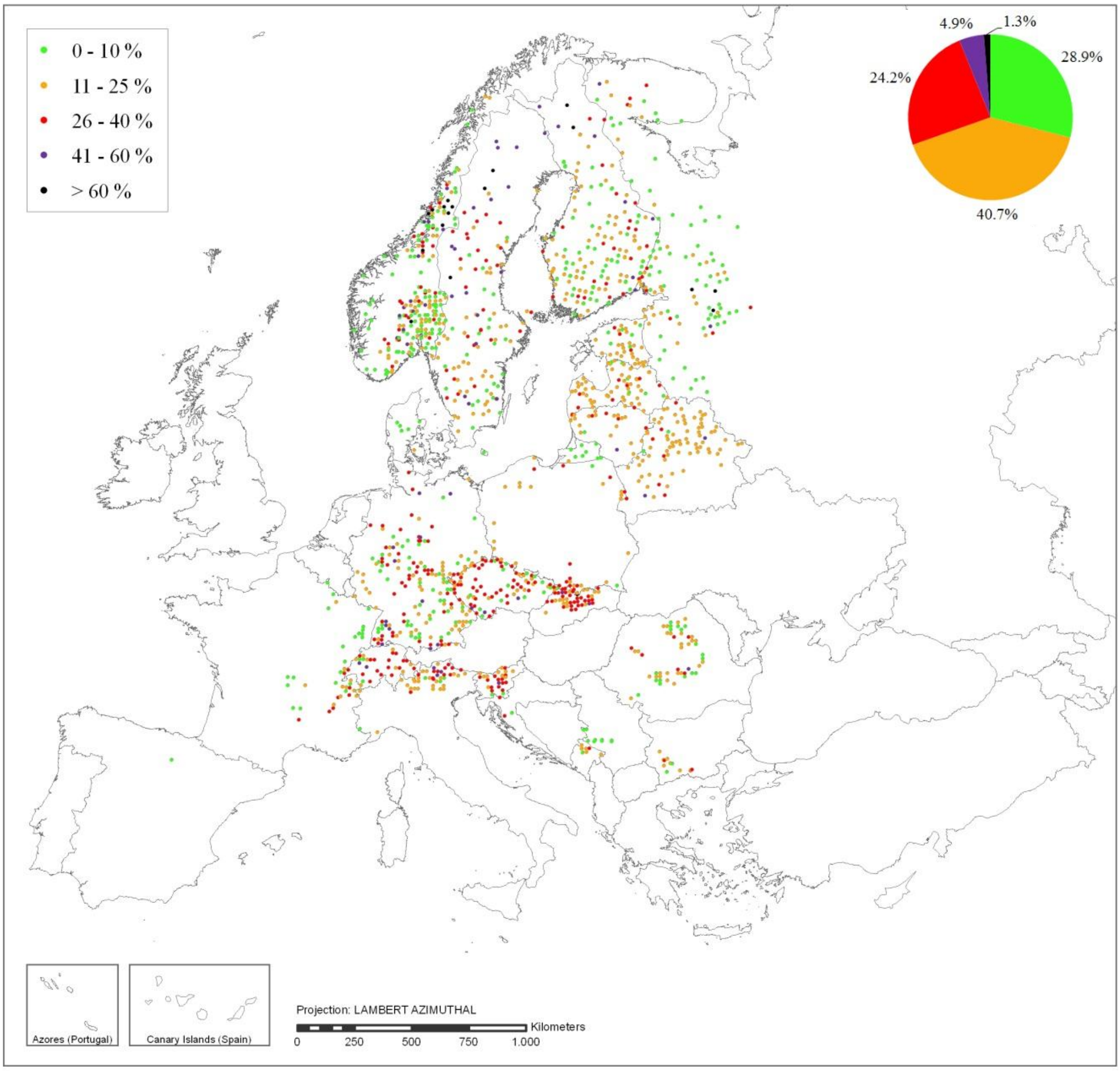

Figure 3.1.2-3: Mean plot defoliation for *Picea abies* (2011)

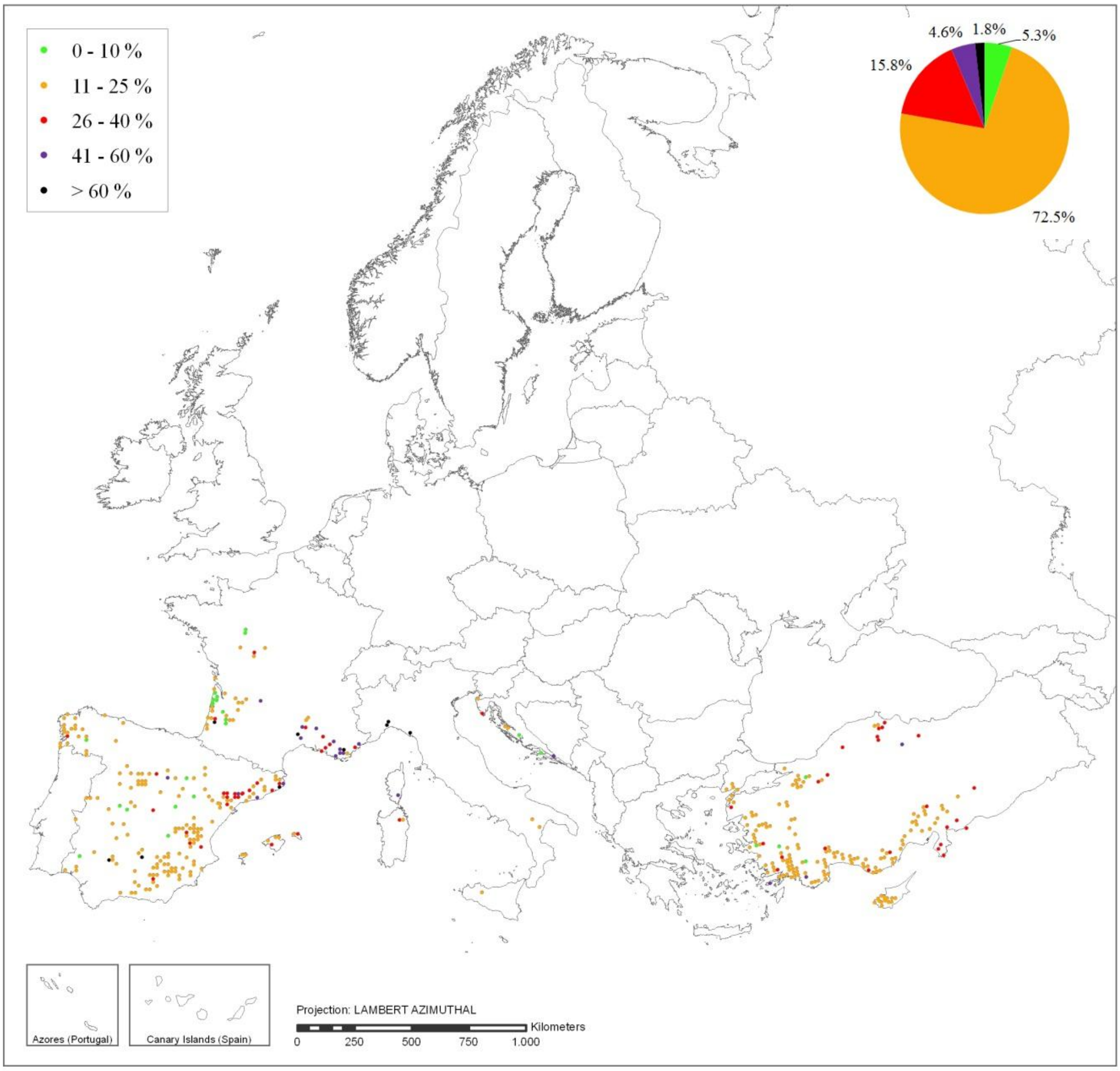

Figure 3.1.2-4: Mean plot defoliation for Mediterranean lowland pine *(Pinus brutia, Pinus halepensis, Pinus pinaster, Pinus pinea),* 2011

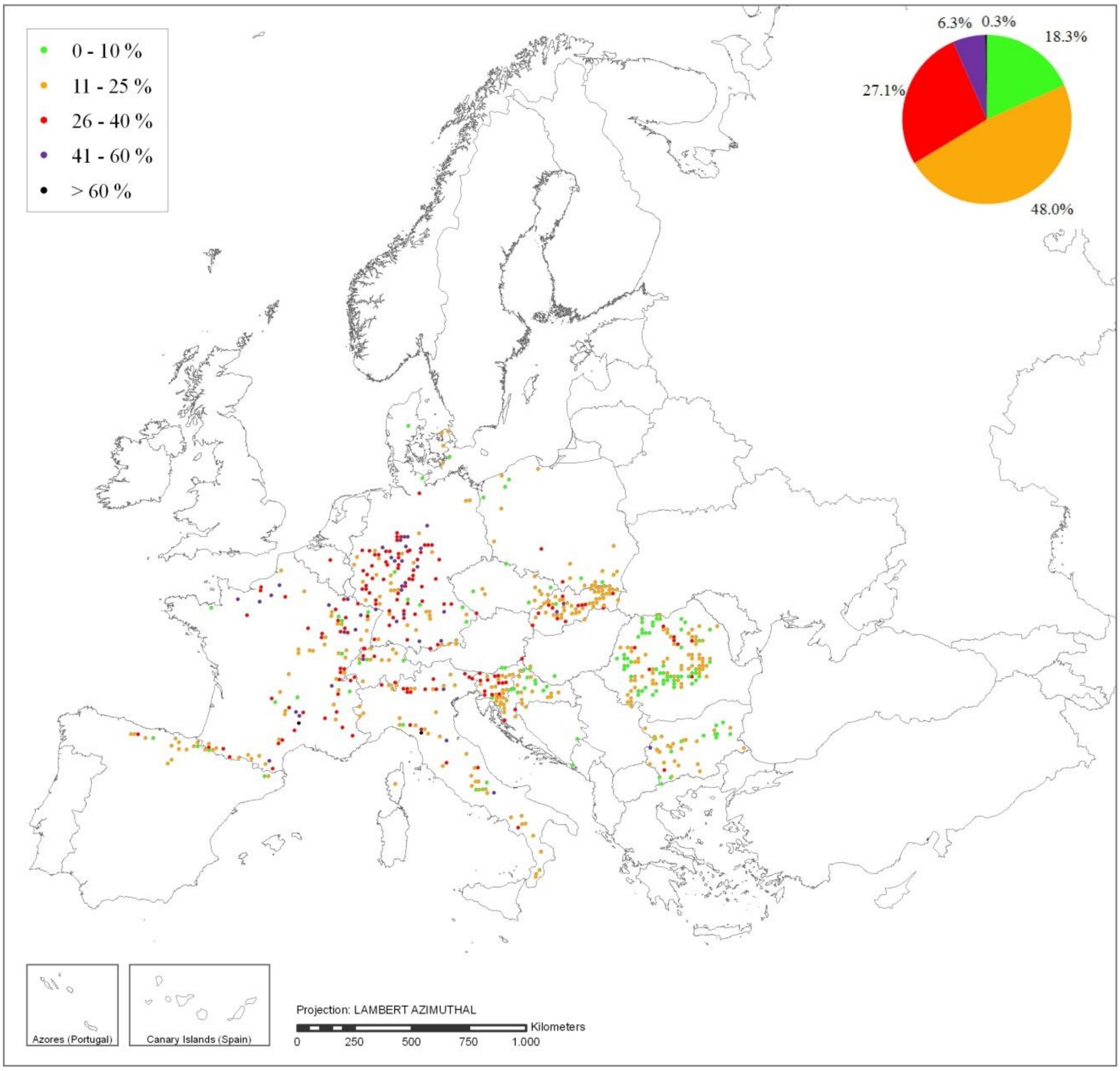

Figure: 3.1.2-5: Mean plot defoliation for *Fagus sylvatica* (2011)

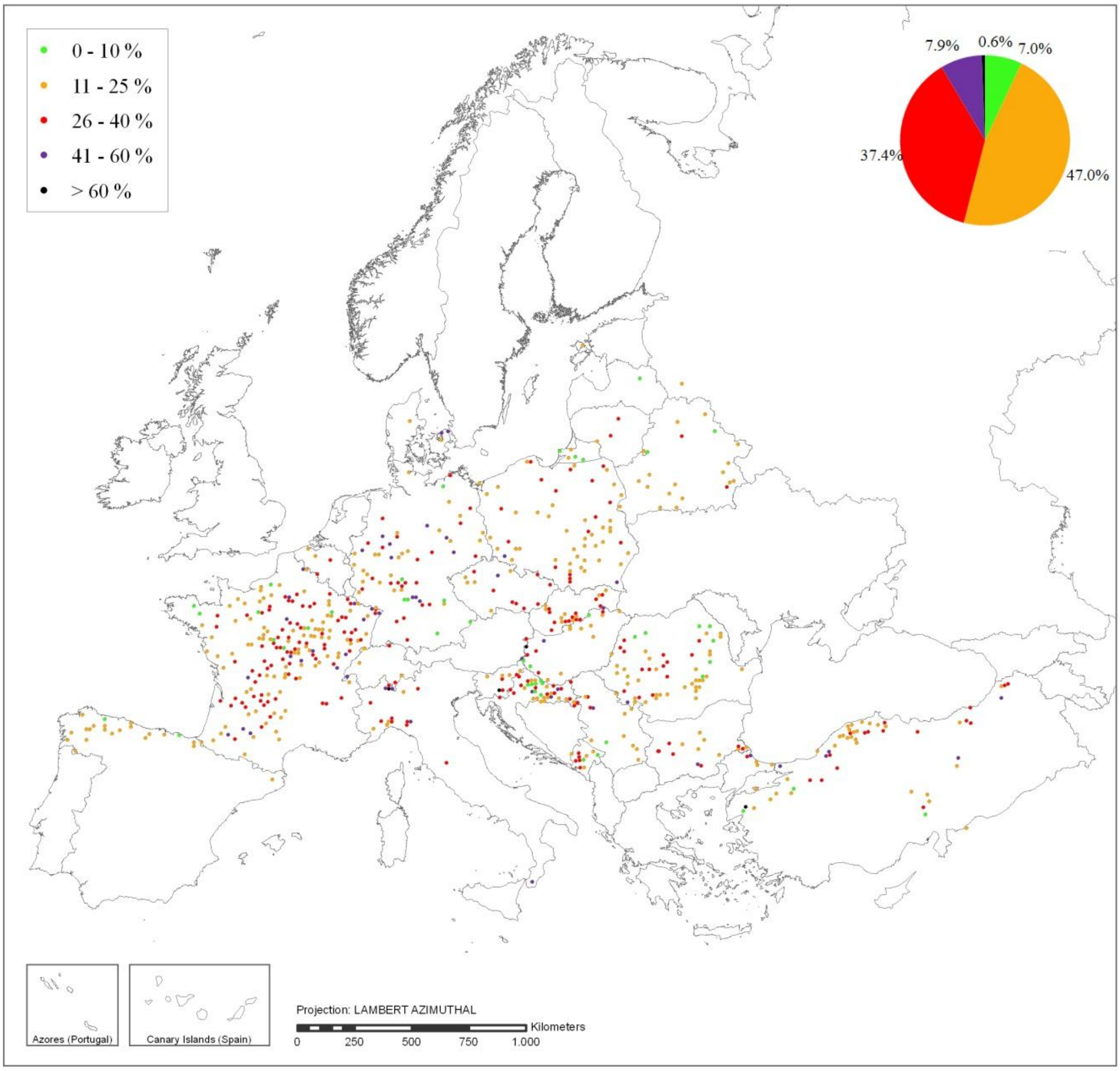

Figure 3.1.2-6: Mean plot defoliation for deciduous temperate oak *(Quercus petraea and Quercus robur),* 2011

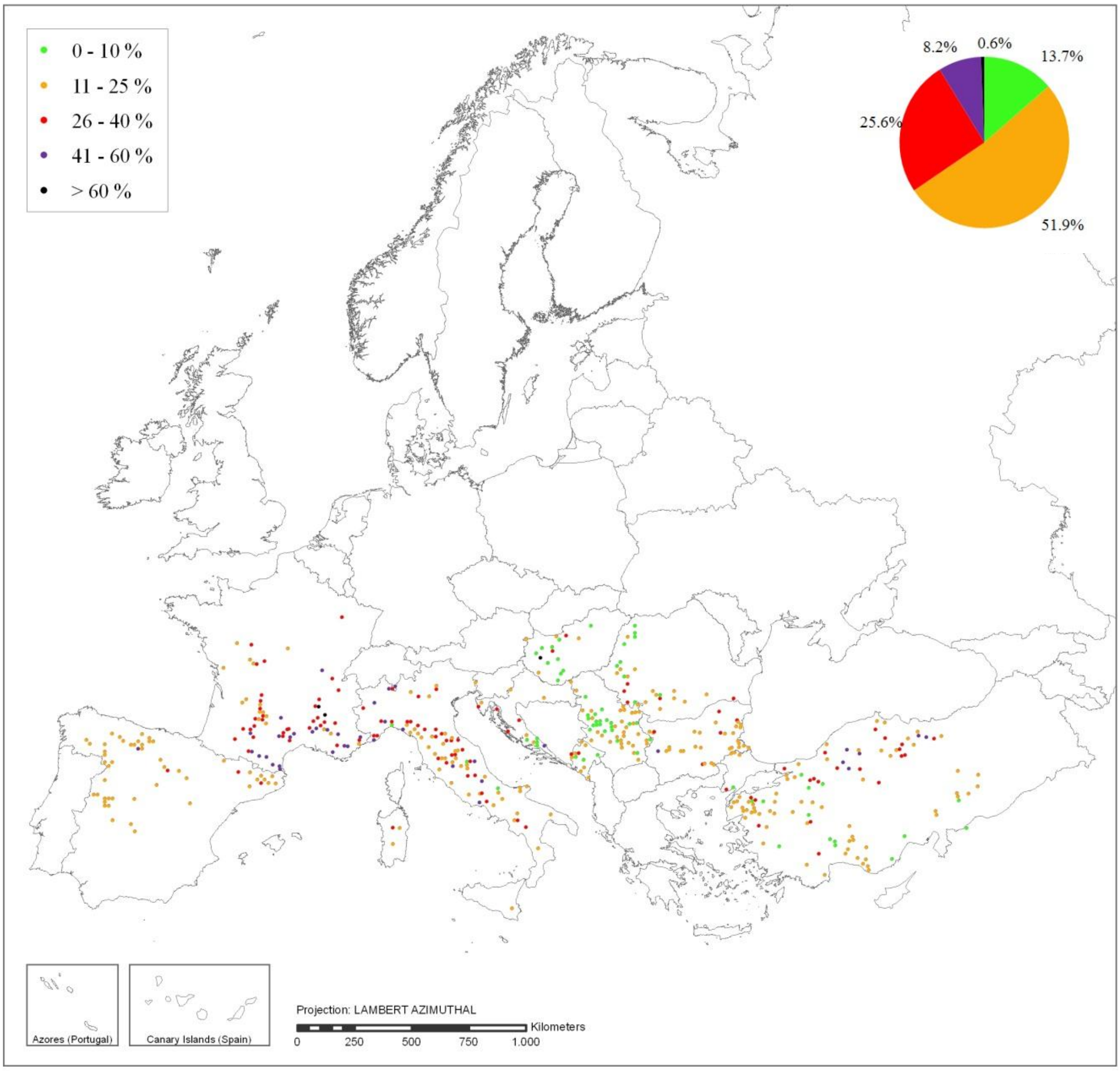

Figure 3.1.2-7: Mean plot defoliation for deciduous (sub-) Mediterranean oak (*Quercus cerris, Quercus frainetto, Quercus pubescens, Quercus pyrenaica*), 2011

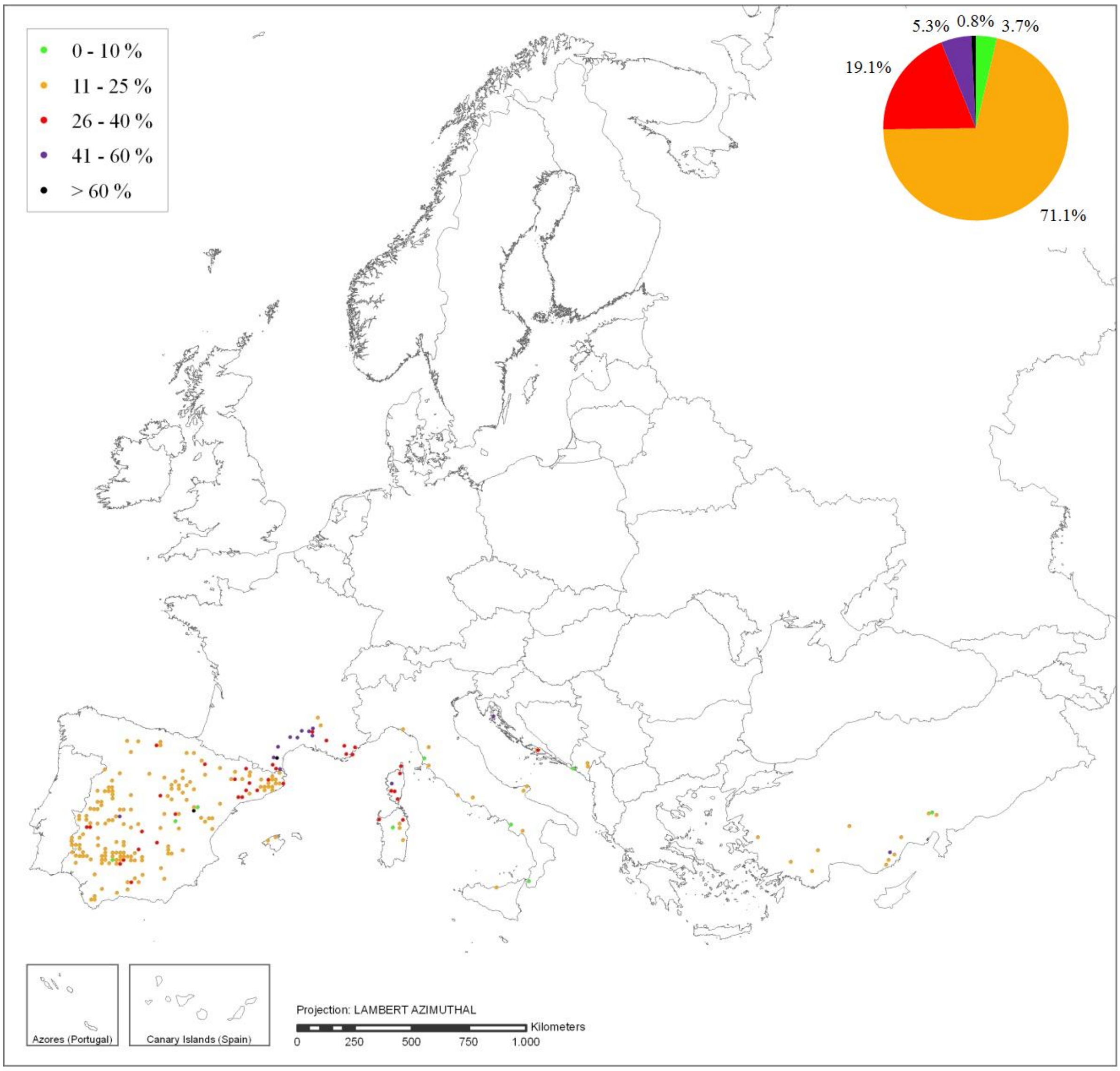

Figure 3.1.2-8: Mean plot defoliation for evergreen oak, temperate oak (*Quercus coccifera, Quercus ilex*, *Quercus rotundifolia, quercus suber*, 2011

3.1.3. Defoliation trends: time series

The development of defoliation is calculated assuming that the sample trees of each survey year reflect the influence of forest conditions. Studies carried out in the past years show that the fluctuation of trees in this sample (due to the exclusion of dead and felled trees as well as inclusion of replacement trees) does not cause bias or other distortions of the results over the years. However, fluctuations due to the inclusion of newly participating countries must be excluded, because forest condition among countries can deviate greatly. For this reason, the development of defoliation can only be calculated for defined sets of countries. Different lengths of time series require different sets of countries, because at the beginning of the surveys the number of participating countries was much smaller than it is today.

For the present evaluation the following three time periods and the following countries were selected for tracing the development of defoliation:

- **Period 1991-2011 ("long term period")**: Belgium, Czech Republic, Denmark, Finland, France[1], Germany, Hungary, Ireland, Italy, Latvia, Poland, Slovak Republic, Spain, and Switzerland.
- **Period 1997-2011 ("many countries"):** Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Norway, Poland, Slovak Republic, Spain, and Switzerland.
- **Period 2002-2011 ("short term period used to calculate the trend of the mean plot defoliation"):** Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Cyprus, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Norway, Poland, Slovak Republic, Spain, and Switzerland.

Several countries could not be included in one of the three time periods because of changes in their tree sample sizes, their assessment methods or missing assessments in certain years. Development of defoliation is presented for the periods 1992-2011 and 1997-2011 in graphs and in tables. Graphs show the fluctuations of mean defoliation and shares of trees in defoliation classes over time.

The maps depict trends in mean defoliation from 2002-2011. Whereas all plots of the countries mentioned above are included for the two respective time periods in graphs, the maps of the trend analysis only represent plots within these countries that were included in all of the surveys. In the last years plots were shifted within Finland and parts of northern Germany (Brandenburg). These plots are not depicted in the maps but the countries are included in the time series calculation.

The temporal development of defoliation is expressed on maps as the slope of linear regression of mean defoliation against the observation year. It can be interpreted as the mean annual change in defoliation. These slopes were statistically tested and considered as 'significant' only if there was at least 95% probability that they are different from zero.

Besides the temporal development, also the change in the results from 2010 to 2011 was calculated. In this case, changes in mean defoliation per plot are called 'significant' only if the significance at the 95% probability level was proven in a statistical test.

[1] Methodological changes in the first years of the assessments

The spatial pattern of the changes in mean defoliation from 2010 to 2011 across Europe is shown in Annex I-4. On 77.9% of the plots between 2010 and 2011 no statistically significant differences in mean plot defoliation were detected. The share of plots with increasing defoliation was 10.7%, the share of plots with a decrease 11.4%.

3.1.3.1. All species

For all species, the two time series show very similar trends for mean defoliation due to the fact that the countries included in the short time series were also included in the evaluation of the long time series (Fig. 3.1.3.1-1 and Fig. 3.1.3.1-2). For *evergreen oak* and *Mediterranean lowland pines* there was hardly any difference in sample sizes on which evaluations of the different time series were based. The largest differences occurred for *Pinus sylvestris* and *Picea abies* the sample sizes for the long time series being 70% smaller than that of the shorter time series.

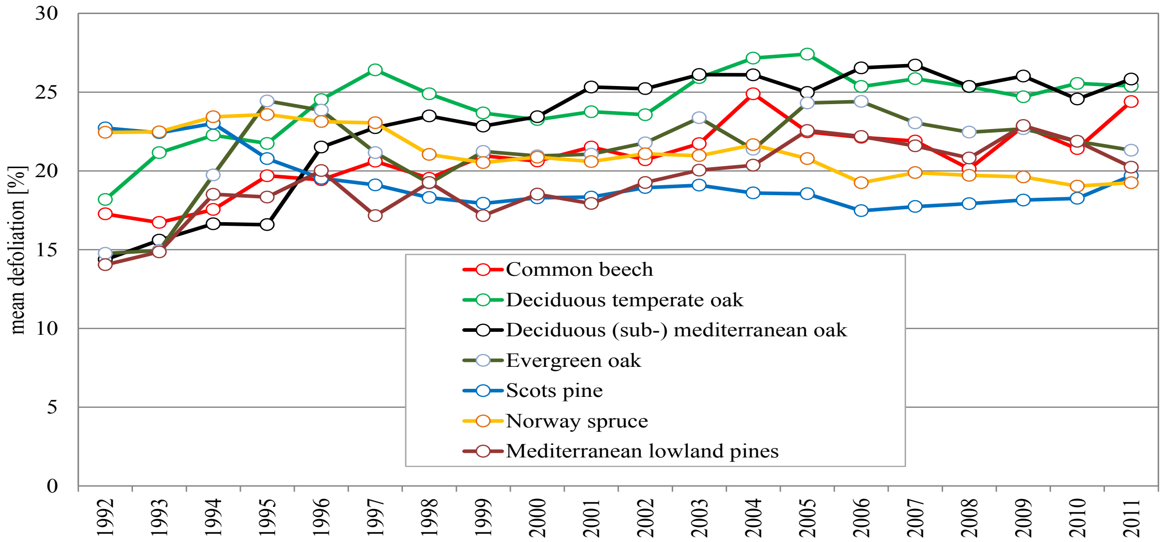

Figure 3.1.3.1-1: Mean defoliation of main species 1992-2011

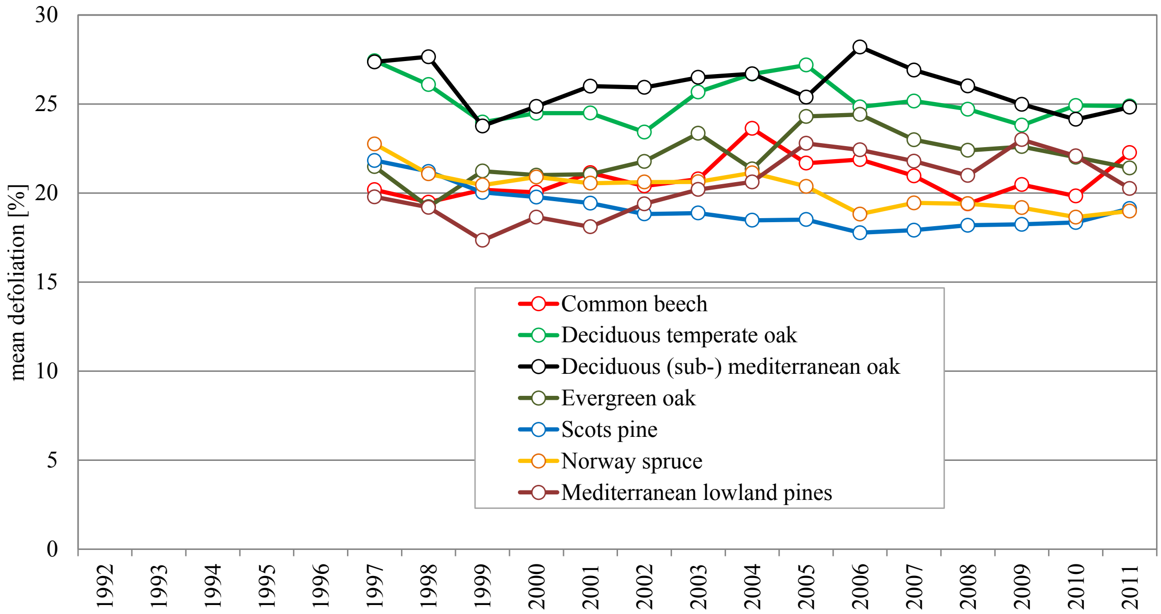

Figure 3.1.3.1-2: Mean defoliation of main species 1997-2011

Since 1992 mean defoliation of the evaluated tree species developed very differently. With the exception of *Picea abies* and *Pinus sylvestris*, all tree species showed a sharp increase in mean defoliation in the first years of the study. Mean defoliation of *Picea abies*, *Fagus sylvatica* and the deciduous temperate oaks reached largest values after the extremely dry and warm summer in 2003. In all samples studied, deciduous temperate oaks and deciduous (sub-) Mediterranean oaks exhibited the highest mean defoliation over the last decade. In contrast, *Pinus sylvestris* clearly showed the lowest mean defoliation from all evaluated species.

Trends in mean plot defoliation for all tree species for the period 2002-2011 are mapped in Fig. 3.1.3.1-3. The percentage of plots with clearly increasing defoliation (13.6%) exceeds the share of plots with decreasing defoliation (12.4%). Plots showing deterioration are scattered across Europe, but their share is particularly high in southern France, at the eastern edge of the Pyrenean Mountains, in the Czech Republic, and in north eastern Italy.

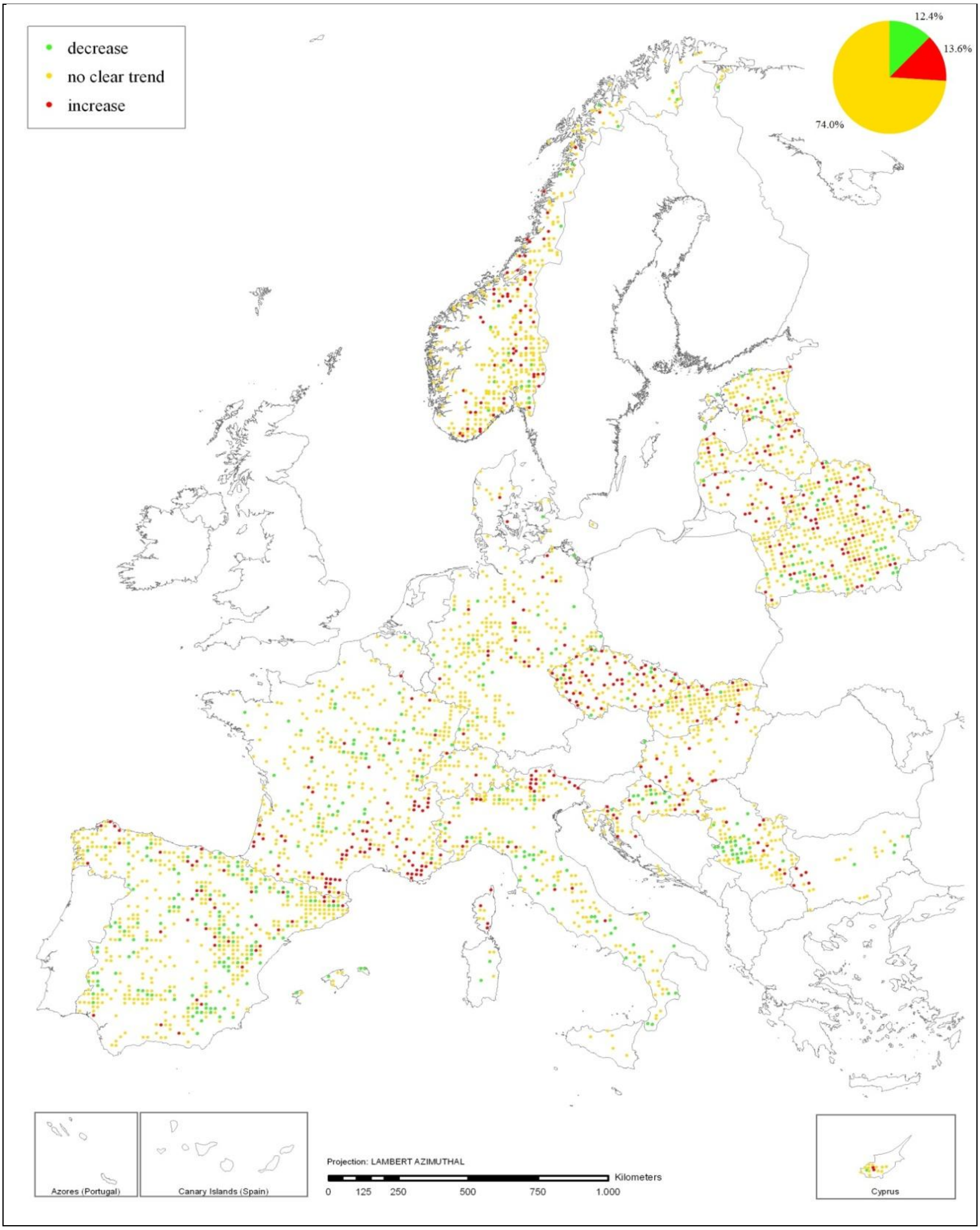

Figure 3.1.3.1-3: Development of mean plot defoliation (slope of linear regression) of all species over the years 2002 – 2011.

3.1.3.2. Pinus sylvestris

Pinus sylvestris is the most common tree species in Europe. The area of its occurrence spreads from Scandinavia to the Mediterranean region. When considering the time series from 1992 on, the mean defoliation has decreased with exception of the recent years showing no change in crown condition. In both time periods the percentage of healthy pines (0-10%) increased and the share of damaged trees (>25%) decreased (Tab. 3.1.3.2-1, Fig. 3.1.3.2-1, Fig. 3.1.3.2-2). As regards the last year in the time series a pronounced increase of the share of trees damaged and an increase of mean defoliation were noticed.

Considered spatially (Fig. 3.1.3.2-3), the only region showing a high share of deteriorated plots lies in the western part of the Czech Republic. For most plots no signs of positive or negative trends in the development of crown condition can be seen. The share of pines exhibiting deteriorated crown development since 2002 (15.2%) exceeds the positive trend (9.9%).

Table 3.1.3.2-1: Shares of trees in different defoliation classes.

	N Trees	0-10%	>10-25%	>25%
1992	19091	29.3	37.3	33.5
1993	19150	28.8	38.9	32.3
1994	18450	27.7	37.9	34.3
1995	20649	33.7	38.1	28.2
1996	20697	35.4	41.6	22.9
1997	20734	34.7	43.8	21.6
1998	21104	35.9	45.4	18.7
1999	21365	36.1	46.7	17.2
2000	21356	34.9	47.8	17.3
2001	21487	33.9	49.3	16.8
2002	21405	31.8	50.3	17.9
2003	21405	30.8	51.4	17.8
2004	23116	34.4	47.8	17.8
2005	23338	35.4	46.3	18.3
2006	20755	38.6	45.8	15.6
2007	21349	36.1	48.7	15.2
2008	19842	35.3	48.8	15.9
2009	19133	35.3	47.7	17.1
2010	19395	35.2	48.2	16.6
2011	17124	29.2	50.8	19.9

	N Trees	0-10%	>10-25%	>25%
1997	29838	27.7	44.6	27.7
1998	30196	29.2	45.8	25.0
1999	30148	30.6	47.6	21.8
2000	29855	30.2	49.9	19.9
2001	29967	30.4	51.3	18.3
2002	29798	32.0	51.6	16.4
2003	30077	31.6	52.0	16.5
2004	31593	35.2	48.3	16.6
2005	31721	35.5	47.6	16.9
2006	28990	37.4	48.1	14.6
2007	29570	34.8	50.9	14.2
2008	28046	32.5	52.7	14.8
2009	27662	32.6	52.0	15.4
2010	28001	33.0	51.9	15.1
2011	25605	29.2	54.0	16.8

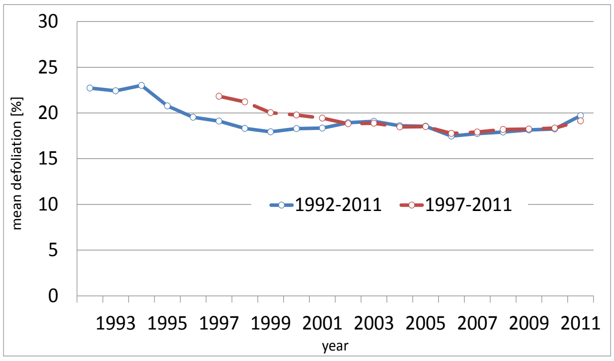

Figure 3.1.3.2-1: M ean defoliation in two periods (1992-2011 and 1997-2011)

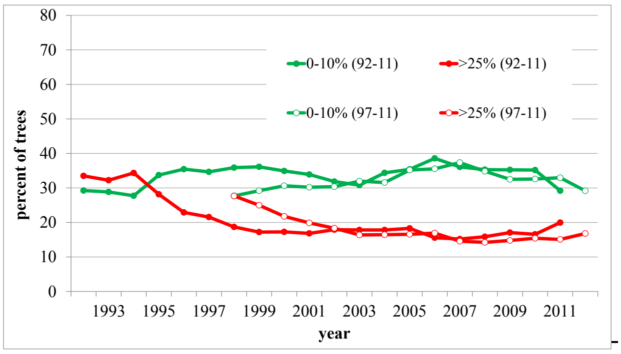

Figure 3.1.3.2-2: Shares of trees of defoliation 0-10% and > 25% in two periods (19922011 and 1997-2011)

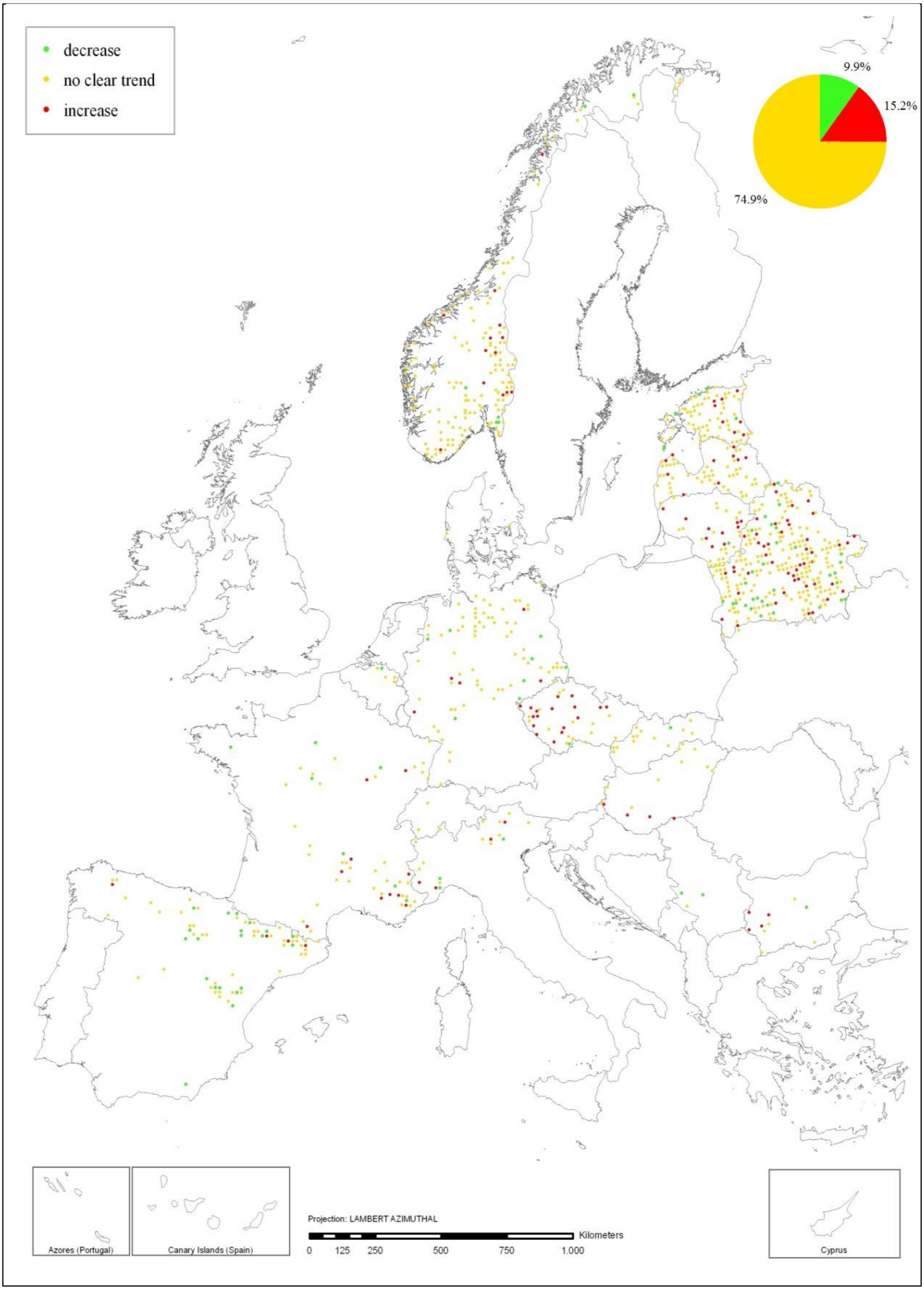

Figure 3.1.3.2-3: Development of mean plot defoliation (slope of linear regression) of *Pinus sylvestris* over the years 2002-2011

3.1.3.3. Picea abies

Picea abies is the second most frequently occurring species in the large scale tree sample. Its area extends mainly from Scandinavia to northern Italy.

The crown condition of *Picea abies* slightly improved over both observation periods. In summer 2003 extreme weather conditions caused the mean defoliation to peak in this year. Until 2006 a recuperation phase was observed. Since then the level of the crown condition remained more or less unchanged (Tab. 3.1.3.3-1, Fig. 3.1.3.3-1, Fig. 3.1.3.3-2).

Since 2006 the share of healthy trees (0-10%) increased permanently. Significant improvements in the crown condition of spruce were observed in 2001 and 2010.

Between 2002 and 2011 no clear trend was observed for about 71% plots. In this time period a deterioration of crown condition occurred on 20.9% of the plots. The share of the plots exhibiting positive trend in crown condition between 2002 and 2011 is 8% (Fig. 3.1.3.3-3).

Table 3.1.3.3-1: Shares of trees in different defoliation classes

	N Trees	0-10%	>10-25%	>25%
1992	14379	30.6	36.3	33.1
1993	14519	31.4	36.1	32.4
1994	14727	29.5	34.7	35.8
1995	16374	30.8	33.1	36.1
1996	16222	31.4	31.6	37.0
1997	16028	29.1	33.7	37.3
1998	15513	33.9	35.7	30.4
1999	15898	35.0	36.2	28.8
2000	15888	33.5	37.4	29.1
2001	15711	33.0	38.4	28.6
2002	15784	32.1	38.3	29.6
2003	15827	31.9	39.2	28.9
2004	16361	31.4	36.7	32.0
2005	16062	32.6	38.0	29.4
2006	14143	38.7	34.8	26.5
2007	13830	36.5	36.2	27.3
2008	13605	37.4	35.5	27.2
2009	13282	37.4	35.7	26.8
2010	13780	39.4	35.2	25.4
2011	12667	39.8	33.9	26.3

	N Trees	0-10%	>10-25%	>25%
1997	17919	29.9	34.2	35.8
1998	17402	34.0	36.2	29.9
1999	17799	35.1	36.7	28.2
2000	17770	33.1	38.3	28.6
2001	17511	32.6	39.5	27.9
2002	17567	33.2	39.1	27.7
2003	17673	32.6	40.3	27.1
2004	18210	32.7	37.4	29.9
2005	17708	33.8	38.6	27.6
2006	15803	39.2	36.3	24.5
2007	15496	37.2	37.5	25.3
2008	15258	37.3	37.3	25.3
2009	15207	37.9	37.5	24.6
2010	15708	40.1	36.5	23.4
2011	14603	39.7	36.2	24.1

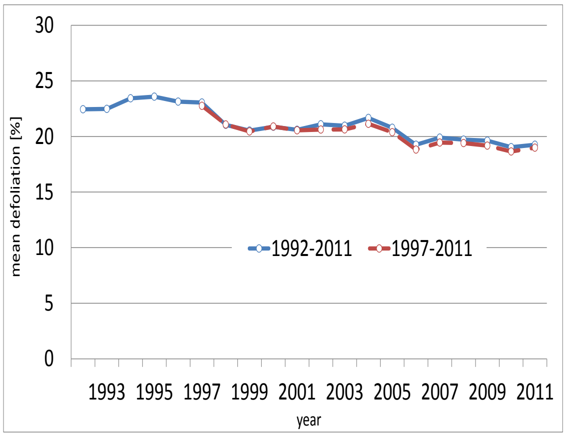

Figure 3.1.3.3-1: Mean defoliation in two periods (1992-2011 and 1997-2011)

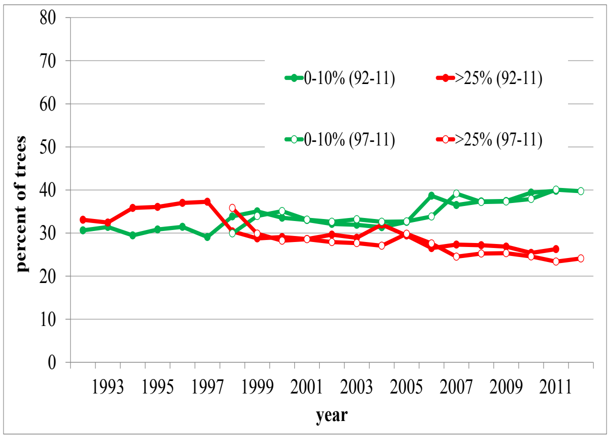

Figure 3.1.3.3-2: Shares of trees of defoliation 0-10% and > 25% in two periods (1992-2011 and 1997-2011)

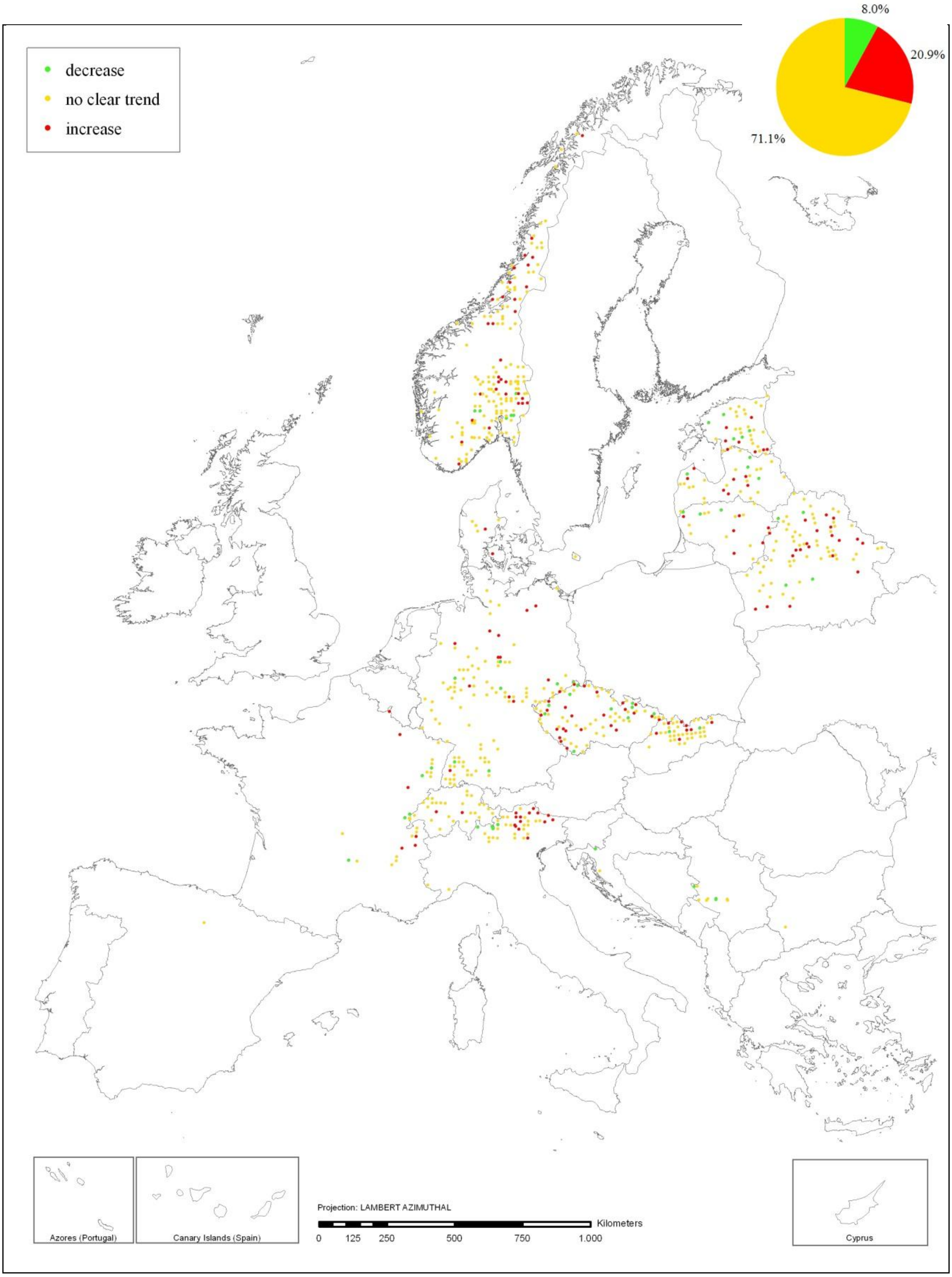

Figure 3.1.3.3-3: Development of mean plot defoliation (slope of linear regression) of *Picea abies* over the years 2002-2011

3.1.3.4. Mediterranean lowland pines

To the group of Mediterranean lowland pines belong *P. pinaster, P. halepensis and P. pinea.* Crown condition of these tree species is characterized by a pronounced increase in mean defoliation since 1992. This is evident from the development of healthy trees. Their share dropped from about 64% in 1992 to 27.9% in 2011. The lowest share of undamaged trees (18.1%) was recorded in 2009. In contrast to the healthy trees the percentage of damaged pines peaked in 2005, decreased thereafter and fluctuated since then reaching about 16% in 2011 (Tab. 3.1.3.4-1, Fig. 3.1.3.4-1 and Fig. 3.1.3.4-2).

As regards the spatial trend, the share of plots showing recovery (14.7%) exceeds the share of plots, on which the mean defoliation increased between 2002 and 2011 (11.7%). These plots are mainly located along the Mediterranean coast in France and in northern Spain (Fig. 3.1.3.4-3).

Table 3.1.3.4-1**:** Shares of trees in different defoliation classes.

	N Trees	0-10%	>10-25%	>25%
1992	3866	63.9	24.3	11.8
1993	3891	60.3	27.1	12.6
1994	3802	50.3	32.7	17.0
1995	3823	39.2	43.8	17.0
1996	3815	36.6	45.4	17.9
1997	3769	40.3	48.3	11.5
1998	3827	37.1	47.3	15.6
1999	5202	40.8	47.6	11.6
2000	5279	39.1	48.6	12.2
2001	5287	34.0	54.6	11.5
2002	5280	29.6	55.8	14.7
2003	5215	27.3	56.6	16.1
2004	5235	28.7	55.2	16.1
2005	5198	20.7	56.0	23.3
2006	5201	21.3	56.6	22.1
2007	5240	22.9	57.0	20.1
2008	5248	21.2	60.5	18.3
2009	5105	18.1	61.0	20.8
2010	5085	23.2	58.7	18.1
2011	5084	27.9	56.0	16.2
	N Trees	**0-10%**	**>10-25%**	**>25%**
1997	3944	38.5	46.4	15.1
1998	3940	37.5	46.5	16.0
1999	5314	40.1	47.6	12.3
2000	5368	38.6	48.6	12.8
2001	5376	33.5	54.3	12.2
2002	5345	29.3	55.5	15.2
2003	5280	27.0	56.2	16.8
2004	5348	28.1	54.7	17.3
2005	5289	20.4	55.3	24.3
2006	5290	21.0	55.8	23.1
2007	5305	22.6	56.6	20.7
2008	5313	21.0	60.2	18.8
2009	5170	17.9	60.5	21.6
2010	5150	23.1	58.2	18.7
2011	5245	28.1	55.4	16.4

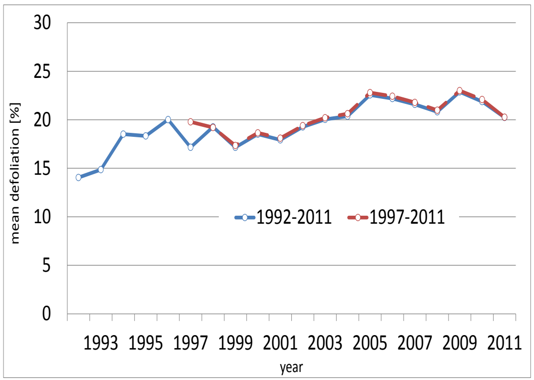

Figure 3.1.3.4-1: Mean defoliation in two periods (1992-2011 and 1997-2011)

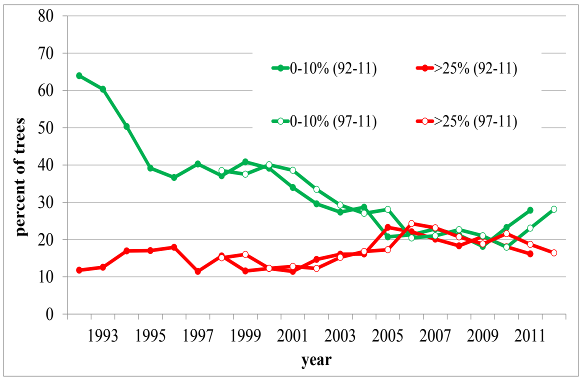

Figure 3.1.3.4-2: Shares of trees of defoliation 0-10% and > 25% in two periods (1992-2011 and 1997-2011)

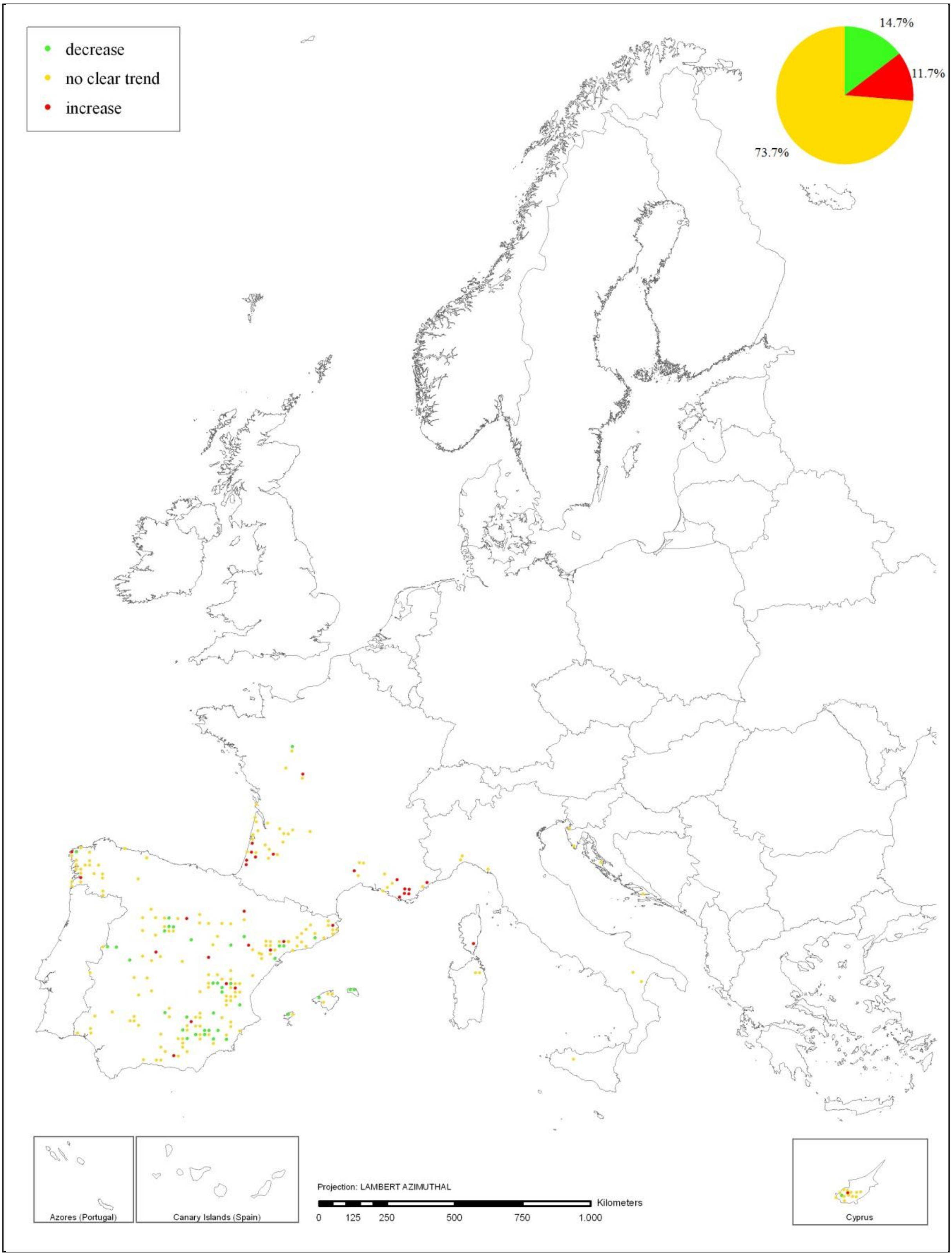

Figure 3.1.3.4-3: Development of mean plot defoliation (slope of linear regression) of Mediterranean lowland pines over the years 2002-2011

3.1.3.5. Fagus sylvatica

Fagus sylvatica is the most frequent deciduous tree species on the large-scale plots. The area of its occurrence spreads from southern Scandinavia to Sicily and from the northern coast of Spain to Bulgaria.

Since the beginning of the study crown condition of this tree species expressed by mean defoliation worsened slightly. The highest defoliation was recorded in the year after the hot and dry summer in central Europe in 2003. Since then a recovery has been observed (Tab. 3.1.3.5-1, Fig. 3.1.3.5-1, Fig. 3.1.3.5-2)

Between 1992 and 2004 the percentage of healthy trees (0-10%) diminished from 43.7 to 18.3%. In 2011 the share of damaged trees (>25%) rose rapidly reaching 34.5% in the long and 29% in the short time series. But this is not reflected in the shares of plots with decreasing (8.1%) and increasing defoliation (10.5%) (Fig. 3.1.3.5-3).

Table 3.1.3.5-1: Shares of trees in different defoliation classes.

	N Trees	0-10%	>10-25%	>25%
1992	6254	43.7	35.5	20.8
1993	6368	45.1	34.7	20.2
1994	6401	41.7	37.3	21.0
1995	6480	35.2	38.7	26.1
1996	6458	33.1	45.4	21.4
1997	6309	29.7	46.9	23.4
1998	6588	32.9	45.1	22.0
1999	7244	26.2	49.5	24.3
2000	7266	29.6	46.7	23.7
2001	7328	25.3	48.0	26.7
2002	7337	26.3	50.4	23.3
2003	7299	23.7	50.2	26.1
2004	7386	18.3	47.3	34.4
2005	7448	24.0	47.7	28.3
2006	6940	26.4	44.9	28.7
2007	7106	23.2	50.6	26.2
2008	7128	29.1	49.1	21.8
2009	6985	24.8	44.2	31.0
2010	7305	26.6	47.8	25.6
2011	7316	22.6	42.9	34.5

	N Trees	0-10%	>10-25%	>25%
1997	7792	33.1	44.5	22.4
1998	8176	35.6	43.3	21.0
1999	8454	30.7	46.9	22.4
2000	8668	33.9	44.0	22.1
2001	8664	29.3	45.4	25.4
2002	8772	30.3	47.5	22.1
2003	8666	28.1	48.4	23.5
2004	8613	21.9	47.3	30.8
2005	8760	28.6	45.9	25.5
2006	8315	30.3	43.4	26.3
2007	8577	28.4	48.1	23.5
2008	8533	32.8	47.6	19.6
2009	9041	32.6	42.2	25.2
2010	9327	32.3	45.6	22.1
2011	9318	30.3	40.8	29.0

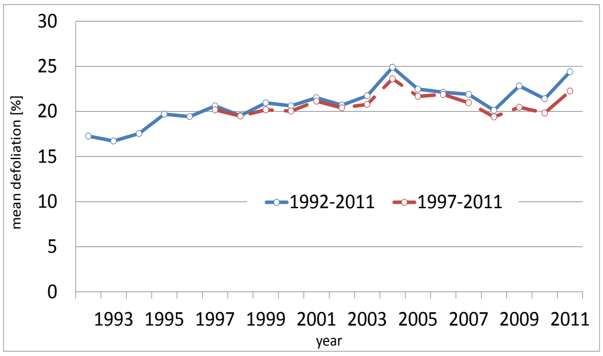

Figure 3.1.3.5-1: Mean defoliation in two periods (1992-2011 and 1997-2011)

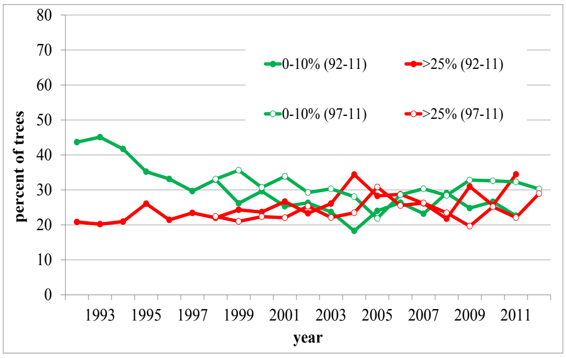

Figure 3.1.3.5-2: Shares of trees of defoliation 0-10% and > 25% in two periods (1992-2011 and 1997-2011)

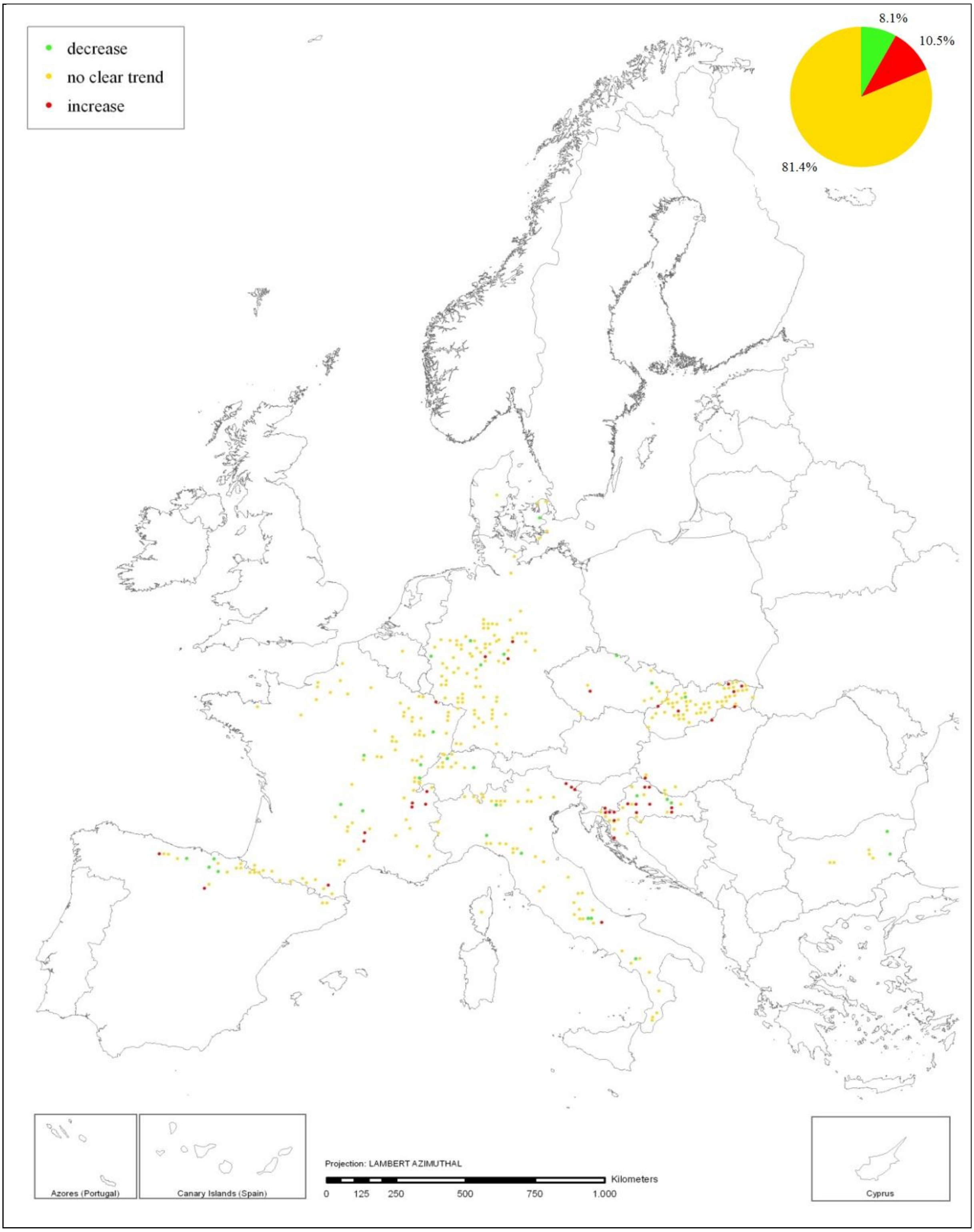

Figure 3.1.3.5-3: Development of mean plot defoliation (slope of linear regression) of *Fagus sylvatica* over the years 2002-2011

3.1.3.6. Deciduous temperate oak

The group of deciduous temperate oaks includes *Quercus robur and Q. petraea* occurring throughout central Europe.

Temporal development of these tree species is characterized by peaks in 1997 and 2005. In the subsequent years some trees may have recovered as the percentage of trees defoliated by 25% and more decreased and varied since then between 33% and 37% in both time series (Tab. 3.1.3.6-1, Fig. 3.1.3.6-1, Fig. 3.1.3.6-2).

The linear trend based on time period 2002-2011 shows that on only 7.7% of all plots the mean defoliation increased. For 75.8% of the plots the calculation does not support the existence of any trends.

A cluster of plots showing decreasing trend of mean defoliation can be seen in central France (Fig. 3.1.3.6-3).

Table 3.1.3.6-1: Shares of trees in different defoliation classes.

	N Trees	0-10%	>10-25%	>25%
1992	5312	42.3	35.2	22.5
1993	5393	36.8	33.1	30.1
1994	5608	34.0	31.9	34.1
1995	5464	32.9	36.5	30.6
1996	5434	24.6	39.1	36.3
1997	5447	16.3	42.7	41.0
1998	5601	20.5	42.6	36.9
1999	5720	20.4	47.9	31.7
2000	5749	21.0	48.4	30.6
2001	5751	18.8	49.7	31.5
2002	5763	18.1	51.0	30.8
2003	5766	14.5	47.3	38.2
2004	5869	14.7	44.7	40.6
2005	5880	13.3	43.6	43.1
2006	5388	16.8	46.2	37.0
2007	5490	15.6	47.1	37.3
2008	5668	15.8	48.0	36.2
2009	5605	17.9	46.6	35.5
2010	5666	16.1	47.6	36.3
2011	5803	17.1	47.3	35.6

	N Trees	0-10%	>10-25%	>25%
1997	6548	16.5	41.9	41.6
1998	6760	20.1	41.6	38.3
1999	6791	21.0	47.4	31.6
2000	6882	20.2	46.6	33.2
2001	6811	18.9	48.4	32.6
2002	6654	18.8	50.8	30.4
2003	6659	15.3	47.6	37.1
2004	6780	16.2	44.5	39.4
2005	6849	14.6	43.5	41.9
2006	6348	19.2	45.6	35.2
2007	6475	17.5	47.6	34.9
2008	6642	17.2	48.8	34.0
2009	6928	19.3	48.1	32.7
2010	6917	17.7	47.5	34.7
2011	7110	18.3	47.9	33.8

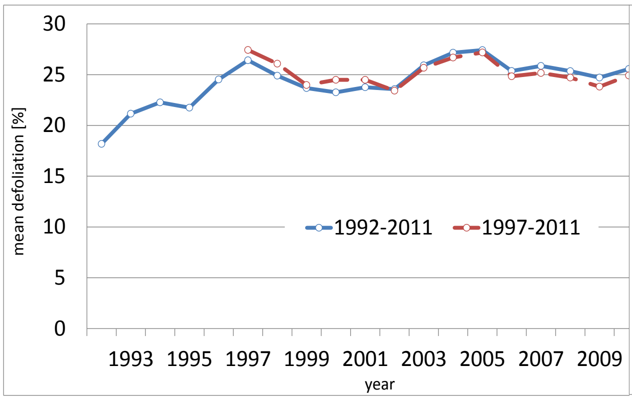

Figure 3.1.3.6-1: Mean defoliation in two periods (1992-2011 and 1997-2011)

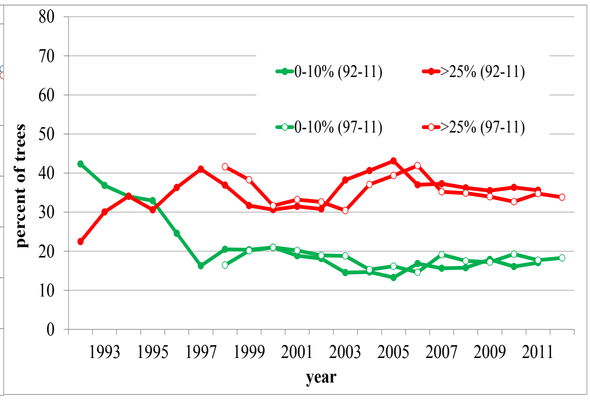

Figure 3.1.3.6-2: Shares of trees of defoliation 0-10% and > 25% in two periods (1992-2011and 1997-2011)

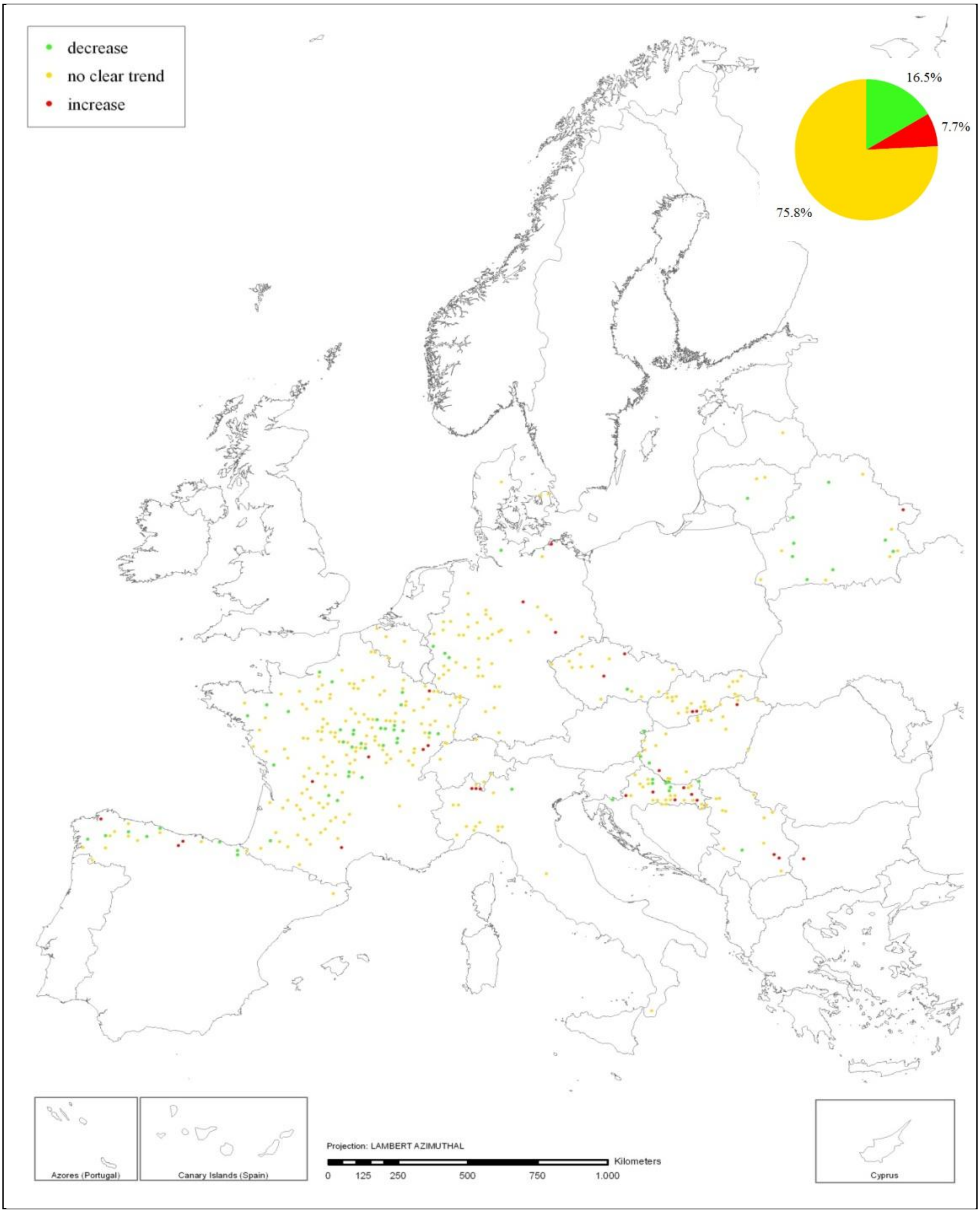

Figure 3.1.3.6-3: Development of mean plot defoliation (slope of linear regression) of deciduous temperate oak species over the years 2002-2011

3.1.3.7. Deciduous (sub-) Mediterranean oak

The group of deciduous (sub-) Mediterranean oak is composed of *Quercus cerris, Q. pubescens, Q. frainetto and Q. pyrenaica.* The occurrence of these oaks is confined to southern Europe.

Crown condition of these oaks deteriorated dramatically until the end of the 1990s. In the following years the share of damaged trees increased at slower rate reaching a maximum of 36.4% in 2006. In the subsequent years a slow decrease in defoliation can be observed (Tab. 3.1.3.7-1, Fig. 3.1.3.7-1 and Fig. 3.1.3.7-2). The share of damaged trees in the last four years levelled off at about 33% (long time series) or 30% (short time series).

The spatial distribution shows a negative trend in crown condition on 12.3% of all plots mainly in southern France. Positive development of the four oak species was identified on 17.4% plots. These plots are more or less scattered over the southern Europe. A small cluster of plots with positive trend of crown condition since 2002 can be identified in Serbia (Fig. 3.1.3.7-3).

Table 3.1.3.7-1: Shares of trees in different defoliation classes.

	N Trees	0-10%	>10-25%	>25%
1992	3156	54.3	32.8	12.8
1993	3154	53.0	31.8	15.2
1994	3123	49.5	32.8	17.7
1995	3170	47.4	34.9	17.7
1996	3218	30.5	43.7	25.8
1997	3056	27.1	42.5	30.4
1998	3084	26.1	41.8	32.1
1999	3678	24.8	46.1	29.1
2000	3648	22.5	46.8	30.6
2001	3686	20.2	45.0	34.8
2002	3599	18.4	46.0	35.6
2003	3519	16.7	46.2	37.0
2004	3625	16.2	48.8	35.0
2005	3580	18.5	48.5	32.9
2006	3583	17.5	46.1	36.4
2007	3588	14.9	49.3	35.8
2008	3606	16.3	50.1	33.6
2009	3608	16.2	50.1	33.6
2010	3967	19.3	48.9	31.8
2011	3970	18.6	46.8	34.7

	N Trees	0-10%	>10-25%	>25%
1997	4037	23.4	40.0	36.6
1998	4392	21.7	39.9	38.3
1999	4628	24.4	45.2	30.4
2000	4530	20.4	45.5	34.1
2001	4704	19.0	44.7	36.3
2002	4599	15.9	48.6	35.4
2003	4376	14.2	48.0	37.8
2004	4468	14.3	48.6	37.1
2005	4409	17.1	49.7	33.2
2006	4577	15.8	47.2	37.0
2007	4387	13.6	50.7	35.7
2008	4390	14.9	51.4	33.7
2009	4832	15.8	53.1	31.1
2010	5262	17.8	51.8	30.4
2011	5335	17.5	52.4	30.1

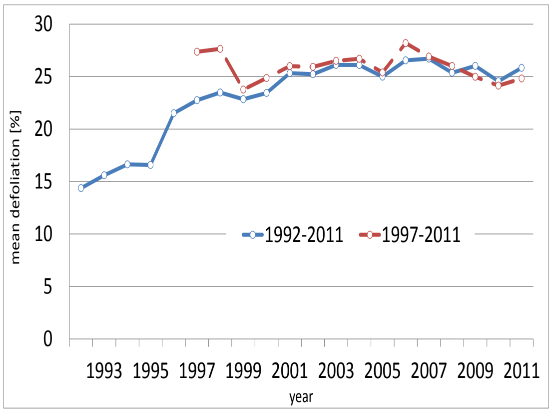

Figure 3.1.3.7-1: Mean defoliation in two periods (1992-2011 and 1997-2011)

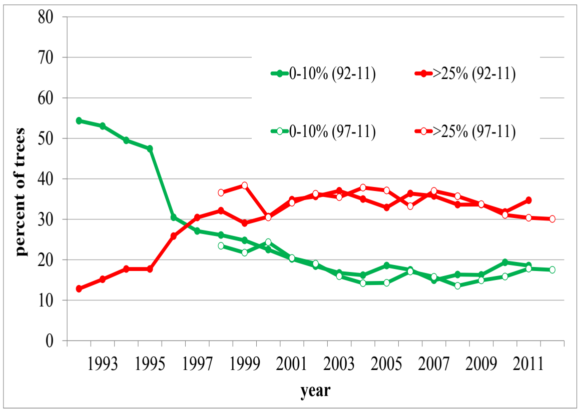

Figure 3.1.3.7-2: Shares of trees of defoliation 0-10% and > 25% in two periods (1992-2011 and 1997-2011)

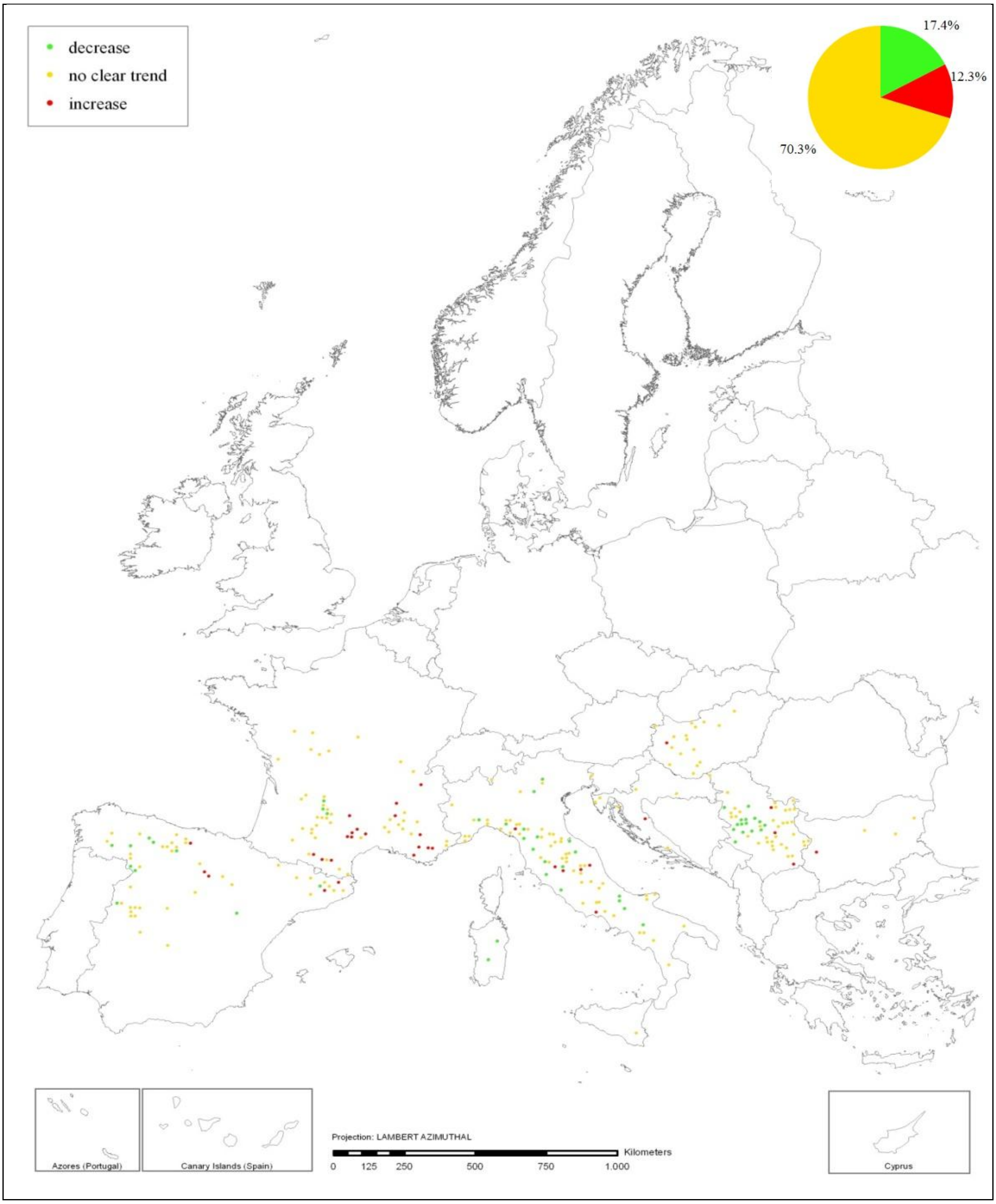

Figure 3.1.3.7-3: Development of mean plot defoliation (slope of linear regression) of deciduous (sub-) Mediterranean oak species over the years 2002-2011

3.1.3.8. Evergreen oak

The group of evergreen oaks includes *Quercus coccifera, Q. ilex, Q. rotundifolia and Q. suber.* As the compositions of countries on which both time series are based do not substantially differ the results presented in Table 3.1.3.8-1 are very similar.

In the early 1990s, at the beginning of the study, the mean defoliation of evergreen oaks was less than 15%, which corresponds with a high percentage of healthy trees. The share of damaged trees (> 25%) shows three peaks: in 1995 (32.3%), in 2005 (27.9%) and in 2006 (27.3%) (Tab. 3.1.3.8-1).

The majority of plots with evergreen oaks are located in Spain. Few of the plots are in southern France and along the western coast of Italy. The share of evergreen oaks with deteriorating trends between 2002 and 2011 is with 8.1% rather small. The share of plots on which these oak species have been recovering since 2002 is by 10% point higher (Fig. 3.1.3.8-3).

Table 3.1.3.8-1: Shares of trees in different defoliation classes.

	N Trees	0-10%	>10-25%	>25%
1992	3362	47.4	44.4	8.2
1993	3315	41.5	51.0	7.5
1994	3288	31.4	52.4	16.2
1995	3329	19.2	48.5	32.3
1996	3307	18.1	53.6	28.4
1997	3306	22.3	58.1	19.6
1998	3264	28.6	56.0	15.4
1999	4232	21.7	57.0	21.3
2000	4308	19.3	60.4	20.4
2001	4324	19.9	62.6	17.5
2002	4311	16.2	62.8	21.0
2003	4218	14.0	62.3	23.6
2004	4280	17.7	63.5	18.8
2005	4229	9.8	62.3	27.9
2006	4233	8.8	63.9	27.3
2007	4318	10.1	67.5	22.5
2008	4336	11.6	67.2	21.2
2009	4345	11.0	67.0	22.0
2010	4446	17.3	62.2	20.5
2011	4473	19.7	62.2	18.1

	N Trees	0-10%	>10-25%	>25%
1997	3354	22.1	57.7	20.2
1998	3288	28.4	56.1	15.5
1999	4256	21.6	57.1	21.2
2000	4332	19.2	60.2	20.6
2001	4348	19.8	62.7	17.4
2002	4335	16.1	63.0	20.9
2003	4242	14.0	62.5	23.5
2004	4328	17.5	63.8	18.6
2005	4277	9.8	62.3	27.9
2006	4281	8.8	63.8	27.4
2007	4366	10.3	67.3	22.4
2008	4360	11.9	67.0	21.1
2009	4369	11.3	66.8	21.9
2010	4494	17.4	61.9	20.8
2011	4545	19.8	61.8	18.3

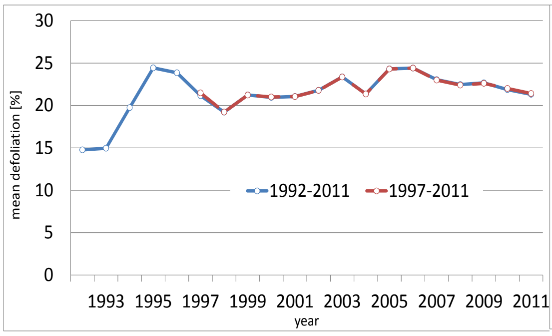

Figure 3.1.3.8-1: Mean defoliation in two periods (1992-2011 and 1997-2011)

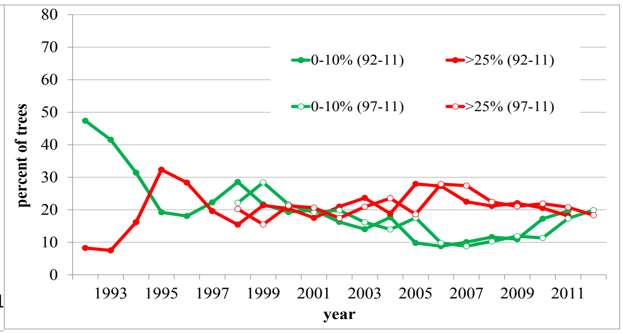

Figure 3.1.3.8-2: Shares of trees of defoliation 0-10% and > 25% in two periods (1992-2011 and 1997-2011)

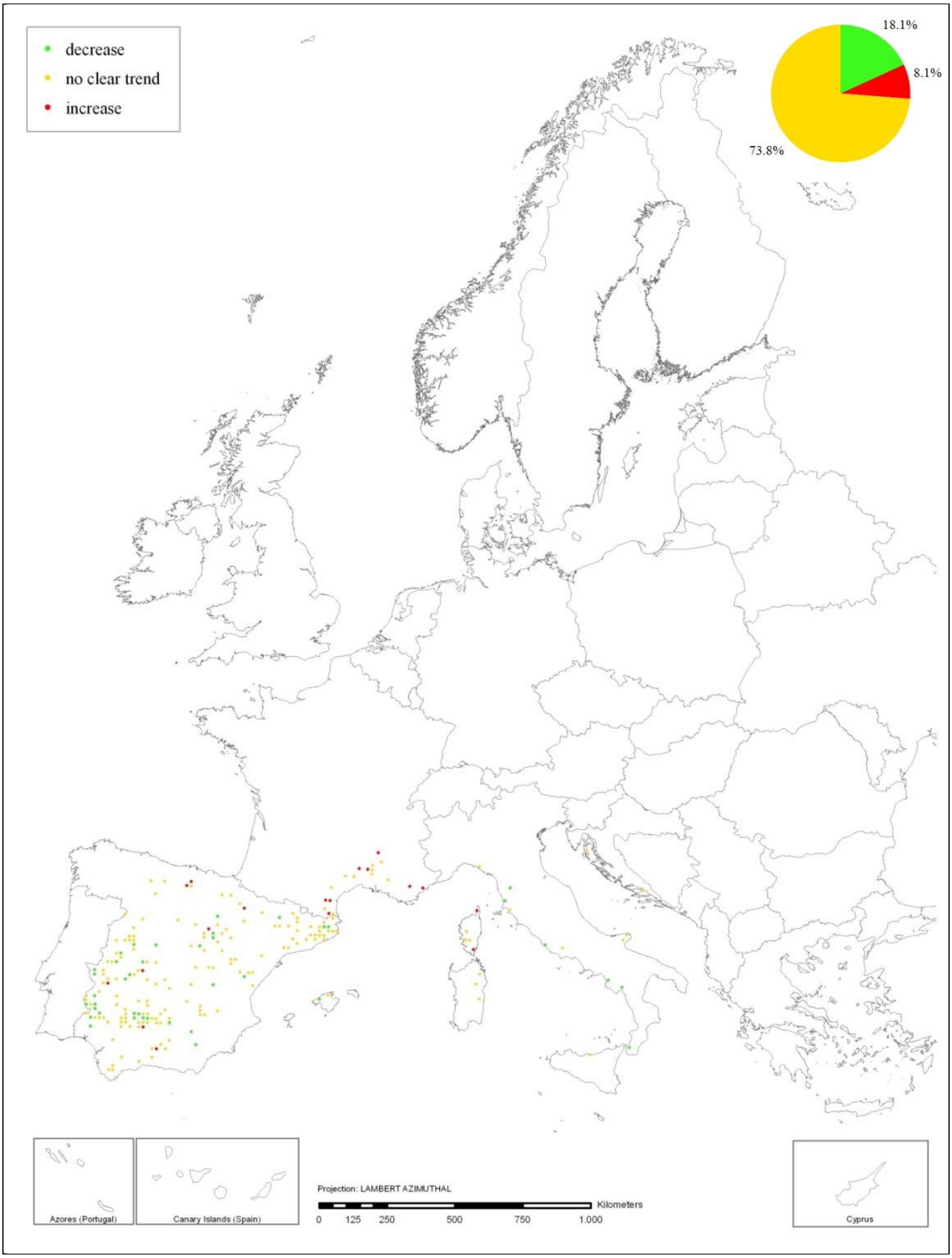

Figure 3.1.3.8-3: Development of mean plot defoliation (slope of linear regression) of evergreen oak species over the years 2002-2011

3.2. Damage cause assessment

Crown condition is the most widely applied indicator for forest health and vitality in Europe. In order to interpret the crown condition accurately, it is necessary to assess tree parameters that have an influence on tree vitality. Parameters assessed in addition to crown condition include discolouration and damages caused by biotic and abiotic factors. Through the assessment of damage and its influence on crown condition, it is possible to draw conclusions on cause-effect mechanisms. Since 2005, tree crowns on Level I plots have been examined based on an amended method for damage assessment, which allows to obtain more information on injury symptoms, possible causes of damage, and extent of the injury.

The aim of the damage cause assessment is to collect as much information as possible on the causal background of tree damages in order to enable a differential diagnosis and to better interpret the unspecific parameter ‘defoliation’.

3.2.1. Background of the survey in 2011

Assessment of damage causes is part of the visual assessment of crown condition. All trees included in the crown condition sample (Level I plots) are required to be regularly assessed for damage causes. In 2011, damage causes were assessed on about 6 000 plots in 28 countries across Europe (Fig. 3.2.1-1). The number of trees showing damage was 44 427. As a particular tree may be affected by more than one damage agent the total number of damage cases recorded was 59 014.

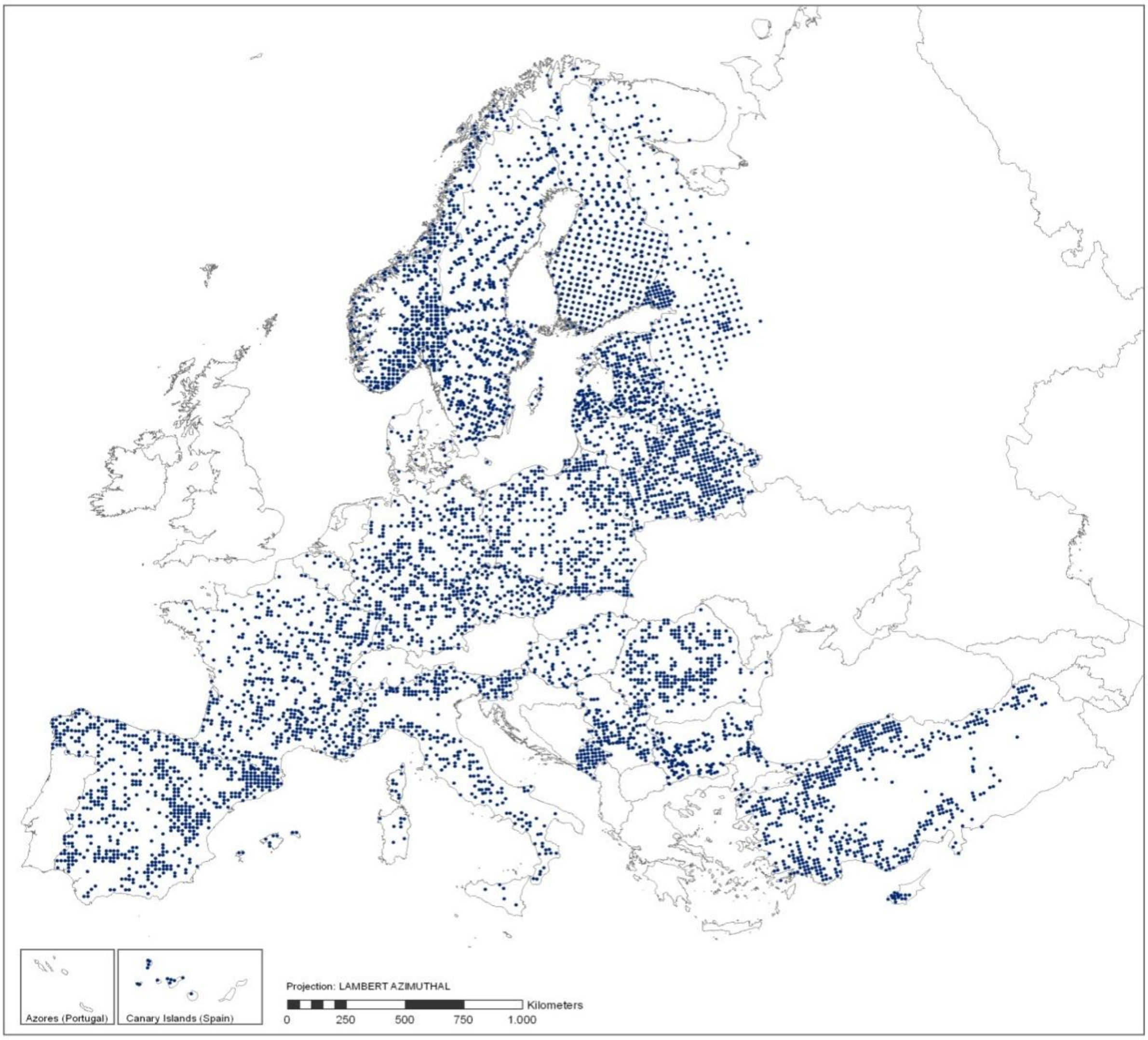

Figure 3.2.1-1: Plots with damage cause assessment in 2011

3.2.2. Assessment parameters

The assessment of damage to trees based on the ICP Forests methodology includes three steps: symptom description, determination of causes, and quantification of the symptoms. Several symptoms of damage can be described for each tree. The symptom description should focus on important factors which may influence crown condition.

Symptoms

Symptom description aims at describing visible damage causes for single trees. The description indicates affected parts of the assessed trees and type of symptoms observed. Symptom description should focus on important factors that may influence the crown condition.

Three main categories are distinguished for indicating the affected part of each tree: (a) leaves/needles, (b) branches, shoots, & buds, and (c) stem & collar. For each affected tree area, further specification is required (Tab. 3.2.2-1). Symptoms are grouped into broad categories like wounds, deformations, necrosis etc. This allows a detailed description of the occurring symptoms.

Table 3.2.2-1: Affected parts of a tree

Affected part	Specification of affected part	Location in crown
Leaves/needles	Current needle year Older needles Needles of all ages Broadleaves (incl. evergreen spec.)	Upper crown Lower crown Patches Total crown
Branches, shoots & buds	Current year shoots Twigs (diameter < 2 cm) Branches diameter 2 – < 10 cm Branches diameter ≥ 10 cm Varying size Top leader shoot Buds	Upper crown Lower crown Patches Total crown
Stem & collar	Crown stem: main trunk or bole within the crown Bole: trunk between the collar and the crown Roots (exposed) and collar (≤ 25 cm height) Whole trunk	
Dead tree	*see below*	
No symptoms on any part of tree	*see below*	
No assessment	*see below*	

Extent

The damage extent is classified in eight classes (Tab. 3.2.2-2) In Trees where multiple damages occurred (and thus multiple extent classes), only the highest value was evaluated.

Table 3.2.2.-2: Damage extent classes

Class
0 5
1 – 10 %
11 – 20 %
21 – 40 %
41 – 60 %
61 – 80 %
81 – 99 %
100 %

Causal agents

For each symptom description a causal agent must be determined. The determination of the causal agent is crucial for the study of the cause-effect mechanism. Causal agents are grouped into nine categories (Tab. 3.2.2-3). In each category a more detailed description is possible through a hierarchical coding system.

Table 3.2.2-3: Main causal agents

Agent group
Game and grazing
Insects
Fungi
Abiotic agents
Direct action of men
Fire
Atmospheric pollutants
Other factors
(investigated but) unidentified

3.2.3. Results in 2011

3.2.3.1. Agent groups

The distribution of the agent groups in 2011 shows that over 15 000 trees displayed symptoms caused by insects (Fig. 3.2.3.1-1) corresponding to 32% of the records (Tab. 3.2.3.1-1). Roughly half of the insect-caused symptoms were attributed to defoliators and to the other half to borers and other insects. Significantly fewer trees, namely over 11 000, displayed damage caused by fungi. In about 6 000 trees, an abiotic symptom (i.e. drought, frost) was found. Altogether, ca. 18 000 trees showed no signs of damage. Multiple agent groups were recorded for a number of trees. The damages due to air pollution refer to "direct smoke damages", indirect effects were not assessed.

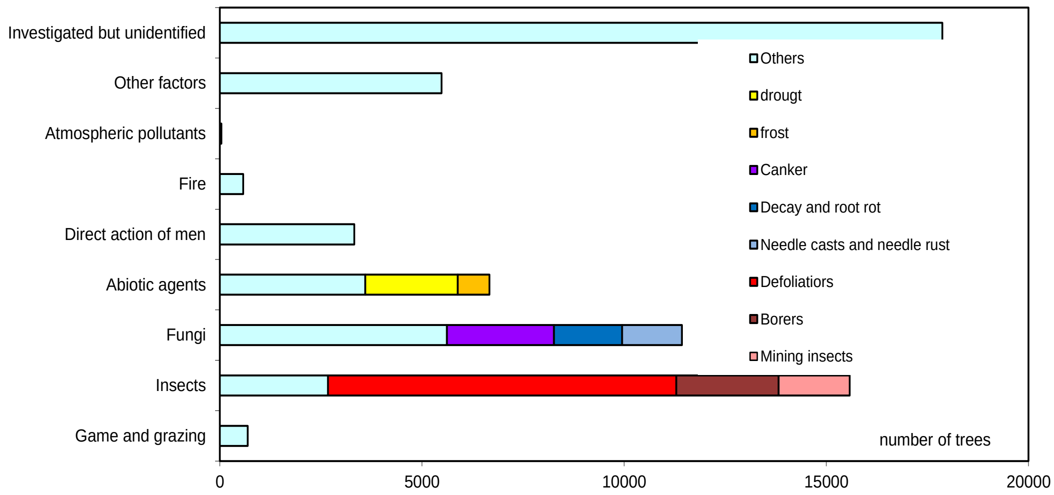

Figure 3.2.3.1-1: Frequency of agent groups

Table 3.2.3.1-1: Percentages of damage types by agent group and country for the year 2011

share of damages by agent group and country for the year 2011	Game and grazing	Insects	Fungi	Abiotic agents	Direct action of men	Fire	Atmospheric pollutants	Other factors	Investigated but unidentified
Belgium	1	9	12	12	8	0	0	0	58
Bulgaria	0	30	31	5	9	0	0	1	24
Cyprus	1	73	0	19	0	0	0	7	0
Czech Rep.	14	1	0	73	3	0	0	4	5
Denmark	6	62	5	18	3	0	0	1	5
Estonia	2	8	43	6	8	0	0	2	31
Finland	1	16	19	7	6	0	0	15	36
France	1	68	22	0	0	0	0	9	0
Germany	3	32	7	7	11	0	0	6	34
Hungary	0	29	17	25	9	1	0	10	9
Italy	1	25	8	4	0	0	0	6	56
Latvia	18	8	13	19	28	0	4	6	4
Lithuania	6	5	14	25	19	0	0	4	27
Poland	1	24	8	5	7	0	0	19	36
Romania	3	29	9	23	6	0	0	4	26
Slovenia	0	24	14	7	8	0	0	4	43
Spain	1	32	14	25	5	4	0	13	6
Sweden	4	2	9	5	21	0	0	1	58
EU	1	28	14	11	5	1	0	8	32
Andorra	0	13	61	13	0	0	0	0	13
Belarus	1	10	41	5	23	1	1	12	6
Montenegro	0	26	10	5	6	2	0	1	50
Norway	1	27	37	13	1	0	0	3	18
Russian Fed.	0	12	26	19	9	2	0	10	22
Serbia	0	22	12	4	0	0	0	2	60
Switzerland	0	0	0	0	0	0	0	0	100
Turkey	0	32	4	6	1	0	0	24	33
Total Europe	1	26	15	11	6	1	0	9	31

Agent Group 'Game and grazing'

In 2011, only minor damage from 'game and grazing' was observed on the assessed trees throughout Europe. Tab. 3.2.3.1-1 displays that 1% of all recorded damages were caused by this agent group. It has however to be taken into account that only adult trees in KRAFT classes 1-3 are regularly assessed for damage types and browsing in the herb and shrub layer is not recorded in this assessment. 78.0% of all affected plots show a share of damaged trees of 25% or lower (Fig. 3.2.3.1-2).

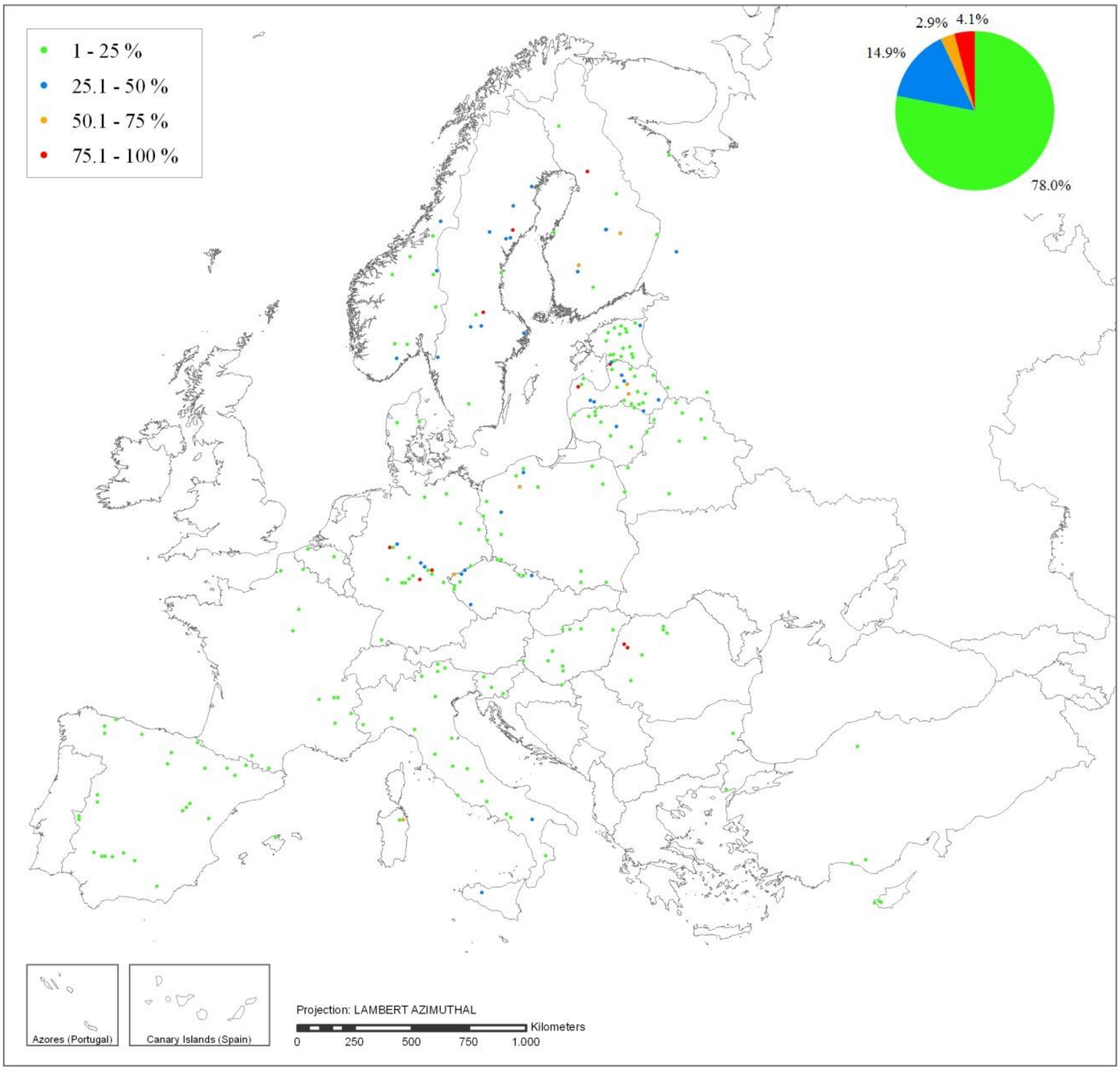

Figure 3.2.3.1-2: Shares of trees per plot with recorded agent group 'game and grazing', 2011

Agent Group 'Insects'

'Insects' were the most frequently detected agent group (32% of all damage types) in 2011. They were observed in different intensities throughout Europe. On around half of all affected plots, more than 25% of the trees were damaged by insects. Plots with over 75% of the trees affected account for nearly 15% of all plots. They are clustered e.g. at the eastern edge of the Pyrenean Mountains, Italy and Cyprus (Fig. 3.2.3.1-3).

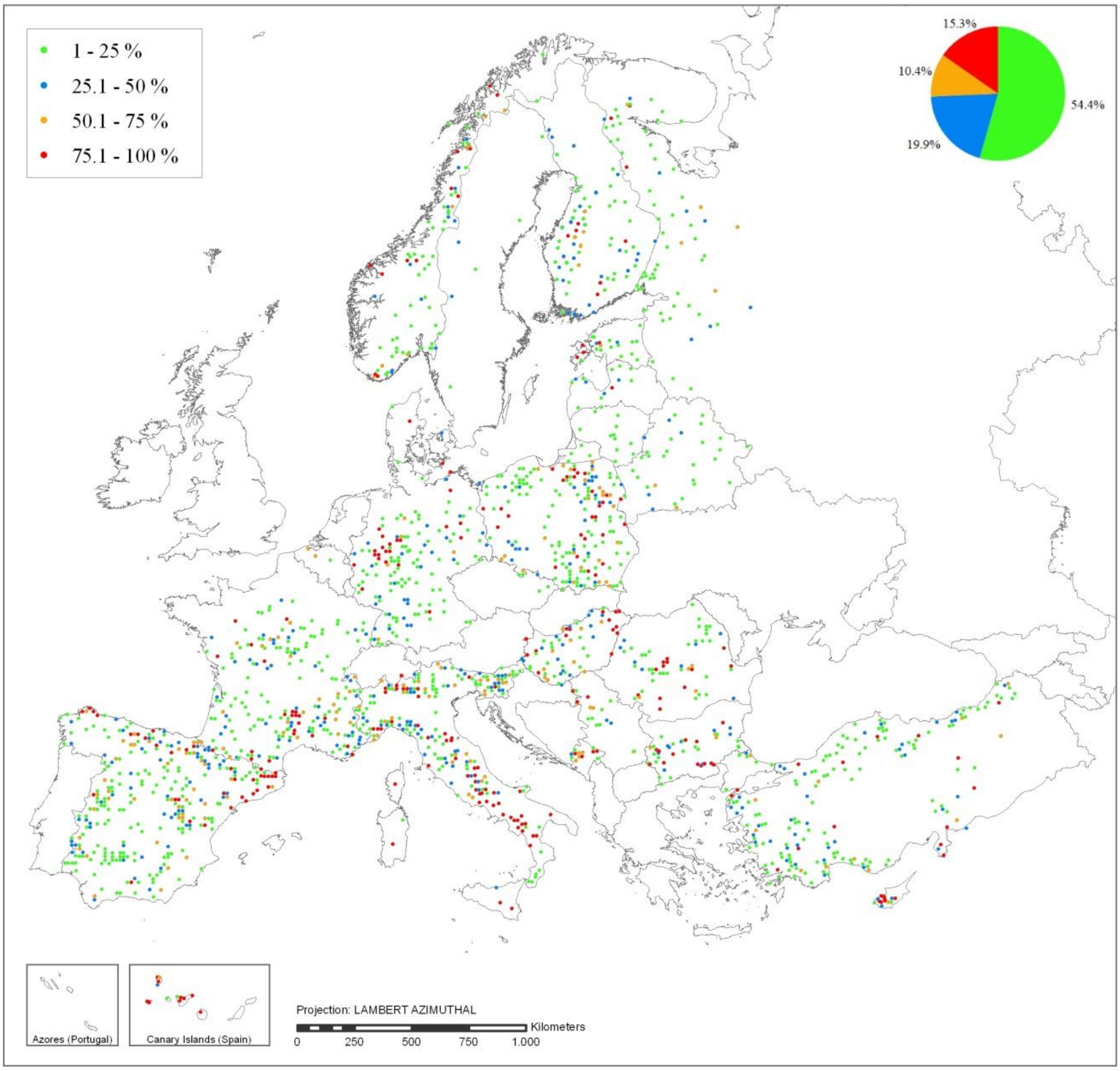

Figure 3.2.3.1-3: Shares of trees per plot with recorded agent group 'insects', 2011

Agent Group 'Fungi'

Most affected plots (71.2%) showed only a small share of damaged trees. On 6.7% of all affected plots, between 50 and 75% of the trees showed damage caused by fungi, and on 5.8% of all plots more than 75% of the trees were damaged. A particularly high share of plots damaged by fungi was found in Estonia and western Bulgaria (Fig. 3.2.3.1-4).

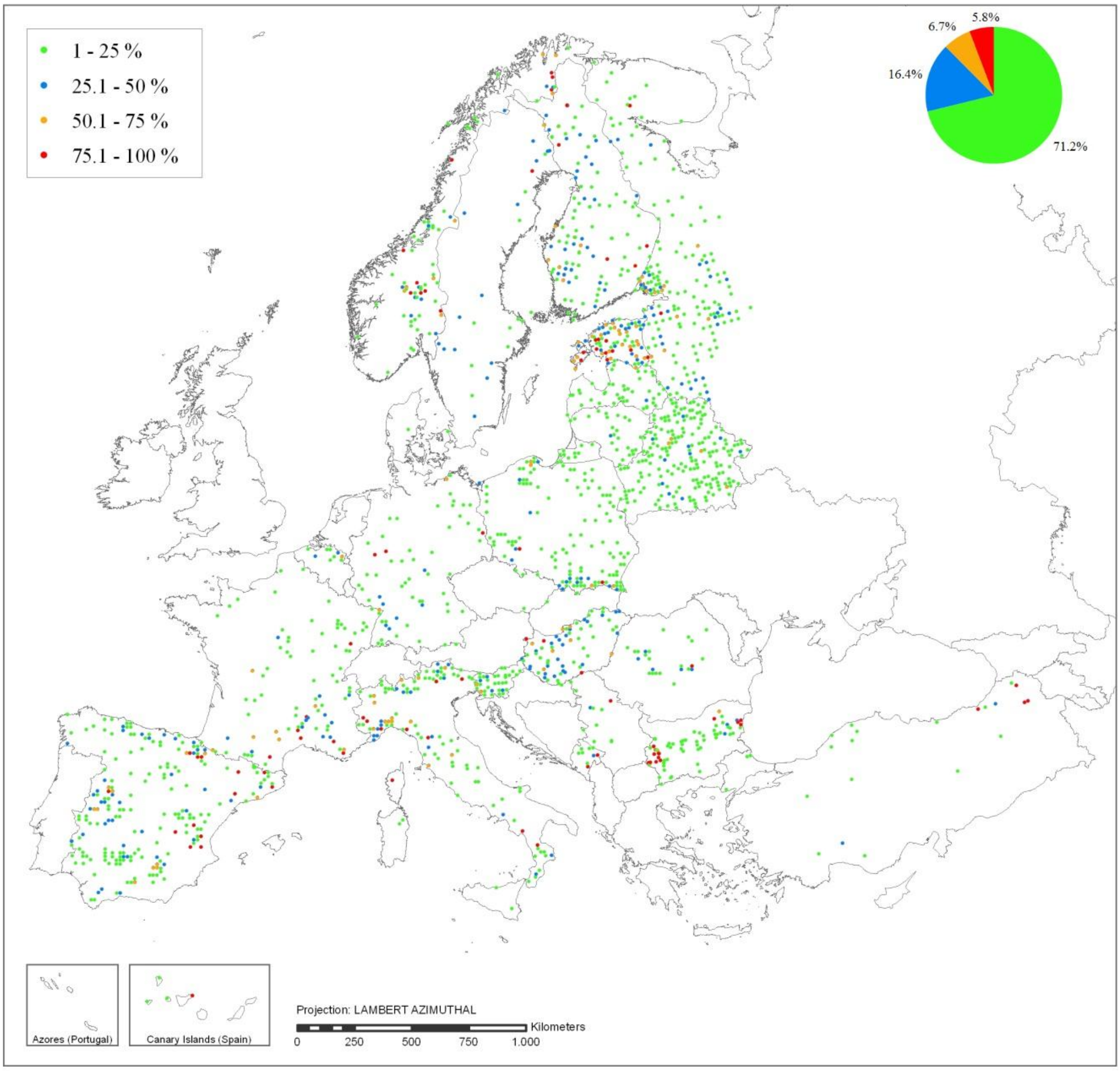

Figure 3.2.3.1-4: Shares of trees per plot with recorded agent group 'fungi', 2011

Agent Group 'Abiotic agents'

In 2011, the share of trees with damage caused by "abiotic agents" was 6%. The most frequent causes were drought, frost/snow, and wind. 79% of all affected plots showed a small share of damaged trees. Plots with a higher share of damaged trees were found mainly in southern Europe. In particular, these plots occurred at the eastern edge of the Pyrenean Mountains (Fig. 3.2.3.1-5).

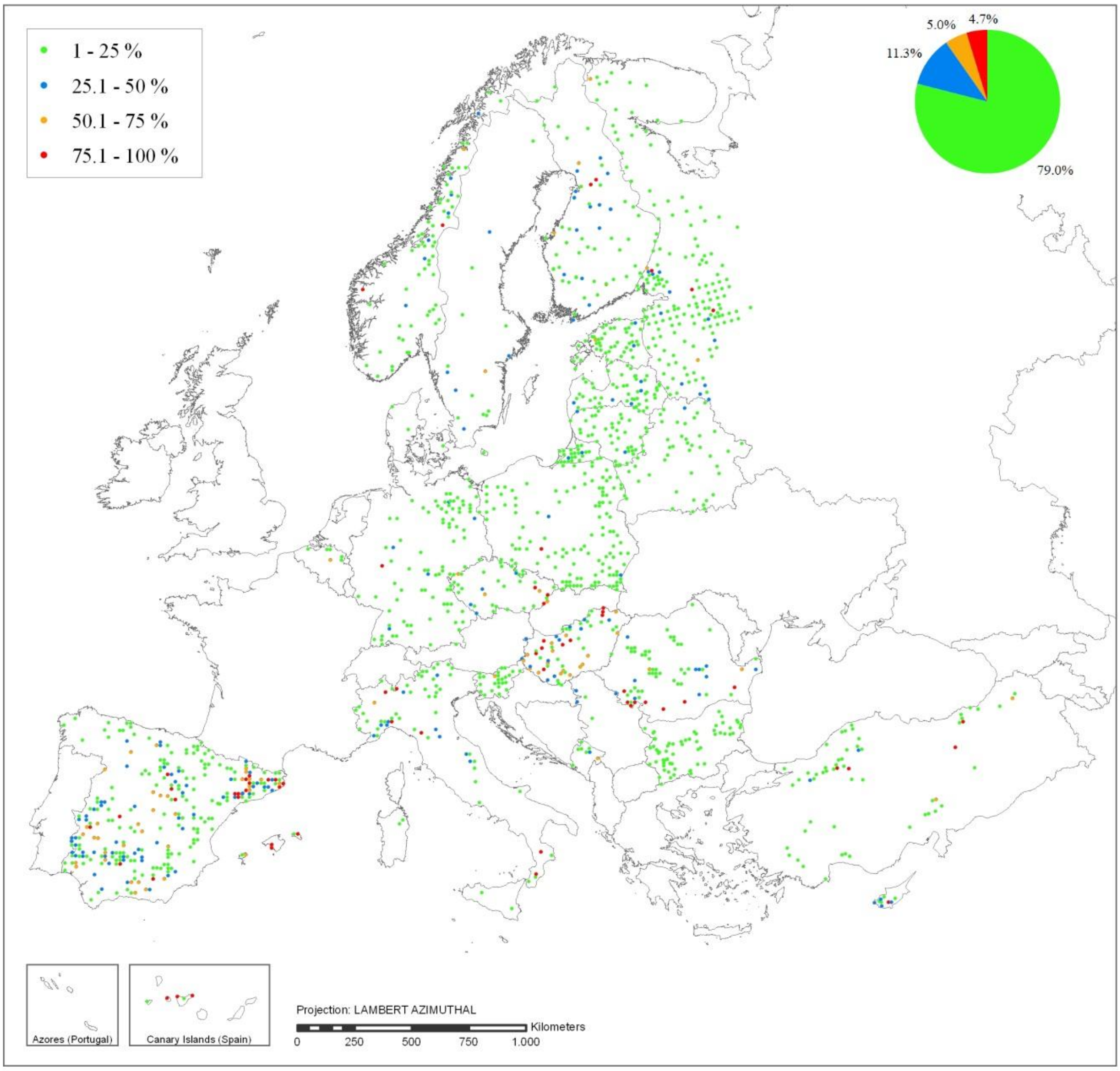

Figure 3.2.3.1-5: Shares of trees per plot with recorded agent group 'abiotic agent', 2011

3.3. Methods of the national surveys

National surveys are conducted in many countries in addition to the transnational surveys. The national surveys in most cases rely on denser national grids and aim at the documentation of forest condition and its development in the respective country. Since 1986, densities of national grids with resolutions between 1 x 1 km and 32 x 32 km have been applied due to differences in the size of forest area, in the structure of forests and in forest policies.

Results of crown condition assessments on the national grids are presented in Chapter 6 and Annex II. 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.

3.4. References

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4. Sulphate and nitrogen deposition and trend analyses

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4.1. Introduction

The atmospheric deposition of sulphur (S) and nitrogen (N) compounds affects forest ecosystems through several processes. Deposition of acidifying compounds, inorganic nitrogen as a nutrient and base cations to forests in Europe is a major driver for many processes in forests. The development of deposition is of high interest and therefore, trend analyses of ICP forests deposition data are regularly produced and published (e.g. Lorenz & Granke, 2009). However, until recently, these trend analyses were usually carried out with data covering the last six years only. Trend analyses with longer time series using linear regression techniques have first been included in the Technical Report 2010 (Granke & Mues, 2010). Trend analyses of part of the ICP Forests deposition data have also been carried out at the national level using Mann Kendall tests or autoregressive time series modelling (e.g. Meesenburg et al., 1995; Kvaalen et al., 2002; Moffat et al., 2002; Lange et al., 2006; Rogora et al., 2006; Wu et al., 2010b; Graf Pannatier et al., 2011).

The various available techniques have their advantages and disadvantages, and the detection and magnitude of trends may to some extent depend on the test used. For example, the linear regression test cannot distinguish between trends caused by changes in precipitation volume and trends caused by changes in the 'pollution climate'. In comparison, non-parametric tests such as Seasonal Mann Kendall tests are more robust against sporadic events, such as high calcium (Ca) peaks caused by Saharan dust events. Secondly, the minimal detectable trend may depend on the uncertainties included in the deposition measurements (ICP-Forests Manual, ICP-Forests, 2010).

When multiple tests are carried out on a large data set, the possible effect of the size of the data set needs to be considered. For example, if hundreds of tests are carried out on the basis of test having a probability threshold of 0.01, the probability of some false positive becomes relevant. On the other hand, even non-significant trends may indicate a significant change, when the trends have the same direction for most of a large number of trends.

4.2. Objectives

The main goal of this study is to detect trends in deposition at ICP Forests Level II sites (with ICP Forests and pre-ICP Forests data) and to investigate possible causes. The specific objectives are to:

- determine the bulk and throughfall deposition of sulphate and inorganic nitrogen (nitrate and ammonium) and its trends

[1] For addresses see Annex III-4

- investigate the influence of the trend analyses technique on the detection of statistically significant trends by comparing the linear regression test with the Seasonal Mann-Kendall approach.
- investigate the minimal detectable trend in case of deposition measurements made according to the ICP Forests Manual.
- investigate and discuss possible reasons for trends on a European and a regional level.

4.3. Methods

Continuous sampling of throughfall (TF) and bulk deposition (BD) is carried out on ICP Forests intensive monitoring plots (Level II) and at a nearby open field, respectively. The methods used in the countries fulfil the requirements defined in the ICP-Forest Manual (earlier versions and ICP-Forests, 2010) to a large extent (Norway: Kvaalen et al., 2002; Moffat et al., 2002; Italy: Mosello et al., 2002; Switzerland: Thimonier et al., 2005; Czech Republic: Boháčová et al., 2010; UK: Vanguelova et al., 2010; Wu et al., 2010a; Swedish Throughfall Monitoring Network (SWETHRO): Pihl Karlsson et al., 2011). Collectors (10 to 20 replicates) are placed in the forest based on a random or fixed design in order to cover the spatial variation. Tests to determine the minimal number of samplers required to cover spatial variations to gain a representative plot mean have been carried out on a number of plots (e.g. Thimonier, 1998; UK: Houston et al., 2002; Belgium: Staelens et al., 2006). Some samples are collected at least monthly, filtered, and then stored at about 4°C before chemical analyses are performed to determine the concentrations of the macronutrients. The laboratory results are checked for internal consistency based on the conductivity, the ion balance, the concentration of organic N and the Na/Cl ratio, and are repeated if suspicious. The QA/QC procedures further include the use of control charts for internal reference material to check long-term comparability within national laboratories as well as participation in periodic working ring tests (e.g., Marchetto et al., 2006) to check international comparability.

Data was submitted annually by countries to the Programme Coordinating Centre (PCC), checked for consistency and stored in ICP Forest database.

We selected the data used in the analysis by applying the following criteria to the deposition data from the years 1998 to 2010: (i) continuous sampling during >330 days per year, (ii) non-missing concentration values for >330 days per year. Hereby, sampling periods with mean precipitation below 0.1 mm days^{-1} were counted as non-missing even if no chemical analyses could be performed.

Since precise dates of the sampling periods have not been submitted for data collected before 2007, the sampling dates were reconstructed based on start and end date and the number of sampling periods per year. Data of the sampling periods were interpolated to regular monthly and annual data with three steps: (i) intersection of sampling periods at end of months/years distributing precipitation quantity proportional to the duration to the new sampling periods, /split of every sampling period overlapping two consecutive months into two new sampling periods, by distributing precipitation quantity in proportion to the duration of the new sampling periods (ii) using deposition=0 for periods with missing concentrations and mean precipitation < 0.1 mm day^{-1} (iii) calculation of the deposition fluxes qc (kg ha^{-1} a^{-1}) of these periods by multiplying precipitation quantity q (L m^{-2}) with the concentrations c (mg L^{-1}) with

$$qc = 0.01\, q\, c$$

and summing up the fluxes of months and years.

Both bulk precipitation and throughfall deposition of sulphur were corrected for the contribution from sea salt to estimate the anthropogenic part of sulphur deposition $SO_4^{--}{}_{corr}$ (mg L^{-1}) with

$$SO_4^{--}{}_{corr} = SO_4^{--} - 0.54\ Cl^-$$

where SO_4^{--} and Cl^- (mg L^{-1}) are the concentration of sulphate and chloride.

Trend analyses were carried out with (i) linear regression (LRegr) (Granke & Mues, 2010) and (ii) Mann-Kendall (MK) test (Mann, 1945; Helsel & Hirsch, 2002) using annual deposition fluxes, and with (iii) Seasonal Mann-Kendall (SK) (Hirsch et al., 1982; Hirsch & Slack, 1984), and (iv) Partial Mann Kendall (PMK) tests (Libiseller & Grimvall, 2002) using month

ly deposition data. The SAS and R software was used for the linear regression and Kendall tests, respectively (Marchetto, 2012). For the Kendall tests (MK, SK, PMK), trend slopes were estimated using Sen's (1968) equations.

We calculated a relative slope *rslope* (a^{-1}), an estimated mean relative change per year, with

$$rslope = slope / mean,$$

where slope (kg ha^{-1} a^{-1}/a) is the estimator for the absolute trend resulting from the trend analyses and mean (kg ha^{-1} a^{-1}) is the mean value of the time series.

The relative slope was plotted against the p-value to investigate patterns that may be used to define a minimal detectable trend for deposition data.

4.4. Results

4.4.1. Current deposition

Mean annual throughfall (TF) and bulk deposition (BD) of sulphur and nitrogen was calculated for 289 and 357 plots with at least one of the years 2008, 2009 and 2010 meeting the mentioned completeness criteria (Figures 4.4.1-1 and 4.4.1-2).

High sulphur deposition has been measured in northern central Europe especially in a region covering Belgium/Netherlands, Central Germany, Czech Republic and Poland, as already mentioned by Granke et al. (2010), reaching up to the southern Baltic and the Central Hungarian area. Furthermore, high values have also been found in some Mediterranean regions in Spain, France, Southern Italy and Greece. Higher values in throughfall than bulk deposition confirm that sulphur is filtered from the air by the tree canopies. High sulphur depositions along the coast mostly occur with high Cl deposition, which is typical for sulphur that originates from sea salt.

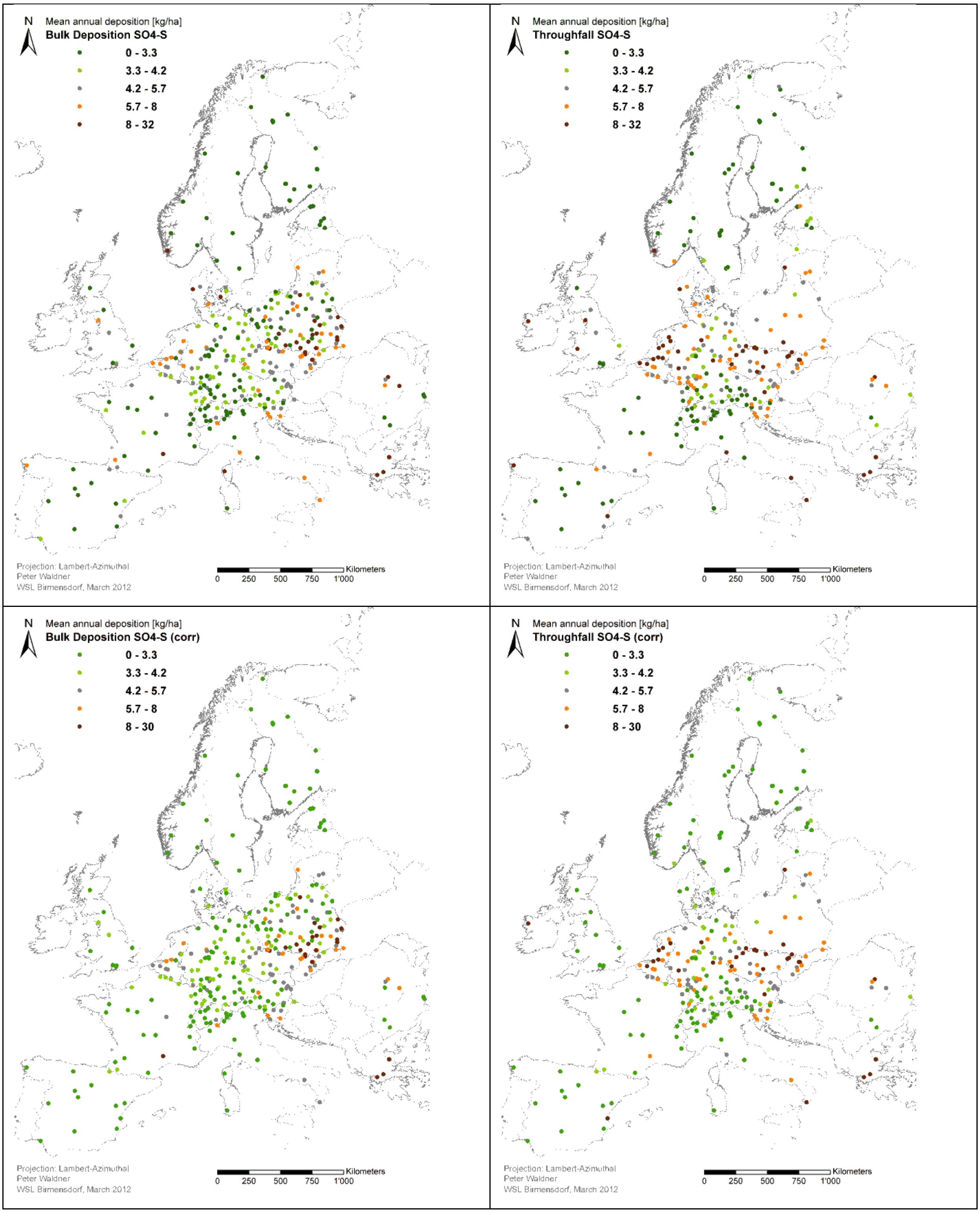

Figure 4.4.1-1 Mean annual sulphate sulphur (SO_4^--) throughfall and bulk deposition 2008 to 2010 with and without sea salt deposition included. Corr = no sea salt included

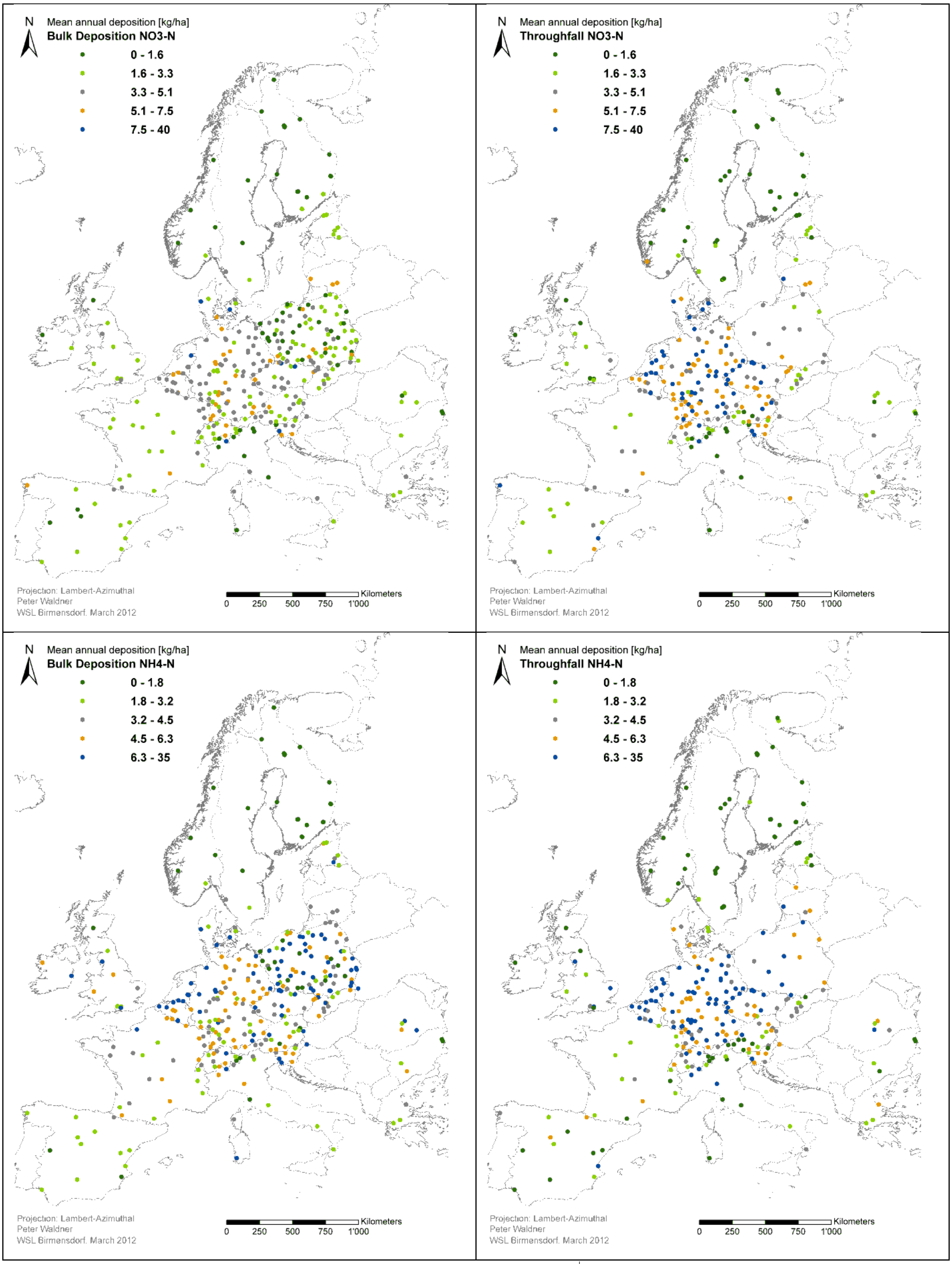

Figure 4.4.1-2 Mean annual nitrate (NO_3^--N) and ammonium (NH_4^+-N) bulk and throughfall deposition during the period from 2008 to 2010.

High nitrogen deposition is also recorded in northern central Europe, as for sulphur, but extends further to the South down to southern Germany and the Swiss Plain, as observed in earlier years (Granke & Mues, 2010). Data from sites in UK and Ireland, not included in Granke et al. (2010), show that for ammonia the high deposition regions extends also further to the West, not only to northern France, but also to central UK and Ireland. In contrast to sulphur, the regions south of the Alps show relatively high bulk and throughfall deposition of nitrate and ammonium as well. In the Mediterranean area, relatively high values have been recorded at some sites in Spain and in southern France.

4.4.2. Temporal trends

For 87 and 55 sites with throughfall and bulk deposition measurements from 1998 to 2001 respectively, we calculated time series for sulphur and nitrogen. These time series include the period 1998 to 2007 for which trend analyses have been carried out by Granke et al. (2010) as well as the period from 2001 to2010 analysed here. At some few of these sites, the correction for sea salt could not be performed because chloride data did not meet the mentioned criteria.

The sulfur deposition showed a decreasing trend for the period from 2001 to 2010 that is detected by linear regression as being significant for the majority of the sites (Figure 4.4.2-1)

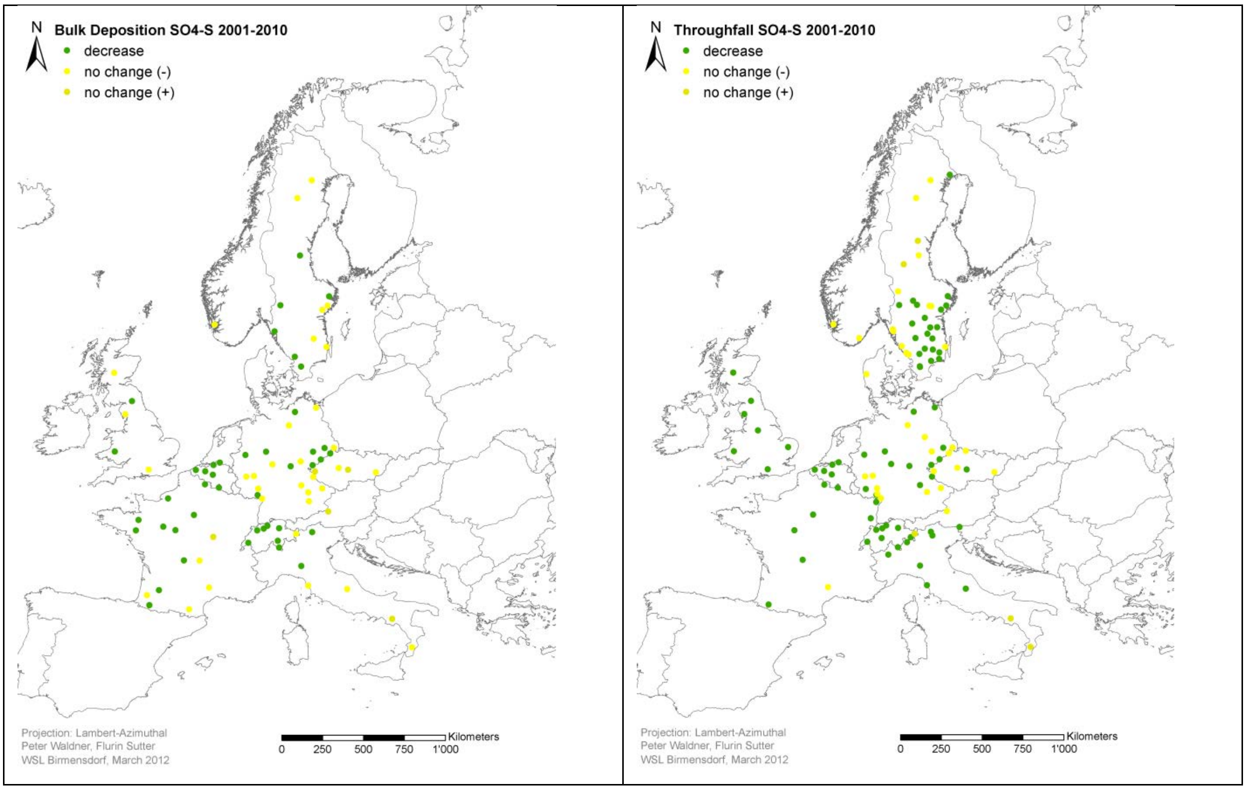

Figure 4.4.2-1 Trend of sulphate (SO_4^{-2}–S) bulk and throughfall deposition on plots with continuous measurements from 2001 to 2010. Non-significant positive trends are indicated with 'no change (+)' and non-significant negative trends with 'no change (-)'.

The mean of the sites with continuous measurement from 1998 to 2010 decreased from about 10 and 7 kg S ha^{-1} a^{-1} to about 5 and 4 kg S ha^{-1} a^{-1} (Figure 4.4.2-3) for throughfall and bulk deposition, respectively. This corresponds to a relative decrease of about 6% per year. However, for the individual sites, the mean relative decrease ranged from about 0% to 10% per year (Figure 4.4.3-1) and low relative decreases have also been estimated for some of the sites with high sulphur deposition. In comparison, the mean precipitation volume remained quite stable except for the drier year 2003 and, to a lesser extent, 2005.

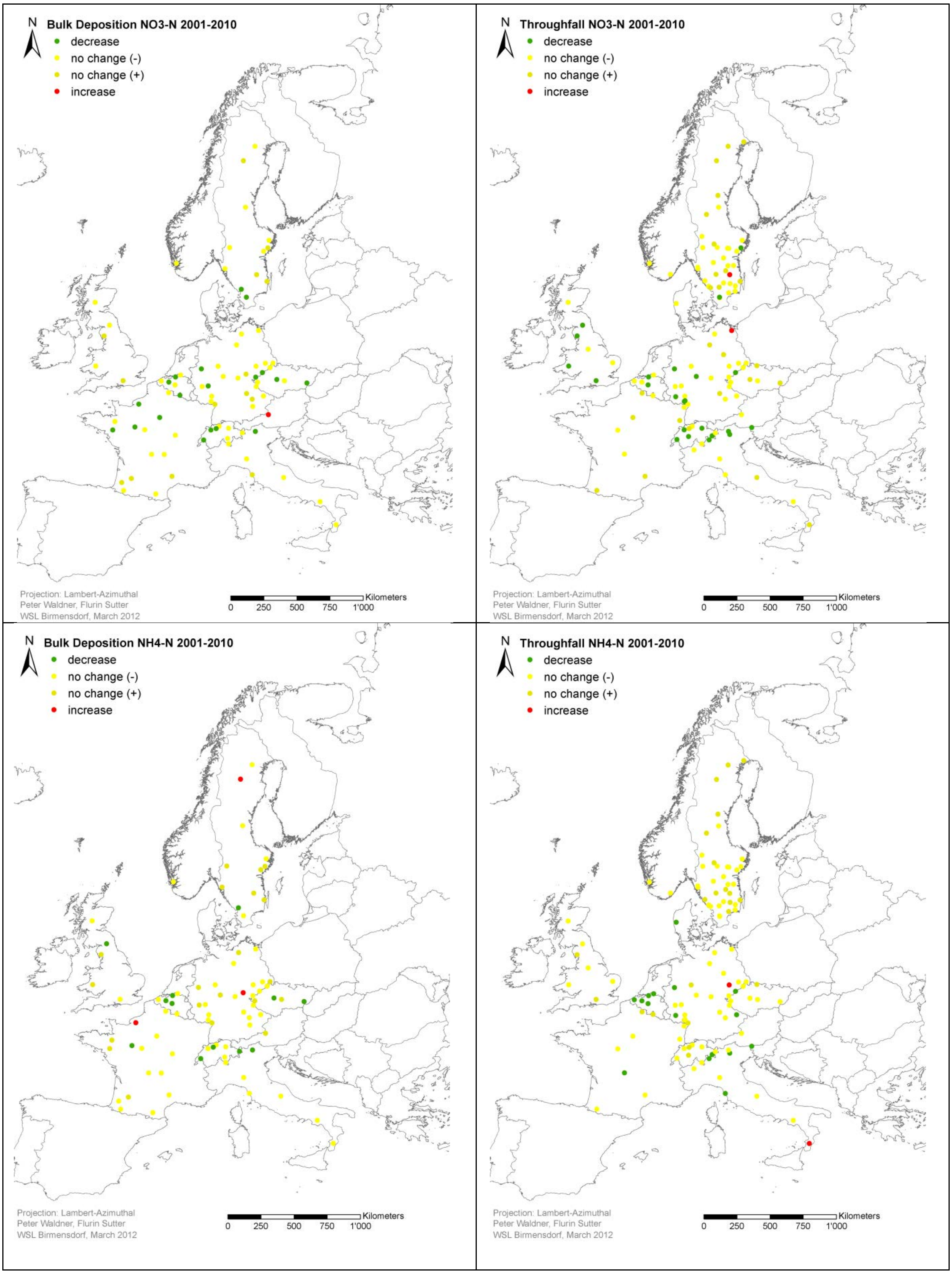

Figure 4.4.2-2: Trend of nitrate (NO_3^--N) and ammonium (NH_4^+-N) bulk and throughfall deposition of plots with continuous measurements from 2001 to 2010. Non-significant positive trends are indicated with 'no change (+)' and non-significant negative trends with 'no change (-)'.

For the plots with continuous inorganic nitrogen deposition measurement in bulk and throughfall from 2001 to 2010, trends that were significant have been detected for less plots than for sulphate (Figure 4.4.2-2) The mean throughfall deposition of inorganic nitrogen on sites with continuous measurements from 1998 to 2010 decreased from about 11 to about 9 kg N ha^{-1} a^{-1} i.e. circa 20%, corresponding to a mean decrease of about 1 to 2% per year (Figure 4.4.2-4).

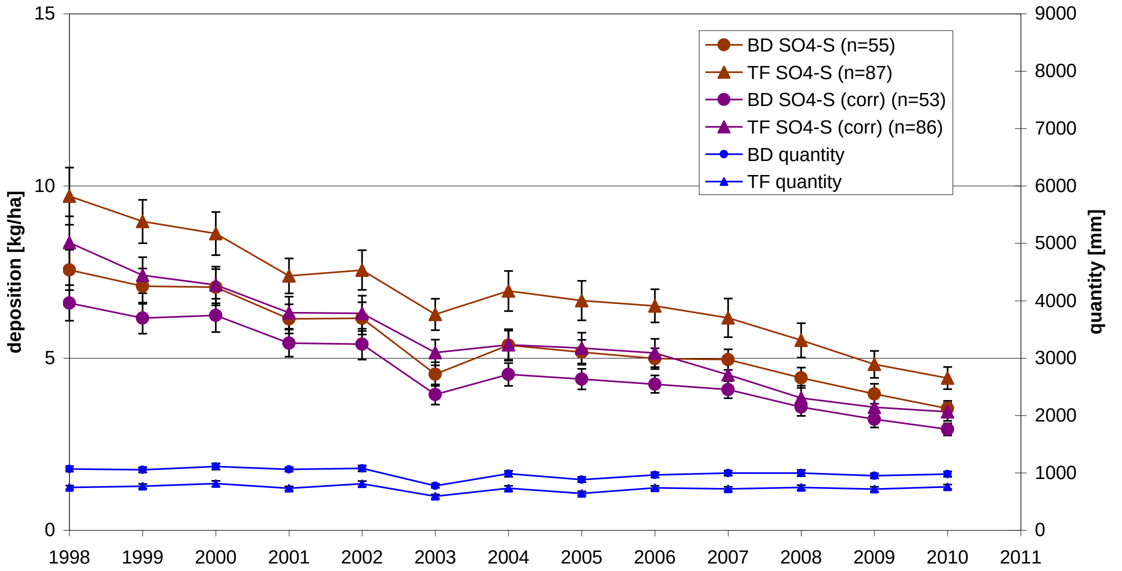

Figure 4.4.2-3: Mean sulphate (SO_4^{--}-S) bulk and throughfall deposition and precipitation volume (quantity) on plots with continuous measurements from 1998 to 2010, with and without correction for sea salt deposition. Corr = no sea salt included. Error bar show the standard error of the mean.

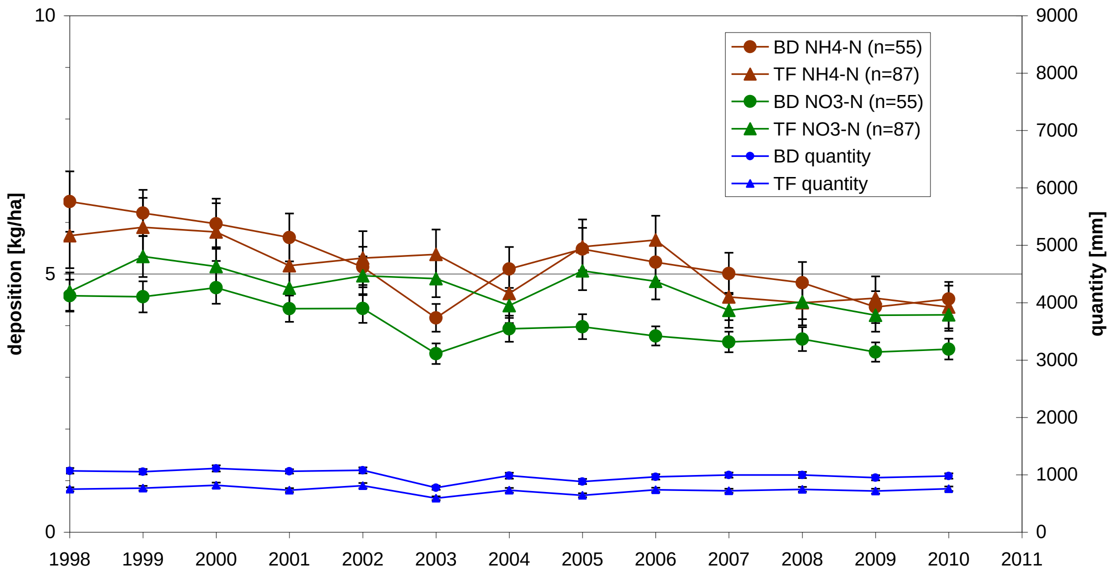

Figure 4.4.2-4: Trend of nitrate (NO_3^--N) and ammonia (NH_4^+-N) bulk and throughfall deposition and precipitation volume (quantity) of plots with continuous measurements from 1998 to 2010. Error bars show the standard error of the mean.

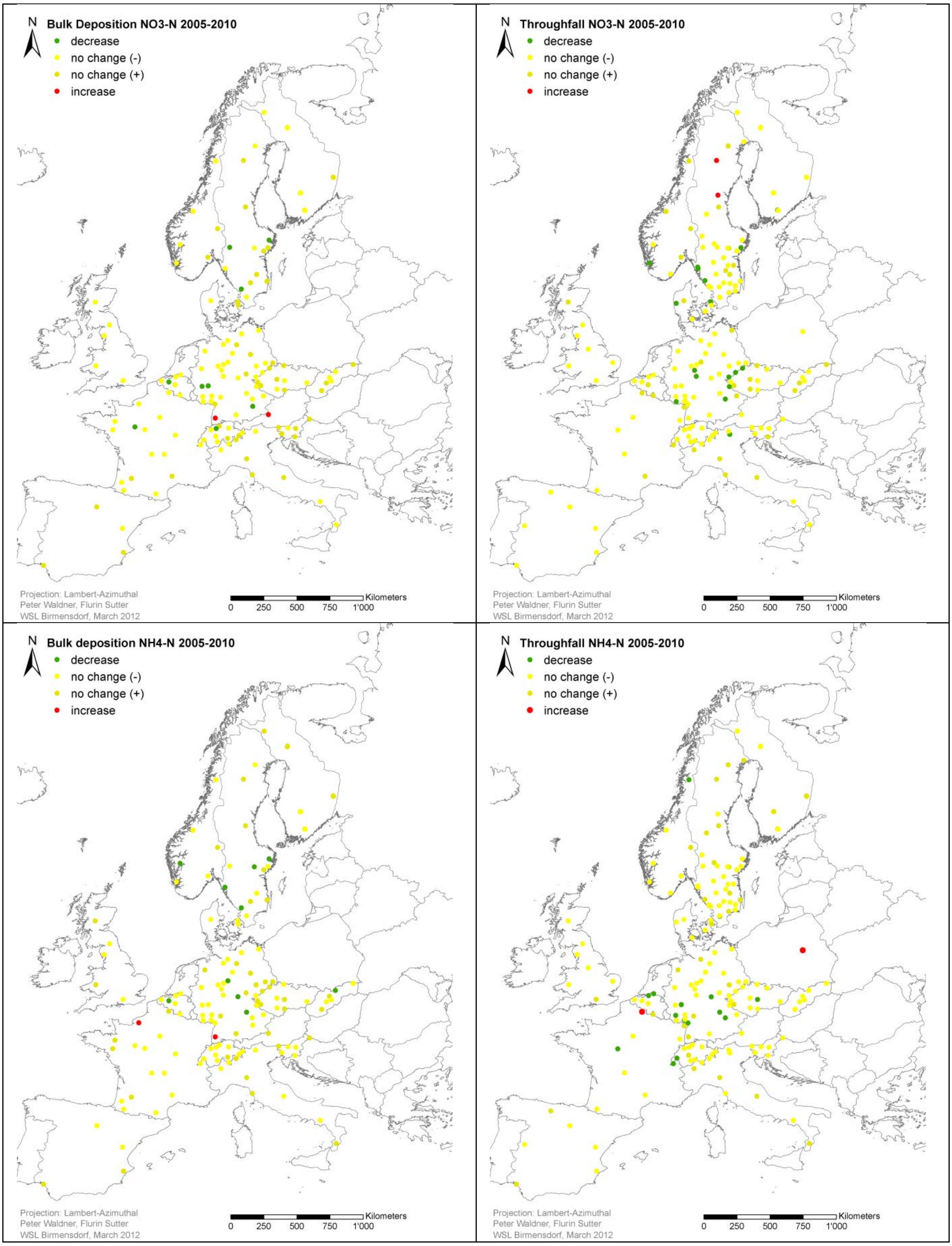

Figure 4.4.2-5: Recent trend of nitrate nitrogen (NO_3^--N) and ammonia nitrogen (NH_4^+-N) bulk and throughfall deposition of plots with continuous measurements from 2005 to 2010.

4.4.3. Comparison of trend analyses techniques

The slope estimates of the Kendall trend analyses techniques showed a quite high agreement to those of linear regression in Figure 4.4.3-1 (left side) for $SO_4^{--}S$ fluxes in throughfall. The agreement of slopes was highest for Mann-Kendall (MK) that was performed with annual data as well. It was a bit less high for Seasonal Mann-Kendall (SK) and Partial Mann-Kendall (PMK) tests that were carried out with monthly data and aim on taking into account seasonal variation and the co-variable precipitation quantity. Significance of a statistical test is given, if the p-value is lower than a certain value, e.g. $p<0.05$ in case of a 95% significance level. In Fig. 4.4.3-1 (right side) the p-values of the Kendall tests are plotted against those of the linear regression (LR) than the slopes test. In general, the differences were lower for longer time series. The relation between the p-values of MK and p-values of LR is not very strong, the points scatter. The p-values of SK and especially PMK however, tend to be lower than those of LR.

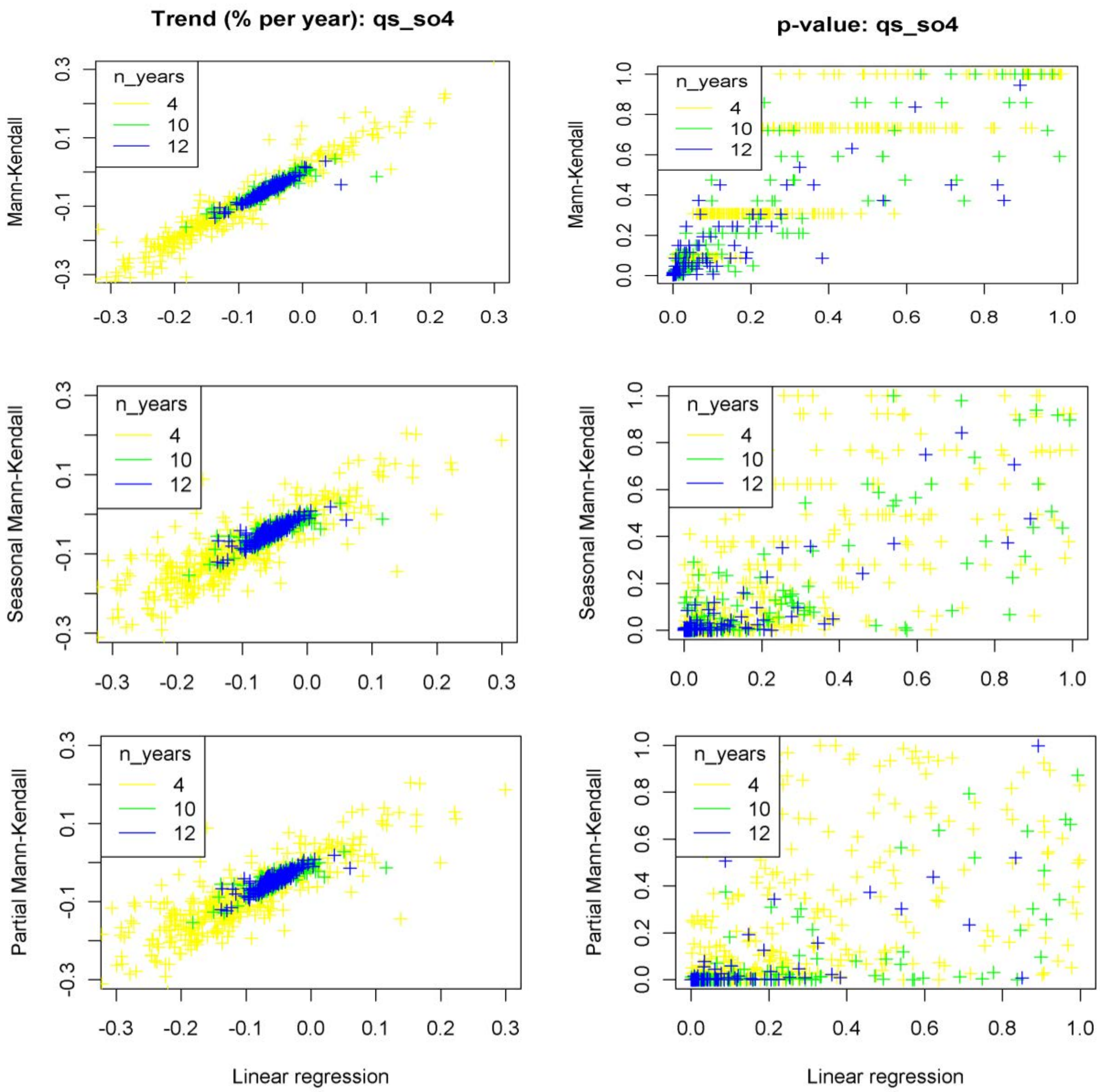

Figure 4.4.3-1: Relative slope (rslope) and p-value of Kendall trends tests MK, SMK and PMK versus linear regression trend test for SO_4^{--}-S throughfall deposition from 1998 to 2010 (12 years), 2001 to 2010 (10 years), and 2007 to 2010 (4 years).

The compared trend analyses techniques resulted thus in similar trend slope estimates, but detection with statistical significance was more frequent for PMK and SK than for MK and LReg.

4.4.4. Estimation of minimal detectable trend

The minimal relative slope of a monotonic trend that is required to identify this trend with statistical significance was investigated by plotting the p-value of the trend test versus the relative slope estimate (*rslope*).

Fig.4.4.4-1 shows the *p-values* are plotted against the relative slope *rslope* for trend tests of throughfall deposition of SO_4^{--}-S time series with 4, 6, 9, 10 and 12 years of continuous measurement until 2010.

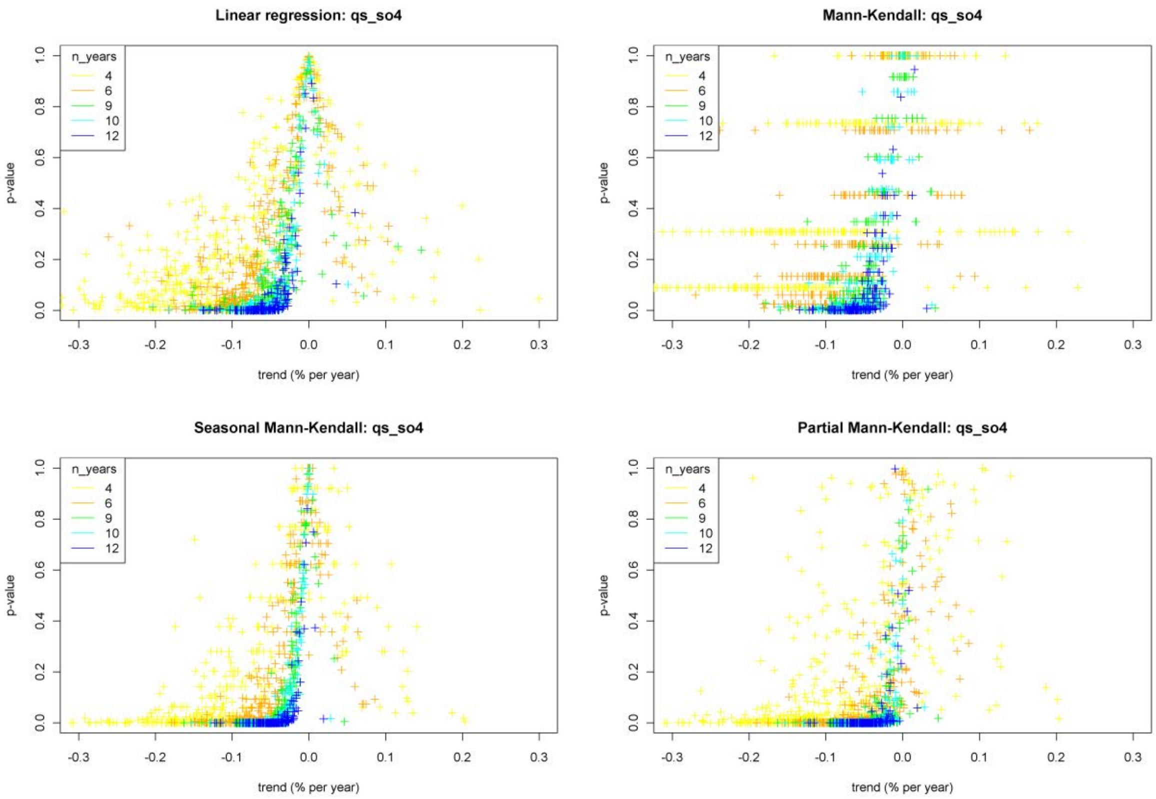

Figure 4.4.4-1: P-value plotted against relative slope estimates of trend analyses with linear regression (LReg), Mann-Kendall (MK) of annual means, Seasonal Mann-Kendall (SK) and Partial Mann-Kendall (PMK) of SO_4^{--}-S throughfall (TF) deposition fluxes time series with 4, 6, 9, 10 and 12 years of continuous data until 2010.

On this p-value vs. rslope graph, most dots, i.e. trend estimates, are within a quite narrow band with the shape of a Gaussian curve. This band and its Gaussian curve shape is narrower for longer the time series and slightly differ from trend test to trend test. For linear regression (LReg) of times series with 12 years of SO_4^{--}S throughfall data, most trends with rslope above 3% to 5% per year have $p<0.05$ (significant) and while most of trends with rslope below 3 to 5% have $p>0.05$ (not significant). We may conclude that an rslope of at least 3% to 5% per year is required to detect a trend with statistical significance in this case. For shorter time series the required relative trend slopes *rslopes* seem to be higher while it seem to be lower for the Seasonal Mann-Kendall (SK) and the Partial Mann-Kendall (PMK) test. The patterns were similar for the major macro nutrients ammonia, nitrate, calcium and magnesia as shown in

Fig. 4.4.4-2 the minimal detectable trends seem to be slightly higher for elements with higher temporal variability due to e.g. sporadic events such as Saharan dust deposition for calcium.

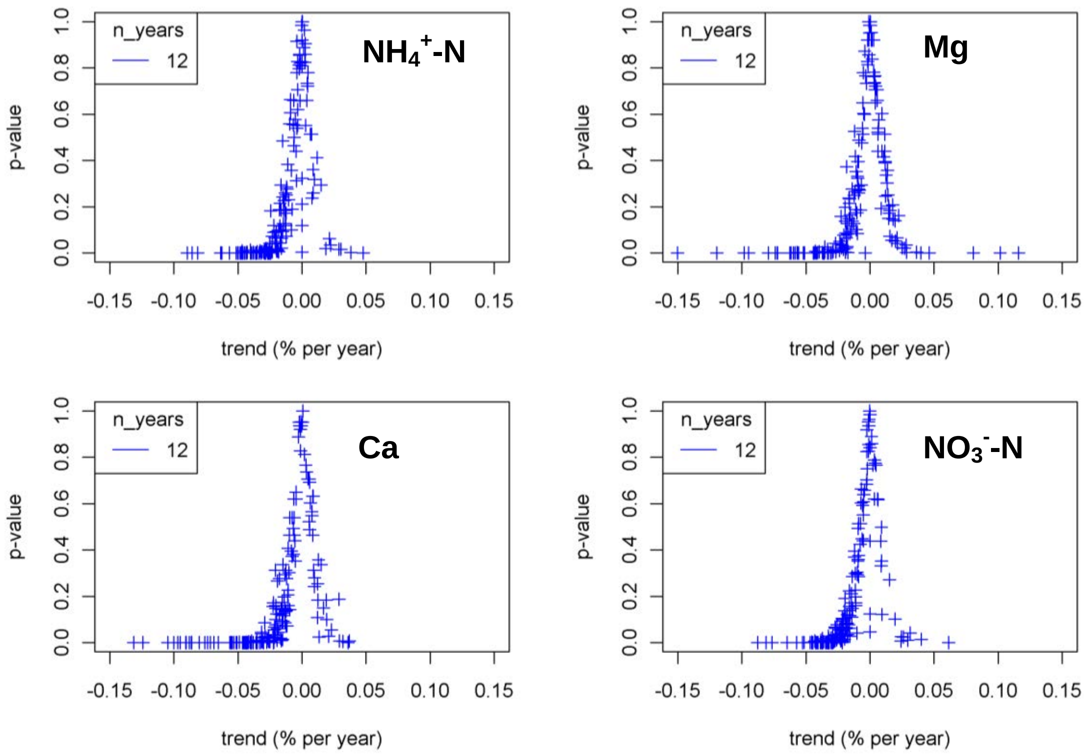

Figure 4.4.4-2: p-value plotted against relative slope estimates of trend analyses with Seasonal Mann-Kendall (SK) for ammonium, magnesium, calcium and nitrate throughfall (TF) deposition fluxes time series with continuous data from 1998 to 2010 (12 years).

4.5. Discussion

This joint evaluation that involved numerous national experts responsible for the deposition measurements in their countries opened the opportunity (i) to reconstruct the sampling periods for older datasets, (ii) to complete the dataset in case of missing years, (iii) to include corrections made on national level as well as to integrate arguments for the interpretation of the results.

The comparison of the trend analyses techniques confirmed that the choice of a specific method has an influence on the number of trends identified as being significant. Seasonal Mann-Kendall and Partial Mann-Kendall tests applied to monthly data identified more significant trends than linear regression techniques. However, there was a quite high agreement between the slope estimates of the trend analyses techniques.

Minimal detectable trends were derived from a quite strong relation between trend significance and relative trend slope seem in the deposition fluxes time series of the same length. The results were relatively consistent in terms of the minimal relative slope required for a trend to be detected as significant for a certain length of time series. The minimal detectable trend (mdT) seem to be a bit smaller for Partial Mann-Kendall tests than for the other tests. The mdT was a bit higher for calcium (Ca) than for the other investigated nutrients. This might be explained ba a higher temporal variability. For Ca often reported that a high part of the annual deposition is due to relatively few peak events (e.g. Rogora et al., 2004).

For time series with 10 years the 'minimal detectable trend' estimated from the p-value vs. rslope diagram is in the same order of magnitude as the data quality objective (DQO) for the determination of the annual deposition defined in the ICP-Forests Manual (ICP-Forests, 2010). Working ring-tests for laboratory inter-comparison (Marchetto et al., 2011) as well as the field inter-comparison exercise with (i) a common (harmonized) sampler on national plots (Zlindra et al., 2011) as well as with (ii) national samplers in a common plot (Bleeker et al., 2003; Erisman et al., 2003) showed that these data quality objectives are realistic and that it can be assumed that they are met for the majority of the ions, laboratories and plots.

The trends found in this study for S and N compounds are in agreement with most other studies (Vanguelova et al., 2010; Graf Pannatier et al., 2011). Meesenburg et al. (1995) carried out trend analyses of annual deposition data from 1981 to 1994 of 4 plot in Germany with linear regression techniques. They also found significant decrease of SO_4^{--} with rslope between -5 and -9% a-1 for all plots but only a slight decreasing tendency for NO_3^- (between 0 and -3% a-1) that was significant only at one plot. Kvaalen et al. (2002) also found a significant decreasing trend (rslope between +2 and -15%) in monthly SO_4^{--}bulk and throughfall deposition from 1986 to 1997 that was significant for 11 out of 13 plots in Norway. Moffat et al. (2002) noted that the small but significant decrease of almost all ions in throughfall deposition from 1987 to 1997 of these plots was in line with earlier findings of Likens et al. (1996) and Stoddard et al. (1999) for stream water chemistry in North America and Europe.

When Rogora et al. (2006) compiled an overview of trend of bulk and throughfall deposition in the Alps for the two periods 1985-2002 and 1990-2002 they found that the decreasing trends of N deposition were still significant at the minority of sites (about 25% of the sites for NO_3^- and 50% of the sites for NH_4^+) while SO_4^{--} trends were clearly significant at all sites with the Seasonal Mann-Kendall that is more conservative than linear regression used for the maps here. Hence, for the 2001 to 2010 period, decreasing trends seem to flatten for SO_4^{--} as well as for NH_4^+ and NO_3^-.

Moreover, Vanguelova et al. (2010) found SO_4^{--} decrease that were significant at only 4 out of 10 plots for bulk deposition but at 8 out of 10 plots for throughfall deposition in the monthly 1995 to 2006 deposition data in UK. In bulk deposition the background level of sea salt sulphur deposition might be relatively high at ? some of the costal plots in UK. Same magnitudes of absolute decreasing trends might thus result in lower relative slopes of the trends at these sites, especially for bulk deposition.

Fagerli et al. (2008) compared NO_3^- and NH_4^+ concentration in wet precipitation modelled by EMEP based on the emissions inventories with measurements for the period from 1980 or later to 2003 and various sites in Europe. They also found decreasing trends being significant for about half of the sites for both modelled and measured data. The significant decreases ranged from about 20% to 60% in 20 years, corresponding thus to relative slope of about 1% to 6% a^{-1}. However, most of the reductions seem to have taken place in the years between 1985 and 1995. Other reasons for decreasing deposition are changes in the tree stand structure, such as the reduction of the number or trees due to a bark beetle attack that occurred on a Czech plot (2161).

However, atmospheric deposition values presented here are restricted to bulk and throughfall deposition fluxes of inorganic compounds. Total deposition to forests also includes organic compounds, stemflow, as wells as canopy uptake. Especially for nitrogen, total deposition typically is significantly higher than the throughfall fluxes.

4.6. Conclusions

In about half of the sites a decrease of N and S was observed in the periods 2001 to 2010 and 2005 to 2010 that was strong enough to be identified with statistical significance.

It could be confirmed that the selection of the trend analyses techniques has an effect on trend detection. There was a quite high agreement in estimated trend slopes. However, Seasonal and Partial Mann-Kendall tests applied to monthly data tend to detect smaller trends with statistical significance than linear regression techniques applied to annual data.

There was a quite consistent relation between the relative slope and p-value of the trend tests for a given length of time series independent of the trend analyses technique used. These patterns also varied surprisingly little between ions. It seems likely that the minimal detectable trend depends mainly on the length of the time series. For time series with a length of 10 years, the minimal detectable trends for N and S compounds seem to be around 3% change per year for linear regression techniques applied to annual data, and around 1% to 2% for Partial Mann-Kendall tests applied to monthly data.

For N compounds, the trends in atmospheric deposition expected to result from the emission reductions in Europe typically are in this range and are unlikely to be detected with statistical significance in time series with a length of much less than 10 years of measurement. For S compounds, typical trends were often higher especially in the 90ties favouring a trend detection with statistical significance.

The deposition trends found in this evaluation are thus quite comparable to those estimated by the European Monitoring and Evaluation Programme from emission inventories. However, its worth noting that the bulk and throughfall fluxes presented here cannot directly be compared to the total atmospheric deposition as estimated by EMEP.

4.7. Acknowledgements

The method for determination of atmospheric deposition fluxes applied in ICP-Forests has been further developed and harmonized by numerous scientists within in the Expert Panel on Deposition that has subsequently been chaired by Erwin Ulrich, Nicolas Clarke and Karin Hansen during the years this investigation is focused on. Application of the methods involved numerous field technicians to install about 4000 samplers, local forest services and field observers to collect more than about a million individual samples, chemical analyses of about 200’000 pooled samples and on-going supervision by about 40 responsible scientists. Data transmission involved national focal centres and the data centre of ICP Forests that was subsequently at FIMCI in the Netherlands, at the Joint Research Centre in Ispra and is today at the Programme Coordination Centre in Hamburg. Data transmission included sophisticated conformity and plausibility checks developed by the involved data base specialists. The comparability of the laboratory analyses has been improved by the activities of the Working Group on QA/QC in labs (standardisation of lab methods, exchange of experience and working ring-tests) initiated and supported by Rosario Mosello, Nils König, Erwin Ulrich, Kirsti Derome, Anna Kowalska, Aldo Marchetto and others. Similarly activities for the field installations were organised by Albert Bleeker, Jan Erisman, Erwin Ulrich, Daniel Zlindra and others. Data quality objectives used here and other methodical improvement were the result by the activities of the QA/QC committee chaired by Marco Ferretti. The atmospheric deposition measurement was established in the frame of the ICP-Forests Programme and was enabled through various ways. Typically this involved access granted by public or private land owners, financial support from the participating countries and the EU, as well as support from

subordinated governmental organisations such as districts, communities or even local forest services.

4.8. References

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5. Exceedance of critical limits and their impact on tree nutrition

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The atmospheric deposition of sulphur (S) and nitrogen (N) compounds affects forest ecosystems through several processes. For N limited stands, enhanced N supply may stimulate the production of above-ground biomass. However, in excess, N loads may lead to nutrient imbalances and sensitivity to frost, insects, and fungi may increase (N saturation hypothesis, postulated by Aber et al., 1989). When N availability exceeds the capacity of the ecosystem to retain N, nitrate leaching from the rooting zone is enhanced. The release of acid anions such as nitrate (NO_3^-) and sulphate (SO_4^{--}), balanced by base cation leaching, may contribute to the acidification of soils and surface waters (acidification hypothesis, postulated by Aber et al., 1989). In acid soils, aluminium (Al) can be mobilized from the soil complex and have adverse effects on fine roots. Both the loss of base cations and the toxic effect of aluminium may further contribute to an unbalanced mineral nutrition of the trees.

The long-term effects of atmospheric deposition on ecosystems can be assessed using the concept of “critical loads” and “critical levels” (CL). These critical values are defined as a quantitative estimate of an exposure to loads or levels below which significant harmful effects on specified sensitive elements of the environment do not occur according to current knowledge (Nilsson & Grennfelt, 1988).

The BC/Al molar ratio, where BC corresponds to the sum of the base cations Ca^{2+}, Mg^{2+} and K^+, is the most widely used criterion for estimating CL for acidity (ALBIOS project, Cronan et al., 1989; ICP-Modelling and Mapping, Spranger et al., 2004; ICP-Forests Technical Report 2010, Iost, 2010).

For nitrogen, CL have been defined with three approaches: the first approach gives a range of typical critical loads for each ecosystem type, e.g. for forests 10 to 20 kg ha^{-1} a^{-1} (empirical CL, Achermann & Bobbink, 2003). The second approach assumes that the leaching of N below rooting zone should not exceed an ‘acceptable’ level. The third approach uses values of N concentrations in the soil solution as a criterion for e.g. nutrient imbalances, N saturation or enhanced sensitivity to frost and fungal diseases (Sverdrup & de Vries, 1994; Lorenz et al., 2008; Technical Report 2011, Iost et al., 2011).

Commonly, a steady state approach (SMB) is used for the European-wide mapping of critical loads exceedances: It is assumed that the ecosystem will reach a steady state and the maximal acceptable load that ensures that a certain criterion remains within defined limits is estimated for this state (cf. Mapping Manual, Spranger et al., 2004; Level I and II plots Nagel et al., 2011). The base cations to aluminium ratio (BC/Al) in the soil solution and the ‘acceptable’ N leaching are among the criteria typically used to define CL for acidity and nutrition N.

On ICP Forests plots, ecosystem responses to deposition are monitored and this data seems to be suited to investigate tree response to critical loads exceedances. However, plots marked on the maps as having CL exceeded may not yet have reached the steady state and changes of soil solution and related effects are thus expected to appear in future only.

[1] For addresses see Annex III-4

In this context, ICP Forests allow to investigate the actual N saturation and acidification status of plots with CL exceeded as well as the tree response to exceedances of critical limits in soil solution.

5.1. Objectives

This study aims at investigating the following relations based on the Level II network:

- Relations between exceedance of critical loads and indicators for N saturation status
- Relations between exceedance of critical loads and indicators for soil acidification status
- Relations between exceedance of critical limits for soil solution and tree responses.

5.2. Methods

This study has been carried out on the plots from the countries shown in Table 5.2-1 of the Level II network of ICP-Forests programme (Fischer et al., 2010), i.e. the intensive monitoring plots of the FutMon project of the LIFE+ programme based on measurements and assessment carried out during 2006-2009.

Table 5.2-1: Study sites and number of plots for combinations of critical loads calculations (CL_{SMB}), the deposition (DP), soil solution (SS) and foliar (FO) analyses and assessment of light green to yellow discolouration or Mg deficiencies (damage cause assessment, DCA) in the years 2007 to 2009.

COUNTRY	CL_{SMB}>SS	DP>SS	SS>FO		DP>FO	yellowing			Deficiencies
	plots	plots	plots	species	plots	plots	species	n	n
France	9	14	14	1	24				
Belgium	4	7	7	1	9	11	1	111	18
Netherlands		1	1	1	4				
Germany	5	59	53	1.2	62	31	1	281	122
Italy	7	9	9	1.1	22	20	1.8	78	
United Kingdom	1	6	5	1.2	5	5	1	22	
Ireland	2	2							
Greece	3	3	3	1	4	3	1	10	
Spain		3	3	1	14	34	1.1	805	
Sweden						5	1	19	
Austria				1.1	20				
Finland	15	17	17	1.0	18	15	1.1	58	
Switzerland		7	7	1.6	12				
Hungary		1	1	1	8	5	1.8	12	
Romania		3							
Poland		1	1	1.0	1	18	1	32	
Slovak Republic	3	3	4	1.2	6	6	3.8	205	
Norway				1	8	6	1.2	29	
Lithuania				1	3	4	1.3	4	
Czech Republic	8	11	11	1	12	14	1.1	73	
Estonia		3	3	1	7	5	1	30	
Slovenia				1	6	7	1	15	
Russian Federation		3							
Bulgaria				1	3				
Latvia		1	1	1	1				
Cyprus				1	2	2	1.5	51	

CL_{SMB}>SS: plots for which CL_{SMB} and SS were determined, etc. yellowing: reporting of occurrence of symptom ‘light yellow to green discolouration’, deficiencies: reporting of occurrence of cause ‘nutrient deficiencies’. plots: number of plots, species: mean number of tree species per plot, n: number of trees.

The measurements and assessments have been carried out according to the Manual of ICP-Forests (ICP-Forests, 2010). For detailed additional descriptions refer to e.g. Thimonier et al. (2010) [list of national studies, to be extended]. The QA/QC measures included checks within the countries, as well as consistency checks during the submission of the data to the data centre at the Programme Coordination Centre (PCC).

Bulk deposition (BD) and throughfall deposition (TF) were continuously collected at weekly to monthly sampling intervals. Annual deposition was calculated as described in the ICP Forests Technical Report (Granke & Mues, 2010), using continuous sampling during at least 333 days as completeness criterion. Volume of bulk deposition was used to derive precipitation quantity.

Soil solution was sampled generally with suction cup lysimeters at same intervals as deposition and analysed chemically in laboratory. Annual mean concentrations of the samples as well as the proportion of samples exceeding critical limits were calculated for each depth and depth classes were aggregated as described in the Technical Reports (Iost, 2010; Iost et al., 2011) (Table 5.2-2). For the comparison of critical loads exceedance and soil solution a generic critical BC/Al=0.8 was used, while for comparison of soil solution and foliar nutrition the tree species specific values in Table 5.2-2 were applied. The values of the lowest lysimeter are referred to as ‘bottom’ hereafter.

Table 5.2-2: Critical limits for N in soil solution (Mapping Manual, Spranger et al., 2004; ICP-Forests Technical Report 2010, Iost, 2010) and indicators of the damage cause assessment (DCA) and the foliar analyses (FO).

Effect	critical limit N (mg N/L)	forest type	depth class used	Indicators compared
Nutrient imbalances	0.2	Coniferous	mineral topsoil	Foliar N, Mg and K nutrition (FO), symptoms of ‘light green to yellow discolouration’ and cause ‘Mg deficiency’ (DCA).
	0.4	Deciduous		
N saturation	1	All	lowest lysimeter	(exceedance of critical loads)
enhanced sensitivity to frost and fungal disease	3	All	mineral topsoil	Cause ‘fungal disease’ on foliage (DCA)

Foliage samples were taken from the upper third of the tree canopy from branches fully exposed to sunlight. Foliage was sampled from at least five trees of the main tree species on the plot. In case of deciduous species, foliage was sampled during full development of the leaves, i.e. in the end of growing season before autumn yellowing. Evergreen foliage was sampled during dormancy period. The ranges of optimal nutrition and the species group compiled by the Expert Panel of Foliage FSCC (Stefan et al., 1997) were used to classify the nutrient concentrations in foliage into ‘low’, ‘in’ and ‘high’ (Table 5.2-3).

Table 5.2-1: Ranges of optimal nutrition for tree foliar concentrations (mg/kg) of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca) and magnesium (Mg) compiled by FSCC (Stefan et al., 1997) and critical values of the molar ratio of base cations to total aluminium (BC/Al_{crit}) in the soil solution according to Sverdrup et al. (1994) and Lorenz et al. (2008).

Species group	N	P	K	Ca	Mg	BC/Al_{crit}
Spruce	12 - 17	1 - 2	3.5 - 9	1.5 - 6	0.6 - 1.5	1.2
Silver Fir	12 - 17	1 - 2	3.5 - 9	1.5 - 6	0.6 - 1.5	1.2
Pine	12 - 17	1 - 2	3.5 - 10	1.5 - 4	0.6 - 1.5	1.2
Douglas	12 - 17	1 - 2	3.5 - 10	1.5 - 4	0.6 - 1.5	0.3
other conifers	12 - 17	1 - 2	3.5 - 10	1.5 - 4	0.6 - 1.5	1.2
Beech	18 - 25	1 - 1.7	5 - 10	4 - 8	1 - 1.5	0.6
Birch	18 - 25	1 - 1.7	5 - 10	4 - 8	1 - 1.5	0.8
Oak	15 - 25	1 - 1.8	5 - 10	3 - 8	1 - 2.5	0.6
other broadleaves	15 - 25	1 - 1.8	5 - 10	3 - 8	1 - 2.5	0.6

The Damage Cause Assessment can be carried out and reported in various level of detail, e.g. only symptom and cause class or Latin name of causing insect. Assessment of a specific symptom detail has been assumed to be carried out if it has been reported at least once in a country and year. Based on this assumption, the proportion of trees showing the symptom has been computed for each year.

Critical loads for nitrogen as a nutrient N_{nut} (CLN_{SMB}) and for acidification (CLA_{SMB}) have been calculated as described in Nagel et al. (2011), based on the measurements described above as well as on soil analyses, using the methods recommended in the Mapping Manual (Spranger et al., 2004). On plots without steady-state mass balance (SMB) calculations, empirical critical loads for N_{nut} (typically in the range between 10 to 20 kg N ha-1 a-1, Achermann and Bobbink, 2003) were used as a reference to classify N loads. Throughfall N deposition was used for calculation of critical loads exceedances.

Means of annual values of the period 2006 - 2009 have been calculated per plot and tree species. The means of the exceedances of critical loads and critical limits and the means of foliar concentrations and occurrence of symptoms per tree species were compared hereafter.

Relations were investigated comparing the percentage of plots using contingence tables and the chi-square test. In addition linear mixed effects models (LME, Pinheiro and Bates, 2011) were applied on annual means from 2006 to 2009. Foliar N and Mg concentrations were used as response variables and the concentrations in soil solution of N and Mg, as well as precipitation, altitude and latitude as explanatory variables. Fixed effects of species group and random effect of survey year nested per plot were included into the regression modelling using the maximum likelihood method.

5.3 Results

Figure 5.3-1 illustrates the changes of the concentrations of dissolved inorganic nitrogen (NH_4^++ NO_3^-) in the water on its path through the ecosystem, as already shown earlier by e.g. de Vries et al. (2003). Despite direct uptake of N from the canopy, the precipitation below canopy (throughfall) often has higher N concentrations than above (values typically close to the bulk deposition), due to dry deposition on the foliage that is washed out with the precipitation. Total deposition of N to forests is thus normally higher than to open land and even higher than the throughfall N deposition shown here. Subsequent concentrations in soil solution are the net result of various processes including immobilisation of nitrogen in the solid phase, nutrient uptake by vegetation, nutrient release from decomposed biomass and water volume changes through e.g. transpiration.

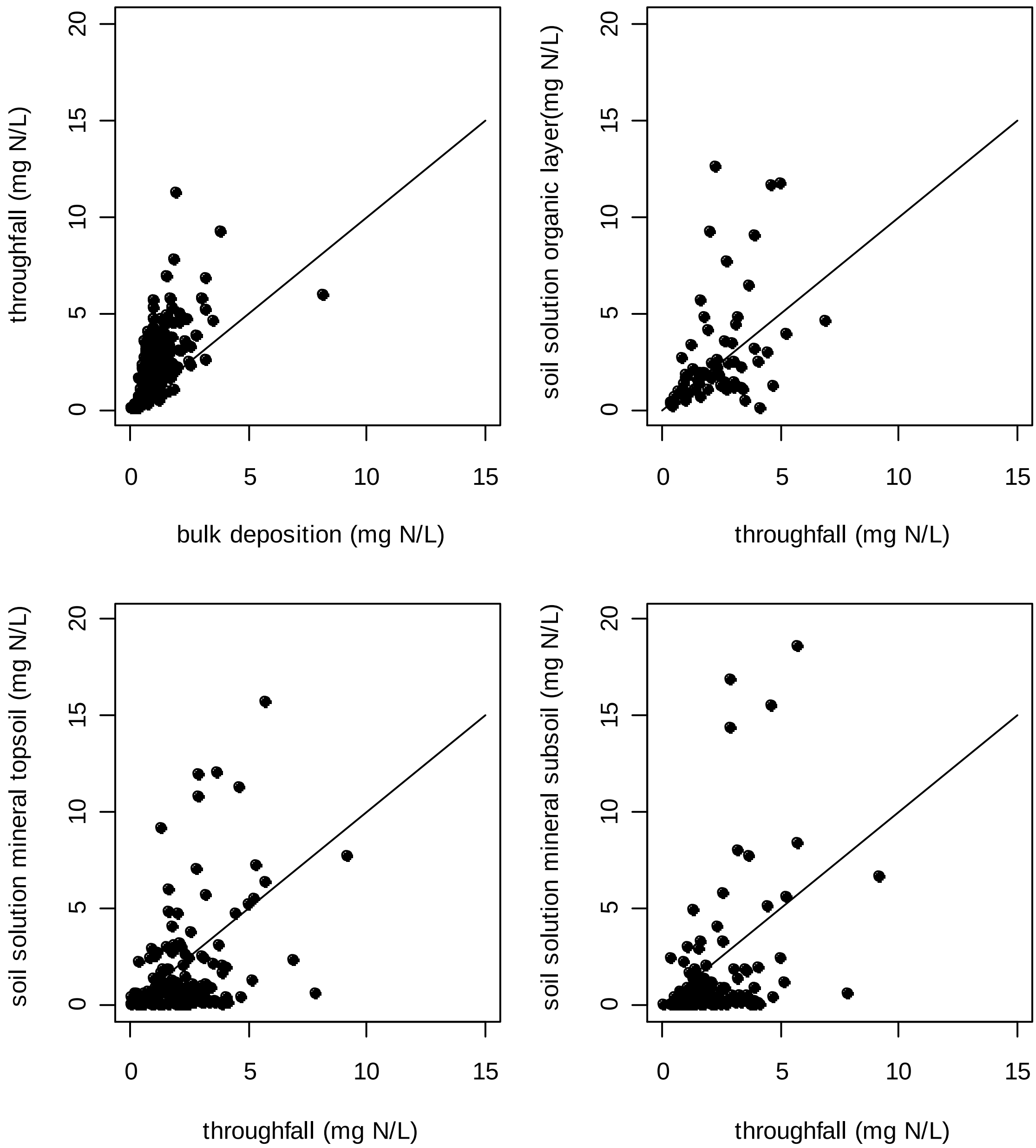

Figure 5.3-1: Concentration of dissolved inorganic nitrogen ($NH_4^+ + NO_3^-$) in bulk precipitation, throughfall precipitation, and soil solution (top right: organic layer, bottom left: mineral topsoil 0-40 cm and bottom right: mineral subsoil 40-80 cm) on selected ICP-Forests level II plots.

The capacity of ecosystems to accumulate nitrogen depends on the N saturation state, which is affected by various processes (Gundersen et al., 1998; MacDonald et al., 2002; Gundersen et al., 2006; Gundersen et al., 2009). Figure 5.3-2 shows that on plots with higher N throughfall (>20 kg N ha^{-1} a^{-1}), nitrate concentrations in the soil solution samples from the lowest lysimeters more often exceeded critical limits for N saturation. Regarding the SMB concept, we may interpret that about half of the plots with critical loads exceeded already show indication of N saturation while the other half may still be in the phase of accumulation and reach saturation later (Figure 5.3-2). We investigated the relation between exceedance of critical loads for eutrophication and exceedance of criticical limits for nitrate in soil solution by using throughfall as indicator for exceedance of empirical critical loads. This way a higher number of plots could be included in the analyses, because SMB critical loads have only been calculated for much less plots.

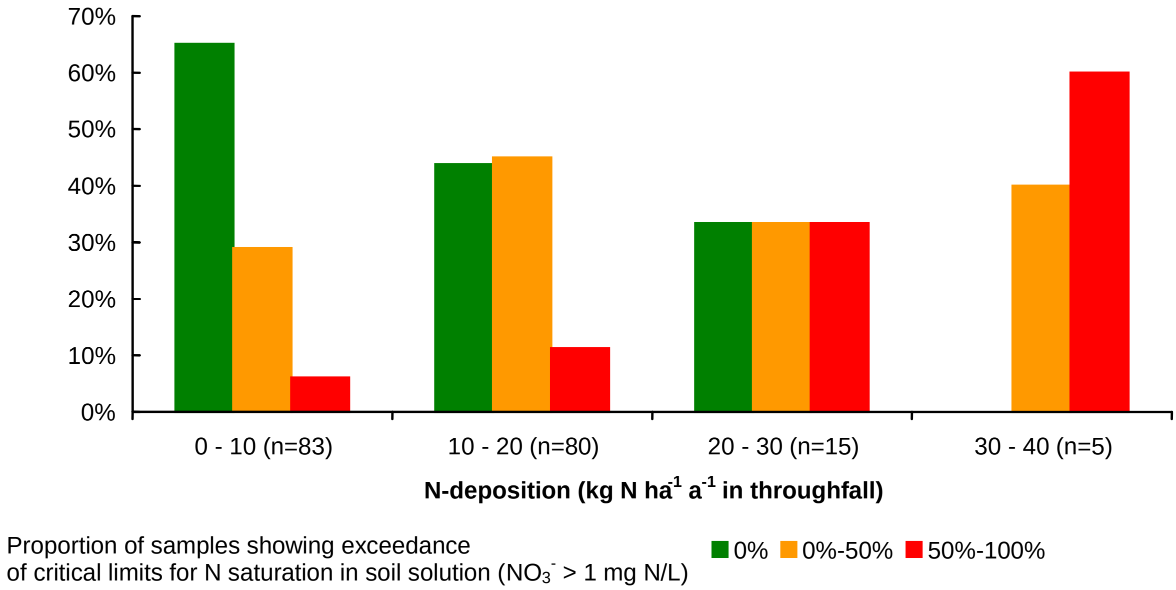

Figure 5.3-2: Percentage of plots with critical limits for N saturation (NO3- > 1 mg/L) in soil solution of the lowest lysimeter exceeded in no sampling period (0%), less than half of the samples (0-50%) and more than half of the samples (50-100%). These percentages plots have calculated for four categories of plots that were defined according to the amount of throughfall N deposition (less than 10, between 10 and 20 and exceeding 20 kg N ha-1 a-1).

Table 5.3-1: Percentage of plots with exceedances of critical limits for BC/Al in soil solution in more than 80% of the soil solution samples for plots with and without exceedances of critical loads for Acidity CLA_{SMB}. The critical BC/Al ratio of 0.8 was used for all plots regardless of the tree species composition on the plot.

depth class	CLA_{SMB}	BC/Al < 0.8		
		<80%	>80%	n
0-20cm	not exc.	65%	35%	(57)
	exceeded	82%	18%	(11)
20-40cm	not exc.	74%	26%	(35)
	exceeded	50%	50%	(6)
40-80cm	not exc.	46%	54%	(28)
	exceeded	38%	63%	(8)
below 80 cm	not exc.	64%	36%	(14)
	exceeded	50%	50%	(2)

Similarly, the proportion of plots with BC/Al criterion exceeded (BC/Al<0.8 in more than 80% of the samples) seems to be higher among the plot with exceedance of critical loads of acidity than among the plots without exceedance of critical loads for acidity (Table 5.3-1). Laboratory determination of the Al speciation showed that the most toxic form, Al^{3+}, typically is about 30% to 100% of total dissolved aluminium, but can also be much lower (Graf Pannatier et al., 2011).

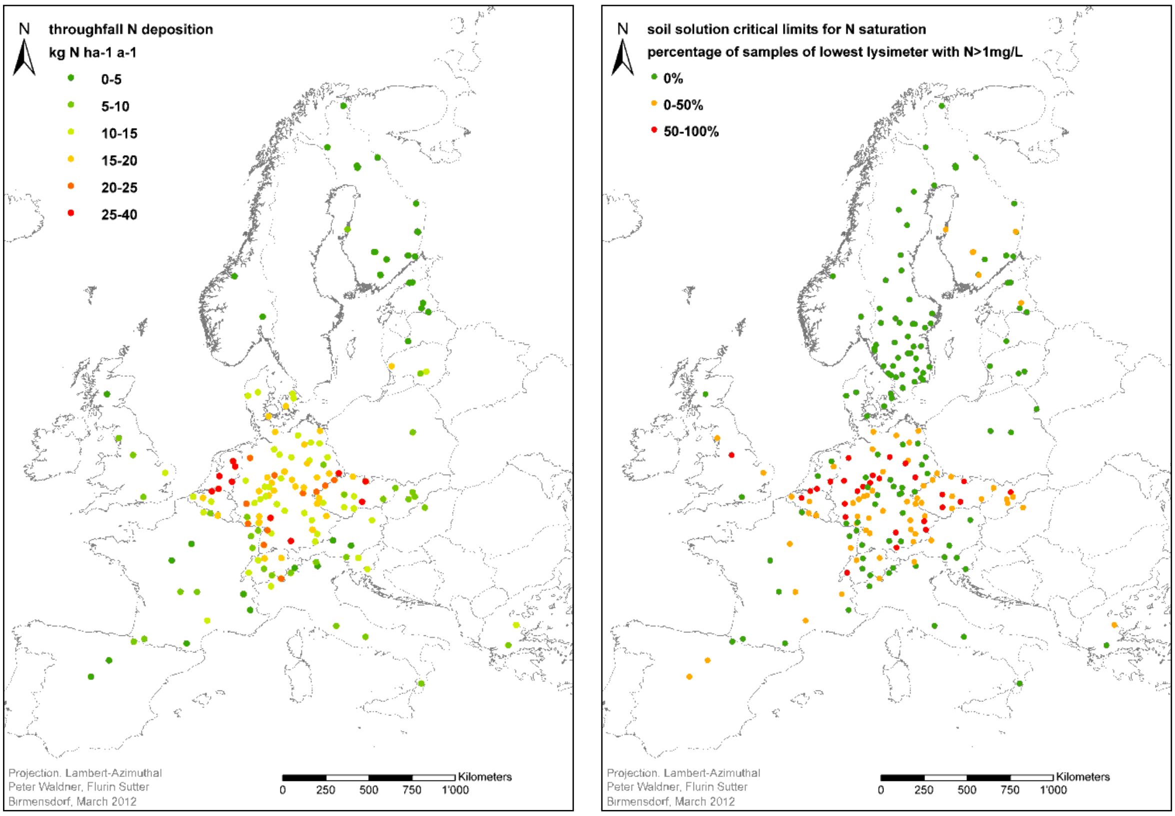

Figure 5.3-3: Throughfall N deposition measurements (left) and exceedances of critical limits of N in soil solution (percentage of samples from lowest lysimeter with sum of concentrations of NO_3^- $+NH_4^+$ >1 mg N/L) for N saturation (right) on ICP-Forests level II plots. Mean of annual deposition with at least 330 day of continuous measurement for the period 2006 to 2009.

The relation between the exceedance of critical limits in soil solution for nutrient imbalances and the class of nutritional status as indicated by the foliar concentrations are shown in Table 5.3-2 and Table 5.3-3 (see also Figure 5.3-3, Figure 5.3-5). Tree species had been summarized to tree species groups in Table 5.3-3.

Generally, coniferous species more often have N values falling into the nutrition class ‘low’ than the broadleaves. This may be related to the fact that conifers are naturally abundant in higher altitudes and latitudes, both regions with lower N deposition (Thimonier et al., 2010). When comparing plots with exceedance to plots without exceedance of critical limits for NO_3^- in soil solution, there seems to be a shift to higher classes for N for Spruce, Pines and Oak and a shift to lower classes for Mg for Spruce, Pines, and Beech. For the groups of Spruce and Pines, the percentage of plots with foliar N concentrations below optimal range is significantly lower for plots with critical limits exceeded. For conifers, Mg concentrations below optimal ranges were only recorded on plots with critical limits exceeded. For Beech, the percentage of plots with low Mg values is higher for plots with critical limits exceeded. For these latter observations, statistical significance was not reached with the chi-square test. However, the LME analyses resulted in a significant positive effect of the N concentration in soil solution on the N concentrations in foliage ($p<0.000$) and negative effect on Mg concentrations ($p=0.01$) and Mg/N ratio ($p<0.000$). For Spruce, Pines, Beech and Oak there is a tendency towards less optimal Mg/N ratios with increasing exceedances of critical limits for N in soil solution.

Table 5.3-2: Relation between exceedance of critical limits for NO_3^- in soil solution sampled in the mineral topsoil (0-40 cm depth) (TR, Iost, 2010) and foliar nutrition classes (FSCC, Stefan et al., 1997) assigned to foliage samples from 2007 to 2009. Percentages of plots with mean foliage concentrations of N, Mg, and K below, in or above the range for optimal nutrition for plots with soil solution critical limits for nutrient imbalances exceeded in 0% and more percent of soil solution samples from the mineral topsoil, respectively.

Species group	NO3-N (mg N/l)		N				Mg				K			
			low	in	High	n	low	in	high	n	low	in	high	n
Spruce	0.2	not exc.	**38%**	62%	0%	(13)	0%	79%	21%	(14)	7%	93%	0%	(14)
		exceeded	**7%**	93%	0%	(42)	2%	93%	5%	(42)	7%	93%	0%	(42)
Pines	0.2	not exc.	**22%**	67%	11%	(9)	0%	89%	11%	(9)	0%	100%	0%	(9)
		exceeded	**0%**	79%	21%	(34)	6%	94%	0%	(34)	0%	100%	0%	(34)
Fir	0.2	not exc.	0%	100%	0%	(1)	0%	0%	100%	(1)	0%	100%	0%	(1)
		exceeded	20%	80%	0%	(10)	10%	60%	30%	(10)	0%	100%	0%	(10)
Beech	0.4	not exc.	0%	71%	29%	(7)	10%	30%	60%	(10)	0%	100%	0%	(10)
		exceeded	0%	72%	28%	(39)	36%	33%	31%	(39)	3%	85%	13%	(39)
Oak	0.4	not exc.	0%	83%	17%	(6)	0%	100%	0%	(6)	0%	83%	17%	(6)
		exceeded	0%	35%	65%	(17)	0%	100%	0%	(17)	0%	76%	24%	(17)

Bold: p-value<0.05 with chi-square test.

For the relation between ‘exceedance’ of critical BC/Al in soil solution and foliar nutrition, it is more difficult to interpret the results shown in Table 5.3-3. However, for the species group Fir, Mg concentrations in foliage below optimum were more frequent on plots with BC/Al < 1.2.

Table 5.3-3: Relation between exceedance of critical BC/Al ratio in soil solution sampled in the mineral topsoil (0-40 cm depth) (TR, Iost et al., 2011) and foliar nutrition classes (FSCC, Stefan et al., 1997). Percentages of plots with mean foliage concentrations of N, Mg, and K below, in or above range for optimal nutrition for plots with BC/Alcrit exceeded in less and more than 80% of soil solution samples, respectively.

Tree species	crit. BC/Al	exceed. (sampl.)	N				Mg				K			
			low	in	high	n	low	in	high	n	low	in	high	n
Spruce	1.2	<80%	20%	80%	0%	(35)	0%	86%	14%	(36)	3%	97%	0%	(36)
		>80%	5%	95%	0%	(20)	5%	95%	0%	(20)	15%	85%	0%	(20)
Pines	1.2	<80%	0%	84%	16%	(19)	5%	95%	0%	(19)	0%	100%	0%	(19)
		>80%	8%	71%	21%	(24)	4%	92%	4%	(24)	0%	100%	0%	(24)
Fir	1.2	<80%	14%	86%	0%	(7)	0%	57%	43%	(7)	0%	100%	0%	(7)
		>80%	25%	75%	0%	(4)	25%	50%	25%	(4)	0%	100%	0%	(4)
Douglas Fir	0.3	<80%	0%	0%	0%	(0)	0%	0%	0%	(0)	0%	0%	0%	(0)
		>80%	0%	100%	0%	(1)	0%	0%	100%	(1)	0%	100%	0%	(1)
Other coni-fers	1.2	<80%	0%	0%	0%	(0)	0%	0%	0%	(0)	0%	0%	0%	(0)
		>80%	0%	0%	0%	(0)	0%	0%	0%	(0)	0%	0%	0%	(0)
Beech	0.6	<80%	0%	76%	24%	(34)	36%	31%	33%	(36)	3%	89%	8%	(36)
		>80%	0%	58%	42%	(12)	15%	38%	46%	(13)	0%	85%	15%	(13)
Oak	0.6	<80%	0%	47%	53%	(19)	0%	100%	0%	(19)	0%	79%	21%	(19)
		>80%	0%	50%	50%	(4)	0%	100%	0%	(4)	0%	75%	25%	(4)
Birch	0.8	<80%	0%	100%	0%	(2)	0%	0%	100%	(2)	0%	100%	0%	(2)
		>80%	0%	0%	0%	(0)	0%	0%	0%	(0)	0%	0%	0%	(0)
Other broadl.	0.8	<80%	0%	50%	50%	(2)	0%	75%	25%	(4)	0%	75%	25%	(4)
		>80%	0%	0%	0%	(0)	0%	0%	0%	(0)	0%	0%	0%	(0)

BC/Al_{crit}: growth reduction to 80% of mean according to (Sverdrup & de Vries, 1994; Lorenz et al., 2008) (no data for Sitka Spruce, few data only), n: number of plots.

The symptom of ‘light green to yellow discolouration’ and the cause ‘nutrient deficiency’ have not been assessed on all plots. The assessment does not completely cover the full range of foliar concentrations found in the whole dataset. Symptoms reported from a plot might have appeared on trees not sampled for foliage analyses. However, foliar Mg concentrations of sampled trees on plots from which symptoms were reported are in the lower part of the concentration range of the tree species (not shown).

Figure 5.3-4 shows that reported ratio of trees with the symptom is higher on plots with soil solution critical limits for nutrient imbalances exceeded. In Finland, where the N nutrition was generally rather low, deformations of needles and branches (wilting, curving, witch’s brooms, etc.) have been observed on Scots pines and Norway spruce.

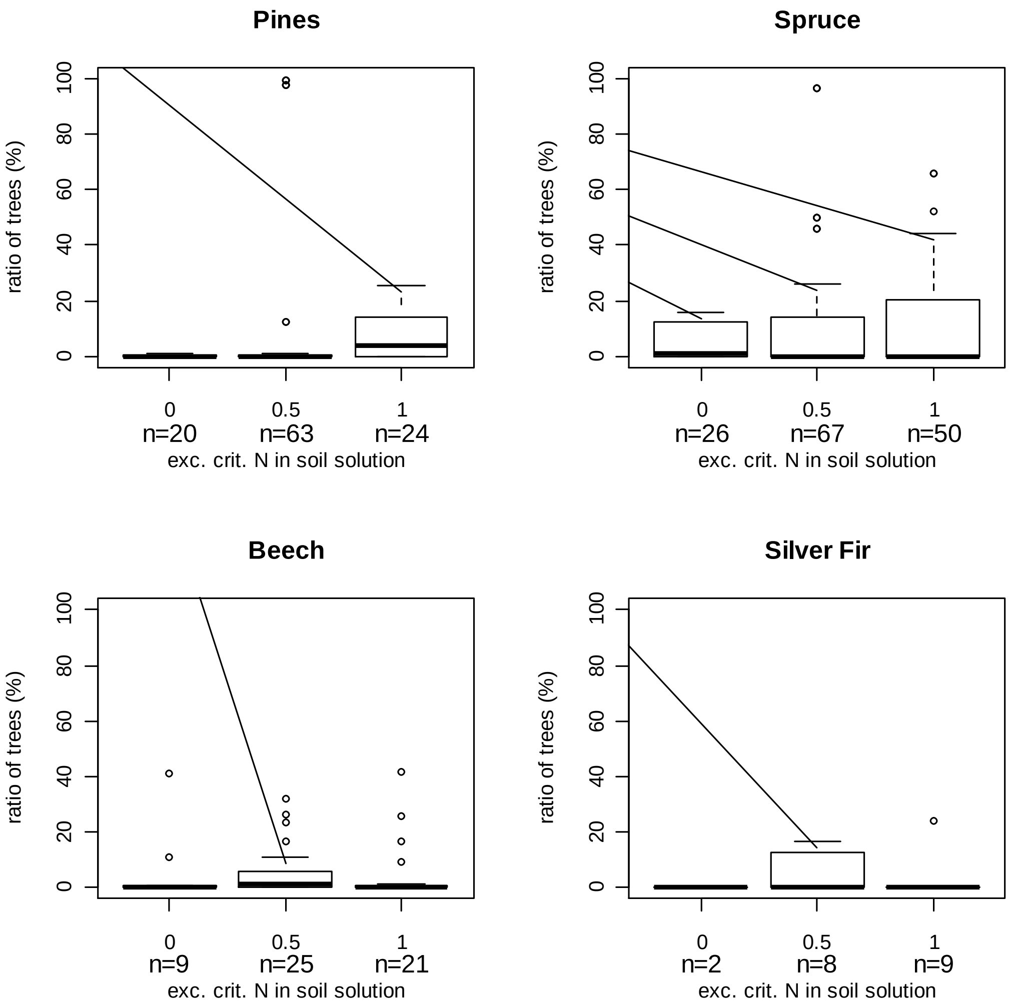

Figure 5.3-4: Percentage of trees with symptom 'light green to yellow discolouration' for plots with critical limits for N in soil solution for nutrient imbalances exceeded in 0%, between 0% and 50%, and >50% of the samples from the mineral topsoil. The relation is shown for the species groups 'Spruce' (top left), 'Pines' (top right), 'Beech' (bottom left), and 'Silver Fir' (bottom right) (n: number of plots).

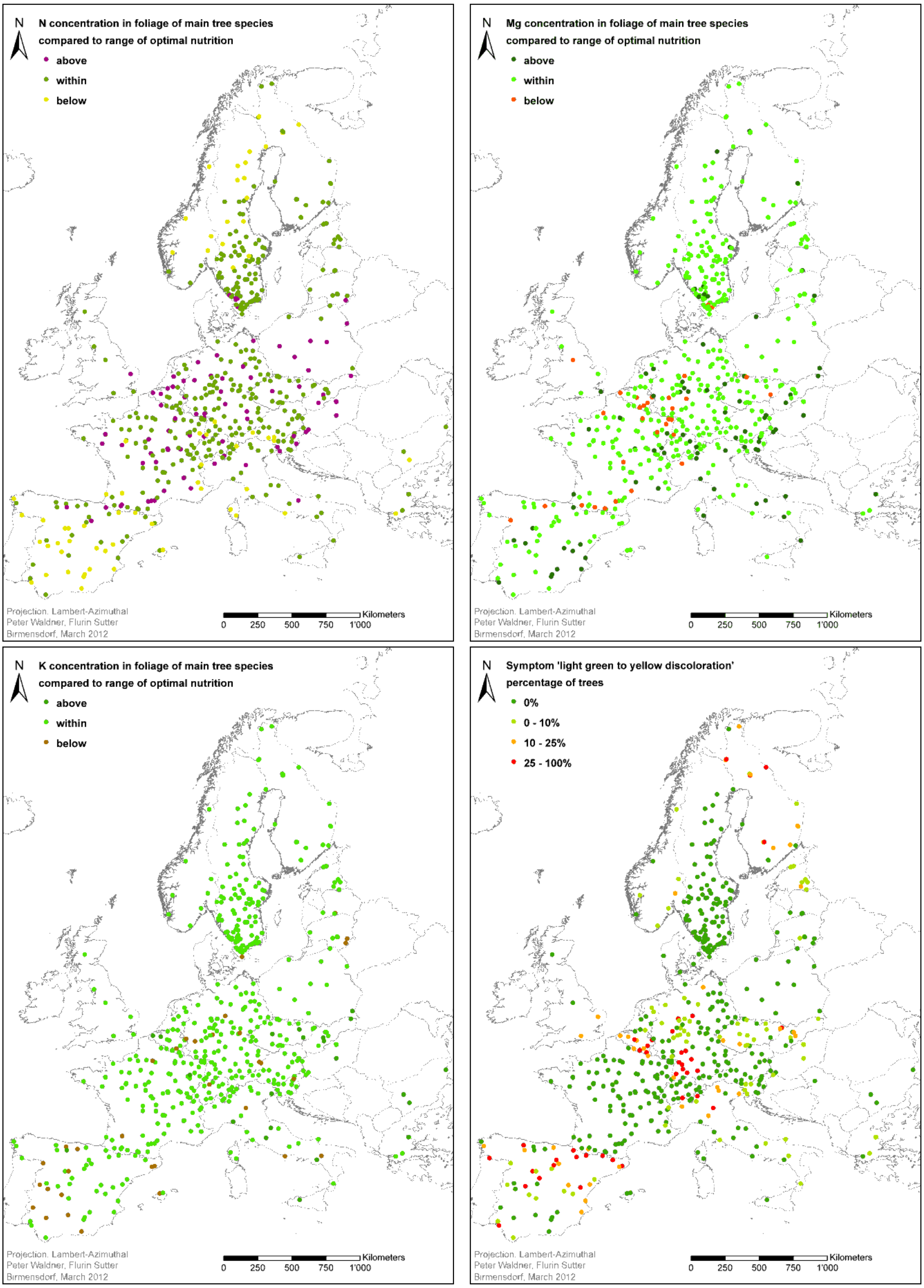

Figure 5.3-5: Foliar nutrition class (FSCC, Stefan et al., 1997) for N (top left), Mg (top right) and K (bottom left) concentrations of the main tree species, and occurrence of the symptom 'light green to yellow discoloration' of foliage reported within the Damage Cause Assessment (bottom right). Means of available values of the years 2006 to 2009 for ICP-Forests level II plots are shown.

Similar relations have been found between exceedance of BC/Al ratio and ratio of trees with reporting of cause ‘insects’, but not for cause ‘fungal disease’ on foliage, with the current set of assessment based on the assumptions mentioned in the method sections.

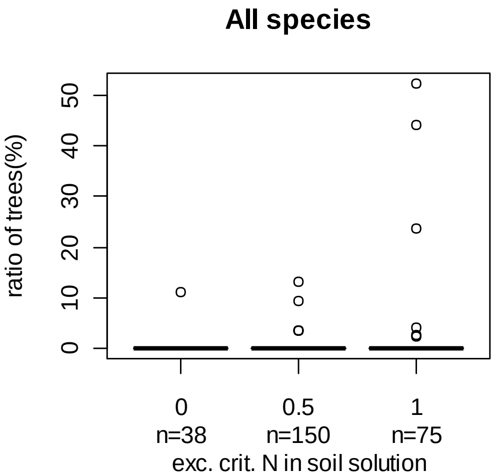

Figure 5.3-6: Percentage of trees with symptom cause ‘nutrient deficiency’ reported for plots with critical limits for N in soil solution for nutrient imbalances exceeded in 0% (“0”), between 0% and 50% (“0.5”), and >50% (“1”) of the samples from the mineral topsoil (n: number of plots).

5.4 Discussion

A correlation or a relation between two variables does not necessary mean that there is a cause effect relationship. There might be confounding factors. In this study the influence of e.g. soil condition, tree age, tree density, management, and drought stress has not been considered.

Critical loads are a concept to prevent long-term effects. Absence of immediate effects of critical loads exceedances is thus fully in accordance with the concept. We built classes of plots with throughfall N using the lower and upper values of empirical critical loads. However, throughfall N generally is lower than the total N deposition that also includes nitrogen taken up in the crown. Hence, it is very likely that critical loads exceedances are more frequent than the >10 or >20 kg N ha^{-1} a^{-1} classes may suggest.

For the critical limit for soil solution that indicates N saturation, we investigated exceedance based on the concentrations of inorganic nitrogen in soil solution samplers of the lowest lysimeters. This was based on the assumption that the lowest sampler is installed more or less at the in the lower end of the rooting zone and that the magnitude of variation is much higher for the N concentration than for the water fluxes. However, for a more precise determination (i) the effective depth of rooting zone should be crosschecked with the profile descriptions and (ii) the leaching should be estimated with a water balance model.

About half of the plots with exceedance of critical loads for N_{nut} already show signs of N saturation and N leaching. It is likely that the other plots may still be in a phase of N accumulation and tend towards saturation. However, we recommend investigating the N balances in a later study.

Regarding critical loads of acidity (CLA_{SMB}), the proportion of samples with BC/Al ratio in the soil solution of the mineral soil (20-80 cm depth) exceeding the critical limit (<0.8) tends to be larger on plots with CLA_{SMB} exceeded than on other plots. As for nitrogen, it cannot be stated that BC/Al is exceeded when CLA_{SMB} is exceeded. We note that the proportion of plots with critical loads exceeded is relatively small (20-30%), while the BC/Al<0.8 criterion is frequently exceeded in soil solution of the mineral soil on about two third of the plots, suggesting soils being acidified. However, we suggest that the proportion of toxic Al^{3+} within total dissolved Al be considered in further assessment of ecological risks. The relationship between BC/Al ratio and foliage nutritional status was not very obvious: The Mg and K concentrations in foliage of conifers tend to be lower on plots with BC/Al ratio exceeded, indicating a possible depletion in base cations due to soil acidification. No such tendency was observed for broadleaves.

5.5 Conclusions

Most relations found in this investigation of the recent data of the ICP-Forests level II plots from 2006 to 2009 support the hypothesis of on-going N saturation and acidification effects due to atmospheric deposition of nitrogen:

- There is a clear relation between N-deposition and the occurrence of high nitrate concentrations below the rooting zone, which indicates that the plots are in the phase of N saturation. About half of the plots with critical loads exceedance show such indication of N saturation. Further we estimate that the other half of the plots with exceedance of critical loads for nutrient nitrogen are still in the phase of accumulation and may show increasing effects in the future.
- There is also a clear relation between exceedance of critical loads of acidity and occurrence of critical BC/Al ratios in soil solution that may indicate aluminium toxicity for plant roots.
- The relation between nitrate in soil solution and foliar nutrition status confirmed the tendency towards less optimal Mg/N ratios with increasing exceedance of critical limits of nitrate in soil solution for all major species groups.
- For the species group 'Pines' there was a similar tendency between foliar nutrition and occurrence of critical BC/Al.
- Exceedances of critical limits for nitrate in soil solution were related to both less favourable foliar nutrition and higher frequency of light to green discolouration, which is a typical symptom of e.g. nutrient deficiencies.

These findings support the critical loads concept. It has to be mentioned that relations between variables cannot always be regarded as a proof of cause effects relationships. There might be confounding factors. In this study, possible confounding by e.g. soil condition, tree age, tree density, management and drought stress has not been investigated.

5.6 References

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6. National reports

Reports on the results of the national crown condition surveys at Level I of the year 2011 were received from 33 countries. For these countries, the present chapter presents summaries. Besides that, numerical data on crown condition in 2011 were received. These results are tabulated and presented as graphs.

It has to be noted, however, that in contrast to the transnational survey (Chapter 3) it is not possible to directly compare the national survey results of individual countries. The sample sizes and survey designs in national surveys may differ substantially and therefore conflict with comparisons. In a number of cases the plots for the transnational survey are identical with the national survey, in other cases the national survey is carried out on condensed nets. Gaps in the Annexes II-1 to II-8, both tabulated and plotted, may indicate that data for certain years are missing. Gaps also may occur if large differences in the samples were given e.g. due to changes in the grid or the participation of a new country.

6.1. Andorra

The assessment of crown condition in Andorra in 2011 was conducted, as for last years, on the 3 plots of the transnational grid, and included 72 trees, 42 *Pinus sylvestris* and 30 *Pinus uncinata*.

The results obtained in 2011 continue to show an improving tendency in forest condition, as registered the last 3 years, although the climate conditions were not as favourable as in these previous years. These results show, for both species, a majority of trees classified in defoliation and discolouration classes 0 and 1.

Related to defoliation, it was registered an increase in not defoliated and slightly defoliated trees, achieving each class the maximum rate since 2004 (63.9% and 27.8% respectively) and a decrease in moderate defoliation class rate. There were no trees registered in severe defoliation class.

Results for discolouration showed an increase in not discolouration class and a decrease in slight and moderate discolouration classes. Severe discolouration was not reported.

In 2011, the assessment of damage causes showed, as in previous surveys, that the main causal agent was the fungus *Cronartium flaccidum* which affected 6.9% of the sampled trees and which was distributed in all plots.

6.2. Belarus

The forest condition survey in 2011 was conducted on 417 Level I plots in the transnational grid. The condition of 9 918 trees was assessed. 71.2% of all trees are coniferous (*Pinus sylvestris* and *Picea abies*, including *Pinus sylvestris* – 61.4%) and 28.8% are deciduous (*Betula spp., Populus tremula, Alnus spp*., etc.).

Over last two years is observed an appreciable improvement of forest condition by sign defoliation. In comparison with 2009 the share of trees without defoliation increased by 2.7% and was 30.5%, the share of trees of 2-4 classes decreased by 2.3% and was 6.1%. Average defoliation of all species was 16.6%.

As in previous years *Alnus glutinosa* has the least defoliation (57.5% not defoliated trees), *Fraxinus excelsior* as in previous years had lowest average defoliation (10.5% not defoliated trees). As a result of the degradation of ashen plantings observed since 2003, basically from phytowreckers was lost about half of sampling trees. The average percent of sampling trees in 2011 was 49.5%.

Quercus robur in previous years had high average defoliation, but since 2006 obvious improvement of a condition is observed. In 2011 the share of trees without defoliation has increased to 29.6%, and the share of trees of 2-4 classes has decreased to 11.4%.

Damage signs were observed by various factors at 11.4% of the estimated trees. More often damage occurred with *Fraxinus excelsior* (36.4%), *Populus tremula* (31.0%) and *Quercus robur* (28.1%) and is rarer with *Pinus sylvestris* (8.0% of the estimated trees). Most often they have been caused by fungi (4.5%), direct influence of the person (2.8%) and insects (1.3%). The greatest share of trees with signs of damage by fungi is noted with *Fraxinus excelsior* (36.4%, *Armillaria sp.*), *Populus tremula* (25.0%, basically *Phellinus tremulae*) and *Quercus robur* (15.8%, basically *Phellinus robustus*). More often damaged mechanically are *Betula pendula* (5.0%) and *Picea abies* (3.1%), by insects *Alnus glutinosa* (10.5%) and *Quercus robur* (3.0%).

Violent hurricanes continue to harm to the Belarus woods. Within the last years the destruction of stands from wind throw has essentially increased. Process of a dieback of spruce stands essentially reduced in last years also definitively has not ended. In the south of the republic degradation of spruce stands continues.

6.3. Belgium

Belgium/Flanders

In 2011 the forest vitality network in Flanders did not change as compared to previous year. The number of trees selected for crown condition assessment was 1 733 on 72 plots of the regional 4 x 4 km grid. The main tree species are *Quercus robur*, *Pinus sylvestris*, *Fagus sylvatica*, *Quercus rubra*, *Pinus nigra subsp. laricio* and *Populus spp*.

Forest condition has slightly deteriorated in comparison to 2010. Overall 20.1% of the trees were in defoliation classes 2-4; this is an increase with 4.0 percentage points. The mean defoliation was 22.0% and increased with 1.6 percentage points. A higher defoliation score was registered both for conifers and broad-leaved trees. The share of trees with severe defoliation was low (1.0%) and the mortality rate was 0.3%.

Broad-leaved tree species revealed a higher defoliation score than conifers. The main differences were noticed in the proportion of moderately to severely defoliated trees, which amounts to 23.7% in broadleaves and 12.7% in conifers.

A high level of damage was observed in *Populus spp*., *Quercus robur* and a sample with 'other broadleaves', with 31.3%, 27.1% and 26.8% of the trees showing moderate to severe leaf loss. The most affected species in the 'other broadleaves' sample were *Alnus glutinosa*, *Fraxinus excelsior* and *Betula pendula*. The proportion of *Fagus sylvatica* and *Pinus nigra* rated as damaged was 18.9% and 16.0% respectively. The least affected species were *Pinus sylvestris* and *Quercus rubra*, with 11.7% and 6.5% of the trees in defoliation classes 2-4.

The deterioration in crown condition of *Fagus sylvatica* could be partly explained by a high fructification. Common or abundant fruiting was recorded on 30.7% of the assessed trees. Fruiting was also abundant in several *Quercus robur* plots. On 30.8% of the *Q. robur* trees defoliators caused more than 10% leaf loss. There was an increase of damage by defoliators on oaks during three consecutive years. The only species with an improvement of the crown condition were *Quercus rubra* and *Pinus nigra*.

In several plots symptoms of *Chalara fraxinea* infection was assessed on natural regeneration of *Fraxinus excelsior*. In 2011 the mean defoliation score of *Common ash* was 23.0% and 26.4% of the trees showed more than 25% defoliation.

The most important symptoms in the survey were devoured leaves (on 42.9% of the trees), dead twigs or branches (42.1%), discolouration (red to brown: 25.6%, yellow: 18.8%) and wounds (22.2%). Frequently noted causes were defoliators, powdery mildew and silvicultural operations. Weather conditions were dry and sunny during spring and autumn but precipitation was high during summer. A summer storm caused serious damage in one transnational 16 x 16 km plot.

Belgium-Wallonia

The survey in 2011 concerned 861 trees on 40 plots, on a regional 8 x 8 km systematic grid. The percentage of trees with a defoliation of 25% and more shows different long term trend for conifers and broad-leaved.

The conifers, which were two times more defoliated in the beginning of the nineties, show this year a rate of 22.8%, lower than last but higher than the last decade.

The broad-leaved showed an increase from 10% in 1990 to about 20% in 2005. These damages were mainly due to the degradation of the beech (scolytidae in 2000-2002, drought in 2003 followed by fruiting in 2004) and of the European oak (drought in 2003). The rate dropped between 2006 and 2008 to 15.2%, but severely increased in 2009 to 32% and further in 2010 to 33.4%. This year the rate is 32.4%.

Concerning the mean defoliation observed for the four main species, after an improvement since 2006 for beech and European oak, they increase to about 25.9% for beech and for European oak this year. Sessile oak is at a bad condition this year with 17.3%. Spruce shows a decrease of mean defoliation, with 15.3% this year, 4.3% lower than last year.
Spring was very dry, with only 40% of normal rain, which could explain the high defoliation for beech and European oak, the more sensitive species.

6.4. Bulgaria

In 2011 The Program for Large-Scale Monitoring of Forests in Bulgaria was carried out in 159 sample plots. The total of sampled trees was 5 583. The crown condition survey has been performed in both coniferous and deciduous forests dominated by the species *Pinus sylvestris L., Pinus nigra Arn., Picea abies (L.) Karst. u Abies alba Mill.*, *Fagus sylvatica L., Quercus frainetto Ten., Quercus petraea (Matt.) Liebl., Quercus cerris L., , Quercus rubra L., Tilia platyphillos Scop.*and *Carpinus betulus L.*. The number of the coniferous trees was 2 397 and the number of deciduous trees 3 186.

Concerning the crown condition survey results the major part 78.42% of the sampled trees is slightly defoliated (up to 25%). Defoliation class 2 has 17.89% of the sampled trees in 2011 survey. In comparison with the crown condition in 2010 the results of this year showed that the trees with defoliation class 0 and 1 have increased by 2.20%. The moderately defoliated trees decreased by 4%. The share of dead trees increased from 0.45% in 2010 to 2.10% in 2011.

The crown condition of the deciduous trees in 2011 showed better results than in the previous year. As a whole, the results for the observed deciduous trees showed a prevalence of the healthy and slightly affected by defoliation trees. Healthy and slightly defoliated had been 92.80% of the observed trees of *Fagus sylvatica*, 86.17% of *Quercus cerris* trees and 85.55% of *Quercus frainettoI.* The highest percentage of deciduous dead trees is observed in oak trees: *Qercus cerris* (5.11%) and Quercus petraea (3.10%). The damages on *Fagus sylvatica* were due to *Rhynchaenus fagi, Ectoedemia libwerdella, Nectria spp.*, and the damages on *Querqus spp.* were caused mainly by *Tortrix viridana*.

Abies alba had the best condition of the sampled coniferous trees, followed by *Picea abies.* A tendency toward deterioration in coniferous sampled trees as a whole was not determined. Most of the damages for conifers species were caused by *Lophoderminium pinastri*.

In 2011 a negative influence in crown conditions both for conifers and deciduous trees was registered caused by abiotic agents such as drought, snow, ice and anthropogenic agents as well.

6.5. Croatia

In the forest condition survey in 2011, 92 sample plots on the 16 x 16 km grid network were included.

The percentage of trees of all species within classes 2-4 in 2011 (25.2%) was lower than in 2010 (27.9%), which was highest in the last ten years. The share of broadleaves in classes 2-4 (21.5%) was also somewhat lower than in 2010 (21.8 %). For conifers, the percentage of trees in classes 2-4 was 45.1%, which is the lowest score since the year 1996. There were 350 conifer trees and 1858 broadleaves in the sample (272 conifer trees vs. 1744 broadleaves in survey 2010).

Abies alba is the most defoliated tree species in Croatia (78.0% trees in classes 2-4) in 2011, followed by Pinus nigra (52.9% trees in classes 2-4). The percentage of moderately to severely damaged Silver fir trees recorded in 2010 was 66.1% and 72.2% in 2009. The lowest value, 36.6% of moderately to severely damaged trees was recorded in 1988, whereas in 1993 the share was already 70.8%. In the year 2001 it reached 84.5 %, and after a slight decrease in 2002 (81.2%), the trend of increasing defoliation was continued with 83.3% of moderately to severely damaged trees in 2003, 86.5% in 2004 and 88.5 % in the year 2005. After that, the values were lower (70.8% in 2006, 67.9% in 2007 and 70.1% in 2008).

The lowest percentage of *Quercus robur* trees in classes 2-4 was recorded in 1988 (8.1%), the highest in 1994 (42.5%), and it has been fairly constant later at around 25-30% until the year 2000. Afterwards it decreased to values below 20% (15.4% in 2003, 18.5% in 2004). In 2005 a slight increase was recorded with 22.1% of moderately to severely defoliated oak trees. In 2006 it was slightly lower at 20.5%, in 2007 it was again lower at 19.6%, returning to values above 20% in 2008 (22.2%), 2009 (22.8%) and 2010 (26.0%) of Pedunculate oak trees in defoliation class 2-4. This year the value is somewhat lower at 22.3%.

Although the maximum percentage of moderately to severely defoliated beech trees was recorded this year (13.2%), *Fagus sylvatica* remains one of the tree species with lowest defoliation. In the last ten years of monitoring, the percentage of Common beech trees in classes 2-4 varied from 5.1% in 2003 to 12.3% in year 2001.

In summary, crown defoliation of all species, broadleaves and conifers, has improved in 2011, but the status of some important species, such as beech and fir, has deteriorated.

6.6. Cyprus

The annual assessment of crown condition was conducted on 15 “Level I” plots during the period September - October 2011. 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 (2010) shows slight improvement among the four categories on all species.

From the total number of trees assessed (360 trees), 12.5% of them were not defoliated, 71.1% were slightly defoliated, 15.8% were moderately defoliated, and 0.6% were severely defoliated.

A comparison with the results of the previous year, 2010 results show an increase in the first two classes, 0.3% in class 0 (not defoliated) and 2.5% in class 1 (slightly defoliated). A decrease of 1.9% in class 2 (moderately defoliated) and a decrease of 0.8% in class 3 (severely defoliated) have been observed. No dead trees have been recorded (class 4, Dead). The observed improvement of crown in 2011 is mainly due to the sufficient rainfall of the period 2008 - 2010 comparing to the rainless period, 2007 - 2008.

In the case of *Pinus brutia*, 14.0% of the sample trees did not show any defoliation, 69.3% were slightly defoliated, 16.0% were moderately defoliated and 0.7% severely defoliated. For *Pinus nigra*, 5.6% of the sample trees did not show defoliation, 72.2% showed slight defoliation while the rest 22.2% were moderately defoliated. Also *Cedrus brevifolia*, 4.2% of the sample trees did not show defoliation, 91.7% were slightly defoliated and 4.2% were moderately defoliated. No dead trees have been observed.

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

48.1% of the total number of sample trees surveyed showed signs of insect attacks and 17.2% showed signs of attacks by “*other agents*, *T8*” (lichens, dead branches and rat attacks). Also 8.3% showed signs of both factors (insect attacks and other agent).

6.7. Czech Republic

In 2011 no pronounced change in the development of total defoliation was recorded in the older age category of conifers (60-years-old stands and older) compared to the preceding year. No pronounced changes occurred in the particular tree species in this age category. Compared to the preceding year, a very moderate decrease in the trend of total defoliation was observed in the younger age category of conifers (stands younger than 59 years) in 2011, when the percentage of conifers in defoliation class 0 slightly increased while it decreased in defoliation class 1. This slight decrease in defoliation occurred in all observed main coniferous species (*Picea abies*, *Abies alba* and *Larix decidua*) with the exception of pine (*Pinus sylvestris*), which showed a moderate upward trend of defoliation for several years.

Similarly like in the same age category of conifers, no pronounced change in the development of total defoliation of broadleaves was recorded in the older age category (60-years-old stands and older). Among the particular tree species, a moderate increase in defoliation was observed only in beech (*Fagus sylvatica*) due to a moderate decrease in its percentage in defoliation class 1 at a simultaneous increase in its percentage in defoliation class 2. Younger broadleaves (stands younger than 59 years) showed a moderate decrease in total defoliation similarly like the same age category of conifers. Their percentage in defoliation class 0 increased from 21.0% in 2010 to 28.3% in 2011 at a simultaneous decrease in their percentage in defoliation class 1 and 2. The less represented tree species – birch (*Betula pendula*) contributed to this positive change in younger broadleaves to the greatest extent as its percentage in defoliation

class 0 increased very significantly.

Younger conifers (less than 59 years) show lower defoliation in the long run than the stands of younger broadleaves. In older stands (60-years-old and more) such a comparison reveals an opposite trend: older conifers have markedly higher defoliation than the stands of older broadleaves. In both age categories the pine crucially contributes to a higher percentage of defoliation in the group of conifers.

At the beginning of the growing season in May some stands (mainly the beech ones) had been damaged to a greater extent by late frost in the stage of flushing. In many cases subsequent flushing from secondary buds failed to fully compensate for the loss of assimilatory tissues. The imbalance of weather conditions (the temperature to precipitation amount ratio) also had adverse effects on the regeneration of damaged crowns. In comparison with the long-term normal temperatures, the average of the monthly temperatures in the growing season was mostly above average (deviation of +3.2° in April). The temperature was below average only in July and October (very moderately). On the contrary, in this comparison the average monthly precipitation amount was mostly below average (at the lowest in April with 74%) and it was above average only in July and October.

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

6.8. Denmark

The Danish forest condition monitoring in 2011 was carried out in the National Forest Inventory (NFI) and on the remaining Level I and Level II plots. Monitoring showed that most tree species had satisfactory health status. Exceptions were *Fraxinus excelsior* in which the problem with extensive dieback of shoots continued. Average defoliation was 28% for all monitored ash trees, and 42% of the trees had more than 30% defoliation. In some ways even these data do not completely reflect the situation because most of the severely diseased ash stands are clear cut or abandoned. Thus the only national long term ash monitoring plot in Denmark was finally discontinued in 2011 because the trees were dying and falling over after two years of defoliation scores above 90%.

Picea sitchensis and *Pinus sylvestris* have recovered and are back to a low average defoliation (8% and 9% respectively). *Picea abies* and other conifers had low defoliation, and the health situation for *P. abies* in Denmark is still very satisfactory with an average defoliation of only 6%. The average defoliation score of *Fagus sylvatica* increased to 11.4%, but this is partly due to the fact that 2011 was a mast year. *Quercus* (*robur* and *petraea*) stayed at a slightly increased defoliation, but even with 16% average defoliation the health condition of oak can be considered satisfactory. The growth season in Denmark was dry in spring but very wet during summer, which was a benefit for most of the forest stands except those suffering from high water levels.

Based on both NFI plots and Level I & II plots, the results of the crown condition survey in 2011 showed that 79% of all coniferous trees and 58% of all deciduous trees have been undamaged. 18% of all conifers and 29% of all deciduous trees showed warning signs of damage. The mean defoliation of all conifers was 7% in 2010, and the share of damaged trees was only 3%, which is an improvement since last year. Mean defoliation of all broadleaves was 14% and 13% were damaged, which is worse than 2010, but most of the increase was due to ash dieback and a few declining oak trees.

6.9. Estonia

Forest condition in Estonia has been systematically monitored since 1988. In 2011 altogether 2,372 trees, thereby 1,489 pines *Pinus sylvestris*, 582 spruces *Picea abies* and 227 birches *Betula pendula,* were examined on 98 permanent Level I sample plots from July to October.

The total share of not defoliated trees, 50.8%, was 2% lower than in 2010. Percentage of trees in classes 2 to 4 (moderately to dead) was 8.0%.

Percentage of conifers in classes 2 to 4 (moderately to dead) was in 2011 8.7%. In Estonia the most defoliated tree species have traditionally been Scots pine (*Pinus sylvestris*), but no considerable changes compared to 2010 happened and number of pine trees in all defoliation classes remained almost at the same level. Some increase of defoliation of Norway spruce (*Picea abies*) occurred, the share of not defoliated trees (defoliation class 0) dropped by 5 %.

Percentage of broadleaves in classes 2 to 4 (moderately to dead) was in 2011 3.0%. No considerable changes compared to 2010 happened.

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 2011 67.2% of all trees assessed had some type of visible damage; thereby 8.0 % of the trees had some kind of insect damages and 44% identifiable symptoms of disease. Needle shedding and shoot blight were as usual the most significant reasons of biotic damage of trees.

6.10. Finland

The large scale crown condition survey (Level I) has been carried out in Finland on a systematic network of permanent sample plots for 25 years, since 1986. Before 2009 a subsample of the permanent plots established during 1985–1986 in connection with the 8th National Forest Inventory (NFI).

The integration between ICP Level 1 and NFI was accomplished in 2009 in Finland. The sampling design of the current NFI is a systematic cluster sampling. The distance between clusters, the shape of a cluster, the number of field plots in a cluster and the distance between plots within a cluster vary in different parts of the country according to spatial variation of forests and density of road network. Principally, every fourth cluster is marked as a permanent cluster. Annually, a new set of permanent plots, established during the 9th NFI in 1996-2003, is assessed in the forest condition survey. The trees are sampled by the relascope

Tallied dominant and co-dominant Norway spruce, Scots pine and Birch trees from six preselected permanent plots from each cluster are assessed. The same permanent plots will be assessed in five-year intervals. In 2009-2010 all trees were assessed, but in 2011, owing to limited resources, a maximum of six trees per appropriate species were included in the sample, resulting in a reduced number of assessed trees.

Please note that because the plots assessed during 2009 -2011 are completely different samples, the results are not directly comparable with each other or with the results of the previous years.

The results of the 2011 forest condition survey are reported from preselected 717 permanent sample plots. Of the 4,147 trees assessed in 2011, 51.7% of the conifers and 62.2% of the broadleaves have not been defoliated (leaf or needle loss 0-10%). The proportion of slightly defoliated (11- 25%) conifers was 36.7% and that of at least moderately defoliated (over 26%) 11.7%. For broadleaves the corresponding proportions were 31.7 and 5.6%, respectively.

The average tree-specific degree of defoliation was 14.3% in Scots pine, 16.7% in Norway spruce, and 12.4% in broadleaves (*Betula pendula* and *B. pubescens*). Compared to the previous year, the mean defoliation of Scots pine in 2011 was higher, but the defoliation of the other species was less in 2011 than in 2010.

Abiotic and biotic damage was also assessed in connection with the large scale monitoring of forest condition. 31% of the Scots pines, 28% of the Norway spruces and 23% of the broadleaves were reported to have visible symptoms attributed to abiotic or biotic damaging agents. The number of symptomatic trees was almost at the same level (29%) as in the previous year. The proportion of insect and abiotic damage was slightly smaller, but the number of unidentified damage much larger than in 2010. Apart from physical contact, pine sawflies, mostly *Neodiprion sertifer*, common pine shoot beetles (*Tomicus sp.*) and *Gremmeniella abietina* were the most abundant identified damaging agents in Scots pine. *Neodiprion sertifer* was having a massive outbreak in the mid-western parts of the country, but the amount of damaged pines was slightly less (4.1%) than in the previous two years, in the nation-wide data.

6.11. France

In 2011, the forest damage monitoring in the French part of the systematic European network comprised 11 352 trees on 554 plots. The increase in plot number is due to a will to take into account the increasing forest area in France for several years.

The climatic conditions of the year have not been really favourable to the forest vegetation due to a particularly dry spring. Nevertheless, a wet and chilly summer impeded to see high levels of defoliation among network's trees.

The foliage slightly increased for most of broadleaved species and even conifers. *Quercus pubescens* and evergreen oak, species which are frequent in the South East of France, still had the worst crown condition of all monitored species in 2011 and did not show any sign of improvement.

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, especially on *Quercus spp*. (mainly on evergreen and pubescent oaks).

6.12. Germany

The forest condition deteriorated in 2011 as compared with 2010. In particular beech trees show significantly worse crown condition than they did in 2010. This is however mainly due to intense fruiting. Spruce and Scots pine are nearly unchanged if the national average is considered. Oak trees have recovered.

The national result 2011 was calculated based on the crown condition data of 10 167 sample trees which were assessed on 410 sampling plots of the national 16 km x 16 km grid. The assessment covers 38 different tree species. About 80% of all trees included in the samples belong to the four main tree species: spruce *(Picea abies)*, Scots pine *(Pinus sylvestris)*, beech *(Fagus sylvatica)* and deciduous temperate oak (*Quercus robur* and *Quercus petraea* are assessed together). The remaining tree species are grouped as "other conifers" and "other broadleaves".

Over all tree species, 28% (2010: 23%) of the forest area was assessed as damaged, i.e. showing more than 25% of defoliation (damage classes 2 to 4). 35% were at the warning stage and 37% were undamaged (2010: 38%). Mean crown defoliation increased from 19.1% to 20.4%.

*Picea abies***:** the area percentage of damaged trees is 27% (2010: 26%)**.** The percentage without crown defoliation is 40%, the same as in the previous year. Mean crown defoliation increased slightly from 18.7% to 19.1%.

Pinus sylvestris: the area percentage of damaged trees is 13% and remains unchanged. 45% (2010: 44%) did not show defoliation**.** Mean crown defoliation slightly decreased from 16% to 15.6%.

Fagus sylvatica: the area percentage of damaged trees is 57%, even more than in 2004. In comparison to the previous year (2010: 33%) this is an increase by 24 percentage points. Only 12% of the trees did not show defoliation (2010: 20%). Mean crown defoliation increased from 23.3% to 30.4%, a level similar to the one reached in 2004. This is mainly due to a prolific mast year. Fruiting was recorded on more than 90% of all beech trees older than 60 years. For beech trees there is a strong relationship between fruiting and crown defoliation. Fruiting needs a lot of resources at the expense of the growth of foliage and wood. Furthermore beech trees might have suffered from the scarcity of water in spring and early summer.

Quercus petraea and *Q. ruber* recovered compared with the previous year. The area of damaged trees decreased by10 % points from 51% to 41%. 21% of the oaks were classified as undamaged. Mean crown defoliation decreased from 29.6% to 26.3%. Damage caused by defoliators has decreased and there were only few mildew infections.

6.13. Hungary

In 2011 the forest condition survey – based on the 16 x 16 km grid – included 1 830 sample trees on 78 permanent plots in Hungary (two of them are temporarily un-stocked). The assessment was carried out between 15th July and 15th August. 86.7% of all assessed trees were broadleaves (a little increasing during the last years), 13.3% were conifers.

Overall health condition of the Hungarian forests compared to previous year became better. Although the share of trees without visible damages decreased from 49.3% to 45.9%, the mean defoliation of all species was 15,8%. This is more than 5 percentage point lower than in 2010.

The percentage of all trees within ICP defoliation classes 2-4 (moderately damaged, severely damaged and dead) in 2011 (18.9%) is lower than in 2010 (21.8%). In Hungary the dead trees remain in the sample till they are standing, but the newly (in the surveyed year) dead trees can be separated. In 2011 the rate of newly dead trees was 1% of all trees that is by 0.7% higher than in the previous year. The number of all dead trees increased just a little.

In the classes 2-4 the most damaged species are *Pinus nigra* (36.2%), *Robini pseudoacacia,* (29.0%), the *Pinus silvestris* (26.3%). These percentages show the rate of sample trees belonging to category 2-4). *Carpinus betulus* had the lowest defoliation (8.9%) in class 2-4. Generally all species' rate decreased in these categories, especially the *Pinus nigra* (almost 20%).

Discoloration can be rarely observed in the Hungarian forests, 94.3% of sample trees did not show any discoloration, compared to the previous year the change is less than 1% in all categories.

According to the classification defined in the ICP manual on crown condition the damage caused by defoliator insects had the biggest rate, 29.0% of all the damages. This damage occurred especially on the following species: *Quercus robur*, *Quercus petraea* and other *Quercus species* and *Pinus Silvestris*. The mean damage values of these trees were 6.1%, 6.6%, 7.7%, 12.6%.

The rate of assessed damages attributed to fungus was 17.0%. Fungal damages assessed on leaves were 4.5%, on branch and on stem together were 12.5% of all assessed trees. The mean damage value was 19.0%. 26.4% of the assessed damages were abiotic. The most important identifiable causes are draught (22.3%), frost (13.9%) and wind-breaking (7.7%).

6.14. Italy

The survey of Level I in 2011 took into consideration the condition of the crown by 8,099 selected trees in 253 plots belonging to the EU network 16 x 16 km. The number of sample areas has compared to the survey of 2010. 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 known causes attributable to both biotic and abiotic. For the latter, not so much the indicators we analysed the frequencies of affected plants, but the comments made as to each plant may have multiple symptoms and more 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 (73.0%) is included in the classes 1 to 4; the 31.3% is included in the classes 2 to 4.

By analysing the sample for groups of species, conifers and broadleaves, it appears that conifers have a transparency of less than deciduous foliage: 33.7% of conifers and 24.4% of broadleaves are without any defoliation (Class 0).

The conifers falling in the defoliation classes 2 to 4 are 27.8% respect to the 32.7% of broadleaves.

From a survey of the frequency distribution of the parameter for transparency species divided into two age categories (<60 and ≥60 years), among the young conifers (<60 years), *Pinus sylvestris* is the 35.5% of trees in the classes 2 to 4, followed by *Larix decidua* (23.6%) and *Picea abies* (21.5%), *Pinus nigra* (20.4%), but the best conditions of trees in the classes 2 to 4, there is on the *Pinus halepensis* with the 4.5%.

Among the old conifers (≥60 years), with the species appear to be worse quality of foliage on *Pinus sylvestris* (66.6%), *Picea abies* (37.6%), *Larix decidua* (26.1%), *Abies alba* (24.8%) of trees in the classes 2 to 4, while *Pinus cembra* (17.6%) to be the conifer is in better condition of trees in the classes 2 to 4.

Among the young broadleaves (<60 years), *Castanea sativa* and *Quercus pubescens* have respectively 70.2% and 50.0% of trees in the classes 2 to 4, while others have a frequency range between 15.4% and 25.1% in classes 2 to 4 distributed in different species: *Quercus cerris* (15.4%), *Fagus sylvatica* (21.7%), and *Ostrya carpinifolia* (25.1%).

Among the old broadleaves (≥60 years) in the classes 2 to 4, *Castanea sativa* has (56.2%), *Quercus pubescens* (42.6%), *Fagus sylvatica* (15.6%), *Quercus ilex* (14.0%) and *Ostrya carpinifolia* (13.7%) *has* the lowest level of defoliation of trees in the classes 2 to 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 (22.3%), subdivided into defoliators (16.4%), aphids (2.1%), wood borers (1.1%), needle miners (1.0%), following symptoms attributed to fungi (6.6%) the most significant are attributable to “dieback and canker fungi” (3.2%), then those assigned to abiotic agents, the most significant are “drought/aridity” (1.1%) and the “hail” (1.0%).

6.15. Latvia

The forest condition survey 2011 in Latvia was carried out in parallel on two plot sets: on the ICP Level I on the grid of 8 × 8 km, totally 288, including 88 plots on the transnational grid 16 × 16 km, and on recently established NFI plots, totally 115. The transition process to the NFI system is still ongoing, therefore the national report of 2011 is based on the ICP Level I plot data.

In total, on Level I plots 6,644 trees were assessed, of which 72% were conifers and 28% broadleaves. Of all tree species, 13.8% were not defoliated, 72.2% were slightly defoliated and 14.0% moderately defoliated to dead. Comparing to 2010 no considerable changes were observed in the distribution in these classes. The proportion of trees in defoliation classes 2-4 remained to be about 5-7% higher for conifers than for broadleaves.

Mean defoliation of *Pinus sylvestris* was 22.4% (21.8% in 2010). The share of moderately damaged to dead trees constituted 16.4% (15.4% in 2010). Slight increase in the defoliation level is observed for *Pinus sylvestris* during the recent years. Mean defoliation of *Picea abies* was 20.7% which is only 0.3 % points higher than in 2010. Changes in the distribution of trees in defoliation classes are insignificant for *Picea abies* as well. The mean defoliation level of *Betula spp*. was 18.0% in 2011, showing insignificant decrease of the defoliation level during the last five years. The share of trees in defoliation classes 2-4 decreased to 8.3%. The worst crown condition of all assessed tree species remained for *Fraxinus excelsior* with mean defoliation 31.8% and the share in defoliation classes 2 to 4 of 41%. It must be mentioned that these results are based on a comparatively low tree number of *Fraxinus excelsior* in the survey.

Visible damage symptoms were observed to a similar extent than in the previous year – 12.2% of the assessed trees (11.3% in 2010). Most frequently recorded damages were caused by abiotic factors (21.3% of all cases), direct action of man (17.7%) and fungi (15.1%). The proportion of insect damages has decreased considerably during the last two years. The greatest share of trees with damage symptoms was recorded for *Populus spp*.

In winter 2010/2011 considerable damage of tree stands in the eastern part of Latvia was caused by freezing rain and snow, breaking tree tops and branches of conifers as well as broadleaves.

An outbreak of *Lymantria monacha* was observed in the vicinity of Riga city in 2011, considerably defoliating about 2000-3000 ha of *Pinus sylvestris* stands. It is expected that the maximum of the outbreak will be reached in 2012.

6.16. Lithuania

The national forest inventory and the regional forest health monitoring grids (4 × 4 km) in Lithuania are combined since 2008. The transnational grid of Level I (16 × 16 km) plots was kept unchanged and the monitoring activities were continued. In 2011 the forest condition survey was carried out on 1 009 sample plots from which 77 plots were on the transnational I Level grid and 932 plots on the national forest inventory grid. In total 5,738 sample trees representing 18 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, Quercus robur.*

The mean defoliation of all tree species slightly decreased to 21.2% (22.6% in 2010). 15.6% of all sample trees were not defoliated (class 0), 69.1% were slightly defoliated and 15.3% were assessed as moderately defoliated, severely defoliated and dead (defoliation classes 2-4). Mean defoliation of conifers was 21.1% (22.0% in 2010) and for broadleaves 21.3% (23.4% in 2010).

Mean defoliation of *Pinus sylvestris* was 21.4% (21.5% in 2010). Starting from 1998 mean defoliation of *Pinus sylvestris* has not exceeded 22.0%. The number of trees in defoliation classes 2-4 was not changed and was 16.0% as in 2010. Mean defoliation of *Picea abies* decreased to 20.1% (22.9% in 2010) and the share of trees in defoliation classes 2-4 distinctly decreased and was 16.9% (28.8% in 2010).

Populus tremula had the lowest mean defoliation and the lowest share of trees in defoliation classes 2-4. Mean defoliation of *Populus tremula* was 17.3% (19.3% in 2010) and the proportion of trees in defoliation classes 2-4 was only 4.4% (14.% in 2010). Mean defoliation of *Alnus glutinosa* decreased to 19.4% (23.4% in 2010) and the share of trees in defoliation classes 2-4 – to 9.5% (25.0% in 2010). In 2009 – 2010 the condition of *Alnus glutinosa* was the worst in the whole observation period (1989 – 2011). Mean defoliation of *Alnus incana* decreased to 22.1% (25.1% in 2010). The share of trees in defoliation classes 2-4 noticeable decreased to 13.7% (28.3% in 2010). Mean defoliation of *Betula spp.* decreased to 19.9% (21.5% in 2010) and the share of trees in defoliation classes 2-4 decreased to 12.7% (19.6% in 2010).

The condition of *Fraxinus excelsior* remained the worst between all observed tree species. This tree species had the highest defoliation since 2000. In 2007 – 2008 mean defoliation of *Fraxinus excelsior* has been gradually decreasing, but increased again in 2009 - 2011. The assessed mean defoliation was 43.5% (41.2% in 2010). The share of trees in defoliation classes 2-4 increased up to 58.3% (55.6% in 2010). Mean defoliation of *Quercus robur* decreased to 21.9% (25.4% in 2010) and the number of trees in defoliation classes 2-4 decreased to 15.7% (24.8% in 2010).

20.7% of all sample trees had some kind of identifiable damage symptoms. The most frequent damage was caused by abiotic agents (5.4%), direct action of man (4.4%) and fungi (4.3%). The highest share of damage symptoms was assessed for *Fraxinus excelsior* (54.2%), *Populus tremula* (34.2%) and *Alnus incana* (33.5%), the least for *Alnus glutinosa* (12.6%) and for *Pinus sylvestris* (16.1%).

In general, the condition of Lithuanian forests is better in 2011 than in 2010. However, mean defoliation of all tree species has varied inconsiderably from 1997 to 2011 and the condition of Lithuanian forests can be defined as relatively stable.

6.17. Republic of Moldova

In 2011 forest condition survey was carried out on 567 plots with a grid of 2 × 2 km. A total number 12 552 sample trees was assessed, including 78 trees of coniferous species and 12 444 trees of broadleaves species.

Climatic conditions at the beginning of the vegetation period were favourable for the growing and the development of arboreal and shrubby vegetation. But in the second half of the year and till the end of vegetation on the territory of the country were observed dry conditions. In spite of this, sanitary condition of plantations in general was insignificantly improved in comparison with the previous year. Thus, share of trees of 2-4 defoliation class decreased with 4.1% comparably with last year and in 2011 makes 18.4% against 22.5% in 2010.

Almost for all species of broadleaves and conifers the decrease in share of trees of the 2-4 defoliation class it is observed, or it remains at the level of the last year. In oak stands the quantity of trees of the 2-4 defoliation class decreased by 6.2% comparably to the last year and amounted to 19.6%. In the conifer stands this group decreased by 1.2% and amounted to 32.1% this year. In the acacia stand trees of the 2-4 defoliation class made 36.4%, which is on 3.3% less than last year.

Only for elm species an increase of this index for 2.1% as compared to the last year can be observed and it constitutes 40.5% for 2011. This can be explained with the intensive crown grazing by *Aprocerus leucopoda* during several years.

6.18. Norway

The results for 2011 show a small increase in crown defoliation for all tree species compared to the year before. The mean defoliation for *Picea abies* was 15.5%, *Pinus sylvestris* was also 15.5%, and for *Betula* spp. 23.6%. After a peak in 2007 with high defoliation for all of the 3 monitored tree species Norway spruce, Scots pine and birch, and then a decrease in defoliation in the following years (2008-2010), this last year 2011 again shows an increase in the defoliation of these tree species. During the last ten years birch had the lowest defoliation in 2001, while 2011 is the year with the third highest defoliation. Norway spruce and Scots pine show only minor changes in defoliation over the last four years (2008-2011).

Of all the coniferous trees, 47.1% were rated as not defoliated in 2011, which is a decrease of about 4% points as compared to the year before. Only 38.7% of the *Pinus sylvestris* trees were rated as not defoliated which is a decrease with 2% points. 53.0% of all Norway spruce trees were not defoliated, a decrease with 4% points compared to the year before. For *Betula spp.* 21.0% of the trees were observed in the class not defoliated, also representing a decrease with 8.6% points compared to the year before. For birch trees, especially the class 'moderately defoliated' increased from 21.7 to 26.9% in 2011. For other classes of defoliated trees, only small changes were observed.

In crown discolouration we observed 11.6% discoloured trees for *Picea abies*, an increase with 2.3% points from 9.3% in 2010. For *Pinus sylvestris*, only 3.8% of the assessed trees were discoloured, an increase with about 1% points from the year before. For *Betula spp*., the discolouration followed up the increase from 2010 and was now 11.4% in 2011. For birch, the observed trees in the most serious class 'Severely discolouration' were 3-doubled from 1.0% in 2010 to 3.3% in 2011.

The mean mortality rate for all species was 0.3% in 2011. The mortality rate was 0.4%, 0.2% and 0.2% for spruce, pine and birch, respectively. The mortality rate of birch has been more normal the last three years and is heavily reduced from the high level of 1-2% which occurred in the three year period 2006-2008 probably due to serious attacks of insects and fungi.

In general, the observed crown condition values result from interactions between climate, pests, pathogens and general stress. According to the Norwegian Meteorological Institute the summer (June, July and August) of 2011 was regarded as warmer than normal (1.2 ºC warmer) and with 40% more precipitation as normal as an average for the whole country. In south-east Norway, where summer drought is a frequent problem for trees, the precipitation in 2011 was the highest ever measured and was 95% higher than normal. The second highest precipitation was in 1964 with 65% more precipitation than normal. There are of course large climatic variations between regions in Norway which range from 58 to 71 ºN.

6.19. Poland

In 2011 the forest condition survey was carried out on 1 947 plots. Forest condition was worse than in the previous year. 14.0% of all sample trees were without any symptoms of defoliation, indicating a decrease by 7 percent points compared to 2010. The proportion of defoliated trees (classes 2-4) increased by 3.3 percent points to an actual level 24.0% of all trees. The share of trees defoliated more than 25% increased by 4.0 percent points for conifers and by 2.0 percent points for broadleaves.

11.3% of conifers were not suffering from defoliation. For 24.2% of the conifers defoliation of more than 25% (classes 2-4) was observed. With regard to the three main coniferous species *Abies alba* remained the species with the lowest defoliation, although indicated a worsening comparing to previous year. A share of 17.3% (11.4% in 2010) of fir trees up to 59 years old and 16.1% (15.5% in 2010) of fir trees 60 year old and older was in defoliation classes 2-4.

19.1% of assessed broadleaved trees were not defoliated. The proportion of trees with more than 25% defoliation (classes 2-4) amounted to 23.5%. As in the previous survey the highest defoliation amongst broadleaved trees was observed in *Quercus spp.* although indicated slight improvement in older stands. In 2011 a share of 28.0% (28.5% in 2010) of oak trees up to 59 years old and 32.2% (37.8% in 2010) of oak trees 60 years old and older was in defoliation classes 2-4. *Fagus sylvatica* remained the broadleaves species with the lowest defoliation, although indicated a worsening comparing to previous year. A share of 9.8% (7.6% in 2010) of beech trees up to 59 years old and 11.8% (7.4% in 2010) of beech trees 60 year old and older was in defoliation classes 2-4.

In 2011 discolouration (classes 1-4) was observed on 2.8% of the conifers and 2.3% of the broadleaves.

6.20. Romania

In the year 2011, the assessment of crown condition on Level I plots in Romania was carried out on the 16 x 16 km transnational grid net, during 15th of July and 15th of September. The total number of sample trees was 5 808, which were assessed on 242 permanent plots. From the total number of trees, 1104 were conifers and 4704 broadleaves. Trees on 12 plots were harvested during the last year and several other plots were not reachable due to natural hazards.

For all species, 48.8% of the trees were rated as healthy, 37.3% as slightly defoliated, 13.0% as moderately defoliated, 0.7% as severely defoliated and 0.2% were dead. The percentage of damaged trees (defoliation classes 2-4) was 13.9%.

For **c**onifers 15.9% of the trees were classified as damaged (classes 2-4). *Picea abies* was the least affected coniferous species with only 12.9% of the trees damaged (defoliation classes 2-4). For broadleaves 13.4% of the trees were assessed as damaged or dead (classes 2-4). Among the main broadleaved species, *Carpinus betulus* had the lowest share of damaged trees (8.0%), followed by *Fagus sylvatica* with 9.0%. The most affected species was *Robinia pseudoaccacia* with a share of 28.7% damaged or dead trees (classes 2-4). For *Quercus sp*. a share of 17.9% trees was rated as damaged or dead.

Compared to 2010, the overall share of damaged trees (classes 2-4) decreased with 3.8 % points. Forest health status was slightly influenced, mainly for broadleaves, by the relatively favourable weather conditions during the April - July period**.**

Concerning the assessment of biotic and abiotic damage factors, most of the observed symptoms were attributed to insects (39.9%), abiotic factors (30.1%), fungi (11.4%), anthropogenic factors (7.4%), and game and grazing (4.1%).

6.21. Russian Federation

As a total, the condition of 9 116 trees on 295 monitoring plots of Level I established in Murmansk, Leningrad, Pskov, Novgorod, Kaliningrad oblasts and Karelian Republics was assessed.

In 2011, compared to 2010, the proportion of not defoliated conifer trees decreased from 84% to 72% correspondingly. Total number of trees of defoliation classes 1- 4 increased in 2011.

The most significant changes have been found for slightly defoliated and, especially, dead trees: from 14.5% and 0.2% in 2010 to 17% and 4% in 2011 correspondingly.

As for broadleaves, no significant changes have been found, except for dead trees, the proportion of which increased from 0.2% in 2010 to 1.6% in 2011.
As a total for all species, the proportion of not defoliated trees decreased from 83% in 2010 to 77% in 2011. The most significant increase has been found for dead trees: from 0.2% in 2010 to 3.3% in 2011.

The main reason for dead trees increasing were hurricanes of 2010 (the first storm occurred July 30, after assessment 2010) in Leningrad region.

6.22. Serbia

In the region of the Republic of Serbia, the established 16 x 16 km grid consists of 103 sampling plots and 27 plots added in 4 x 4 km grid. All together number of plots is 130 (not including the autonomous province (AP) of Kosovo and Metohija). The assessment at Level I was performed according to the ICP Forests Manual of Methods. Actual monitoring has been carried out in 2011 on 119 plots since few plots were clear cut. In 2011 the researchers of the NFC Serbia - Institute of Forestry with collaborators from other institution in Serbia, carried out visual assessment of defoliation and discolouration and collected other necessary field data.

Defoliation
The total number of trees assessed on all plots was 2 743 of which 333 were conifers and a considerably higher number i.e. 2 410 were broadleaves. The distribution of the conifers assessed was as follows: *Abies alba* (21.0%), *Picea abies* (42.1%), *Pinus nigra* (20.1% and *Pinus silvestris* (16.8%). The most represented broadleaved species were: *Carpinus betulus* (5%), *Fagus moesiaca* (33.2%), *Quercus cerris* (21%) , *Quercus frainetto* (15.2%), *Quercus petraea* (7.0 %) and other species (18.6%). For coniferous species the assessment resulted in the following distribution of damage classes:

Picea abies: 87.2% (not defoliated), 11.4% (slight defoliation) 1.4% (moderate defoliation) 0% (severe defoliation and dead trees),

Pinus nigra: 34.3% (not defoliated), 17.9%, (slight defoliation) 35.8% (moderate defoliation), 12% (severe defoliation) 0% (dead trees),

Pinus sylvestris: 89.3% (not defoliated), 8.9% (slight defoliation), 0% (moderate defoliation), 1.8% (severe defoliation), 0% (dead trees),

Abies alba 92.9% (not defoliated), 4.3% (slight defoliation), 0% (moderate defoliation), 2.8% (severe defoliation), 0% (dead trees),

The percentage of all conifers classified according to damage classes was as follows: no defoliation 78.1 %, slight defoliation 10.8%, moderate defoliation 7.8% and severe defoliation 3.3%.

The assessment of all broadleaved tree species yielded the following distribution: no defoliation 68.6%, slight defoliation 24.2%, moderate defoliation 6.0%, severe defoliation 0.6% and 0.6% dead trees.

As regards the individual broadleaves the assessment brought following results

Carpinus betulus: 84.4% (not defoliated), 8.3% (slightly defoliated), 4.6% (moderately defoliated) 1.8% (severely defoliated), 0.9% (dead trees), *Fagus moesiaca:* 85.7% (not defoliated), 12.0% (slightly defoliated), 1.6% (moderately defoliated) 0.3% (severely defoliated), 0.4% (dead trees),

Quercus cerris: 61.3% (not defoliated), 34.4% (slightly defoliated), 4.1% (moderately defoliated) 0.2% (severely defoliated), 0% (dead trees),

Quercus frainetto: 66.2% (not defoliated), 26.7% (slightly defoliated), 6.5% (moderately defoliated) 0.3% (severely defoliated), 0.3% (dead trees),

Quercus petraea: 36.3% (not defoliated), 44.0% (slightly defoliated), 17.9% (moderately defoliated) 0% (severely defoliated), 1.8% (dead trees),

Other broadleaves: 57.1% (not defoliated), 28.4% (slightly defoliated), 11.4% (moderately defoliated) 1.8% (severely defoliated), 1.3% (dead trees).

Discolouration

Discoloration was assessed in main coniferous and broadleaved species according to 5 damage classes as with defoliation. In contrast to defoliation the percentages of the trees showing no discoloration were very high: *Picea abies* (99.3%), *Pinus sylvestris* (92.9%), *Abies alba* (92.8%). An exception is *Pinus nigra* with only 55.2% trees without any discolouration symptoms. Taking all coniferous species together 88.0% trees were not discoloured at all, followed by 9.9% showing slight discolouration, 1.5% moderately and 0.6% severely discoloured. As regards the broadleaves the degree of discoloration resembles that of conifers i.e. most of the trees did not show discolouration. The percentages of trees showing no discolouration are

Carpinus betulus (81.7%), *Fagus moesiaca* (98.9%), *Quercus cerris* (none 96.0%), *Quercus frainetto* (91.8%), *Quercus petraaea* (94.6%). In the remaining broadleaves 90% trees assessed are not discoloured. If all broadleaves are included into calculation the percentage of trees without discolouration is 94.6%, followed by trees slightly discoloured (4.2%), trees showing moderate (0.7%) and severe discolouration (0.5%). The above results quantify only the degree of defoliation and discolouration which are unspecific effects caused by adverse factors such as climate stress, insect pests or pathogenic fungi. Moreover, the foliage density reflects an adaptation processes to the natural growth condition on particular site.

6.23. Slovak Republic

The 2011 national crown condition survey was carried out on 108 Level I plots of the 16x 16 km grid net. The assessments covered 4 935 trees, 4 017 of which being assessed as dominant or co-dominant trees according to Kraft. Of the 4 017 assessed trees, 34.7% were damaged (defoliation classes 2-4). The respective figures were 46.6% for conifer and 26.4% for broadleaves trees. Compared to the 2010, the share of tree defoliated more than 25% decreased by 3.9%. Mean defoliation for all tree species together was 25.4%, with 29.2% for conifers and 22.7% for broadleaved trees. Results show that crown condition in Slovak Republic is worse than the European average. It is mainly due to worse condition of coniferous species.

Compared to 2010 survey, worsening (average defoliation) was observed in species *Fraxinus excelsior* L. and *Picea abies* Karst.

Since 1987, the lowest damage has been observed for *Fagus sylvatica* and *Carpinus betulus*, with exception of fructification years. The most severe damage has been observed for *Abies alba*, *Picea abies* and *Robinia pseudoacacia*.

From the beginning of the forest monitoring in 1987 until 1996 the results show a significant decrease in defoliation and visible forest damage. Since 1996, the share of damaged trees (25-

32%) and average defoliation (22-25%) has been relatively stable. The recorded fluctuation of defoliation depends mostly on meteorological conditions.

As a part of crown condition survey, damage types were assessed. In 2011, 27.3% of all sampling trees (4,935) had some kind of damage symptoms. The most frequent damage was caused by logging activities (9.3%) and fungi 7.7%) at tree stems. Other damage causes were abiotic agents (3.3 %), and epiphytes (2.3 %). Epiphytes had the most important influence on defoliation. 57% of trees damaged by epiphytes revealed defoliation above 25%.

6.24. Slovenia

In 2011 the Slovenian national forest health inventory was carried out on 44 systematically arranged sample plots (grid 16 x 16 km). The assessment encompassed 1 046 trees, 396 coniferous and 650 broadleaved trees. The sampling scheme and the assessment method was the same as in the previous years, with the exception on two sample plots, where after felling no appropriate new trees were present on the plot which could be included in the assessment.

The mean defoliation of all tree species was estimated to 25.4%. Compared to 2010 survey, worsening of mean defoliation was observed for 0.7% (mean defoliation in 2010 was 24.7%). In year 2011 mean defoliation for coniferous trees was 25.2% (in year 2010 was 24.1%) and for broadleaves 25.5% (year before 24.5%). One of the reasons could be that year 2011 was the fructification year of beech.

In 2011 the share of trees with more than 25% of unexplained defoliation (damaged trees) reached 31.4%. In comparison to the results of 2010, when the share of trees with more than 25% of unexplained defoliation was 31.8%, the value decreased for 0.4%.

Especially significant is the change of damaged trees for broadleaves where the share of damaged trees increased from 28.1% in year 2010 to 30.0% in 2011, while the share of damage coniferous decreased from 37.8% in 2010 to 33.6% in 2011.

In the previous year's coniferous were more damaged than broadleaves. But in year 2011 the proportion has changed and broadleaves were more damaged then coniferous.

In general, the mean defoliation of all tree species has slightly increased since 1991. The situation improved in year 2010 and in 2011 the mean defoliation increased again for 0.7%. However the condition of Slovenian forests can be defined as relatively stable.

6.25. Spain

Results obtained in the 2011 inventory show that the general health condition of trees continue with its recovery process. 88.2% of the surveyed trees were healthy, compared to 85.4% in the previous year, and even better if compared to the situation in 2009 (82.3%). 10.2% of the trees were included in defoliation classes 2 and 3, indicating defoliation levels higher than 25%, whereas in 2010 this percentage was 12.2% (15.7% in 2009). The number of damaged trees decreased slightly whereas the number of dead ones decreased more noticeably, reaching the minimum level of 1.6%.

This overall improvement is more relevant in conifers, with a percentage of 89.6% of healthy trees (86.9% last year) than in broadleaves (86.8% this year and 83.9% in 2010). The mortality of trees was due to sanitary cuts, forest management operations and to decline processes derived from specific water deficits.

Regarding other possible damaging agents, there is a clear decrease in its percentage which is especially remarkable for abiotic damages as well as for insects and fungi.

There are drastic reductions both in spring defoliators on broadleaves and in pine processionary caterpillar (*Thaumetopoea pityiocampa*).

In general lines, also conifer borers show this decrease, associated with the least number of trees damaged by abiotic agents (mainly drought).

The unchanged and a slight and punctual localized increase in the numbers of some broadleaves borer and some specific defoliator should be quoted as well. The same trend is observed in the records for fungi, in particular for those which are affecting foliage of broadleaves and the vascular ones

However there is a certain increase in fungi affecting needles of conifers, particularly Sirococcus.

Mistletoe damages and degenerative processes affecting juniper stands remain broadly stable, if compared to the previous year. The specific damages which were observed in previous years on alders seem not to have followed an upward trend, and there has not been an increase in damages related to *Seca* syndrome.

The importance of atmospheric pollution in the evolution of forest condition is a factor which cannot be quantified directly, as it is frequently disguised by other kind of processes which are more apparent. However, in combination with other agents it can contribute to the degradation processes of forests.

6.26. Sweden

The national results are based on assessment of the main tree species *Picea abies* and *Pinus sylvestris* in the National Forest Inventory (NFI), and concerns, as previously, only forest of thinning age or older. In total, 7 596 trees on 3 223 sample plots were assessed. The Swedish NFI is carried out on permanent as well as on temporary sample plots. The permanent sample plots, which are two thirds of the total sample, are re-measured every 5th year.

The proportion of trees with more than 25% defoliation is for Norway spruce (*Picea abies)* 29.6% (28.9% in 2010) and for Scots pine (*Pinus sylvestris)* 10.0% (11.7 % in 2010). Greater defoliation is seen in southern Sweden on Scots pine while an improvement is apparent in central Sweden. However, the majority of changes seen in defoliation levels during recent years are minor.

An outbreak of bark beetles (*Ips typographus* and *Polygraphus poligraphus*) has been seen in central Sweden since 2008. In one county (300 000 ha older spruce forest) a special target inventory of spruce trees killed by bark beetle was undertaken. The results from the special target inventory in 2011 show that the quantity Norway spruce trees killed was about the same for the two bark beetle species and in total effected a standing volume of 850 000 m^{3}sk. It seems that in the two previous year's even larger volumes were affected.

Needle loss on Scots pine caused by European pine sawfly (*Neodiprion sertifer*) is still seen in southeastern Sweden. Damage on Norway spruce in southernmost Sweden by spruce scale (*Physokermes inopinatus*) has ceased as the insect population collapsed. The decline in *Fraxinus excelsior* is continuing in southern Sweden. In northern Sweden resin top disease *(Cronartium flaccidum*) is still a problem in young Scots pine stands. Damage on forest plantation by rodents has increased, especially in northern Sweden, but a decrease in the population of rodents is foreseen in 2012. Still, the most important damage problems are 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*. The invasive species *Lep-*

toglossus occidentalis was in 2011 found for the first time in Sweden. The species has its origin in western North America and lives on the seeds of conifers.

6.27. Switzerland

In 2011 the Swiss national forest health inventory was carried out on 47 plots of the 16 x 16 km Level I grid using the same sampling and assessment methods as in the previous years.

Crown condition of most tree species in 2011 decreased substantially as compared to 2010. In 2011 30.8% of the trees had more than 25% unexplained defoliation (i.e. subtracting the known causes such as insect damage or frost damage) as compared to 22.2% in 2010. In 2011 41.3% of the trees had more than 25% total defoliation (2010: 32.0%). The same increase was observed for most species for the Level II plots. Only oak species showed lower crown defoliation in 2011.

The very high defoliation in 2011 can be explained by two main factors: the extremely high seed production of almost all main tree species and the very dry first half of the year in Northern and Western Switzerland and the inner-alpine valleys.

For common beech, Norway spruce, oaks, sycamore maple record high proportions of fruit baring trees were recorded and silver fir and European larch were close to maxima. Beech trees with recorded high levels of seed increased in crown defoliation compared to 2010 by 10%, trees with low seed production by 9%, while trees without observable seeds decreased in defoliation by 2%. In 2009, the second highest seed year, only for trees with high seed amounts an increase in defoliation had been observed. For Norway spruce and silver fir on Level I plots in 2011, the trees with cone production also showed a higher increase in defoliation than trees without or with few cones. However, the relationship was less clear than for beech and varied by plots. During branch sampling for foliar chemical analysis on selected Swiss Level II sites, branches of some Norway spruce trees were found with a large amount of male and female flowers, but almost no new shoot and needles formed in 2011. The replacement of normal shoots by male flowers may partially explain the increased crown transparency in 2011. For oak, in 2011 the proportion of recorded insect decreased resulting in a decrease in crown defoliation despite the high seed production. This may be due to the extremely early leaf unfolding of the oaks in 2011 before some defoliators emerged.

On some Swiss Level II sites the soil water potential measured by the end of June (the beginning of the crown defoliation survey) was the lowest recorded since the beginning of measurements in 1997. This was due to the record low precipitation in parts of Switzerland during the first half of 2011 (mainly April and May). Only the southern alpine sites and the sites at higher altitude in the Alps showed little or no water shortage.

Annual mortality rates in the Level I survey were higher than usual, but could be explained by the death of several chestnut coppice trees on some plots. On one Level II plot Scots pine mortality increased to 4% as a result of the drought in 2011. The crown defoliation and the proportion of common ash trees with high defoliation increased for the first time since the observation of the ash wilting. This was also true on sites, where other species showed no change in crown defoliation.

6.28. Turkey

The national results for crown conditions were obtained from 13 282 trees in 563 Level I plots located in 16 km x 16 km grid. About 63.9% of the assessed trees were conifers, 36.1% were broadleaves. The most common species were *Pinus brutia*, *Pinus nigra*, *Quercus cerris* and *Fagus orientalis* and their account for 24.2%, 18.5 %, 7.3% and 6.9% of the assessed trees, respectively. The assessment includes 61 different tree species and most of them are broadleaves.

The mean defoliation rates 19.3% for broadleaves. The defoliation rates for the assessed main broadleaves is descending in the following order; *Quercus pubescens* (29.6%), *Quercus petraea* (25.1%) and *Castanea sativa* (23.7%). About 31.5% of the broadleaves have no defoliation (class 0). 17.3% of the observed trees had defoliation rates greater than 25% (classes 2, 3 and 4).

The mean defoliation rates greater than 35% for the other less common tree species such as *Prunus avium, Populus nigra, Salix alba* and *Ulmus glabra.*

The mean defoliation rates were 17.1% for the conifers. *Juniperus communis,* with 21.0%, has the highest defoliation rate among the conifers. *Pinus pinaster* and *Pinus brutia* followed *Juniperus communis* with 20.4% and 19.7% mean defoliation rates, respectively. About 33.9% of the conifers have no defoliation (class 0). However, 11.6% of the observed all conifer trees had defoliation rates greater than 25% (classes 2, 3 and 4).

The assessed over all tree species, the mean defoliation rates were 17.9%. The healthy trees (class 0) rates were about 33%. But, 13.6% of the observed trees are having more than 25% defoliation rate (classes 2, 3 and 4).

Insects account for about 32.2% of the damaging agents. *Thaumetopoea pityocampa* and *Lymantria dispar* are the most common species observed in the Level I plots. *Viscum alba*, a parasitic plant species, is considered responsible for the 8.5% of the defoliation.

Similar to the previous years, defoliation rates of broadleaves are higher than that of the conifers. Estimated defoliation rates are higher for the tree species in the northern and northeastern part of the country. However, there has been an improvement in health status of trees for the last four years.

6.29. Ukraine

In 2011 the organization of forest monitoring field works was changed due to order of State Agency of Forest Resources of Ukraine No 60 from 30 March 2011. Starting from the field season 2011 the responsibility for collecting the data has been entrusted to the State Forest Management Enterprises (SFME's). Assessment of indicators for monitoring sites level 1 is carried out by specialists of SFME's under the methodological guidance experts from Ukrainian Research Institute of Forestry and Forest Melioration (URIFFM) and officers from Regional Forest Administrations (RFA). Responsibility for QA/QC of forest monitoring data is placed to RFA and URIFFM, experts from URIFFM is responsible for maintaining of national forest monitoring data base. The series of trainings for officers from RFA and for field specialists from SFME's has been conducted in 2011 for standardization in assessment of defoliation and others indicators.

In 2011, 3 3878 sample trees were assessed on 1 476 forest monitoring plots in 25 administrative regions of Ukraine. Mean defoliation of conifers was 11.3% and of broadleaved trees was 11.7%.

For the total sample some deterioration of tree condition was observed compared to the previous year. In 2011, the percentage of healthy trees slightly decreased (64.9% against 67.7%). At the same time, the share of the slight to moderate defoliated trees increased from 32% to 35%. These changes may be related to change of sample volume.

For the sample of common sample trees (CSTs) (32,160 trees) the tendency to deterioration of crown condition was observed. Mean defoliation slightly increased in 2011 (11.5%) comparing to 2010 (10.9%).

Some deterioration of tree condition was registered for CSTs of *Picea abies, Pinus sylvestris* and *Fraxinus excelsior*, that is characterized by statistically significant decreasing of share of trees in defoliation class 0 (for *Picea abies* on 4.1%, for *Pinus sylvestris* – on 3% and *Fraxinus excelsior* – on 3.1%) and increasing in all other classes. Changes in distribution within defoliation classes of CSTs of other main tree species (*Fagus sylvatica* and *Quearcus robur)* were insignificant.

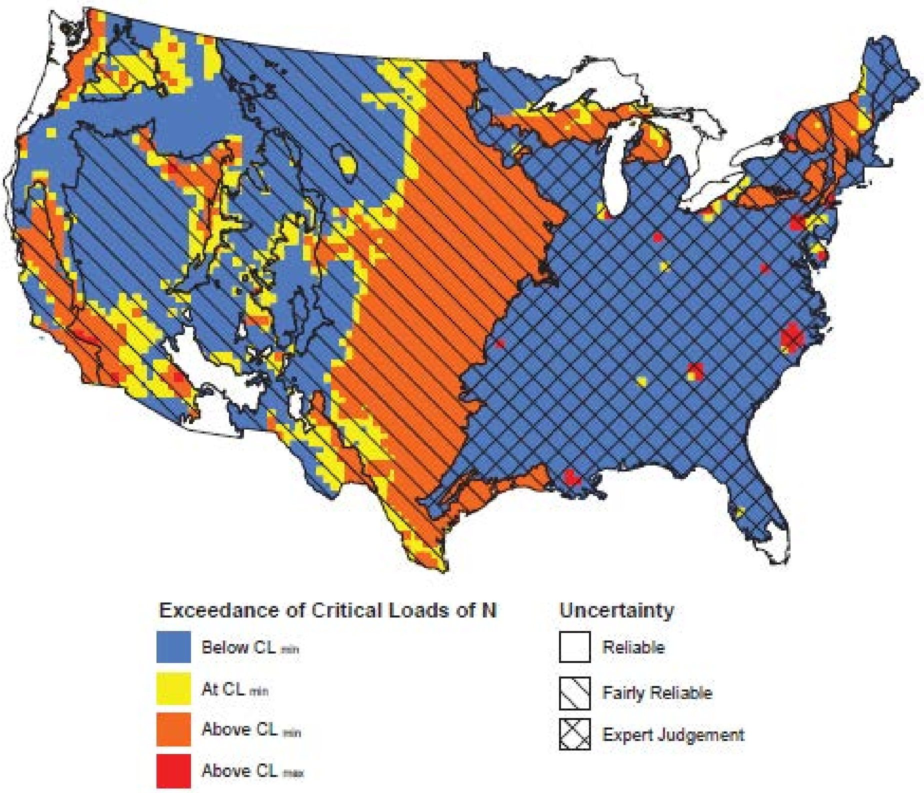
Some deterioration of tree condition may be explained post-pointed effect of extreme hot and dry weather condition in summer 2010 that may cause some weakening of trees and increasing of defoliating insect's impact.

6.30. United States of America

Within the USDA Forest Service critical loads for acidification and nutrient nitrogen are being determined through collaboration between research and management branches. This information was recently used to support watershed condition assessments in the US. The Forest Service is also working cooperatively with other federal agencies (i.e., U.S. National Park Service, U.S. Environmental Protection Agency, U.S. Geological Survey) to develop a national database of critical loads that can be used to identify at risk ecosystems to air pollution, assess air pollution impacts, and track the effectiveness of air pollution control strategies. This interagency critical loads group (CLAD, Critical Loads of Atmospheric Deposition Science Committee of the National Atmospheric Deposition Program) is also actively working with international organizations (i.e. North American Forest Commission, Canada Transboundary Pact, United Nations Economic Commission for Europe (UNECE) ICP Forests) who have been using critical loads in air quality management and policy development for over two decades.

Phase I of this project was completed in 2011. The Western Governors' Association (WGA) provided Phase I project coordination with oversight from the U.S. National Park Service, and input from the USDA Forest Service, and Environmental Protection Agency. The WGA provided active leadership in project coordination and management of the Phase I pilot study effort to provide comprehensive, regionally-scaled U.S. critical loads data to the UNECE Coordination Centre for Effects (CCE) by the CCE-driven due dates. Iterative collaboration to gather and collate data and Critical Loads results with scientists and researchers from the U.S. NPS, the USDA FS, and the U.S. EPA, along with private consultants and university faculty was employed to create shared data and map products, in order to deliver the Phase I project's U.S. Critical Loads data, maps, and analytical results. For the first time, these U.S. results were distributed to the CCE by the mid-March 2011 CCE deadline and then presented at the April 18-21 CCE workshop. The U.S. NPS, USDA FS, and U.S. EPA designed the FOCUS Phase I project to coordinate input from members of the Critical Loads' research community, in order to summarize, compile in a database, and document research results and data for publication in maps and other products.

In 2011 the USDA Forest Service published a monograph on empirical critical loads for nitrogen in the major ecoregions of the United States. This is the first time that a synthesis of critical loads for the entire United States has been published. A synthesis review article based on this work was also published in the journal Ecological Applications. These publications review the empirical critical loads for ecoregions ranging from tundra and taiga to various forest types, deserts, Mediterranean California, deserts, and tropical and subtropical forests, wetlands and inland surface waters. Comparisons are made to European critical loads and factors affecting the critical load are discussed. Critical load maps and exceedance maps are also included in these reports.

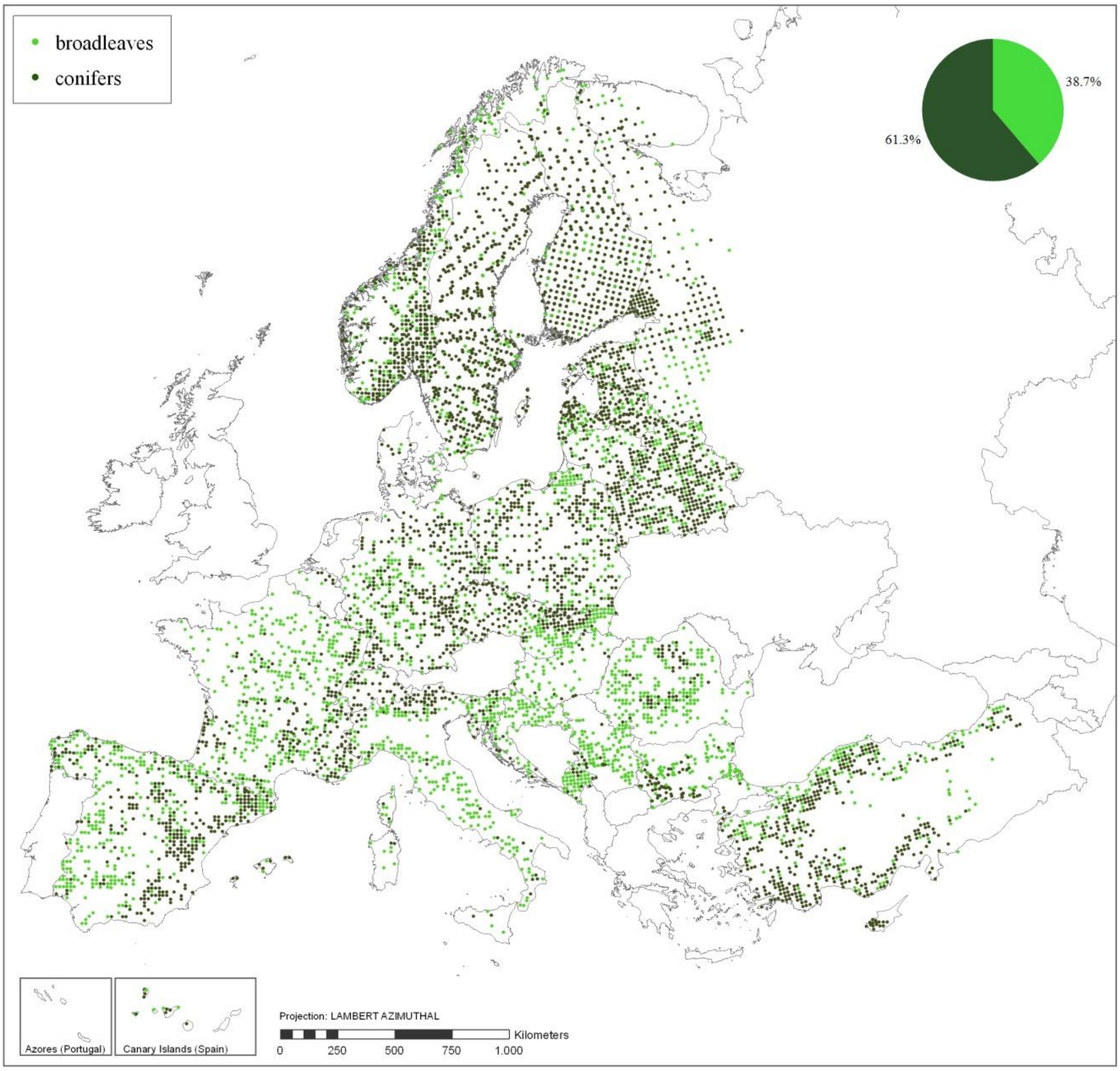


Map showing the CL exceedance of N deposition for herbaceous plants and shrubs by ecoregion in the United States. The exceedance indicates when regions are at risk for detrimental effects from N deposition. Reliability of estimates is shown with hatching.

A workshop with participation of the ICP Forests, Canadian and Mexican experts was held in Riverside, CA in April 2011 to discuss the USDA Forest Service capacity to integrate measurements and modelling efforts related to the computation of critical loads/levels and their exceedances and to further develop collaboration with the ICP Forests. One of the workshop conclusions was that the USDA Forest Service Forest Inventory and Analysis (FIA) forest health monitoring plots (P3-similar to ICP Level II plots) should include the Experimental Forest & Rangeland network sites where data needed for evaluation of critical loads (such as wet deposition, or air chemistry) are collected.

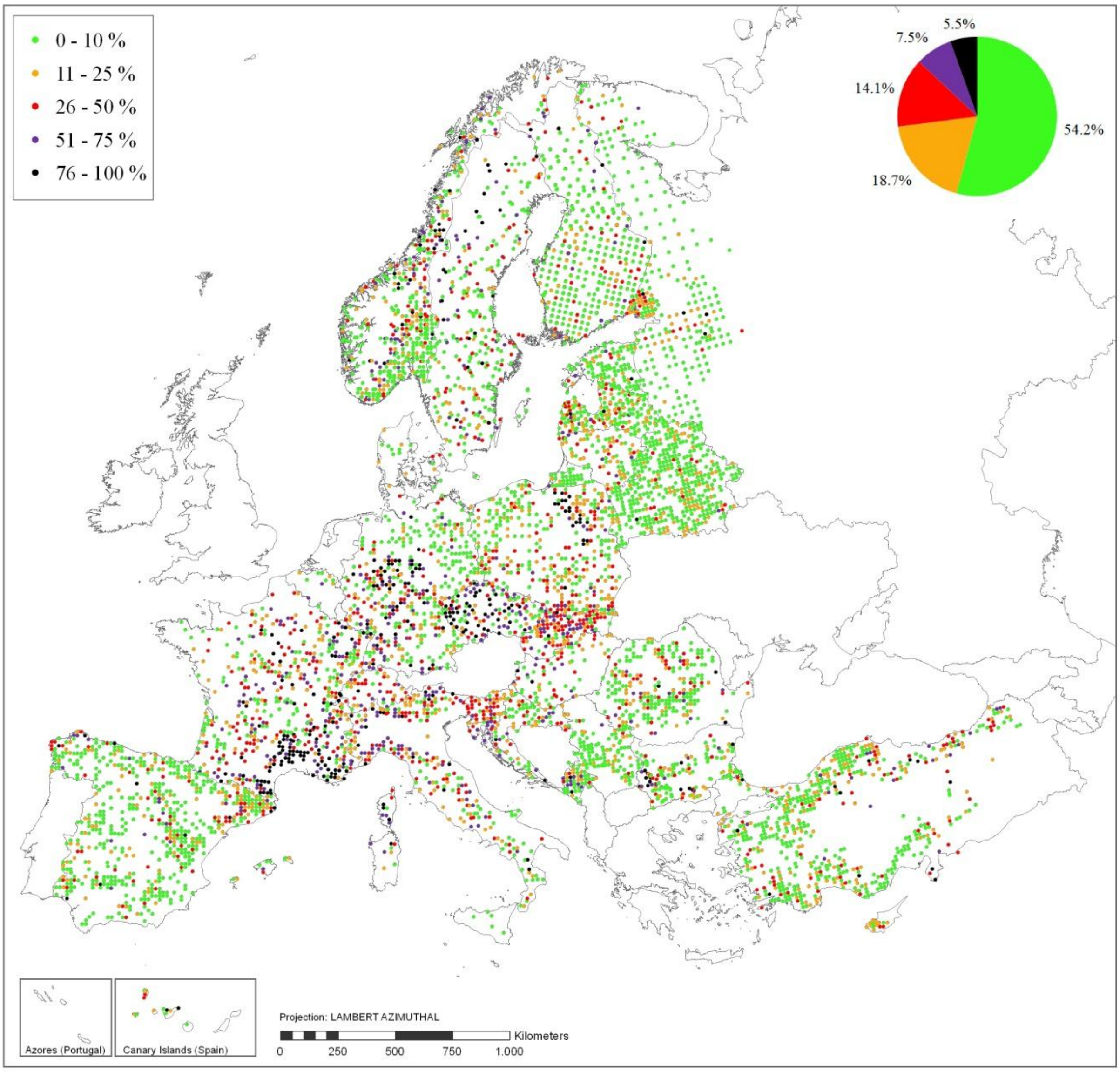
Annex I: Maps of the transnational evaluations

Annex I-1: Broadleaves and conifers



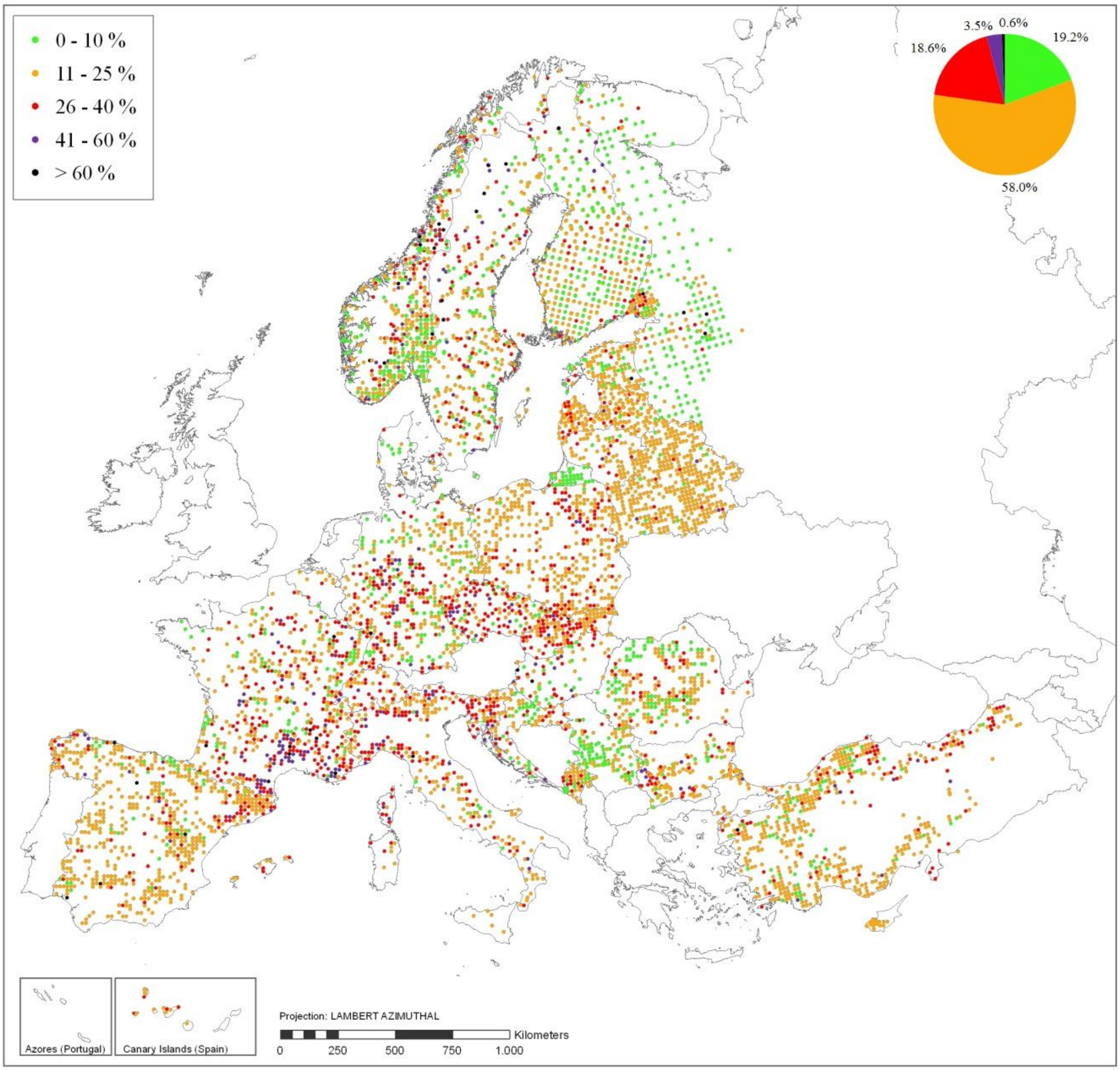
Shares of broadleaves and conifers assessed on Level I plots in 2011

Annex I-2: Percentage of trees damaged (2011)



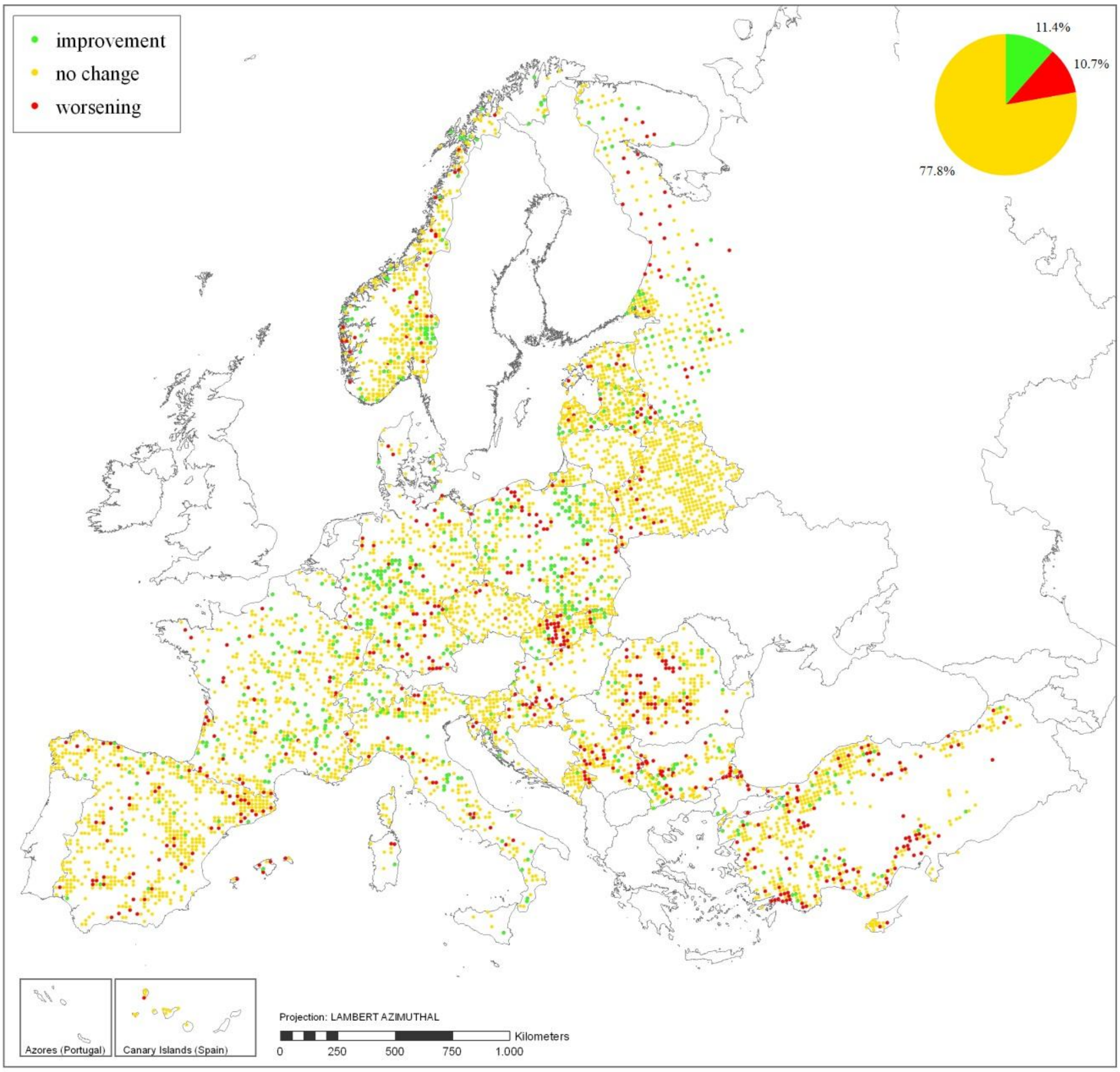
Percentage of trees assessed as damaged (defoliation >25) on Level I plots in 2011

Annex I-3: Mean plot defoliation of all species (2011)



Mean plot defoliation of all species (2011)

Annex I-4: Changes in mean plot defoliation (2010-2011)



Changes in mean defoliation of all trees assessed on Level I between 2010 and 2011

Annex II: National results

Annex II-1: Forests and surveys in European countries (2011)

Participating Countries	Total area (1000 ha)	Forest area (1000 ha)	Coniferous forest (1000 ha)	Broadleaves forest (1000 ha)	Area surveyed (1000 ha)	Grid size (km x km)	No. of sample plots	No. of sample trees
Albania	2875	1063	171	600	no survey in 2011			
Andorra	46.8	17.7	15.4	2.3	17.7	16 x 16	3	72
Austria	8385	3878	2683	798	no survey in 2011			
Belarus	20760	8010	4785	3225	8010	16 x 16	416	9583
Belgium	3035.1	700.4	281	324		4^2 / 8^2	112	2594
Bulgaria	11000	3820	1040	2398		$4^2/8^2/16^2$	159	5583
Croatia	5654	2061	321	1740		16 x 16	92	2208
Cyprus	925.1	297.7	172	0	138	16x16	15	360
Czech Republic	7886	2647	2014	633	2647	$8^2/16^2$	136	5418
Denmark	4310	586	289	263		$7^2/16^2$	18	411
Estonia	4510	2212	1113.4	1098.7	2212	16 x 16	98	2372
Finland	30415	20150	17974	1897	19871	16^2 / 24x32	717	4147
France	54883	15840	4041	9884	13100		554	11352
Germany	35702	11076	6490	3857	10347	16^2 / 4^2	410	10167
Greece	12890	2034	954	1080	no survey in 2011			
Hungary	9300	1922	220	1702	1922	16 x 16	78	1830
Ireland	7028	680	399	37	no survey in 2011			
Italy	30128	8675	1735	6940			253	8099
Latvia	6459	3162	1452	1710		8x8		
Liechtenstein	16	8	6	2	no survey in 2011			
Lithuania	6530	2170	1158	900		8x8/16x16	1009	5738
Luxembourg	259	89	30	54	no survey in 2011			
Rep. of Macedonia					no survey in 2011			
Rep. of Moldova	3384		5.36	287.19		2x2	567	12552
Netherlands	3482	360	140	136	no survey in 2011			
Norway	32376	12000	6800	5200	12000	$3^2/9^2$	1735	9417
Poland	31268	9200	6955	2245	9200	16 x 16	1947	38940
Portugal	8893	3234	1081		no survey in 2011			
Romania	23839	6233	1873	4360		16 x 16	242	5808
Russian Fed.	1700075	809090	405809	195769	36173	32x32	295	9116
Serbia	8836	2360	179	2181	1868	16 x 16/4 x 4	130	2743
Slovak Republic	4901	1961	815	1069	1961	16 x 16	108	4017
Slovenia	2014	1183	445	738	1183	16 x 16	44	1046
Spain	50471	18173	6600	9626		16 x 16	620	14880
Sweden	41000	28300	19600	900	20600	varying	3223	7596
Switzerland	4129	1279	778	501	1279	16 x 16	47	1008
Turkey	77846	21537	13158	8379	9057	16 x 16	563	13282
Ukraine	60350	9400	2756	3285	6033	16 x 16	1476	33878
United Kingdom	20933	2665	1306	854	no survey in 2011			
TOTAL	2336794	1018073.8	515644.16	274675.19	157618.7	varying	15067	224219

Annex II-2: Percent of trees of all species by defoliation classes and class aggregates (2011)

Participating countries	Area surveyed (1000 ha)	No. of sample trees	0 none	1 slight	2 moderate	3+4 severe and dead	2+3+4
Albania			no survey in 2011				
Andorra	18	72	63.9	27.8	8.3	0.0	8.3
Austria			no survey in 2011				
Belarus	8010	9583	30.5	63.4	4.8	1.3	6.1
Belgium		2594	22.8	53.7	21.4	2.1	23.5
Bulgaria		5583	28.2	50.2	17.9	3.7	21.6
Croatia		2208	40.5	34.2	21.4	3.9	25.2
Cyprus	138	362	12.5	71.1	15.8	0.6	16.4
Czech Republic	2647	5418	15.2	32.1	50.9	1.8	52.7
Denmark		411	65.2	24.8	7.1	2.9	10.0
Estonia	2212	2372	50.8	41.1	5.7	2.4	8.1
Finland	19871	4147	53.7	35.7	9.3	1.3	10.6
France	13100	11352	26.0	34.1	35.4	4.5	39.9
Germany	10347	10167	36.7	35.3	26.1	1.9	28.0
Greece			no survey in 2011				
Hungary	1922	1830	62.3	18.8	13.8	5.1	18.9
Ireland			no survey in 2011				
Italy		8099	27.0	41.7	27.4	3.9	31.3
Latvia		6644	13.8	72.2	12.4	1.6	14.0
Liechtenstein			no survey in 2011				
Lithuania		5738	15.6	69.0	13.2	2.2	15.4
Luxembourg			no survey in 2011				
Rep. of Macedonia			no survey in 2011				
Rep. of Moldova		12552	45.0	36.6	15.7	2.7	18.4
Netherlands			no survey in 2011				
Norway	12000	9852	40.9	38.2	17.4	3.5	20.9
Poland	9200	38940	14.0	62.1	22.9	1.1	24.0
Portugal			no survey in 2011				
Romania		5808	48.8	37.3	13.0	0.9	13.9
Russian Fed.	36173	9116	77.2	14.5	4.3	4.0	8.3
Serbia	1868	2743	69.8	22.6	6.2	1.4	7.6
Slovak Republic	1961	4017	9.2	56.1	33.0	1.7	34.7
Slovenia	1183	1046	18.0	50.7	26.7	4.7	31.4
Spain		14880	28.1	60.1	9.1	2.7	11.8
Sweden	20600	7596	50.5	30.6	12.8	6.1	18.9
Switzerland	1279	1008	21.1	48.0	20.4	10.5	30.9
Turkey	9057	13282	33.0	53.4	11.4	2.3	13.6
Ukraine	6033	33878	64.9	28.3	6.3	0.5	6.8
United Kingdom			no survey in 2011				

Andorra, Cyprus, Ireland, Sweden: only conifers assessed.

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

Annex II-3: Percent of conifers by defoliation classes and class aggregates (2011)

Participating countries	Coniferous forest (1000 ha)	No. of sample trees	0 none	1 slight	2 moderate	3+4 severe and dead	2+3+4
Albania			no survey in 2011				
Andorra	18	72	63.9	27.8	8.3	0.0	8.3
Austria			no survey in 2011				
Belarus	4785	6821	27.9	66.3	4.8	1.0	5.8
Belgium		750	17.8	67.0	14.4	0.9	15.2
Bulgaria	1040	2397	19.1	47.6	28.6	4.8	33.3
Croatia		350	26.0	28.9	35.1	10.0	45.1
Cyprus	172	360	12.5	71.1	15.8	0.6	16.4
Czech Re-public	2014	4201	14.0	27.1	56.7	2.2	58.9
Denmark	289	229	77.7	16.6	4.4	1.3	5.7
Estonia	1113	2071	47.6	43.7	6.3	2.4	8.7
Finland	17974	4147	51.6	36.7	10.4	1.3	11.7
France	4041	3925	40.2	27.9	28.8	3.1	31.9
Germany	6490	6083	43.2	36.5	18.9	1.4	20.3
Greece			no survey in 2011				
Hungary	220	244	43.0	28.3	21.3	7.4	28.7
Ireland			no survey in 2011				
Italy		1857	33.7	38.5	25.1	2.7	27.8
Latvia	1452	4757	8.0	76.0	14.4	1.6	16.0
Liechtenstein			no survey in 2011				
Lithuania	1158	3431	14.5	69.2	15.1	1.2	16.3
Luxembourg			no survey in 2011				
Rep. of Macedonia			no survey in 2011				
Rep. of Moldova	5	75	26.9	41.1	32.0	0.0	32.0
Netherlands			no survey in 2011				
Norway	6800	7499	47.1	35.6	14.4	2.9	17.3
Poland	6955	25683	11.3	64.5	23.3	1.0	24.2
Portugal			no survey in 2011				
Romania	1873	1104	52.8	31.3	14.6	1.3	15.9
Russian Fed.	405809	5713	72.4	17.0	5.4	5.2	10.6
Serbia	179	333	78.1	10.8	7.8	3.3	11.1
Slovak Republic	815	1657	4.3	49.1	43.2	3.4	46.6
Slovenia	445	396	22.0	44.4	28.3	5.3	33.6
Spain		7439	32.5	57.1	8.0	2.4	10.4
Sweden	19600	7596	50.5	30.6	12.8	6.1	18.9
Switzerland	778	722	19.3	49.2	22.5	9.0	31.5
Turkey	13158	8488	33.9	54.5	10.3	1.3	11.6
Ukraine	2756	13742	66.9	26.3	6.5	0.3	6.8
United Kingdom			no survey in 2011				

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

Annex II-4: Percent of broadleaves by defoliation classes and class aggregates (2011)

Participating countries	Broadleav. forest (1000 ha)	No. of sample trees	0 None	1 slight	2 moderate	3+4 severe and dead	2+3+4
Albania			no survey in 2011				
Andorra	2		only conifers assessed				
Austria			no survey in 2011				
Belarus	3225	2762	37.0	56.6	4.7	1.7	6.4
Belgium		1844	24.9	48.2	24.0	2.8	26.7
Bulgaria	2398	3186	35.1	52.1	9.9	2.9	12.8
Croatia		1858	43.3	35.3	18.8	2.7	21.5
Cyprus			only conifers assessed				
Czech Republic	633	1217	19.3	49.5	30.7	0.5	31.2
Denmark	263	182	58.4	28.8	10.2	2.6	12.8
Estonia	1099	301	73.1	23.9	1.3	1.7	3.0
Finland	1897	4147	62.2	31.7	5.1	0.9	6.0
France	9884	7407	18.5	37.3	38.9	5.3	44.2
Germany	3857	4084	27.4	34.6	35.9	2.1	38.0
Greece			no survey in 2011				
Hungary	1702	1586	65.3	17.4	12.6	4.7	17.3
Ireland			no survey in 2011				
Italy		5838	24.4	42.9	28.2	4.5	32.7
Latvia	1710	1887	28.5	62.7	7.2	1.6	8.8
Liechtenstein			no survey in 2011				
Lithuania	900	2307	17.3	68.9	10.4	3.4	13.8
Luxembourg			no survey in 2011				
Rep. of Macedonia			no survey in 2011				
Rep. of Moldova	287	12444	45.0	36.6	15.6	2.8	18.4
Netherlands			no survey in 2011				
Norway	5200	2353	21.0	46.8	26.9	5.4	32.3
Poland	2245	13257	19.1	57.4	22.1	1.4	23.5
Portugal			no survey in 2011				
Romania	4360	4704	47.8	38.8	12.7	0.7	13.4
Russian Federation	195770	3403	85.3	10.4	2.5	1.8	4.3
Serbia	2181	2410	68.6	24.2	6.0	1.2	7.2
Slovak Republic	1069	2360	12.7	60.9	25.9	0.5	26.4
Slovenia	738	650	15.5	54.5	25.7	4.3	30.0
Spain		7441	23.7	63.1	10.3	3.0	13.2
Sweden			only conifers assessed				
Switzerland	501	284	24.9	45.5	15.7	13.9	29.6
Turkey	8379	4794	31.5	51.3	13.3	4.0	17.2
Ukraine	3285	20136	63.6	29.6	6.1	0.6	6.7
United Kingdom			no survey in 2011				

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

Annex II-5: Percent of damaged trees of all species (2000-2011)

Participating Countries	All species Defoliation classes 2-4												Change % points 2010/2011
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Albania	10.1	10.2	13.1		12.2		11.1						
Andorra					36.1		23.0	47.2	15.3	6.8	15.3	8.3	-7.0
Austria	8.9	9.7	10.2	11.1	13.1	14.8	15.0				14.2		
Belarus	24.0	20.7	9.5	11.3	10.0	9.0	7.9	8.1	8.0	8.4	7.4	6.1	-1.3
Belgium	19.0	17.9	17.8	17.3	19.4	19.9	17.9	16.4	14.5	20.2	22.1	23.5	1.4
Bulgaria	46.3	33.8	37.1	33.7	39.7	35.0	37.4	29.7	31.9	21.1	23.8	21.6	-2.2
Croatia	23.4	25.0	20.6	22.0	25.2	27.1	24.9	25.1	23.9	26.3	27.9	25.2	-2.7
Cyprus		8.9	2.8	18.4	12.2	10.8	20.8	16.7	47.0	36.2	19.2	16.4	-2.8
Czech Republic	51.7	52.1	53.4	54.4	57.3	57.1	56.2	57.1	56.7	56.8	54.2	52.7	-1.5
Denmark	11.0	7.4	8.7	10.2	11.8	9.4	7.6	6.1	9.1	5.5	9.3	10.0	0.7
Estonia	7.4	8.5	7.6	7.6	5.3	5.4	6.2	6.8	9.0	7.2	8.1	8.1	0.0
Finland	11.6	11.0	11.5	10.7	9.8	8.8	9.7	10.5	10.2	9.1	10.5	10.6	0.1
France ·	18.3	20.3	21.9	28.4	31.7	34.2	35.6	35.4	32.4	33.5	34.6	39.9	5.3
Germany a)	23.0	21.9	21.4	22.5	31.4	28.5	27.9	24.8	25.7	26.5	23.2	28.0	4.8
Greece	18.2	21.7	20.9			16.3				24.3	23.8		
Hungary	20.8	21.2	21.2	22.5	21.5	21.0	19.2	20.7		18.4	21.8	18.9	-2.9
Ireland	14.6	17.4	20.7	13.9	17.4	16.2	7.4	6.0	10.0	12.5	17.5		
Italy	34.4	38.4	37.3	37.6	35.9	32.9	30.5	35.7	32.8	35.8	29.8	31.3	1.5
Latvia	20.7	15.6	13.8	12.5	12.5	13.1	13.4	15.0	15.3	13.8	13.4	14.0	0.6
Liechtenstein													
Lithuania	13.9	11.7	12.8	14.7	13.9	11.0	12.0	12.3	19.6	17.7	21.3	15.4	-5.9
Luxembourg	23.4												
Rep. of Macedonia								23.0					
Rep. of Moldova	29.1	36.9	42.5	42.4	34.0	26.5	27.6	32.5	33.6	25.2	22.5	18.4	-4.1
Netherlands	21.8	19.9	21.7	18.0	27.5	30.2	19.5						
Norway	24.3	27.2	25.5	22.9	20.7	21.6	23.3	26.2	22.7	21.0	18.9	20.9	2.0
Poland	32.0	30.6	32.7	34.7	34.6	30.7	20.1	20.2	18.0	17.7	20.7	24.0	3.3
Portugal	10.3	10.1	9.6	13.0	16.6	24.3							
Romania	14.3	13.3	13.5	12.6	11.7	8.1	8.6	23.2		18.9	17.8	13.9	-3.9
Russian Fed.		9.8	10.9							6.2	4.4	8.3	3.9
Serbia	8.4	14.0	3.9	22.8	14.3	16.4	11.3	15.4	11.5	10.3	10.8	7.6	-3.2
Slovak Republic	23.5	31.7	24.8	31.4	26.7	22.9	28.1	25.6	29.3	32.1	38.6	34.7	-3.9
Slovenia	24.8	28.9	28.1	27.5	29.3	30.6	29.4	35.8	36.9	35.5	31.8	31.4	-0.4
Spain	13.8	13.0	16.4	16.6	15.0	21.3	21.5	17.6	15.6	17.7	14.6	11.8	-2.8
Sweden	13.7	17.5	16.8	19.2	16.5	18.4	19.4	17.9	17.3	15.1	19.2	18.9	-0.3
Switzerland	29.4	18.2	18.6	14.9	29.1	28.1	22.6	22.4	19.0	18.3	22.2	30.9	8.7
Turkey									24.6	18.7	16.8	13.6	-3.2
Ukraine	60.7	39.6	27.7	27.0	29.9	8.7	6.6	7.1	8.2	6.8	5.8	6.8	1.0
United Kingdom *	21.6	21.1	27.3	24.7	26.5	24.8	25.9	26.0			48.5		

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

Annex II-6: Percent of damaged conifers (2000-2011).

Participating countries	Conifers Defoliation classes 2-4												change % points 2010/ 2011
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Albania	12.3	12.4	15.5		14.0		13.6						
Andorra					36.1		23.0	47.2	15.3	6.8	15.3	8.3	-7.0
Austria	9.1	9.6	10.1	11.2	13.1	15.1	14.5				14.5		
Belarus	26.1	23.4	9.7	9.5	8.9	8.4	7.5	8.1	8.1	8.3	7.7	5.8	-1.9
Belgium	19.5	17.5	19.7	18.6	15.6	16.8	15.8	13.9	13.2	13.6	16.2	15.2	-1.0
Bulgaria	46.4	39.1	44.0	38.4	47.1	45.4	47.6	37.4	45.6	33.0	31.1	33.3	2.2
Croatia	53.3	65.1	63.5	77.4	70.6	79.5	71.7	61.1	59.1	66.5	56.9	45.1	-11.8
Cyprus		8.9	2.8	18.4	12.2	10.8	20.8	16.7	46.9	36.2	19.2	16.4	-2.8
Czech Republic	58.3	58.1	60.1	60.7	62.6	62.7	62.3	62.9	62.8	63.1	60.1	58.9	-1.2
Denmark	8.8	6.7	4.5	6.1	5.8	5.5	1.7	3.1	9.9	1.0	5.4	5.7	0.3
Estonia	7.5	8.8	7.9	7.7	5.3	5.6	6.0	6.7	9.3	7.5	9.0	8.7	-0.3
Finland	12.0	11.4	11.9	11.1	10.1	9.2	9.6	10.4	10.1	9.9	10.6	11.7	1.1
France	12.0	14.0	15.2	18.9	18.6	20.8	23.6	24.1	25.1	26.8	27.4	31.9	4.5
Germany a)	19.6	20.0	19.8	20.1	26.3	24.9	22.7	20.2	24.1	20.3	19.2	20.3	1.1
Greece	16.5	17.2	16.1			15.0				26.3	23.7		
Hungary	21.5	19.5	22.8	27.6	24.2	22.0	20.8	22.3		27.1	35.1	28.7	-6.4
Ireland	14.6	17.4	20.7	13.9	17.4	16.2	7.4	6.2	10.0	12.5	17.5		
Italy	19.2	19.1	20.5	20.4	21.7	22.8	19.5	22.7	24.0	31.6	29.1	32.2	3.1
Latvia	20.1	15.8	14.3	12.2	11.9	13.2	15.2	16.2	16.7	14.8	15.0	16.0	1.0
Liechtenstein													
Lithuania	12.0	9.8	9.3	10.7	10.2	9.3	9.5	10.2	19.1	17.4	19.8	16.3	-3.5
Luxembourg	7.0												
Rep. of Mace-donia													
Rep. of Moldova				55.4	35.5	38.0	38.6	34.3			33.3	32.1	-1.2
Netherlands	23.5	20.7	17.5	9.4	17.2	17.9	15.3						
Norway	21.8	25.1	24.1	21.2	16.7	19.7	20.2	23.0	19.2	17.9	16.4	17.3	0.9
Poland	32.1	30.3	32.5	33.2	33.4	29.6	21.1	20.9	17.5	17.2	20.3	24.2	3.9
Portugal	4.3	4.3	3.6	5.3	10.8	17.1							
Romania	9.8	9.6	9.9	9.8	7.6	4.7	5.2	21.8		21.7	16.1	15.9	-0.2
Russian Fed. c)		9.8	10.0							7.3	5.1	10.6	5.5
Serbia	10.0	21.3	7.3	39.6	19.8	21.3	12.6	13.3	13.0	12.6	12.0	11.1	-0.9
Slovak Republic	37.9	38.7	40.4	39.7	36.2	35.3	42.4	37.5	41.1	42.7	46.8	46.6	-0.2
Slovenia	34.5	32.2	31.4	35.3	37.4	33.8	32.1	36.0	40.7	38.8	37.8	33.6	-4.2
Spain	12.0	11.6	15.6	14.1	14.0	19.4	18.7	15.8	12.9	14.9	13.1	10.4	-2.7
Sweden	13.5	18.4	17.7	20.4	16.0	19.6	20.1	17.9	17.3	15.1	19.2	18.9	-0.3
Switzerland	33.0	19.1	19.9	13.3	27.4	28.2	22.5	20.7	18.7	18.8	20.9	31.5	10.6
Turkey								8.1	16.2	16.0	14.5	11.6	-2.9
Ukraine	47.3	16.8	14.6	15.4	11.4	8.1	6.9	7.1	7.1	6.3	5.6	6.8	1.2
United King-dom*	20.2	20.6	25.1	25.8	23.2	22.2	23.3	16.1			38.6		

Andorra: observe the small sample size. *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*: Change of grid net since 2006. *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. *Note that some differences in the level of damage across national borders may be at least partly due to differences in standards used. This restriction, however, does not affect the reliability of the trends over time.*

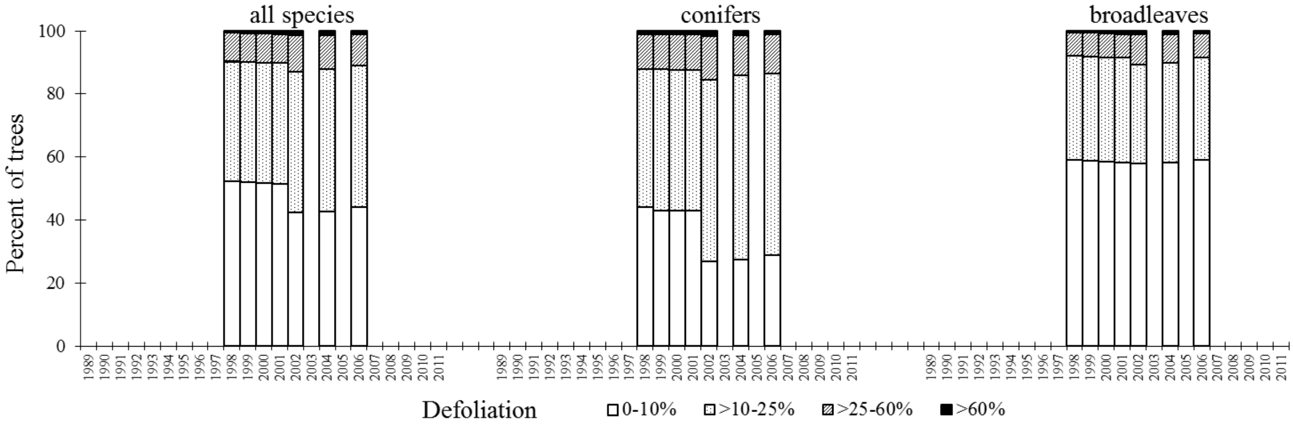
Annex II-7: Percent of damaged broadleaves (2000-2011).

Participating countries	Broadleaves Defoliation classes 2-4												Change % points 2010/2011
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Albania	8.4	8.4	10.7		10.3		8.5						
Andorra	only conifers assessed												
Austria	7.6	10.4	11.3	10.2	13.6	12.9	20.1				10.5		
Belarus	16.9	13.3	9.0	15.8	12.9	10.6	8.9	8.2	7.6	8.7	6.9	6.4	-0.5
Belgium	18.8	18.3	17.0	16.6	21.3	21.4	18.8	17.5	15.3	23.4	24.6	26.7	2.1
Bulgaria	45.8	26.0	29.0	27.2	30.1	23.1	36.4	21.1	17.8	12.2	18.2	12.8	-5.5
Croatia	18.3	18.7	14.4	14.3	17.2	19.2	18.2	20.0	19.1	20.7	21.9	21.5	-0.4
Cyprus	only conifers assessed												
Czech Republic	21.4	21.7	19.9	24.4	31.8	32.0	31.2	33.5	32.2	32.9	32.2	31.2	-1.0
Denmark	13.9	8.5	15.4	16.6	19.1	14.4	14.8	10.3	8.0	10.0	12.1	12.8	0.7
Estonia	9.5	2.1	2.7	6.7	5.3	3.4	8.6	7.6	3.4	3.5	2.5	3.0	0.5
Finland	9.9	8.8	8.8	8.3	8.4	7.2	10.3	10.9	10.6	4.7	9.2	6.0	-3.2
France ·	21.6	23.6	25.5	33.5	38.7	41.3	42.0	41.6	36.5	37.1	38.7	44.3	5.6
Germany a)	29.9	25.4	24.7	27.3	41.5	35.8	37.2	32.8	28.4	36.1	29.4	38.0	8.6
Greece	20.2	26.6	26.5			17.9				5.2	23.9		
Hungary	20.8	21.5	20.8	22.0	21.0	20.9	19.0	20.6		17.1	19.7	17.3	-2.4
Ireland													
Italy	40.5	46.3	44.6	45.0	42.0	36.5	35.2	40.4	35.8	36.8	30.1	32.7	2.6
Latvia	22.2	14.8	12.8	13.5	14.3	12.9	8.5	11.8	11.5	11.6	9.4	8.8	-0.6
Liechtenstein													
Lithuania	17.7	16.3	19.0	24.6	21.8	15.4	16.6	17.7	20.3	18.4	23.7	13.8	-9.9
Luxembourg	33.5												
Rep. of Moldova	29.2	36.9	42.5	42.3	33.9	26.4	27.6	32.5	33.6	25.2	22.4	18.4	-4.0
Netherlands	18.8	18.5	29.6	33.7	46.9	53.1	26.2						
Norway	34.0	33.7	30.4	29.0	33.2	27.6	33.2	36.3	33.8	31.0	26.8	32.3	5.5
Poland	32.0	31.4	33.1	39.6	38.7	34.1	18.0	18.9	19.1	18.5	21.5	23.5	2.0
Portugal	13.2	12.8	12.6	16.2	19.0	27.0							
Romania	15.8	14.7	14.8	13.3	13.0	9.3	9.9	23.5		18.3	18.0	13.4	-4.6
Russian Fed. c)			16.0							4.4	3.2	4.3	1.1
Serbia b)	6.7	6.7	0.6	21.5	13.5	15.7	11.0	15.7	11.3	9.9	10.7	7.2	-3.5
Slovak Republic	13.9	26.9	14.5	25.6	19.9	13.6	17.0	16.6	20.8	24.5	32.9	26.4	-6.5
Slovenia	18.4	26.7	25.9	22.6	24.2	28.5	27.6	35.7	34.6	33.3	28.1	30.0	1.9
Spain	15.7	14.4	17.3	19.1	16.1	23.3	24.4	19.5	18.4	20.7	16.1	13.2	-2.9
Sweden	7.5	14.1	9.6	11.1	8.3	9.2	10.8						
Switzerland	22.1	16.3	16.0	18.1	32.8	27.9	22.6	26.1	19.6	17.4	25.2	29.6	4.4
Turkey									38.3	23.4	21.2	17.2	-4.0
Ukraine	69.6	53.3	36.7	35.3	43.2	9.2	6.2	7.1	9.1	7.2	6.4	6.7	0.3
United Kingdom *	23.8	21.9	30.3	23.2	30.6	28.2	29.2	35.3			56.1		

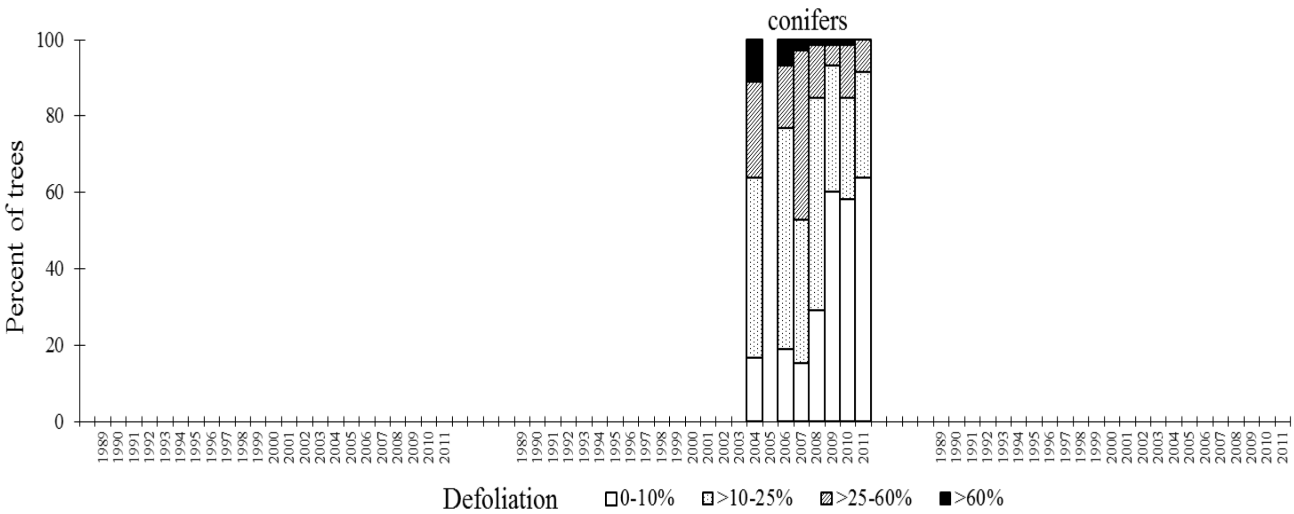
Note that some differences in the level of damage across national borders may be at least partly due to differences in standards used. This restriction, however, does not affect the reliability of the trends over time.

Annex II-8: Changes in defoliation (1989-2011)

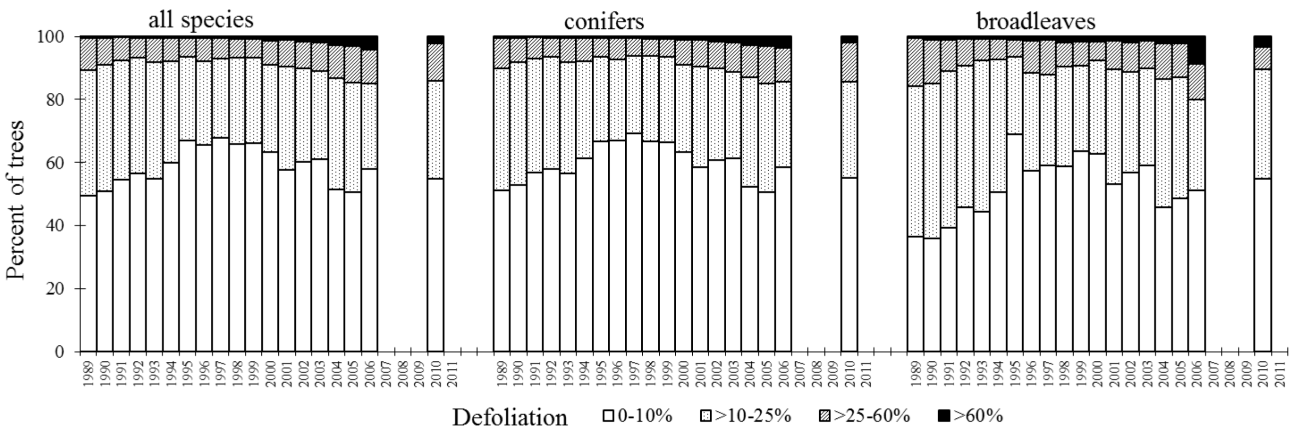
Albania



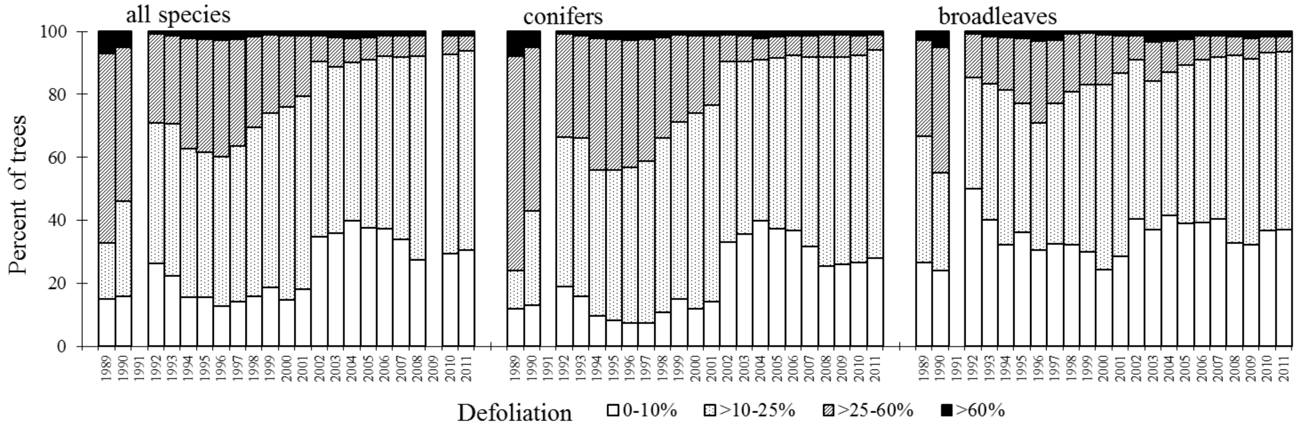
Andorra



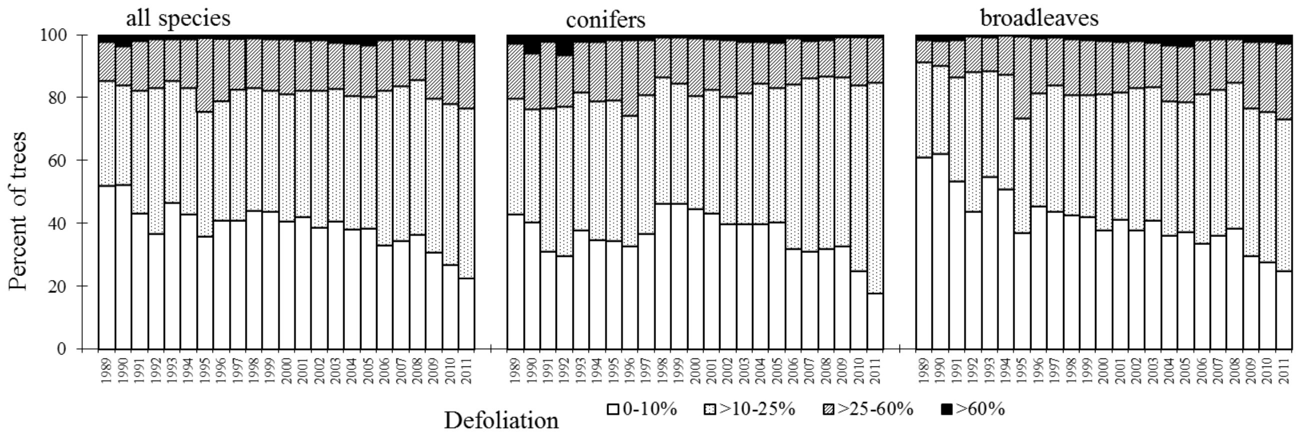
Austria



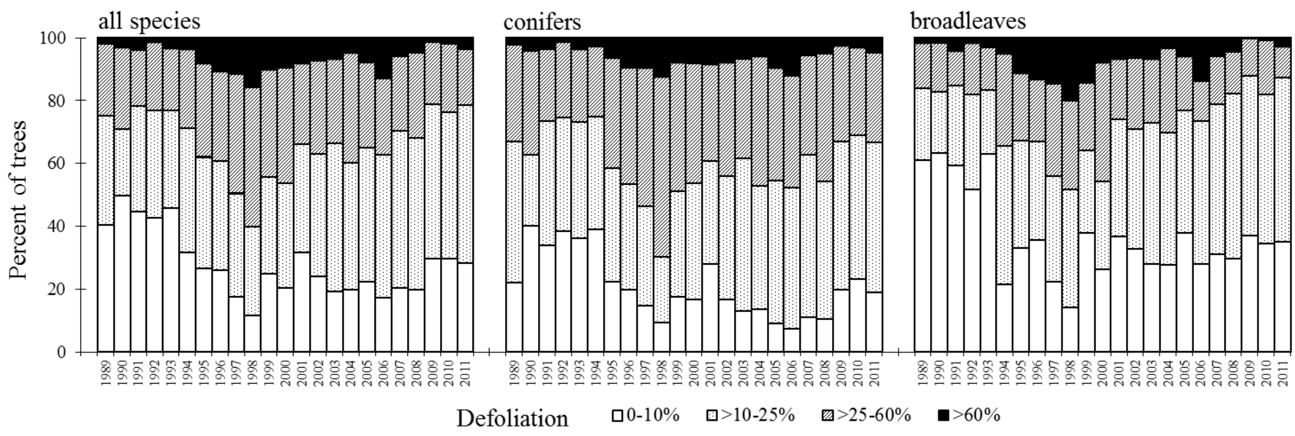
Belarus



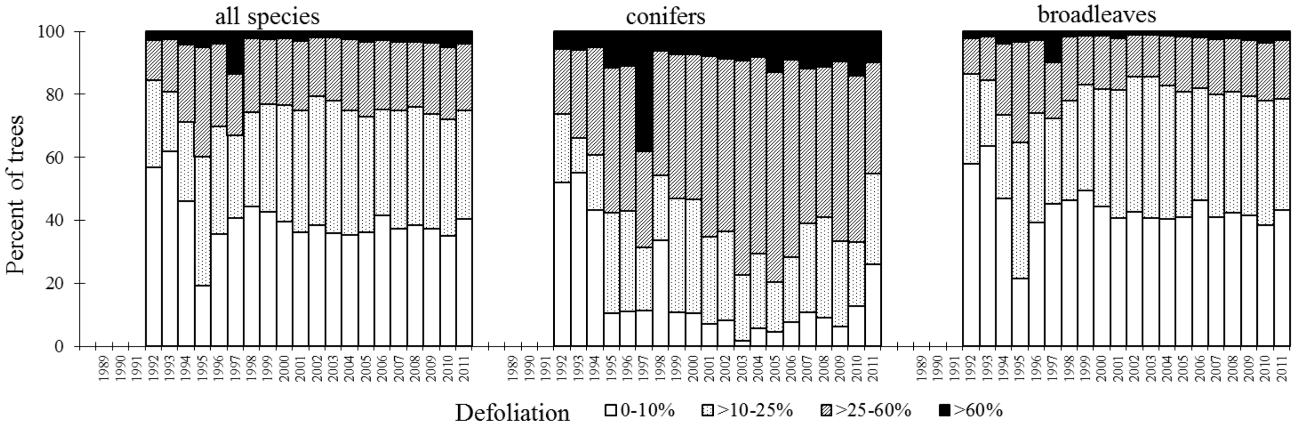
Belgium



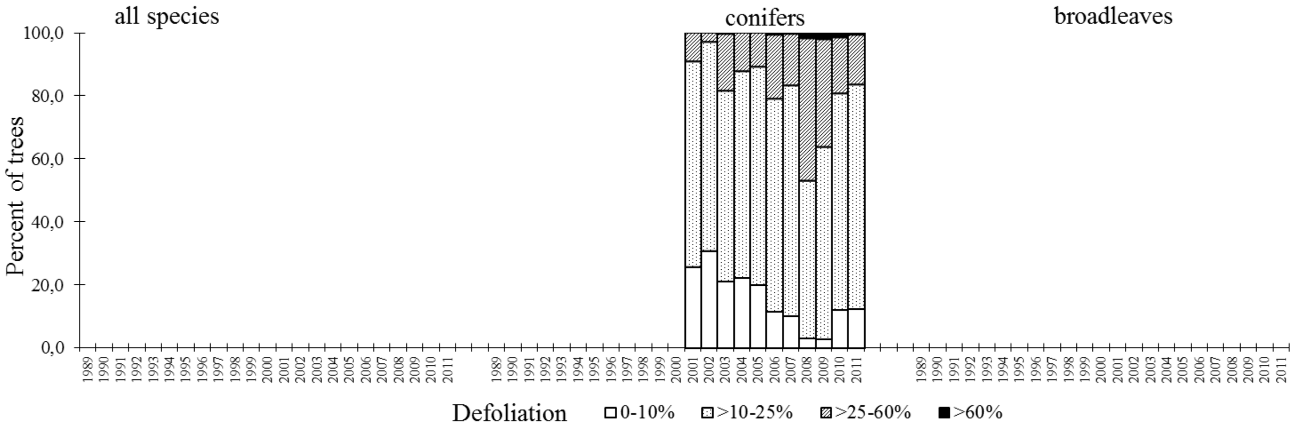
Bulgaria



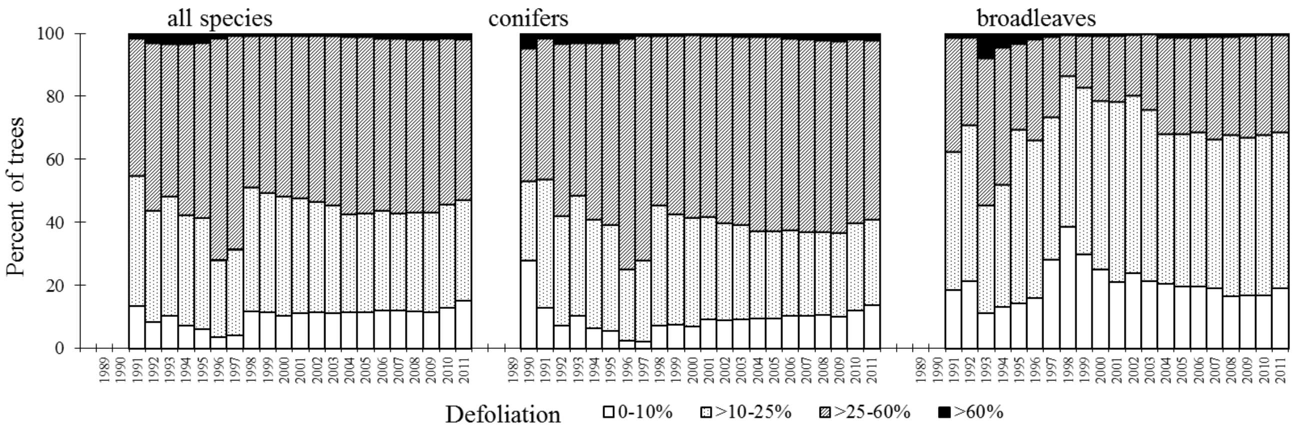
Croatia



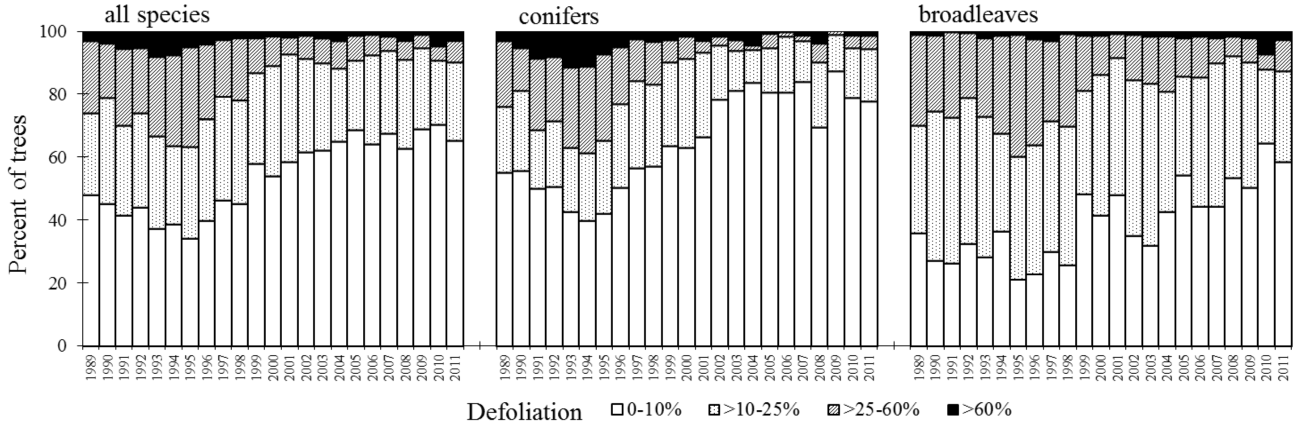
Cyprus



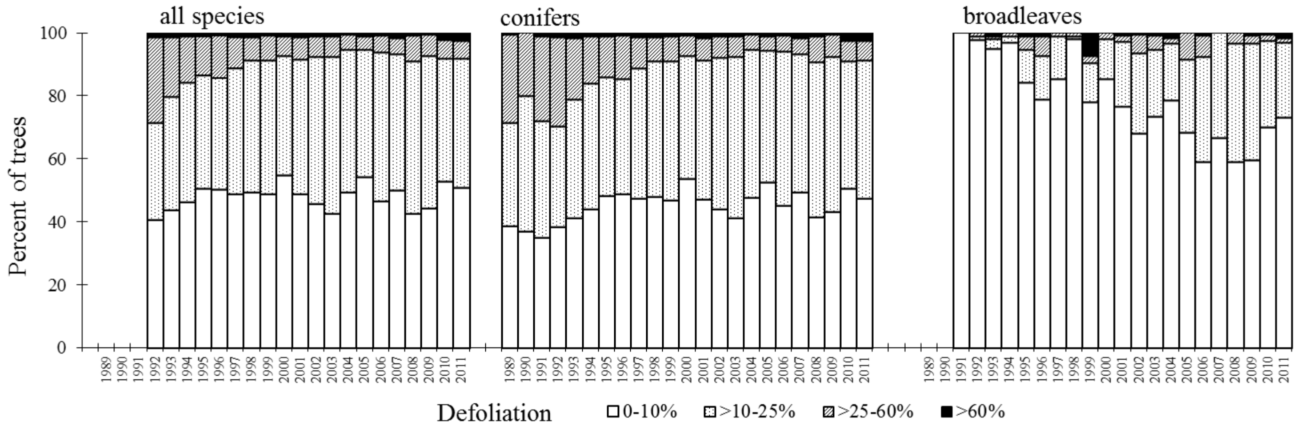
Czech Republic



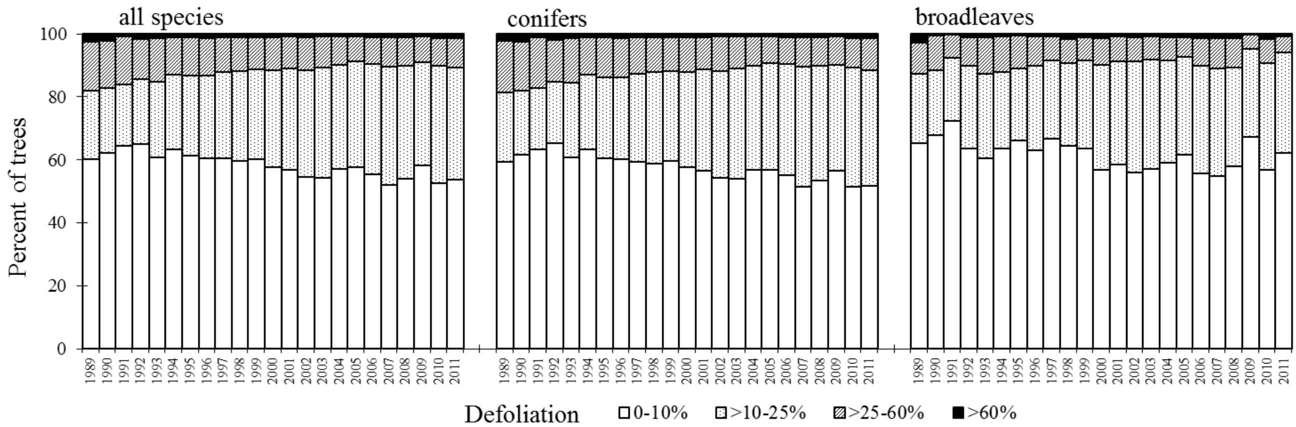
Denmark



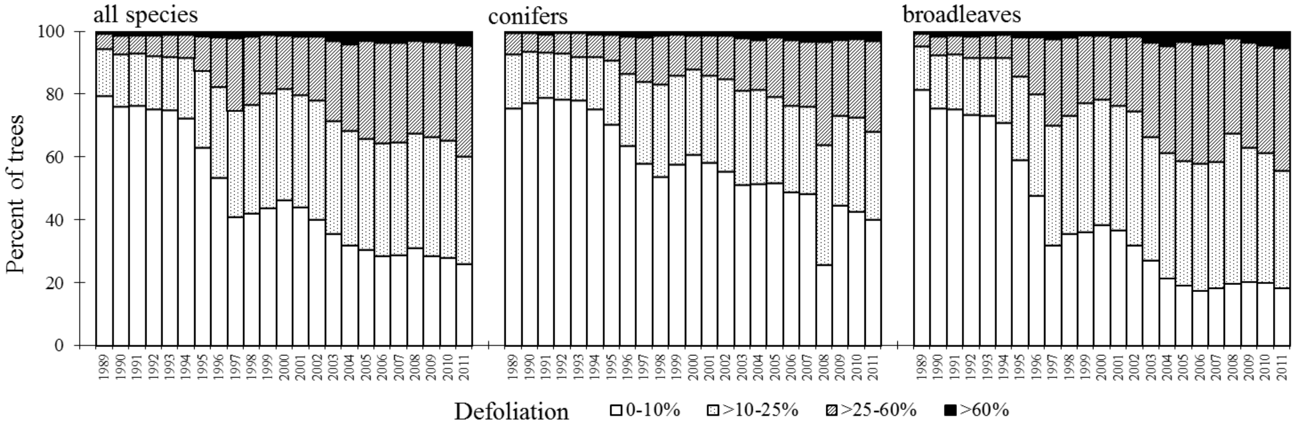
Estonia



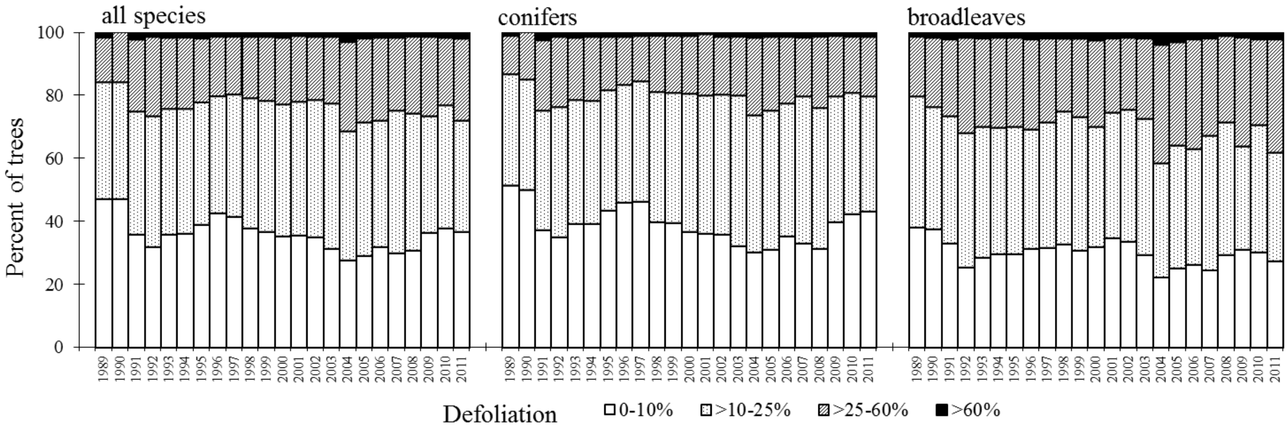
Finland



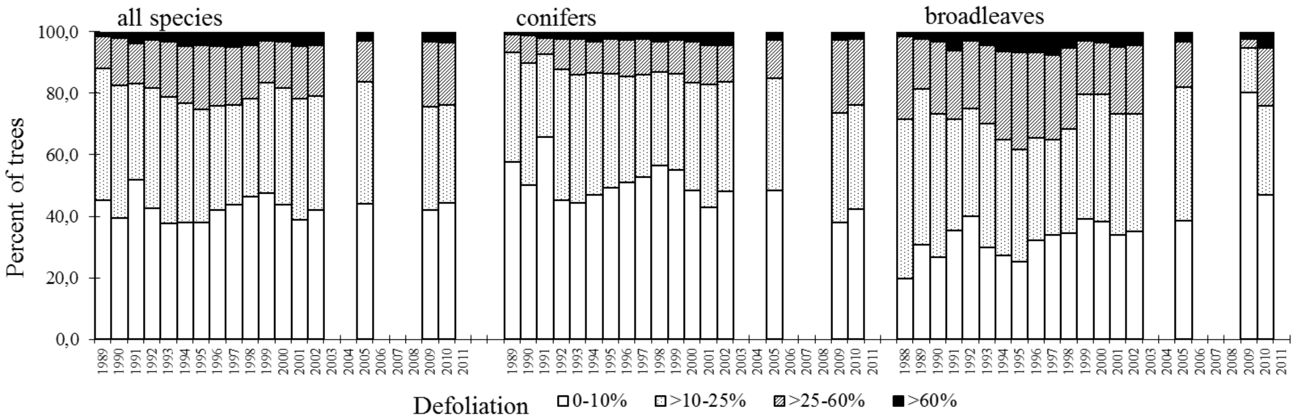
France



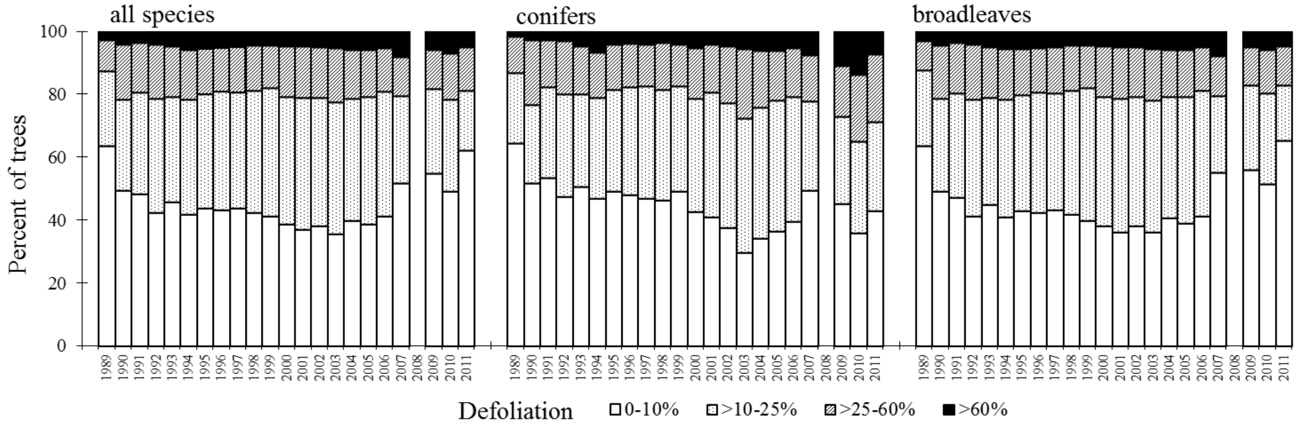
Germany



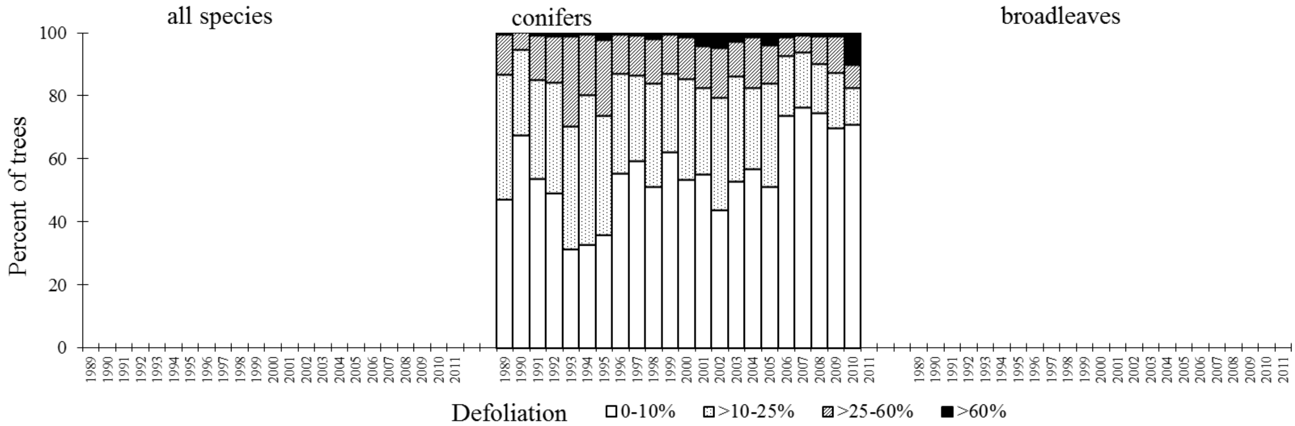
Greece



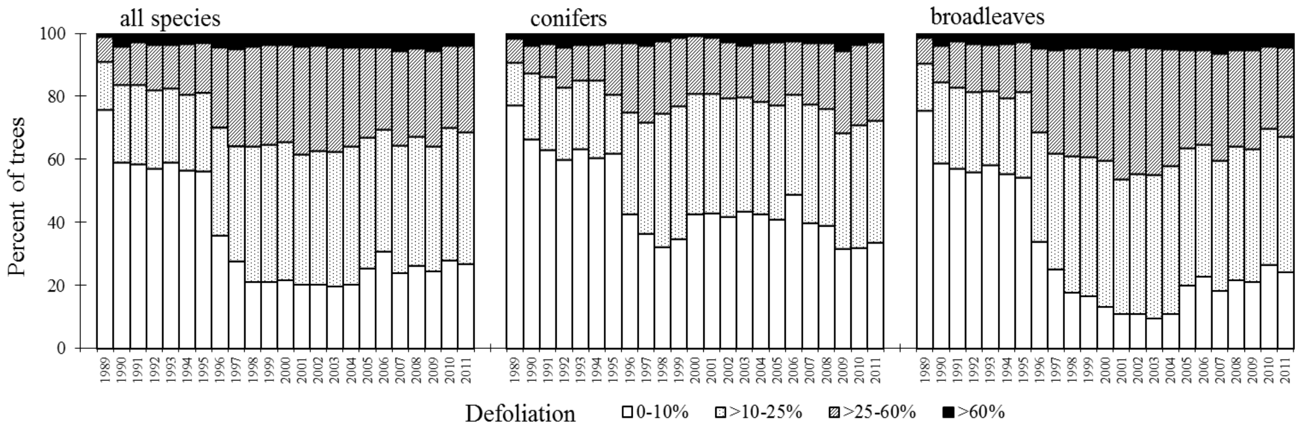
Hungary



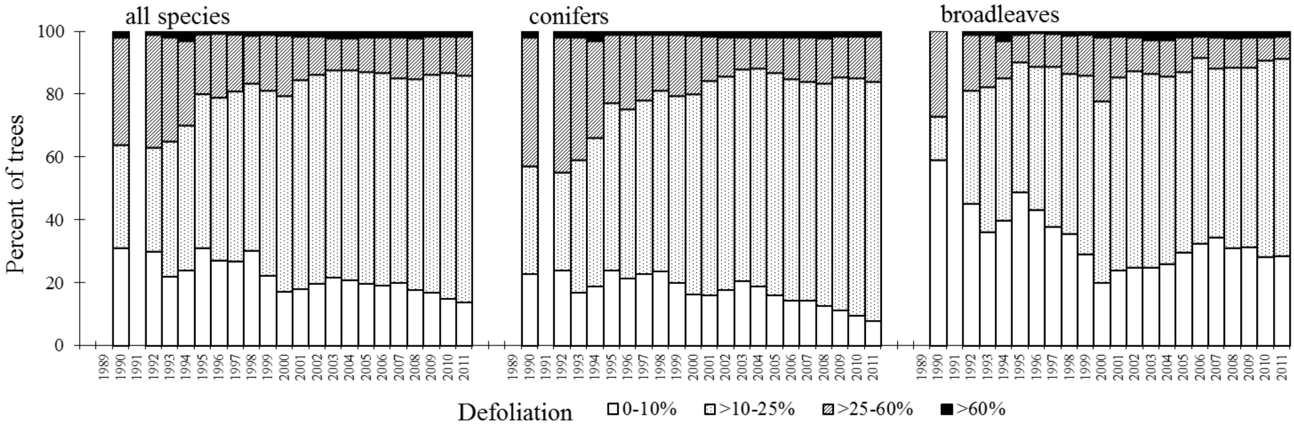
Ireland



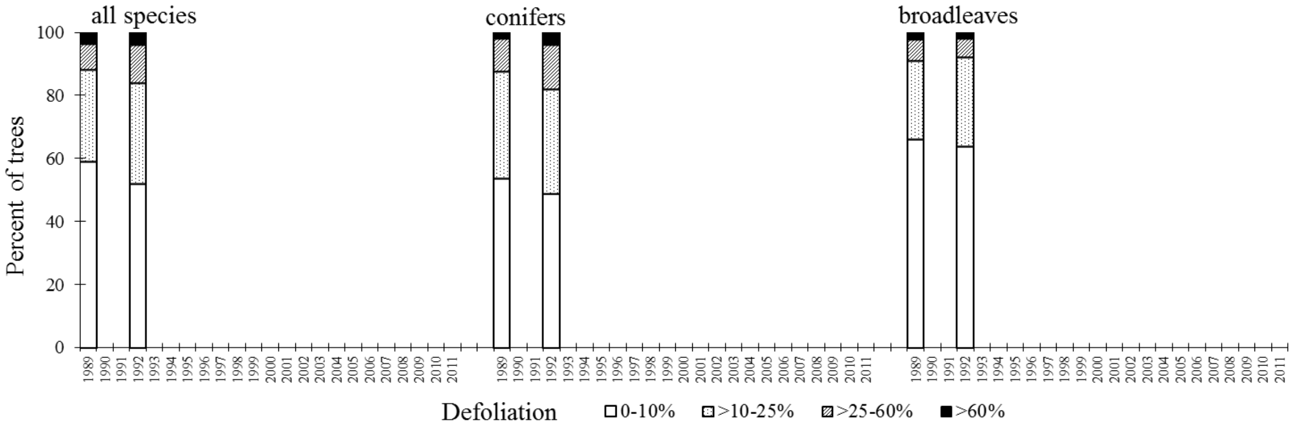
Italy



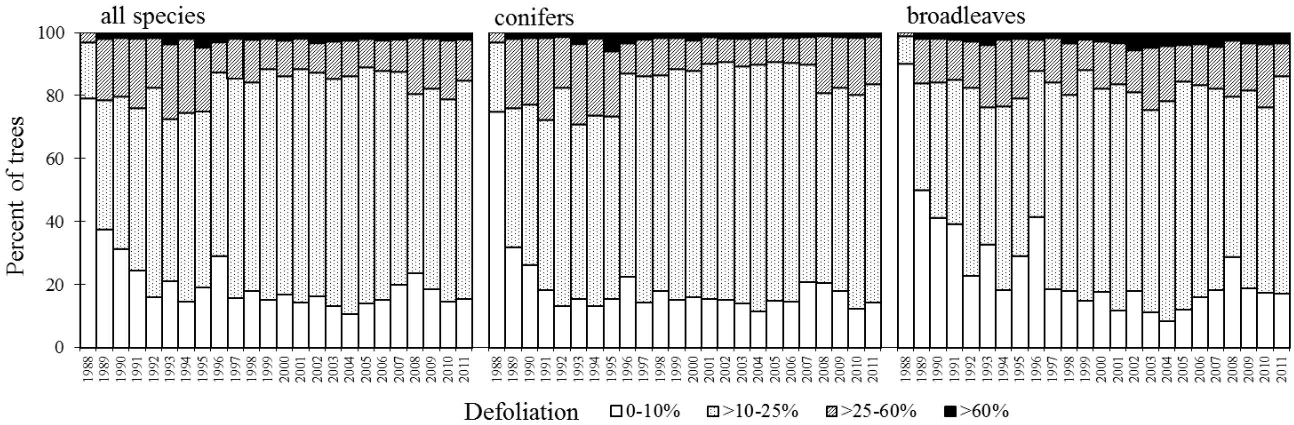
Latvia

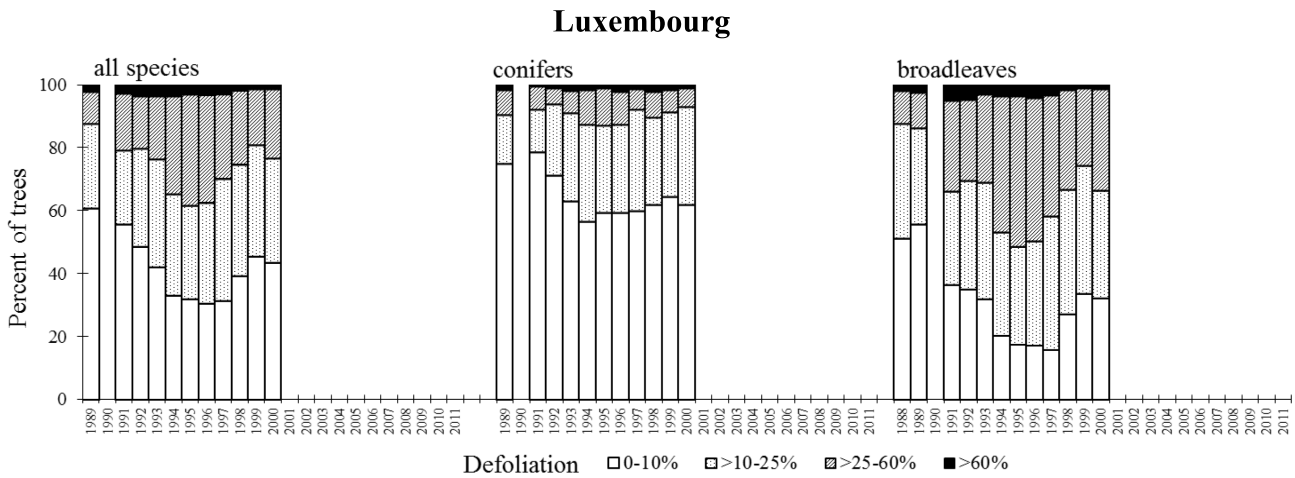


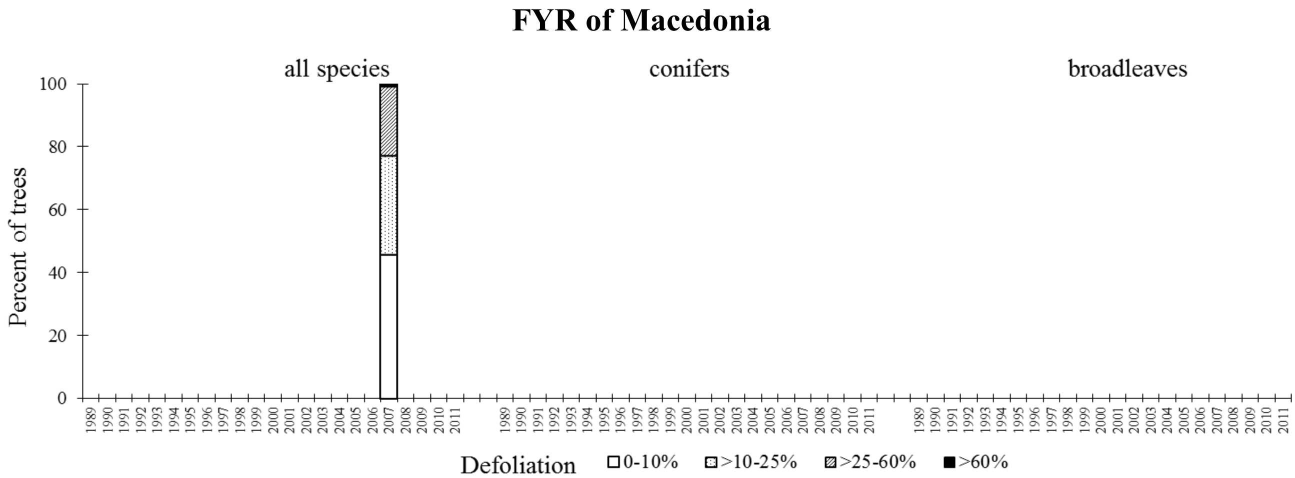
Liechtenstein

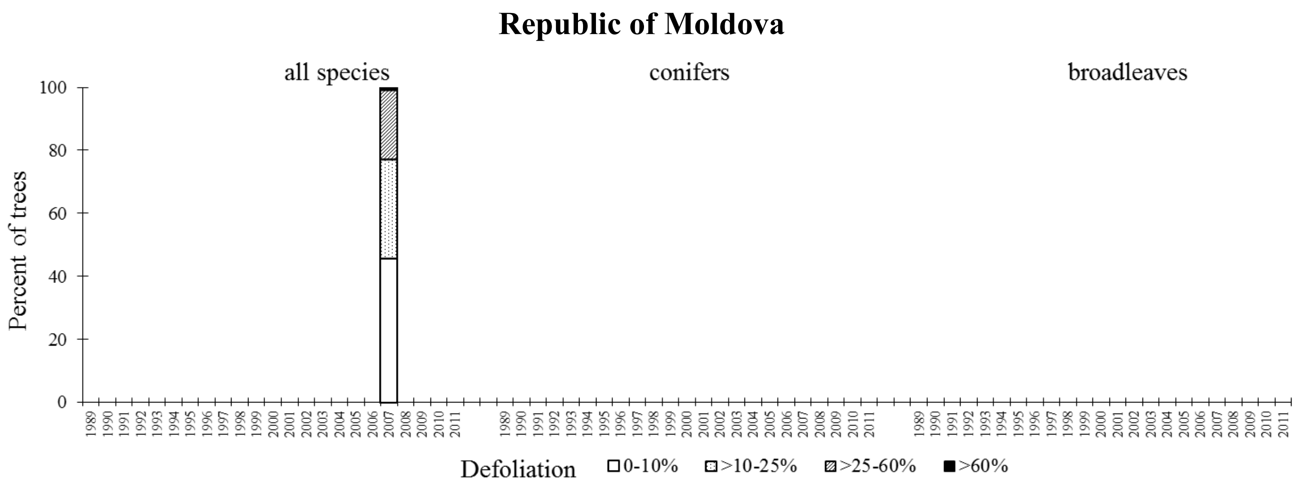


Lithuania

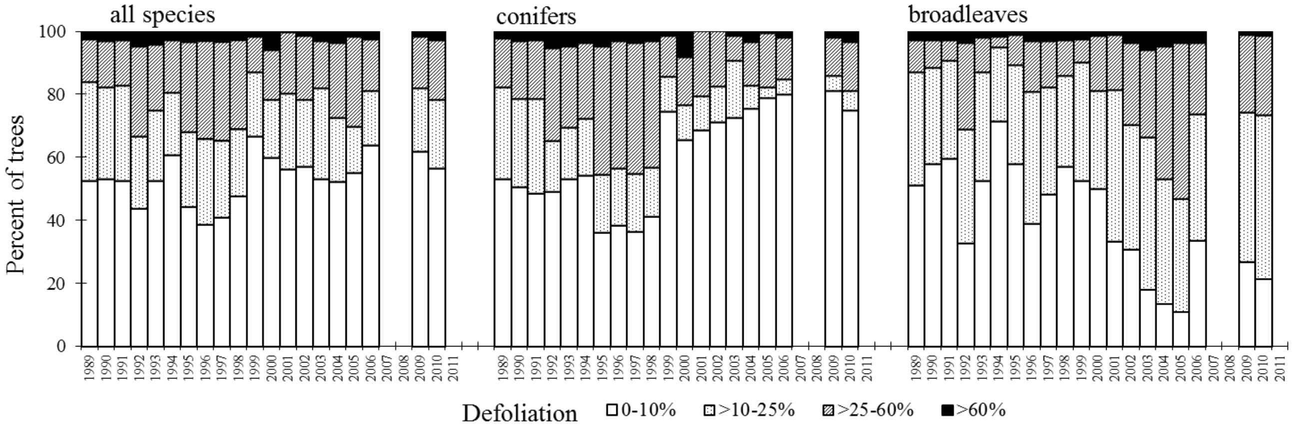



Luxembourg
all species
conifers
broadleaves
Percent of trees
Defoliation □0-10% □>10-25% ▨>25-60% ■>60%

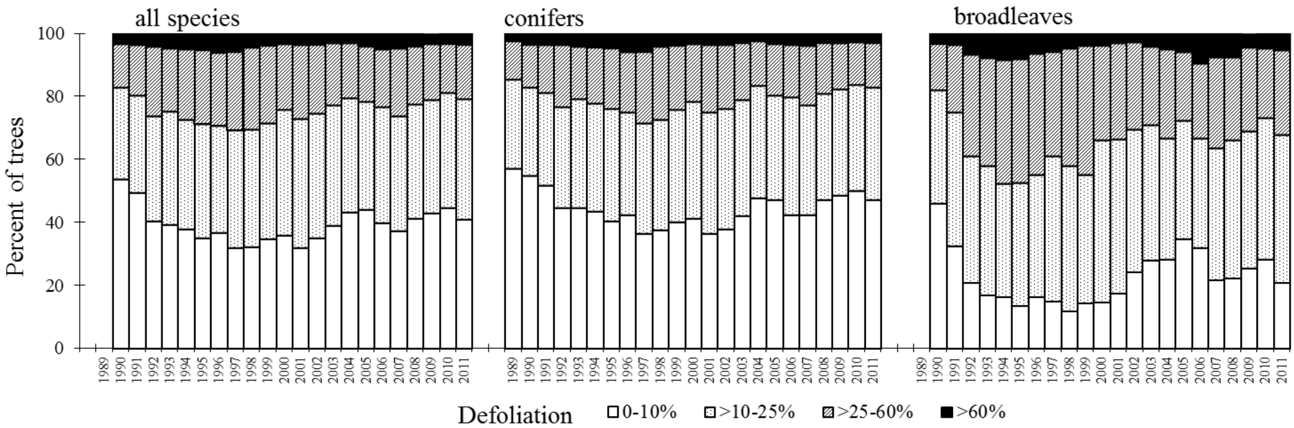

FYR of Macedonia
all species
conifers
broadleaves
Percent of trees
Defoliation □0-10% □>10-25% ▨>25-60% ■>60%


Republic of Moldova
all species
conifers
broadleaves
Percent of trees
Defoliation □0-10% □>10-25% ▨>25-60% ■>60%

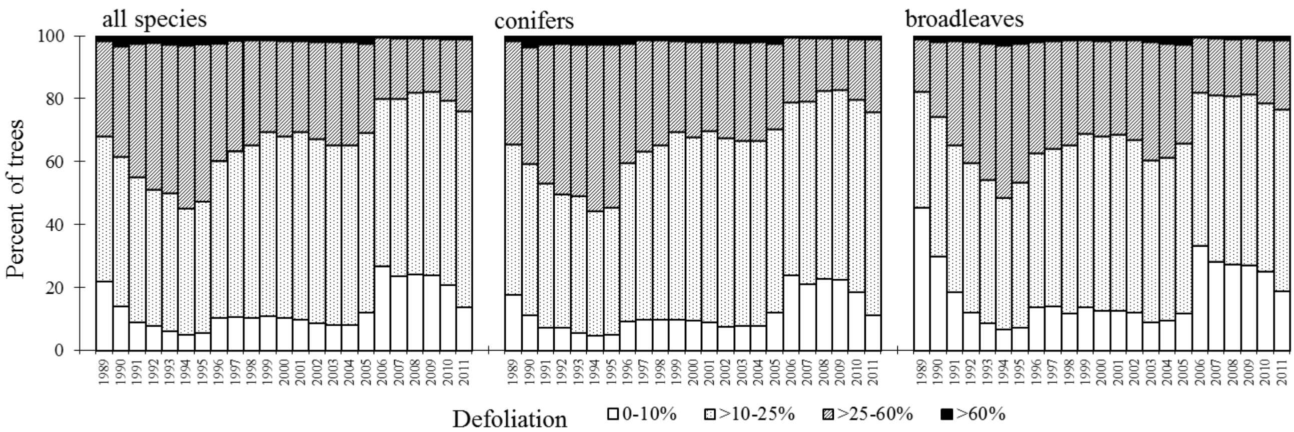
Netherlands

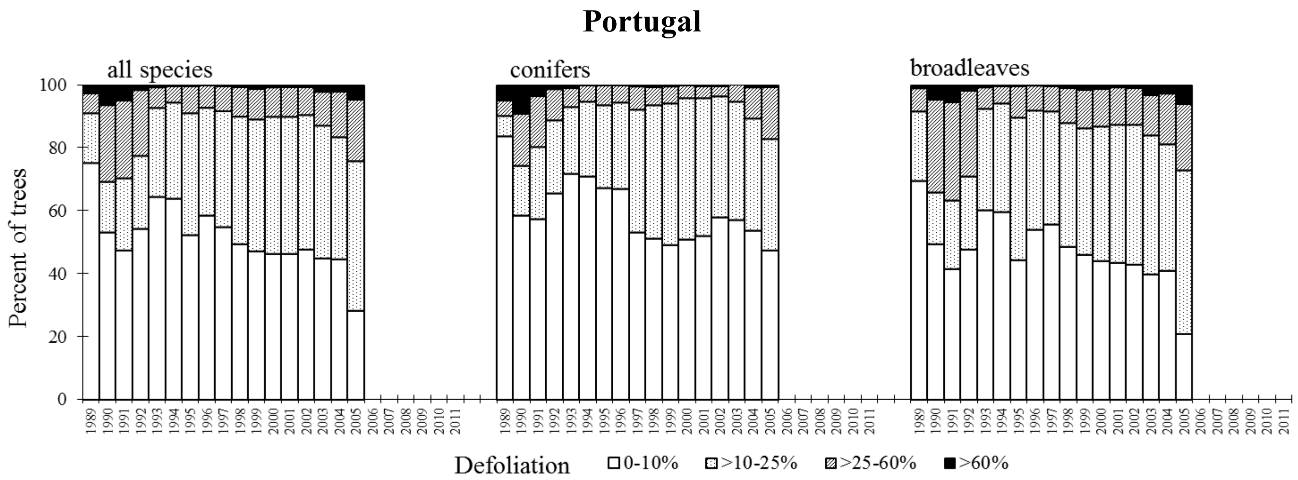


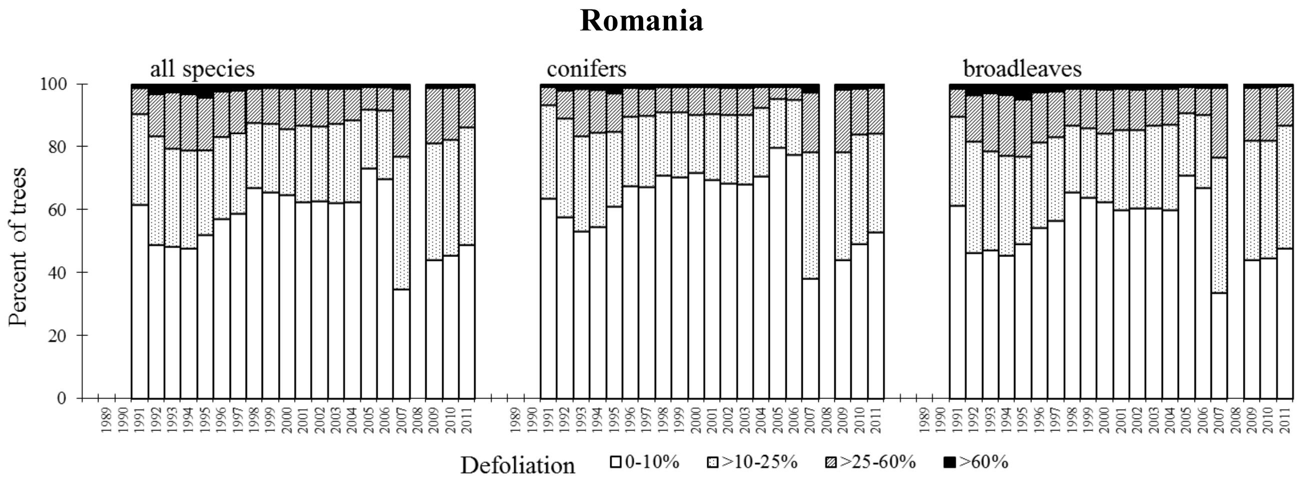
Norway

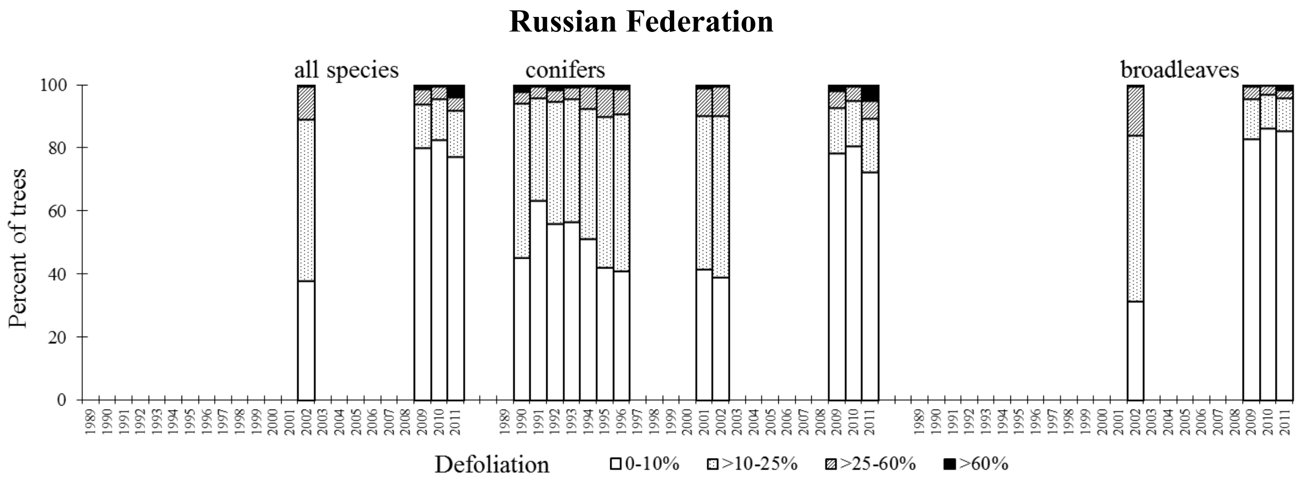


Poland

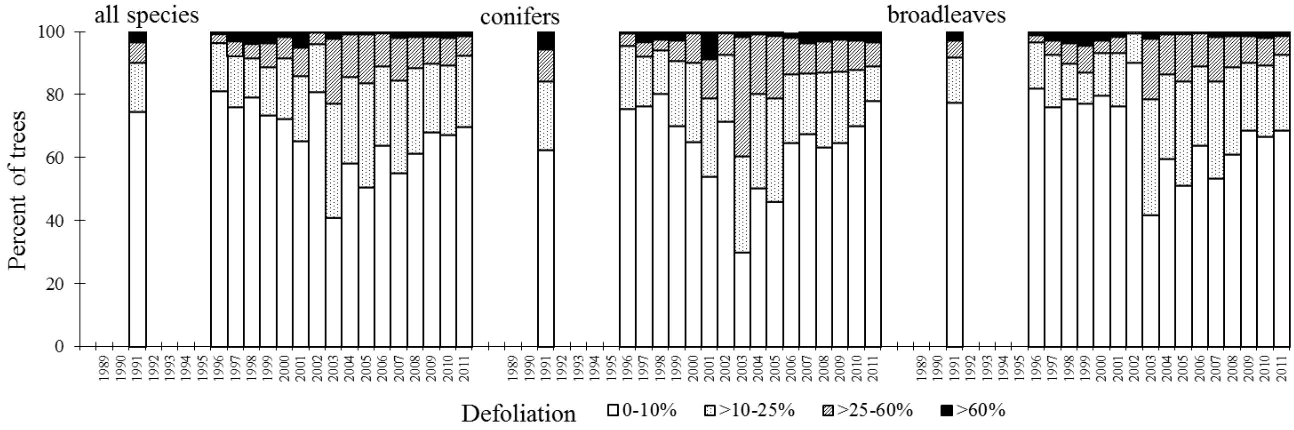



Portugal
all species
conifers
broadleaves
Percent of trees
Defoliation
0-10%
>10-25%
>25-60%
>60%

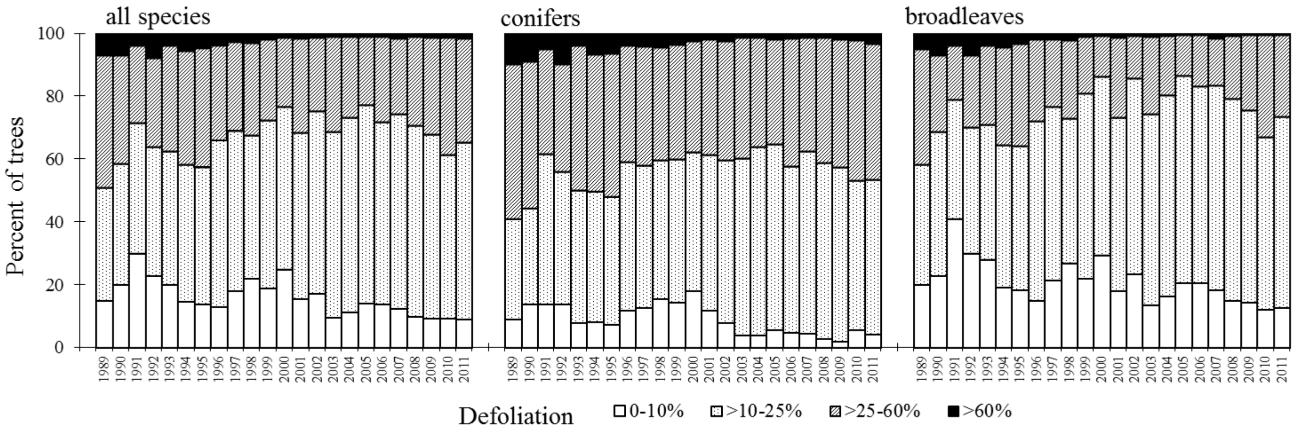

Romania
all species
conifers
broadleaves
Percent of trees
Defoliation
0-10%
>10-25%
>25-60%
>60%


Russian Federation
all species
conifers
broadleaves
Percent of trees
Defoliation
0-10%
>10-25%
>25-60%
>60%

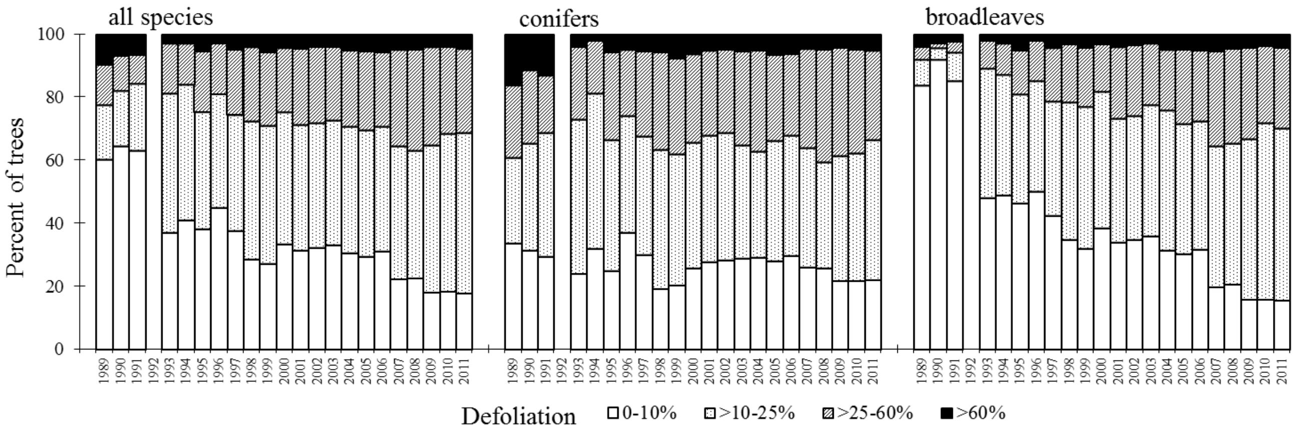
Serbia



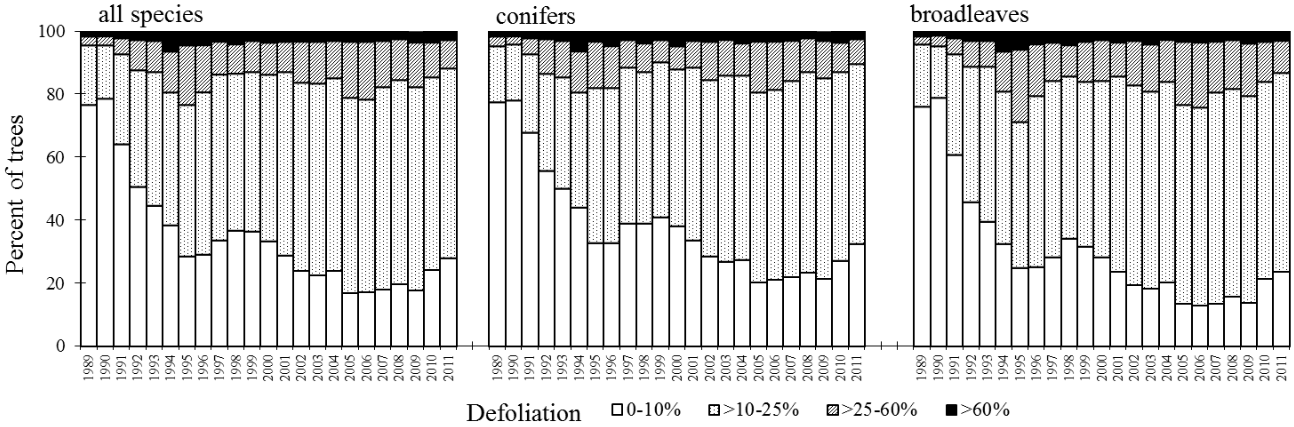
Slovak Republic



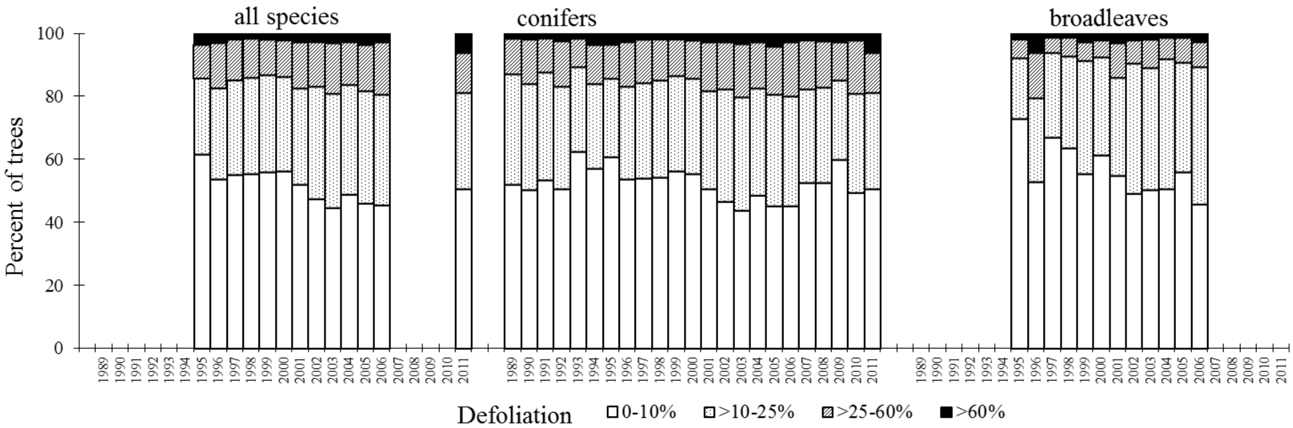
Slovenia



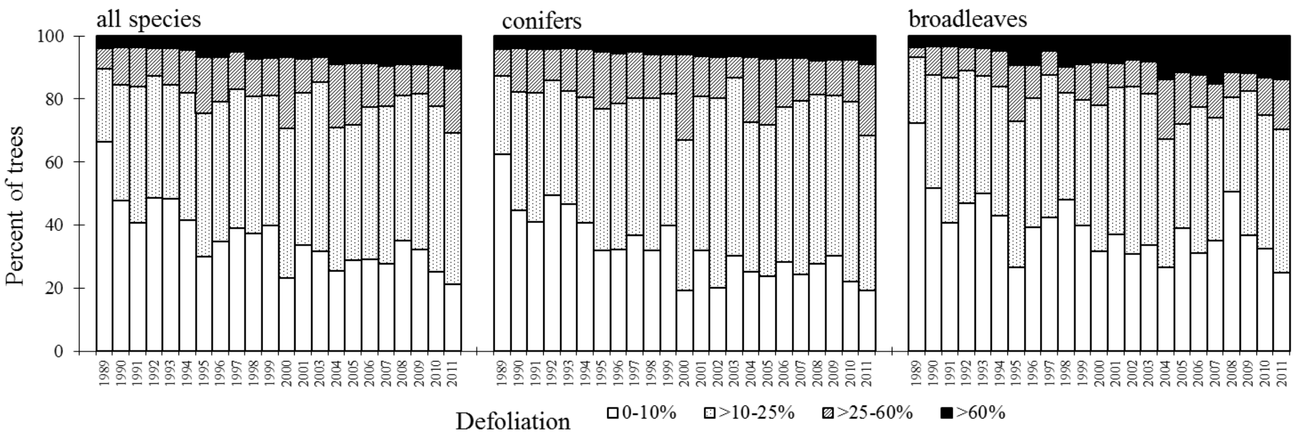
Spain



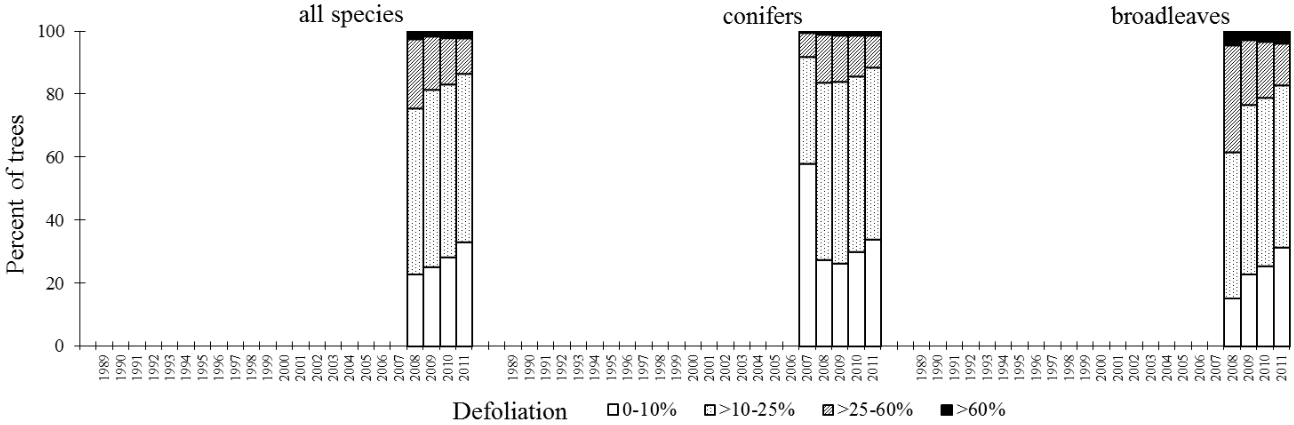
Sweden



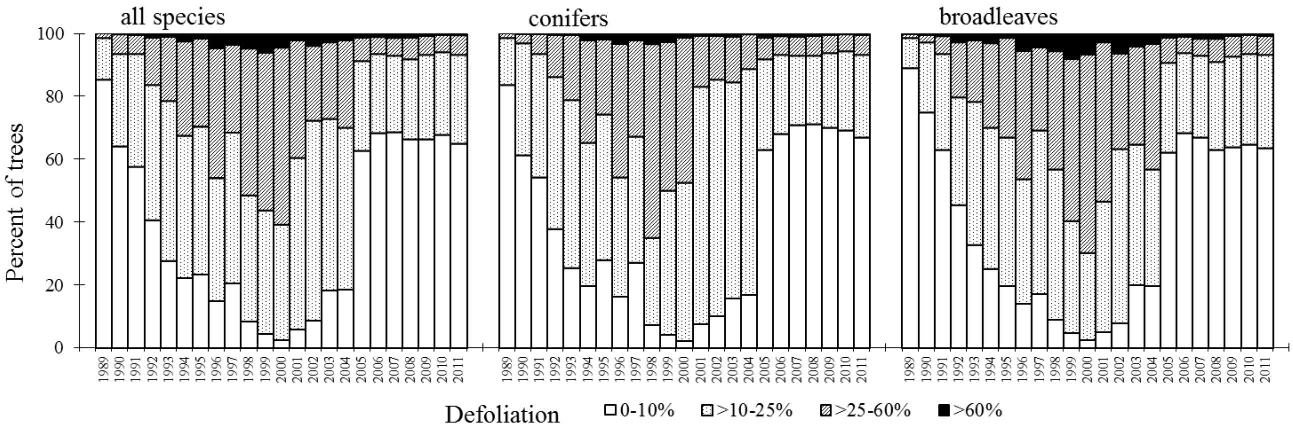
Switzerland



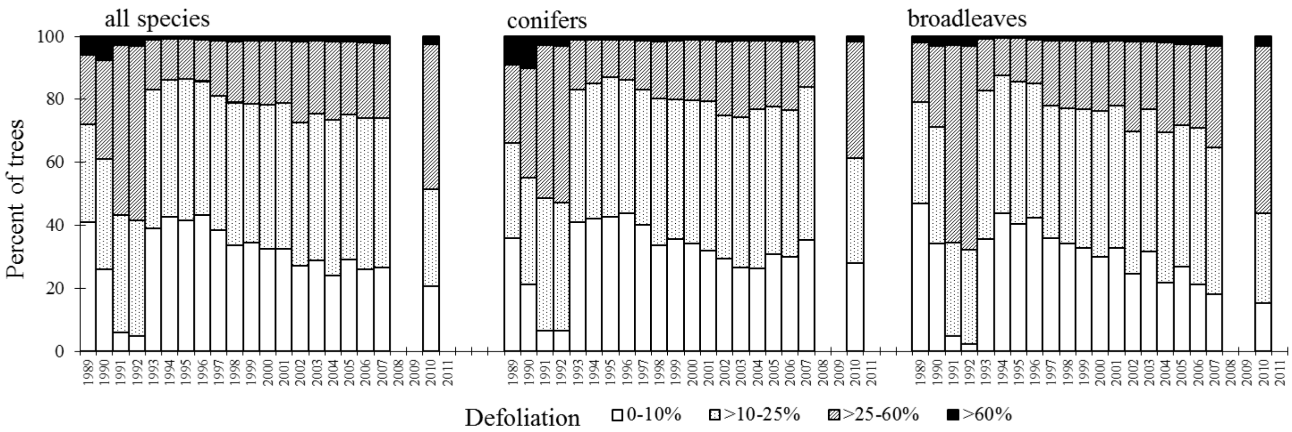
Turkey



Ukraine



United Kingdom



Annex III: Addresses

Annex III-1: UNECE and ICP Forests

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ICP Forests Lead Country	International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz – Ref. 535 Postfach 14 02 70 53107 BONN GERMANY Phone: +49 228 99 529-41 30/Fax: +49 228-99 529 42 62 e-mail: sigrid.strich@bmelv.bund.de Ms Sigrid Strich
PCC of ICP Forests	Programme Coordinating Centre of ICP Forests Thünen – Institut für Weltforstwirtschaft Leuschnerstr. 91 21031 Hamburg GERMANY Phone: +49 40 739 62 140/Fax: +49 40 739 62 199 e-mail: martin.lorenz@ti.bund.de Internet: http://www.icp-forests.org Mr Martin Lorenz

Annex III-2: Expert Panels, WG and other Coordinating Institutions

Expert Panel
on Soil and Soil Solution

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Mr Bruno De Vos, Chair

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Ms Tiina Nieminen, Co-chair

Expert Panel
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and Litterfall

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Mr Pasi Rautio, Chair

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Mr Alfred Fürst, Co-chair Foliage

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Ms Liisa Ukonmaanaho, Co-chair Litterfall

Expert Panel on Forest Growth	Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft WSL Zürcherstr. 111 8903 BIRMENSDORF SWITZERLAND Phone: +41 44 73 92 594/Fax: +41 44 73 92 215 e-mail: matthias.dobbertin@wsl.ch Mr Matthias Dobbertin, Chair
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Expert Panel on Deposition Measurements	IVL Swedish Environmental Research Institute 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 Ms Karin Hansen, Chair Expert Panel Depostion
	Slovenian Forestry Institute Gozdarski Inštitut Slovenije GIS Večna pot 2 1000 LJUBLJANA SLOVENIA Phone: +38 6 12 00 78 00/Fax: +38 6 12 57 35 89 e-mail: daniel.zlindra@gozdis.si Mr Daniel Zlindra, Co-chair
Expert Panel on Ambient Air Quality	Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft (WSL) Zürcherstr. 111 8903 BIRMENSDORF SWITZERLAND Phone: +41 44 73 92 564/Fax: +41 44 73 92 215 e-mail: marcus.schaub@wsl.ch Mr Marcus Schaub, Chair

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Mr Vicent Calatayud, Co-chair

Expert Panel on Crown Condition Assessment and Damage Types

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Servicio de Sanidad Forestal y Equilibrios Biológicos (SSF),
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(Ministerio de Medio Ambiente y Medio Rural y Marino)
Forest Health Unit (DG Nature and Forest Policy)
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e-mail: gsanchez@mma.es,
Mr Gerardo Sánchez, Co-chair

Expert Panel on Biodiversity and Ground Vegetation Assessment

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Mr Pat Neville, Chair

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Mr Roberto Canullo, Chair

Committee on Quality Assurance	TerraData Environmetrics srl Via L. Bardelloni 19 58025 Monterotondo Marittimo (GR) ITALY Phone: +39 056 691 66 81 e-mail: ferretti@terradata.it Mr Marco Ferretti, Chair
	Nordwestdeutsche Forstliche Versuchsanstalt Grätzelstraße 2 37079 Göttingen GERMANY Phone: +49 551 69 40 11 41/Fax. +49 551 69 40 11 60 e-mail: Nils.Koenig@NW-FVA.de Mr Nils König, Co-chair
WG on Quality Assurance and Quality Control in Laboratories	Nordwestdeutsche Forstliche Versuchsanstalt Grätzelstraße 2 37079 Göttingen GERMANY Phone: +49 551 69 40 11 41/Fax. +49 551 69 40 11 60 e-mail: Nils.Koenig@NW-FVA.de Mr Nils König, Chair
	Forest Research Institute Sękocin Stary, 3 Braci Leśnej Street 05-090 RASZYN POLAND Phone: +48 22 71 50 300/Fax: +48 22 72 00 397 e-mail: a.kowalska@ibles.waw.pl Ms Anna Kowalska, Co-chair
Expert Panel on Meteorology and Phenology	Bayerische Landesanstalt für Wald und Forstwirtschaft (LWF) Hans-Carl-von-Carlowitz-Platz 1 85354 Freising GERMANY Phone: +49 (81 61) 71 49 21 / Fax: +49 (81 61) 71 49 71 e-mail: Stephan.Raspe@lwf.bayern.de Mr Stephan Raspe, Chair
	Slovenian Forestry Institute Večna pot 2 SI-1000 LJUBLJANA SLOVENIA Phone: +386 (1) 200 78 46 149 / Fax: +386 (1) 257 35 89 e-mail: ursa.vilhar@gozdis.si Ms Urša Vilhar, Co-chair Phenology

Forest Foliar Coordinating Center (FFCC)	Bundesforschungs- und Ausbildungszentrum für Wald, Naturgefahren und Landschaft (BFW) Seckendorff-Gudent-Weg 8 1131 WIEN AUSTRIA Phone: +43 1 878 38 11 14/Fax: +43 1 878 38 12 50 e-mail: alfred.fuerst@bfw.gv.at Mr Alfred Fürst
Forest Soil Coordinating Centre	Research Institute for Nature and Forest (INBO) Gaverstraat 4 9500 GERAARDSBERGEN BELGIUM Phone: +32 54 43 61 75/Fax: +32 54 43 61 89 e-mail: nathalie.cools@inbo.be Ms Nathalie Cools

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Albania (Min)	Ministry of the Environment, Forests and Water Administration Dep. of Biodiversity and Natural Resources Management Durresi Str., Nr. 27 TIRANA ALBANIA Phone: +355 42 70 621, +355 42 70 6390 Fax: +355 42 70 627 e-mail: info@moe.gov.al
(NFC)	Forest and Pasture Research Institute "Halil Bego" Str, L. 23 TIRANA ALBANIA Phone: +355 437 12 42/Fax +355 437 12 37 ikpk@albaniaonline.net
Andorra (Min) (NFC)	Ministeri de Medi Ambient, Agricultura i Patrimoni Natural Govern d'Andorra, Departament de Medi Ambient Tècnica de l'Àrea d'Impacte Ambiental C. Prat de la Creu, 62-64 500 ANDORRA LA VELLA PRINCIPAT D'ANDORRA Phone: +376 87 57 07/Fax: +376 86 98 33 e-mail: Silvia_Ferrer_Lopez@govern.ad, Anna_Moles@govern.ad Ms Silvia Ferrer, Ms Anna Moles

Austria
(NFC)

Bundesforschungs- und Ausbildungszentrum für Wald,
Naturgefahren und Landschaft (BFW)
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Mr Ferdinand Kristöfel

(Min)

Bundesministerium für Land- und Forstwirtschaft,
Umwelt und Wasserwirtschaft, Abt. IV/2
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1010 WIEN
AUSTRIA
Phone: +43 1 71 100 72 14/Fax: +43 1 71 10 0 0
e-mail: vladimir.camba@lebensministerium.at
Mr Vladimir Camba

Belarus
(NFC)

Forest inventory republican unitary company
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220089 MINSK
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e-mail: belgosles@open.minsk.by, olkm@tut.by
Mr Valentin Krasouski

(Min)

Committee of Forestry
Myasnikova st. 39
220048 MINSK
BELARUS
Phone/Fax: +375 172 00 45 82
e-mail: mlh@mlh.by
Mr Petr Semashko

Belgium
Wallonia
(Min)
(NFC)

Service public de Wallonie (SPW)
Direction générale opérationnelle Agriculture,
Ressources naturelles et Environnement (DGARNE)
Département de la Nature et des Forêts - Direction des Ressources Forestières
Avenue Prince de Liège 15
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BELGIUM
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Fax: +32 (81) 33 58 11
e-mail: Christian.Laurent@spw.wallonie.be, etienne.gerard@spw.wallonie.be
Mr Christian Laurent, Mr Etienne Gérard, Mr. Mathieu Jonard

(NFC) Earth and Life Institute, Environmental Sciences
Université catholique de Louvain
Croix du Sud, 2 - L7.05.09
1348 LOUVAIN-LA-NEUVE
BEGLIUM
Phone: +32 10 47 37 02 and +32 10 47 25 48
Fax: +32 10 47 36 97
e-mail: isabelle.caignet@uclouvain.be, mathieu.jonard@uclouvain.be
Ms Isabelle Caignet, Mr Mathieu Jonard

Flanders (Min) Ministry of the Flemish Region (AMINAL)
Flemish Forest Service
Koning Albert II-laan 20 bus 22
1000 BRUSSELS
BELGIUM
Phone: +32 2 553 81 02/Fax: +32 2 553 81 05
e-mail: carl.deschepper@lne.vlaanderen.be
Mr Carl De Schepper

Flanders (NFC) Research Institute for Nature and Forest
Gaverstraat 4
9500 GERAARDSBERGEN
BELGIUM
Phone: +32 54 43 71 15/Fax: +32 54 43 61 60
e-mail: peter.roskams@inbo.be
Mr Peter Roskams

Bulgaria (NFC) Executive Environment Agency
Monitoring of Lands, Biodiversity and Protected Areas Department
136 "Tzar Boris III" Blvd., P.O. Box 251
1618 SOFIA
BULGARIA
Phone: +359 2 940 64 86/Fax:+359 2 955 90 15
e-mail: forest@eea.government.bg
Ms. Genoveva Popova

(Min) Ministry of Environment and Water
National Nature Protection Service
22, Maria Luiza Blvd.
1000 SOFIA
BULGARIA
Phone: + 359 2 940 61 12/Fax: +359 2 940 61 27
e-mail: p.stoichknova@moew.government.bg
Ms. Penka Stoichkova

Canada (Min) (NFC) Natural Resources Canada
580 Booth Str., 12th Floor
OTTAWA, ONTARIO K1A 0E4

	CANADA Phone: +1 (613) 947 90 60/Fax: +1 (613) 947 90 35 e-mail: Pal.Bhogal@nrcan.gc.ca Mr Pal Bhogal
Québec (Min) (NFC)	Ministère des Ressources naturelles Direction de la recherche forestière 2700, rue Einstein, bureau RC. 102 STE. FOY (QUEBEC) G1P 3W8 CANADA Phone: +1 418 643 79 94 Ext. 65 33/Fax: +1 418 643 21 65 e-mail: rock.ouimet@mrnf.gouv.qc.ca Mr Rock Ouimet
Croatia (Min) (NFC)	Hrvatski šumarski institut Croatian Forest Research Institute Cvjetno naselje 41 10450 JASTREBARSKO CROATIA Phone: +385 1 62 73 027/Fax: + 385 1 62 73 035 e-mail: nenadp@sumins.hr Mr Nenad Potocic
Cyprus (Min) (NFC)	Ministry of Agriculture, Natural Resources and Environment Research Section - Department of Forests Louki Akrita 26 1414-NICOSIA CYPRUS Phone: +357 22 81 94 90/Fax: +357 22 30 39 35 e-mail: achristou@fd.moa.gov.cy Mr Andreas Christou
Czech Republic (NFC)	Forestry and Game Management Research Institute (VULHM) Jíloviště-Strnady 136 PRAGUE 5 – Zbraslav PSČ 156 04 CZECH REPUBLIC Phone: +420 257 89 22 21/Fax: +420 257 92 14 44 e-mail: lomsky@vulhm.cz Mr Bohumír Lomský
(Min)	Ministry of Agriculture of the Czech Republic Forest Management Tešnov 17 117 05 PRAGUE 1

	CZECH REPUBLIC Phone: +420 221 81 11 11/Fax: +420 221 81 29 88 e-mail: info@mze.cz, posta@mze.cz Mr Tomáš Krejzar
Denmark (NFC)	Forest & Landscape Frederiksberg University of Copenhagen Rolighedsvej 23 1958 Frederiksberg C DENMARK Phone: +45 35 33 18 97/Fax: +45 35 33 15 08 e-mail: moi@life.ku.dk Mr Morten Ingerslev
(Min)	Danish Ministry of the Environment, Nature Agency Haraldsgade 53 2100 Copenhagen DENMARK Phone: +45 72 54 30 00 e-mail: nst@nst.dk Ms Agnete Thomsen
Estonia (NFC)	Estonian Environment Information Centre Rõõmu tee 2 51013 TARTU ESTONIA Phone:+37 27 33 97 13/Fax: +37 27 33 94 64 e-mail: kalle.karoles@metsad.ee Mr Kalle Karoles
(Min)	Ministry of the Environment Forest and Nature Conservation Department Narva mnt 7a 15172 TALLINN ESTONIA Phone: +27 2 626 29 13/Fax: +27 2 626 28 01 e-mail: andres.talijarv@envir.ee Mr Andres Talijärv
Finland (NFC)	Finnish Forest Research Institute (METLA) Parkano Research Unit Kaironiementie 15 39700 PARKANO FINLAND Phone: +358 10 211 40 61/Fax: +358 10 211 40 01 e-mail: paivi.merila@metla.fi Ms Päivi Merilä

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France (NFC)	Office National des Forêts Direction technique et commerciale bois Département recherche - Bâtiment B Boulevard de Constance 77300 Fontainebleau FRANCE Phone: +33 1 60 74 92-28/Fax: +33 1 64 22 49 73 e-mail: manuel.nicolas@onf.fr Mr Manuel Nicolas
(Min)	Ministère de l'alimentation, de l'agriculture et de la pêche Direction générale de l'alimentation Sous-Direction de la qualité et de la protection des végétaux Département de la santé des forêts 251 rue de Vaugirard 75732 Paris cedex 15 FRANCE Phone: +33 1 49 55 51 95/Fax: +33 1 49 55 59 49 e-mail: jean-luc.flot@agriculture.gouv.fr, fabien.caroulle@agriculture.gouv.fr Mr Jean-Luc Flot, Mr Fabien Caroulle
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(Min)	Ministry of Rural Development and Foods Gen. Secretariat for Forests and the Natural Environment Dir. of Forest Resources Development Halkokondili 31 101 64 ATHENS GREECE Phone: +30 210 52 42 349/Fax: +30 210 52 44 135 e-mail: pbalatsos@yahoo.com, skollarou@yahoo.gr Mr Panagiotis Balatsos, Mrs Sofia Kollarou
Hungary (NFC)	State Forest Service Central Agricultural Office (CAO), Forestry Directorates Széchenyi u. 14 1054 BUDAPEST HUNGARY Phone: +36 1 37 43 216/Fax: +36 1 37 43 206 e-mail: kolozs.laszlo@aesz.hu Mr László Kolozs
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Italy (Min) (NFC)	Ministry for Agriculture and Forestry Policies Corpo Forestale dello Stato National Forest Service, Headquarter, Division 6^ (NFI, CONECOFOR Service and forest monitoring) via G. Carducci 5 00187 ROMA ITALY Phone: +39 06 466 570 43/Fax: +39 06 481 89 72 e-mail: e.pompei@corpoforestale.it Mr Enrico Pompei
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