W O R K   R E P O R T

Institute for World Forestry

Forest Condition in Europe

2006 Technical Report of ICP Forests

by

M. Lorenz (Federal Research Centre for Forestry and Forest Products)
R. Fischer (Federal Research Centre for Forestry and Forest Products)
G. Becher (Federal Research Centre for Forestry and Forest Products)
V. Mues (Federal Research Centre for Forestry and Forest Products)
W. Seidling (Federal Research Centre for Forestry and Forest Products)
Ph. Kraft and H.-D. Nagel (OEKO-DATA)

Federal Research Centre
for Forestry and Forest Products (BFH)

and

Department of Wood Science
University of Hamburg

Bundesforschungsanstalt für Forst- und Holzwirtschaft Hamburg
(Federal Research Centre for Forestry and Forest Products)
Address: Leuschnerstr. 91, D-21031 Hamburg, Germany
Postal address: P.O. Box: 80 02 09, D-21002 Hamburg, Germany

Phone: +40 / 73962-101
Fax: +40 / 73962-299
E-mail: weltforst@holz.uni-hamburg.de
Internet: http://www.bfafh.de
http://www.icp-forests.org

Institute for World Forestry

Forest Condition in Europe

2006 Technical Report of ICP Forests

Work report of the Institute for World Forestry 2006 / 1

Hamburg, September 2006

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.org

Programme Coordinating Centre (PCC)
c/o Federal Research Centre for Forestry and Forest Products (BFH)
Leuschnerstr. 91
D-21031 Hamburg
Germany

Authors

M. Lorenz (Federal Research Centre for Forestry and Forest Products)
R. Fischer (Federal Research Centre for Forestry and Forest Products)
G. Becher (Federal Research Centre for Forestry and Forest Products)
V. Mues (Federal Research Centre for Forestry and Forest Products)
W. Seidling (Federal Research Centre for Forestry and Forest Products)
Ph. Kraft and H.-D. Nagel (OEKO-DATA)

Acknowledgements

33 countries supported the preparation of the present report by submission of data. Several countries and the European Commission granted financial support. A complete list of the national and international institutions participating in ICP Forests is provided in Annex V.

Mrs. C. Lübker of PCC carried out technical and administrative work.

CONTENTS *page*

PREFACE

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 close cooperation with the European Commission (EC). ICP Forests is working under the Convention on Long-range Transboundary Air Pollution (CLRTAP) under the United Nations Economic Commission for Europe (UNECE). With 40 countries including Canada and the United States of America participating, the programme has over the last 20 years grown up into one of the largest biomonitoring networks of the world. ICP Forests aims to provide CLRTAP with scientific information on the effects of air pollution on forests. For this purpose, it assesses the large-scale spatial and temporal variation of forest condition on a European-wide grid (Level I) as well as cause-effect relationships at the ecosystem scale by means of intensive monitoring on permanent observation plots (Level II).

At Level I, crown condition is assessed annually on a transnational 16 x 16 km grid and on national grids of individual densities. Also on the transnational grid, soil condition and foliage chemistry were assessed once. At Level II, besides crown condition, soil condition and foliage chemistry, also increment, ground vegetation, air quality, deposition, soil solution meteorology and the phenology of tree crowns are assessed. This required the development and international harmonization of methods and standards for the implementation of data management and data quality control as well as for scientific evaluations of the monitoring data and for continuous reporting of results. The results obtained by ICP Forests reveal the extent and development of forest damage and contribute to the enlightenment of the complex causes and effects involved. They constitute a part of the scientific basis of the legally binding protocols on air pollution abatement policies of the countries of UNECE under CLRTAP.

Besides fulfilling its obligations under CLRTAP, ICP Forests will use its well developed monitoring system to also contribute to other processes of international environmental policies in close cooperation with EC. This will comprise the provision of information on several indicators for sustainable forest management laid down by the Ministerial Conference on the Protection of Forests in Europe (MCPFE). It may also include the contribution of urgently needed information on species diversity and carbon sequestration as requested by the United Nations Framework Conventions on Climate Change and on Biological Diversity. The recent summer heat and drought events across large parts of Europe and the reactions of forests to them underline the need for monitoring and evaluation of the impact of climate change on forests.

The monitoring results of each year are summarized in annual Executive Reports. The methodological background and detailed results of the individual surveys are described in Technical Reports. The present Technical Report on Forest Condition in Europe refers to the results of the large-scale transnational survey of the year 2005 and presents results of individual studies of the intensive monitoring data made available by the year 2003.

SUMMARY

The year 2005 marked the twentieth year in which the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) assessed forest condition in Europe in close cooperation with the European Commission (EC). 32 of the 40 countries assessed crown condition of 349 397 sample trees on 21 156 sample plots on their individual national grids. Results on the European scale were derived from a subsample of 133 840 trees on 6 093 plots in 30 countries. These plots are part of the 16 x 16 km transnational grid covering 34 countries. The transnational survey of 2005 revealed a mean defoliation of 20.6%. Of the main species, *Quercus robur* and *Q. petraea* had by far the highest mean defoliation (26.9%), followed by *Fagus sylvatica* (20.3%), *Picea abies* (20.2%) and *Pinus sylvestris* (18.3%).

For the calculation of the long-term development of defoliation, a group of those countries were selected which had been submitting data every year since 1990 without interruption. Several of the main species in these countries show an increase in defoliation from 1990 to 2005. This applies in particular to *Pinus pinaster* (increase from 13.2% to 18.9% mean defoliation), *Fagus sylvatica* (17.9%-22.2%), *Quercus ilex* and *Quercus rotundifolia* (13.8%-23.8%) as well as *Quercus robur* and *Quercus petraea* (21.0%-25.5%). Defoliation of *Picea abies* undulated around 23% without a clear trend. Of the main species, *Pinus sylvestris* is the only one experiencing a decrease in defoliation (24.3%-22.6%). Its recovery particularly in Poland and in parts of the Baltic States since the mid 1990s renders *Pinus sylvestris* in a slightly better condition than in 1990. Due to the severe heat and drought in summer 2003, crown condition of all main species except *Pinus sylvestris* and *Quercus ilex* and *Q. rotundifolia* deteriorated rapidly from 2003 to 2004 in southern Finland, southernmost Sweden, central and southern Germany, some parts of France and total Bulgaria. From 2004 to 2005 a recuperation was visible for *Fagus sylvatica, Picea abies*, as well as for *Quercus robur* and *Quercus petraea*.

The development of defoliation was also calculated for a shorter time series (1997-2005) involving a large number of countries. The underlying tree sample covers a number of countries in which the drought of 2003 did not occur. Hence, the drought impact on defoliation and the recovery from it were less pronounced.

For sulphate, nitrate, ammonium, calcium, sodium and chlorine, the spatial and temporal variation of bulk and throughfall deposition was evaluated. The spatial variation was mapped for the mean deposition over the year 2001-2003. The temporal variation was calculated for the period 1998-2003. Depending on data availability, between 197 and 260 intensive monitoring plots were involved in the study. Spatial patterns of deposition can be recognised and reflect partly the regional emission situation. High sulphate deposition in coastal areas is correlated with high sodium deposition, indicating sea salt as an origin. Throughfall deposition is confirmed to be higher than bulk deposition. In the period of observation, throughfall deposition of sulphate decreased from 8.8 kg ha^{-1} a^{-1} to 5.6 kg ha^{-1} a^{-1}, while bulk deposition decreased from 6.2 kg ha^{-1} a^{-1} to 4.2 kg ha^{-1} a^{-1}. Also bulk deposition of nitrogen compounds decreased, but at a lower rate than sulphate. No clear trend is obvious in throughfall deposition of the nitrogen compounds.

Nitrogen deposition at Level II was related to species composition of ground vegetation. Nitrogen indicating plants occurred more frequently on plots with high nitrogen deposition. The biogeographic region in which the plots are situated and the acid-base status of the soils are additional and predominant natural factors that determine the species composition. A five year monitoring period was too short to detect significant changes in species composition.

1. INTRODUCTION

The present report describes the results of the 20th European-wide survey of crown condition which was assessed by ICP Forests and EC in the year 2005. Besides that, the report presents results of analyses of the intensive monitoring of ICP Forests and EC. The report is outlined in the following way:

The sampling, assessment, evaluation, and the results of the large-scale (Level I) crown condition survey are laid down in Chapter 2. This includes a brief overview of the first results of the new assessment of symptoms, causes and extent of damage types. Also described are the results of the crown condition assessment of the year 2005. Emphasis is laid upon the current status and the development of crown condition with respect to species and regions.

Latest results of the intensive (Level II) monitoring are presented in Chapter 3. First of all, bulk deposition, throughfall deposition and their trends are described for ammonium, nitrate and sulphate. Depositions of these substances as measured by ICP Forests are in a second step compared with the respective depositions modelled by the Co-operative Programme for Monitoring and Evaluation of the Long-range transmission of Air Pollutants in Europe (EMEP). Moreover, effects of nitrogen depositions and acidity on the ground vegetation on ICP Forests plots are shown. Finally, the results of a dynamic modelling approach are presented which attempts to estimate the development of forest soils under the impact of air pollution to be expected in future years.

Chapter 4 consists of national reports by the participating countries, focussing on crown condition in 2005 as well as its development and its causes.

Maps, graphs and tables concerning the transnational and the national results are presented in Annexes I and II. Annex III provides a list of tree species with their botanical names and their names in the official UNECE and EU languages. The statistical procedures used in the evaluations are described in Annex IV. Annex V provides a list of addresses.

2. LARGE-SCALE CROWN CONDITION SURVEYS

2.1 Methods of the surveys in 2005

2.1.1 Background

Transnational forest condition monitoring under ICP Forests is carried out following harmonized methods. These are laid down in the "Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests" (LORENZ et al., 2004). In the following sections, the selection of sample plots, the assessment of stand and site characteristics, the assessment of crown condition and the assessment of damage types are described. The sections also refer to the evaluation and presentation of the survey results.

2.1.2 Selection of sample plots

2.1.2.1 The transnational survey

The transnational survey aims to provide a periodic overview on the spatial and temporal variation in forest condition in relation to natural as well as anthropogenic stress factors (in particular air pollution) at the European-wide and national scale. This aim is achieved by means of large-scale monitoring on a 16 x 16 km transnational grid of sample plots. In several countries, the plots of the transnational grid are a subsample of a denser national grid (Chapter 2.1.2.2). The coordinates of the transnational grid were calculated and provided to the participating countries by EC. If a country had already established plots, the existing ones were accepted, provided that the mean plot density resembled that of a 16 x 16 km grid, and that the assessment methods corresponded to those of the ICP Forests Manual and the relevant Commission Regulations. The fact that the grid is less dense in parts of the boreal forests can be shown to be of negligible influence due to their homogeneity.

The transnational survey in 2005 was carried out on 6 093 plots in 30 countries. The number of plots was slightly lower as compared to 2004. This is partly due to a reduced number of plots in Portugal were the forest fires have affected a number of Level I plots in 2005. The number of plots in each participating country is presented in Table 2.1.2.1-1 for the last 13 years. In addition, 13 plots were assessed on the Canary Islands, but excluded from the transnational evaluation as they are not located in those geoclimatic regions to which all other plots were assigned (Annex I-1). They are, however, shown in the respective maps. The figures in Table 2.1.2.1-1 are not necessarily identical to those published in previous reports. Rearward changes in the data base are in principle possible due to consistency checks and subsequent data corrections as well as new data submitted by countries. In 2005, only very minor rearward changes were carried out.

The spatial distribution of the plots assessed in 2005 is shown in Figure 2.1.2.1-1. The plot sample is stratified according to geoclimatic regions adapted from those by WALTER et al. (1975), and WALTER and LIETH (1967). For an explanation of these regions see Annex I–1. Percentages of plots in the 10 different regions are given in Table 2.1.2.1-2.

Table 2.1.2.1-1: Number of sample plots from 1993 to 2005 according to the current database.

Country	Number of sample plots												
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Austria	76	76	76	130	130	130	130	130	130	133	131	136	136
Belgium	29	29	29	29	29	29	30	29	29	29	29	29	29
Cyprus									15	15	15	15	15
Czech Republic	178	205	199	196	196	116	139	139	139	140	140	140	138
Denmark	25	25	24	23	22	23	23	21	21	20	20	20	22
Estonia	86	90	90	91	91	91	91	90	89	92	93	92	92
Finland	405	382	455	455	460	459	457	453	454	457	453	594	609
France	506	534	543	540	540	537	544	516	519	518	515	511	509
Germany	412	417	417	420	421	421	433	444	446	447	447	451	451
Greece	96	96	95	95	94	93	93	93	92	91	-	-	87
Hungary	65	62	63	60	58	59	62	63	63	62	62	73	73
Ireland	22	21	21	21	21	21	20	20	20	20	19	19	18
Italy	212	209	207	207	181	177	239	255	265	258	247	255	238
Latvia	101	94	94	99	96	97	98	94	97	97	95	95	92
Lithuania	74	73	73	67	67	67	67	67	66	66	64	63	62
Luxembourg	4	4	4	4	4	4	4	4	-	4	4	4	4
The Netherlands	13	13	13	12	11	11	11	11	11	11	11	11	11
Poland	476	441	432	431	431	431	431	431	431	433	433	433	433
Portugal	143	147	141	142	144	143	143	143	144	145	136	133	119
Slovak Republic	111	111	111	110	110	109	110	111	110	110	108	108	108
Slovenia	34	34	42	42	42	41	41	41	41	39	41	42	44
Spain	460	444	454	447	449	452	598	607	607	607	607	607	607
Sweden	59	340	726	766	758	764	764	769	770	769	776	775	784
United Kingdom	69	66	63	79	82	88	85	89	86	86	86	85	84
EU	3656	3913	4372	4466	4437	4363	4613	4620	4645	4649	4532	4691	4765
Andorra												3	-
Belarus					416	416	408	408	408	407	406	406	403
Bulgaria		109	120	120	120	135	115	108	109	99	106	103	103
Croatia	84	88	82	83	86	89	84	83	81	80	78	84	85
Moldova	12	12	11	10	10	10	10	10	10	-	-	-	-
Norway	390	384	386	387	386	386	381	382	408	414	411	442	460
Romania	167	199	241	224	237	235	238	235	232	231	231	226	229
Russian Fed.		7	134										-
Serbia and Montenegro											103	130	-
Switzerland	45	45	47	49	49	49	49	49	49	49	48	48	48
Total Europe	4354	4757	5393	5339	5741	5683	5898	5895	5942	5929	5915	6133	6093

Table 2.1.2.1-2: Distribution of the 2005 sample plots over the climatic regions.

Climatic region	Number of plots	Percentage of plots
Boreal	1167	19.2
Boreal (Temperate)	940	15.4
Atlantic (North)	342	5.6
Atlantic (South)	278	4.6
Sub-atlantic	1124	18.5
Continental	246	4.0
Mountainous (North)	303	5.0
Mountainous (South)	705	11.6
Mediterranean (Higher)	400	6.5
Mediterranean (Lower)	588	9.6
All regions	6093	100.0

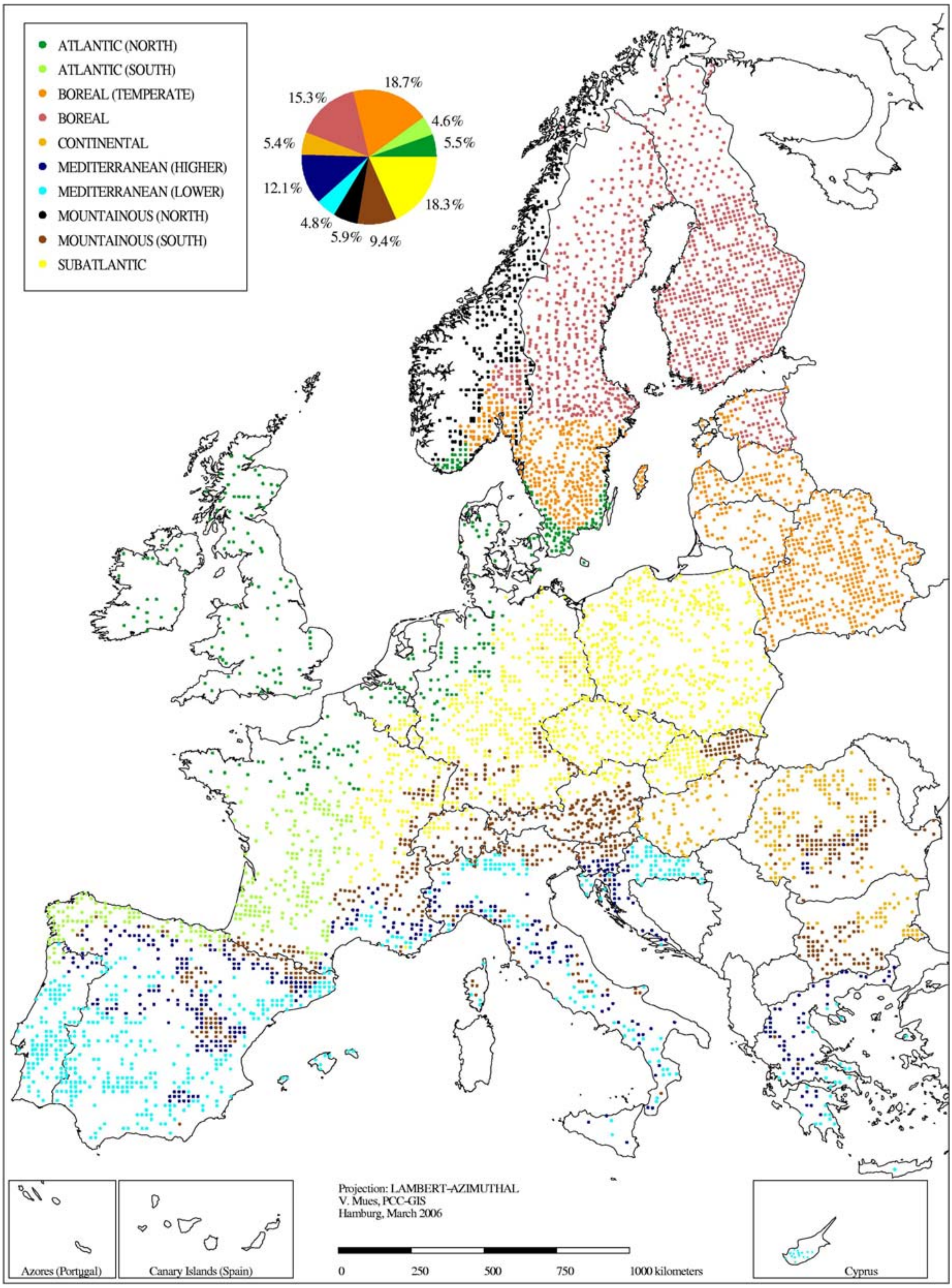


Figure 2.1.2.1-1: Plots according to climatic regions (2005).

2.1.2.2 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 tabulated in Annexes II-1 to II-7 and are displayed graphically in Annex II-8. 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.

2.1.3 Assessment parameters

2.1.3.1 Stand and site characteristics

The following plot and tree parameters are reported on the transnational plots in addition to defoliation and discolouration:
Country, plot number, plot coordinates, altitude, aspect, water availability, humus type, soil type (optional), mean age of dominant storey, tree numbers, tree species, identified damage types and date of observation (Table 2.1.3.1-1).
Within a demonstration project at Level I (BioSoil) that includes the repetition of the soil survey using a more differentiated classification of soil types than the one reproduced in Table 2.1.3.1-1 will be carried out.

Table 2.1.3.1-1: Stand and site parameters given within the crown data base.

Registry and location	country	state in which the plot is assessed [code number]
	plot number	identification of each plot
	plot coordinates	latitude and longitude [degrees, minutes, seconds] (geographic)
	date	day, month and year of observation
Physiography	altitude [m a.s.l.]	elevation above sea level, in 50 m steps
	aspect [°]	aspect at the plot, direction of strongest decrease of altitude in 8 classes (N, NE, ... , NW) and "flat"
Soil	water availability	three classes: insufficient, sufficient, excessive water availability to principal species
	humus type	mull, moder, mor, anmor, peat or other
	soil type	optional, according to FAO (1990) xx
Climate	climatic region	10 climatic regions according to WALTER et al. (1975)
Stand related data	mean age of dominant storey	classified age; class size 20 years; class 1: 0-20 years, ..., class 7: 121-140 years, class 8 irregular stands
Additional tree related data	tree number	number of tree, allows the identification of each particular tree over all observation years
	tree species	species of the observed tree [code]
	identified damage types	treewise observations concerning damage caused by game and grazing, insects, fungi, abiotic agents, direct action of man, fire, known regional pollution, and other factors

Nearly all countries submitted data on water availability, humus type, altitude, aspect, and mean age. The numbers of plots for which these site parameters were reported increased distinctively in recent years (Table 2.1.3.1-2). The data set is now almost complete for these parameters.

Table 2.1.3.1-2: Number of sample plots and plots per site parameter.

Country	Number of plots	Number of plots per site parameter					
		Water	Humus	Altitude	Aspect	Age	Soil
Austria	136	136	128	136	136	136	130
Belgium	29	29	29	29	29	29	28
Cyprus	15	15	15	15	15	15	0
Czech Republic	138	138	58	138	138	138	58
Denmark	22	22	22	22	22	22	22
Estonia	92	92	92	92	92	92	92
Finland	609	609	609	609	609	609	609
France	509	509	509	509	509	509	509
Germany	451	451	451	451	451	451	420
Hungary	73	61	40	61	61	73	61
Ireland	18	18	18	18	18	18	18
Greece	87	87	85	87	87	87	87
Italy	238	238	238	238	238	238	0
Latvia	92	92	92	92	92	92	92
Lithuania	62	62	62	62	62	62	62
Luxembourg	4	4	4	4	4	4	4
The Netherlands	11	11	11	11	11	11	11
Poland	433	433	424	433	433	433	38
Portugal	119	119	119	119	119	119	113
Slovak Republic	108	0	108	108	108	108	108
Slovenia	44	43	43	44	44	44	43
Spain	607	607	607	607	607	607	431
Sweden	784	784	771	784	784	784	589
United Kingdom	84	84	84	84	84	84	84
EU	4765	4644	4619	4753	4753	4765	3609
Percent of EU plot sample		97.5	96.9	99.8	99.8	100.0	75.7
Belarus	403	403	400	403	403	403	399
Bulgaria	103	103	103	103	103	103	103
Croatia	85	85	85	85	85	85	66
Norway	460	0	430	460	460	460	370
Romania	229	229	229	229	229	229	216
Switzerland	48	45	45	48	48	48	45
Total Europe	6093	5509	5911	6081	6081	6093	4808
Percent of total plot sample		90.4	97.0	99.8	99.8	100.0	78.9

2.1.3.2 Defoliation

On each sampling point of the national and transnational grids situated in forest, at least 20 sample trees are selected according to standardised procedures. Predominant, dominant, and co-dominant trees (according to the system of Kraft) of all species qualify as sample trees, provided that they have a minimum height of 60 cm and that they do not show significant mechanical damage. Trees removed by management operations or blown over by wind must be replaced by newly selected trees. Due to the small percentage of removed trees, this replacement does not distort the survey results, as has been shown by a special evaluation.

The variation of crown condition is mainly the result of intrinsic factors, age and site conditions. Moreover, defoliation may be caused by a number of biotic and abiotic stressors. Defoliation assessment attempts to quantify foliage missing as an effect of stressors including air pollutants and not as an effect of long lasting site conditions. In order to compensate for site conditions, local reference trees are used, defined as the best tree with full foliage that could grow at the particular site. Alternatively, absolute references are used, defined as the best possible tree of a genus or a species, regardless of site conditions, tree age etc. depicted on regionally applicable photos, e.g. photo guides (Anonymus, 1986).

Changes in defoliation and discolouration attributable to air pollution cannot be differentiated from those caused by other factors. Consequently, defoliation due to factors other than air pollution is included in the assessment results. Trees showing mechanical damage are not included in the sample. Should mechanical damage occur to a sample tree, any resulting loss of foliage is not counted as defoliation. In this way, mechanical damage is ruled out as a cause as far as possible (compare 2.1.3.3).

In principle, the transnational survey results for defoliation are assessed in 5% steps. The assessment down to the nearest 5 or 10% permits studies of the annual variation of defoliation with far greater accuracy than using the traditional system of only 5 classes of uneven width (Chapter 2.1.4). Discolouration is reported both in the transnational and in the national surveys using the traditional classification.

The total numbers of trees assessed from 1993 to 2005 in each country are shown in Table 2.1.3.2-1. The figures are not necessarily identical to those published in previous reports for the same reasons explained in Chapter 2.1.2.1.

Of the tree sample of the year 2005, 114 species (-groups) were reported. 64.3% of the plots were dominated by conifers, 35.7% by broadleaves (Annex I-2). Plots in mixed stands were assigned to the species group which comprised the majority of the sample trees. Most abundant were *Pinus sylvestris* with 27.8% followed by *Picea abies* with 19.9%, *Fagus sylvatica* with 8.9%, and *Quercus robur* with 3.7% of the total tree sample (Annex I-3).

Table 2.1.3.2-1: Number of sample trees from 1993 to 2005 according to the current database.

Country	Number of sample trees												
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Austria	2121	2107	2101	3670	3604	3577	3535	3506	3451	3503	3470	3586	3528
Belgium	685	684	678	684	683	692	696	686	682	684	684	681	676
Cyprus									360	360	360	360	361
Czech Rep	4423	5087	4933	4853	4844	2899	3475	3475	3475	3500	3500	3500	3450
Denmark	600	600	576	552	528	552	552	504	504	480	480	480	528
Estonia	2064	2159	2160	2184	2184	2184	2184	2160	2136	2169	2228	2201	2167
Finland	4427	4261	8754	8732	8788	8758	8662	8576	8579	8593	8482	11210	11535
France	10118	10672	10851	10800	10800	10740	10883	10317	10373	10355	10298	10219	10129
Germany	10729	10866	10907	10980	10990	13178	13466	13722	13478	13534	13572	13741	13630
Greece	2272	2272	2248	2248	2224	2204	2192	2192	2168	2144	-	-	2054
Hungary	1361	1322	1342	1298	1257	1383	1470	1488	1469	1446	1446	1710	1662
Ireland	462	441	441	441	441	441	417	420	420	424	403	400	382
Italy	5884	5791	5703	5836	4873	4939	6710	7128	7350	7165	6866	7109	6548
Latvia	2420	2257	2262	2368	2297	2326	2348	2256	2325	2340	2293	2290	2263
Lithuania	1843	1760	1776	1643	1634	1616	1613	1609	1597	1583	1560	1487	1512
Luxembourg	95	93	96	96	96	96	96	96	-	96	96	96	97
The Netherlands	260	260	257	237	220	220	225	218	231	232	231	232	232
Poland	9520	8820	8640	8620	8620	8620	8620	8620	8620	8660	8660	8660	8660
Portugal	4308	4414	4230	4260	4319	4290	4290	4290	4320	4350	4080	3990	3569
Slovak Rep.	5144	5115	5091	5018	5033	5094	5063	5157	5054	5076	5116	5058	5033
Slovenia	816	816	1008	1008	1008	984	984	984	984	936	983	1006	1055
Spain	11040	10656	10896	10728	10776	10848	14352	14568	14568	14568	14568	14568	14568
Sweden	311	3989	10310	10925	10910	11044	11135	11361	11283	11278	11321	11255	11422
United Kingdom	1656	1584	1512	1896	1968	2112	2039	2136	2064	2064	2064	2040	2016
EU	82559	86026	96772	99077	98097	98797	105007	105469	105491	105540	102761	105879	107077
Andorra												72	
Belarus					9974	9896	9745	9763	9761	9723	9716	9682	9484
Bulgaria		4370	4812	4789	4788	5389	4379	4197	4209	3753	3870	3629	3611
Croatia	2016	2150	1970	1974	2030	2066	2015	1991	1941	1910	1869	2009	2046
Moldova	288	288	263	236	253	234	259	234	234	-	-	-	
Norway	4016	3942	3905	3948	4028	4069	4052	4051	4304	4444	4547	5014	5319
Romania	4004	4776	5688	5375	5687	5637	5712	5640	5568	5544	5544	5424	5496
Russian Fed.		183	3180										
Serbia and Mont.											2274	2915	
Switzerland	500	509	824	854	880	868	857	855	834	827	806	748	807
Total Europe	93383	102244	117414	116253	125737	126956	132026	132200	132342	131741	131387	135372	133840

2.1.4 Evaluation and presentation of the survey results
2.1.4.1 Scientific background

The interpretation of the results of the crown condition assessments has to take into account the following limitations:

Defoliation has a variety of causes. 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 can not be precisely quantified, damaged trees can not 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. However, in many countries the natural growing conditions are most favourable in those areas receiving the highest depositions of air pollution. 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. 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).

2.1.4.2 Classification of defoliation data

The national survey results are submitted to PCC as country related mean values, classified according to species and age classes. These data sets are accompanied by national reports providing explanations and interpretations. All tree species are referred to by their botanical names, the most frequent of them listed in 11 languages in Annex III.

The results of the evaluations of the crown condition data are preferably presented in terms of mean plot defoliation or the percentages of the trees falling into 5%-defoliation steps. However, in order to ensure comparability with previous presentations of survey results, partly the traditional classification of both defoliation and discolouration has been retained for comparative purposes, although it is considered arbitrary by some countries. This classification (Table 2.1.4.2-1) is a practical convention, as real physiological thresholds cannot be defined.

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.

Table 2.1.4.2-1: 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

Classically, trees in classes 2, 3 and 4 are referred to as "damaged", as they represent trees of 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".

Attention must be paid to the fact that *Quercus robur* and *Quercus petraea* are evaluated together and referred to as "*Quercus robur* and *Q. petraea*". Similarly, *Quercus ilex* and *Quercus rotundifolia* are evaluated together and noted as "*Quercus ilex* and *Q. rotundifolia*".

The most important results have been tabulated separately for all countries having participated (called "total Europe") and for the 24 EU-Member States.

2.1.4.3 Mean defoliation and temporal development

For all evaluations related to the tree species a criterion had to be set up to be able to decide if a given plot represents this species or not. The number of trees with species being evaluated had to be three or more per plot ($N \geq 3$). The plot wise species specific mean defoliation was calculated as the mean of defoliation values of the trees of the selected species on the respective plot.

The temporal development of defoliation is expressed on maps as the slope, or regression coefficient, of a linear regression of mean defoliation against the year of observation. It can be interpreted as the mean annual change in defoliation. A value of e.g. 3% means an increase by 3% defoliation per year on average. These slopes are called "significant" only if there was less than 5% probability that they are different from zero by random variation.

Besides the temporal development, also the change in the results from 2003 to 2004 was calculated (Annex I-7). In this case, changes in mean defoliation per plot are called "significant" only if both,

- the change ranges above the assessment accuracy, i.e. is higher than 5%,
- and the significance at the 95% probability level was proven in a statistical test.

For detailed information on the respective calculation method for the change from 2004 to 2005 see Annex IV.

2.2 Results of the transnational survey in 2005

2.2.1 Crown condition in 2005

The crown condition assessment of the year 2005 comprised 133 840 sample trees on 6 093 sample plots. Of these trees a share of 23.2% was scored as damaged, i.e. had a defoliation of more than 25% (Table 2.2.1-1). The share of damaged broad-leaves exceeded with 26.0% the share of damaged conifers with 21.1%. The percentages of damaged trees are mapped for each plot in Annex I-4. Table 2.2.1-1 shows also the mean and the median of defoliation. Mean defoliation in total Europe was 20.6%. A map of mean plot defoliation of all species is given in Annex I-5.

Table 2.2.1-1: Percentages of trees in defoliation classes and mean defoliation for broad-leaves, conifers and all species.

	Species type	Percentage of trees in defoliation class							Defoliation		No. of trees
		0-10%	>10-25%	0-25%	>25-60%	>60%	dead	>25%	Mean	Median	
EU	Broad-leaves	25.9	46.1	72.0	24.4	2.7	0.8	28.0	23.0	20	41070
	Conifers	35.7	42.5	78.2	19.3	1.5	1.0	21.8	19.7	15	66007
	All species	32.0	43.9	75.9	21.3	1.9	0.9	24.1	21.0	20	107077
Total Europe	*Fagus sylv.*	33.3	43.7	77.0	20.8	1.6	0.6	23.0	20.3	15	11898
	Quercus robur + Q. petraea	15.2	43.8	59.0	37.7	2.4	0.9	41.0	26.9	25	8447
	Broad-leaves	29.0	45.0	74.0	22.7	2.4	0.9	26.0	22.2	20	53696
	Picea abies	38.5	35.2	73.7	23.0	2.0	1.3	26.3	20.2	15	26582
	Pinus sylv.	37.2	46.4	83.6	14.6	1.0	0.8	16.4	18.3	15	37180
	Conifers	36.1	42.8	78.9	18.6	1.5	1.0	21.1	19.5	15	80144
	All species	33.3	43.5	76.8	20.3	1.9	1.0	23.2	20.6	15	133840

Defoliation classes have uneven widths. For this reason, the frequency distributions for the 5% classes in which defoliation data are submitted were calculated. These frequency distributions are shown for the broadleaved trees, for the coniferous trees and for the total of all trees in Figures 2.2.1-1a and 2.2.1-1b for each climatic region as well as for the total of all regions. Also given are the number of trees, the mean defoliation and the median. Mean defoliation is lowest with 15.0% in the Boreal region and it is highest with 24.0% in the Mediterranean (lower) region.

Figures 2.2.1-2 to 2.2.1-5 show maps of mean plot defoliation for *Pinus sylvestris*, *Picea abies*, *Fagus sylvatica*, and *Quercus robur* and *Q. petraea*. The maps reflect partly the differences in crown condition between species and regions seen in Table 2.2.1-1 and in Figures 2.2.1-1a and 2.2.1-1b: Defoliation is highest for *Quercus robur* and *Quercus petraea* and it is lowest for *Pinus sylvestris*. For *Pinus sylvestris* the map shows large and partly well defined regions of both high and low defoliation. Particularly many plots with hardly defoliated *Pinus sylvestris* trees are situated in Finland and in northern and central Sweden, i.e. in the Boreal region. In contrast, *Picea abies* and especially the main broad-leaved species, *Fagus sylvatica* as well as *Quercus robur* and *Quercus petraea*, show highly defoliated plots throughout their habitat.

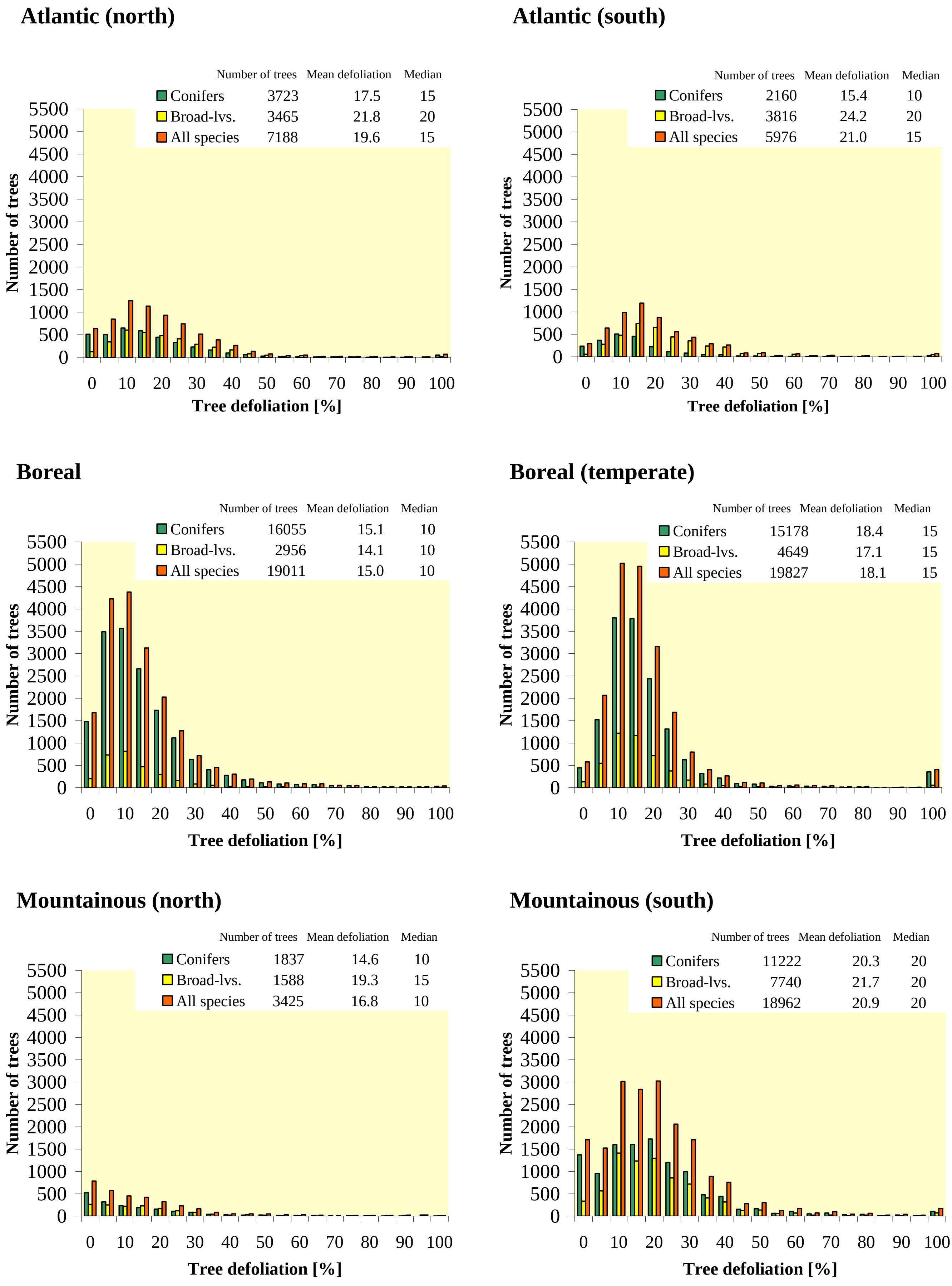


Figure 2.2.1-1a: Frequency distribution of trees in 5%-defoliation steps.

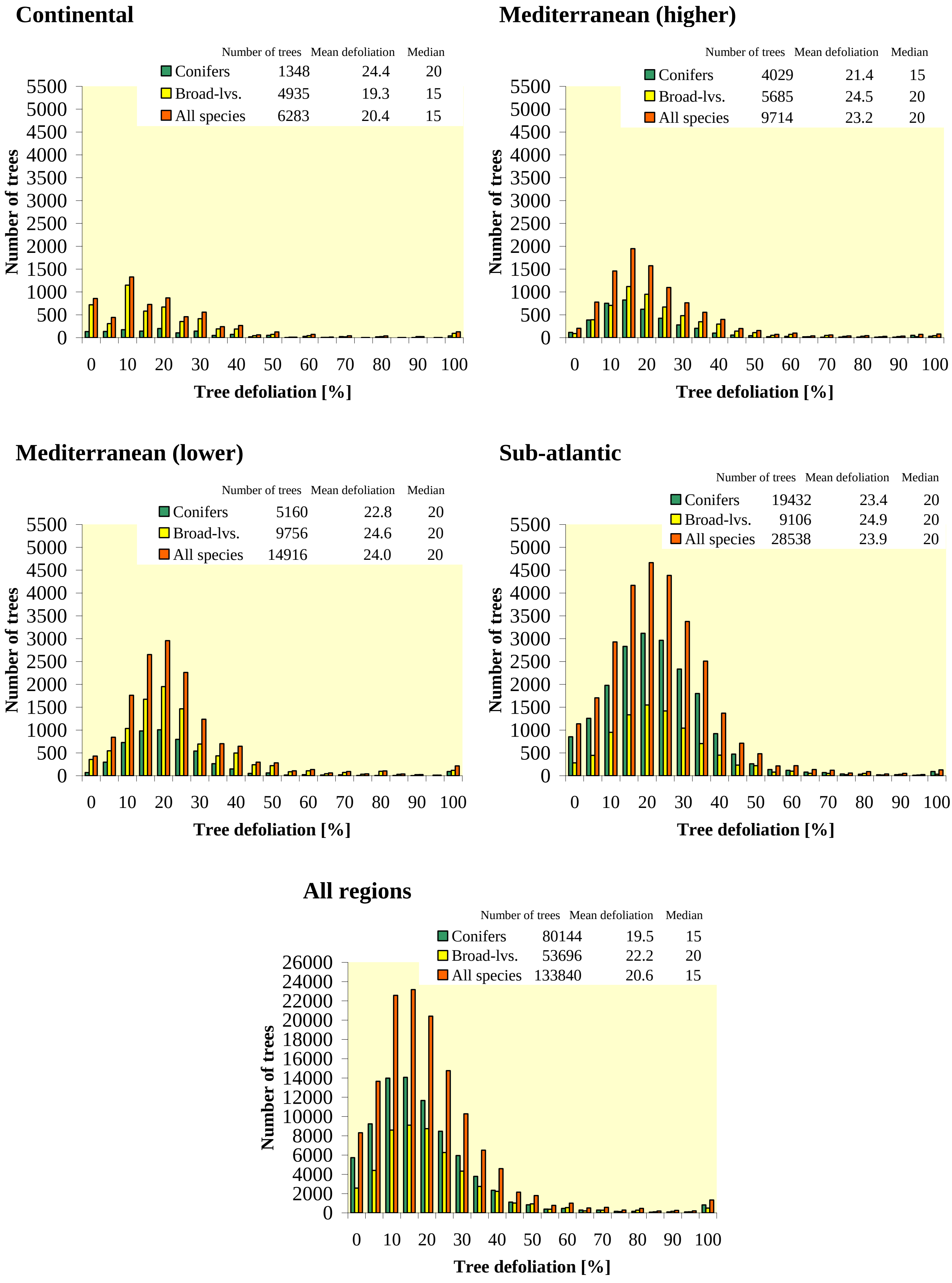


Figure 2.2.1-1b: Frequency distribution of trees in 5%-defoliation steps.

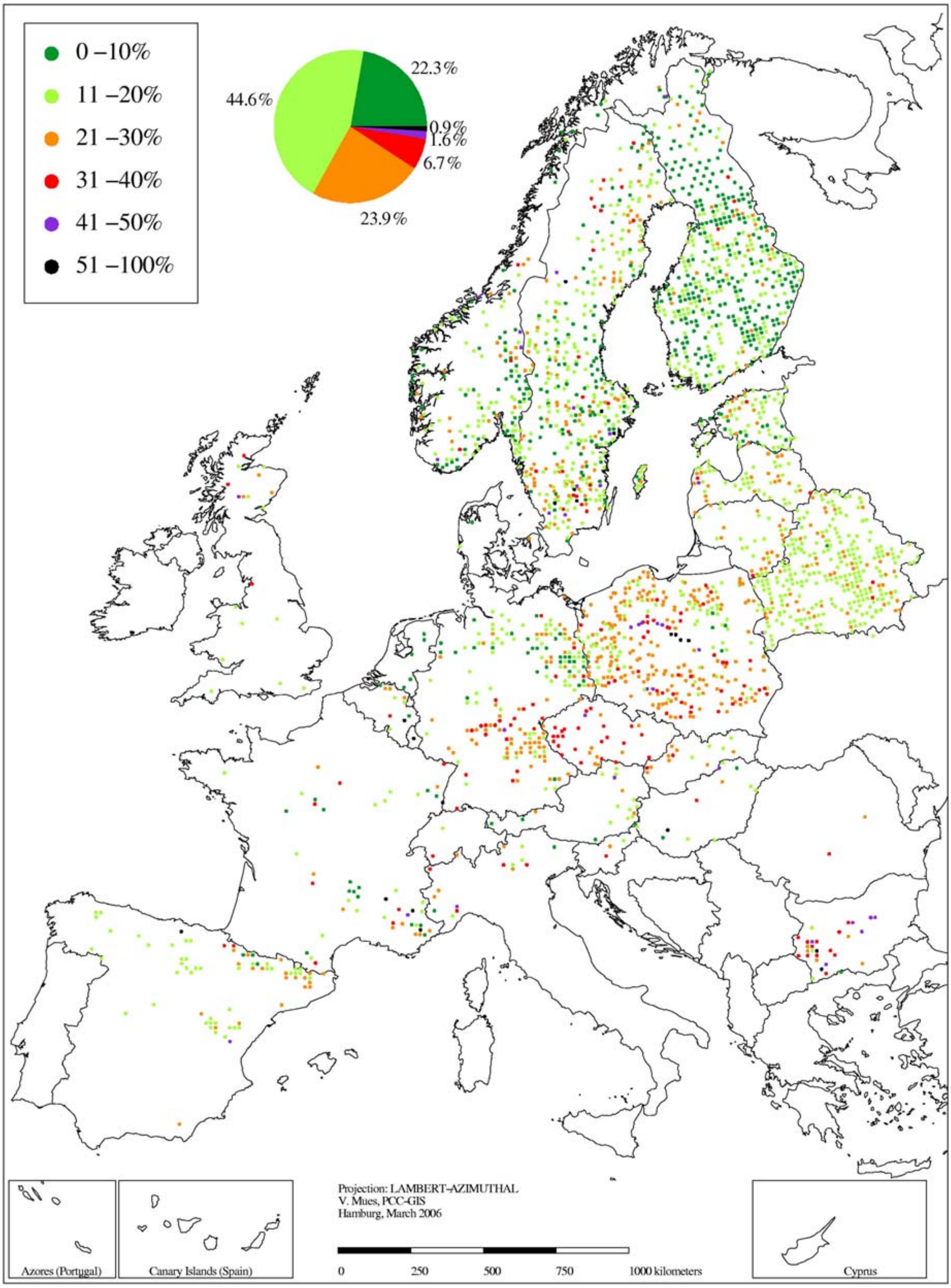


Figure 2.2.1-2: Mean plot defoliation of *Pinus sylvestris.*

Note that some differences in the level of defoliation across national borders may be at least partly due to differences in standards used.

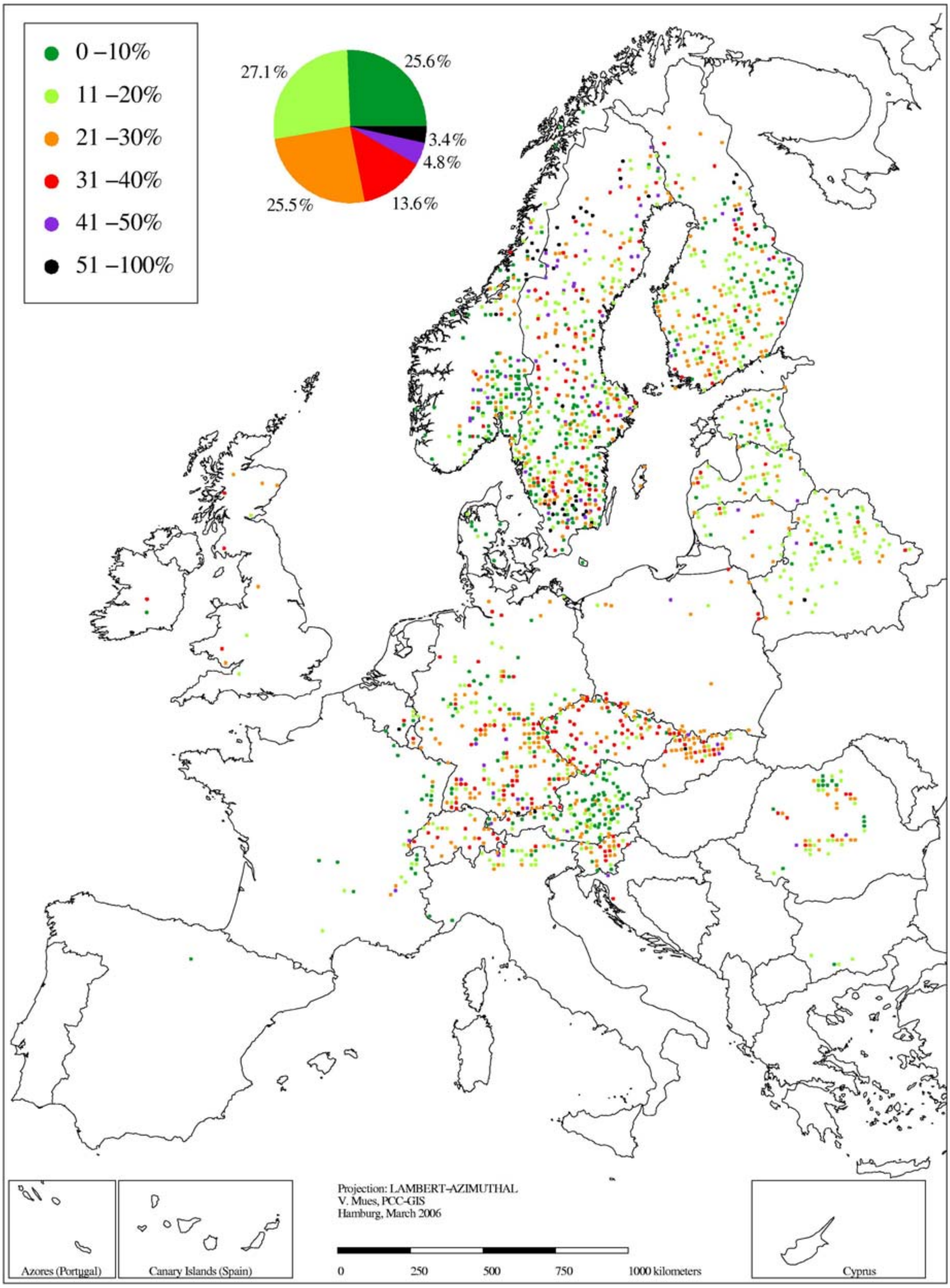


Figure 2.2.1-3: Mean plot defoliation of *Picea abies.*

Note that some differences in the level of defoliation across national borders may be at least partly due to differences in standards used.

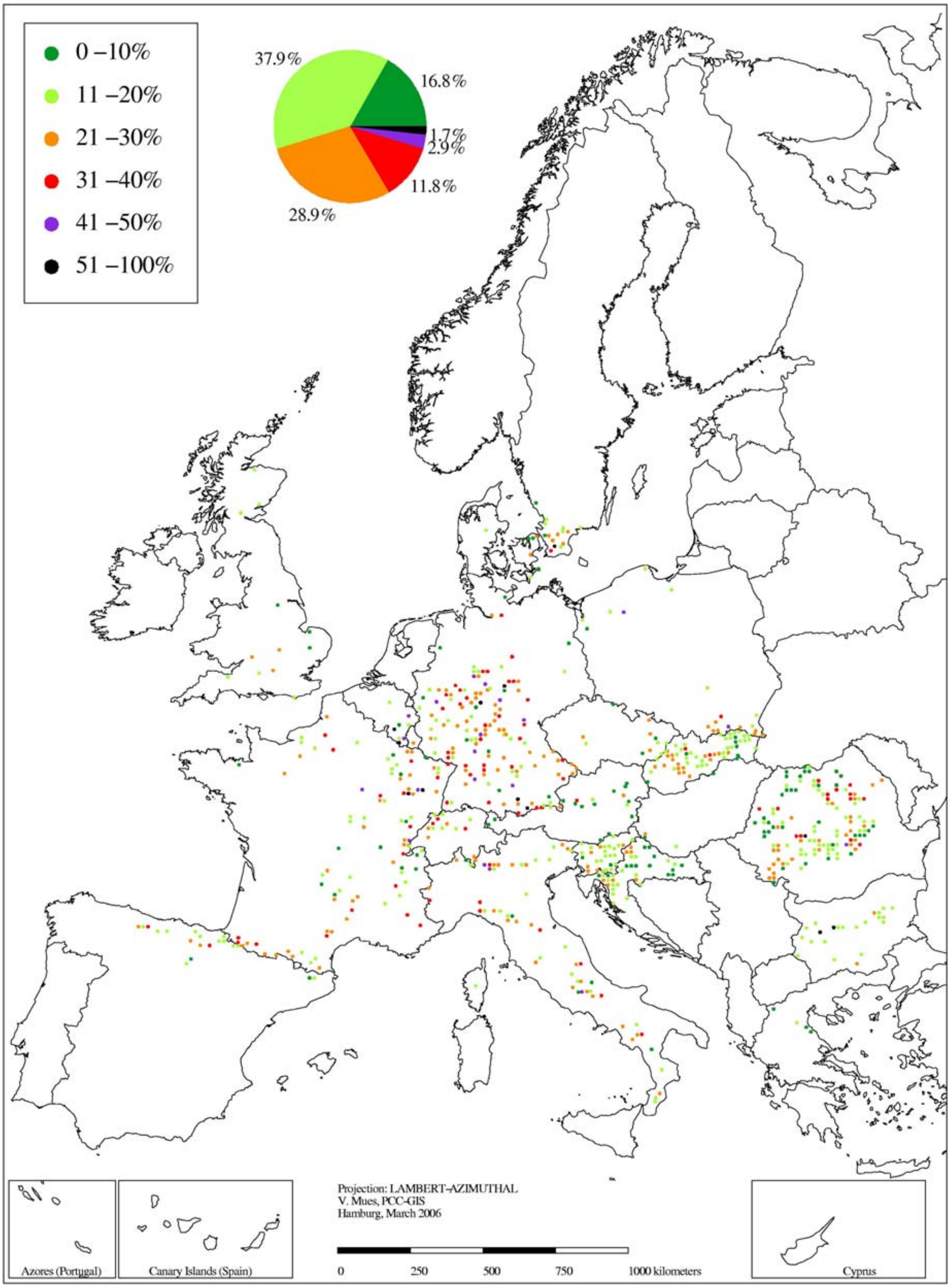


Figure 2.2.1-4: Mean plot defoliation of *Fagus sylvatica.*

Note that some differences in the level of defoliation across national borders may be at least partly due to differences in standards used.

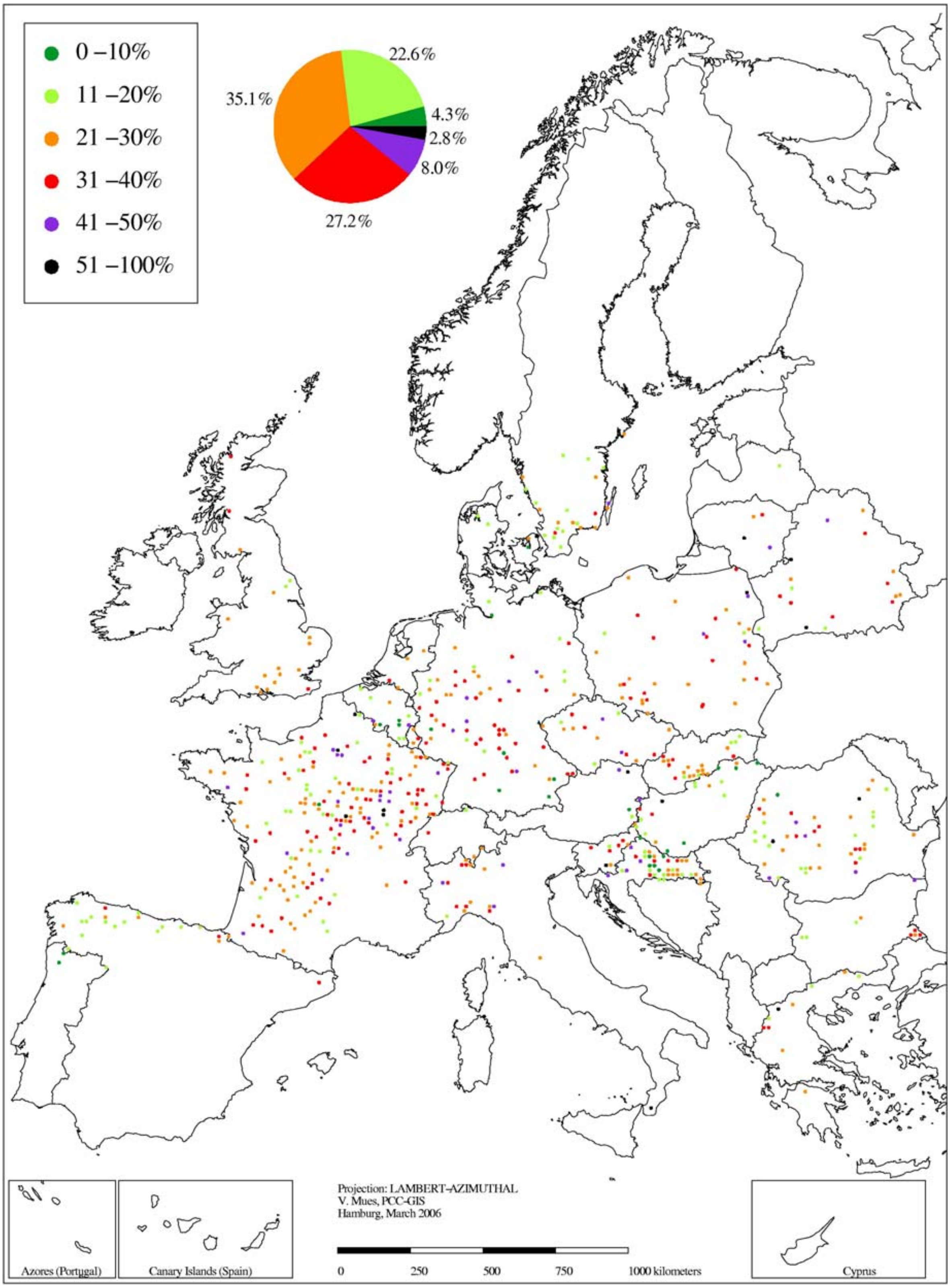


Figure 2.2.1-5: Mean plot defoliation of *Quercus robur* and *Quercus petraea.*

Note that some differences in the level of defoliation across national borders may be at least partly due to differences in standards used.

Table 2.2.1-2 shows the discolouration of the 133 840 trees of the crown condition survey. Of these trees, a share of 6.2% is discoloured, i.e. has a discolouration of more than 10%. Annex I-6 shows a map of mean plot discolouration.

Table 2.2.1-2: Percentages of trees in discolouration classes and mean defoliation for broad-leaves, conifers and all species.

	Species type	Discolouration						No. of trees
		0-10%	>10-25%	>25-60%	>60%	dead	>10%	
EU	Broad-leaves	94.8	2.8	1.1	0.5	0.8	5.2	41070
	Conifers	94.6	3.5	0.8	0.2	0.9	5.4	66007
	All species	94.6	3.3	1.0	0.2	0.9	5.4	107077
Total Europe	Broad-leaves	94.0	3.6	1.0	0.6	0.8	6.0	53696
	Conifers	93.6	4.4	0.9	0.3	0.8	6.4	80144
	All species	93.8	4.1	0.9	0.4	0.8	6.2	133840

2.2.2 Development of defoliation

2.2.2.1 Approach

The development of defoliation is calculated assuming that the tree sample of each survey year represents forest condition. The experience and special studies of previous years shows that the fluctuation of trees in this sample due to the exclusion of dead and felled trees as well as due to inclusion of replacement trees does not cause 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 two time series and respectively, the following countries were selected for tracing the development of defoliation:

- Period 1990-2005:
  Belgium, Denmark, Germany (west), Hungary, Ireland, Latvia, Poland, Portugal, Slovak Republic, Spain, Switzerland, and The Netherlands.
- Period 1997-2005:
  Austria, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, The Netherlands, and United Kingdom.

Several countries could not be included in one or both time series because of changes in their tree sample sizes, changes in their assessment methods or missing assessments in certain years. Development of defoliation is presented either as graphs or in maps. Graphs show the fluctuations of either mean defoliation or shares of trees in defoliation classes over time. Maps indicate trends in mean defoliation calculated as described in Chapter 2.1.5.3.

In addition to the development of defoliation in the above mentioned periods, also the change in mean defoliation from 2004 to 2005 was mapped (Annex I-7). This biannual comparison shows a significant increase in defoliation on 16.5% of the plots, whereas only 10.3% of the plots show a significant decrease. Although the plots with increased defoliation are scattered all across Europe, they are particularly frequent on the Iberian Peninsula due to the fact that dry years increase the risk of forest fires and the susceptibility of trees to be attacked by bark beetles. Increased defoliation due to drought and biotic agents was also observed in parts of France and Bulgaria. The deterioration of crown condition in southernmost Sweden is partly explained by severe storm in January 2005.

Chapter 2.2.2.2 presents trends in defoliation for the six most frequent tree species. For each of these species, Chapters 2.2.2.3 to 2.2.2.8 describe the trends in different climatic regions. In each of these chapters the development of defoliation of the respective species is visualised for the total tree sample of all climatic regions in one graph. Additional graphs reflect particular developments in selected climatic regions. Each chapter contains also a map indicating trends of mean plot defoliation. Annexes I-8 and I-9 provide for each of the two time series and each of the six species the number of sample trees and their distribution over the defoliation classes for each year. This information is given for the total of all climatic regions and for each region separately. In addition, the same information is provided for three more species, namely *Abies alba*, *Picea sitchensis* and *Quercus suber* because of their ecological and economical importance in some regions.

2.2.2.2 Main tree species

From 1990 to 2005, *Pinus pinaster*, *Fagus sylvatica*, *Quercus ilex* and *Quercus rotundifolia* as well as *Quercus robur* and *Quercus petraea* show an obvious increase in defoliation (Figure 2.2.2.2-1). Defoliation of *Picea abies* undulates without a clear trend. *Pinus sylvestris* is the only species with slightly decreasing defoliation since 1990. Its recovery particularly in Poland, Belarus and in parts of the Baltic States since the mid 1990s renders this species in 2005 in a slightly better condition than at the beginning of the time series. Being less susceptible to drought, *Pinus sylvestris* shows no rise in defoliation even after the dry summer of the year 2003. In contrast, *Picea abies*, *Fagus sylvatica* as well as *Quercus robur* and *Quercus petraea* reacted upon the drought with a marked increase in defoliation from 2003 to 2004. In 2005, their crown condition recovered obviously. A different development over the last two years is shown by the Mediterranean species *Pinus pinaster* as well as by *Quercus ilex* and *Quercus rotundifolia*.

The impact by and the recovery from the drought in 2003 is less pronounced in the time series from 1997 to 2005 (Figure 2.2.2.2-2). The reason is that the underlying tree sample covers a large number of countries, in many of which no drought occurred in 2003. Trends in mean plot defoliation for the period 1997-2005 are mapped in Figure 2.2.2.2-3. The share of plots with distinctly increasing defoliation (20.6%) surmounts the share of plots with decreasing defoliation (12.9%). The latter improving plots are largely *Pinus sylvestris* plots in Belarus and Poland.

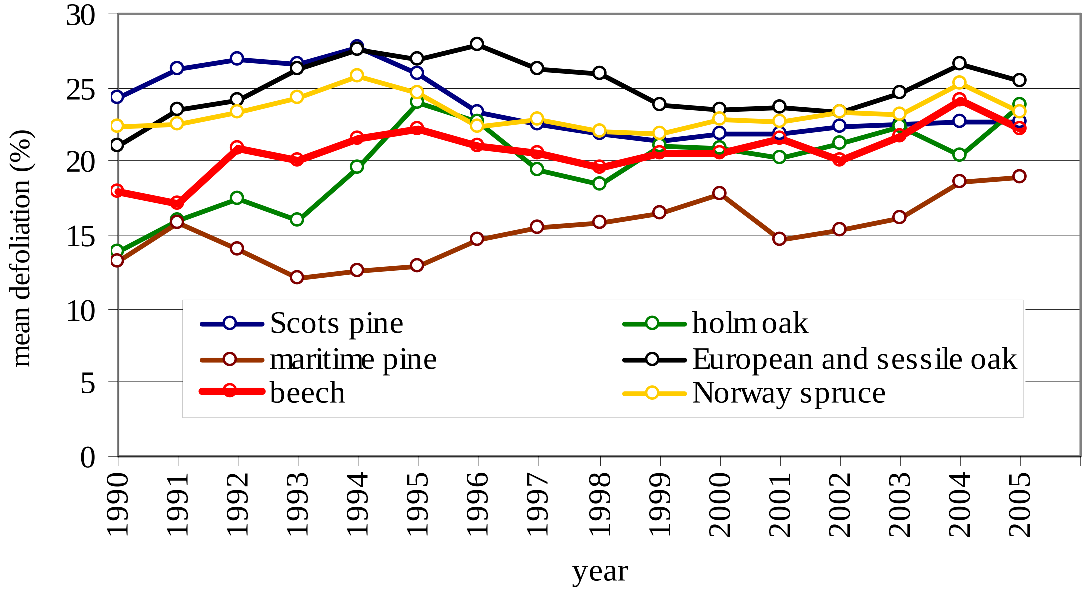


Figure 2.2.2.2-1: Mean defoliation of main species 1990 – 2005.

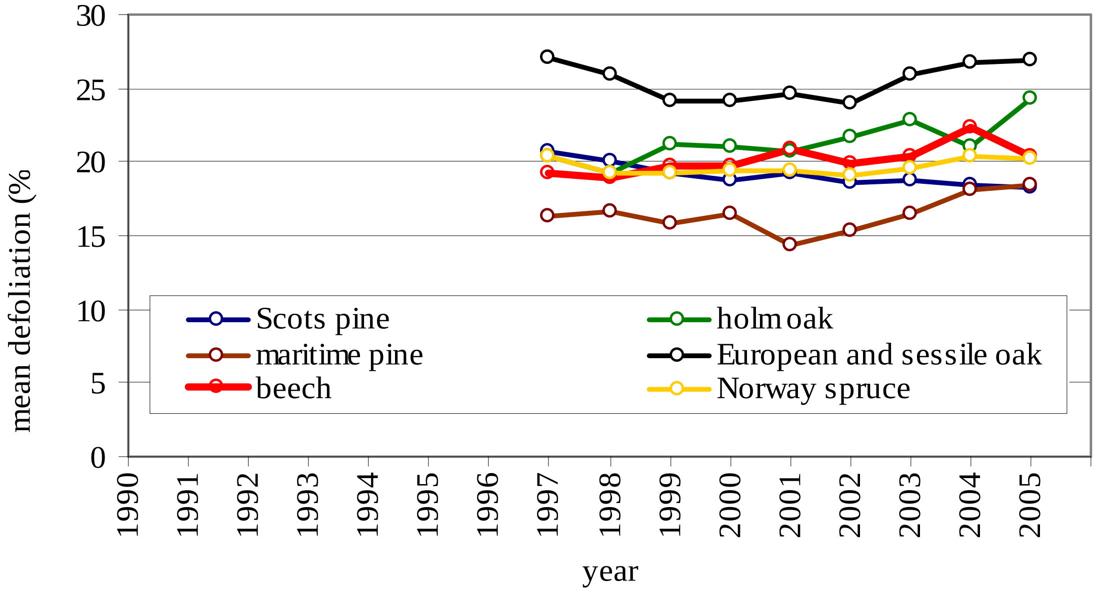


Figure 2.2.2.2-2: Mean defoliation of main species 1997 – 2005.

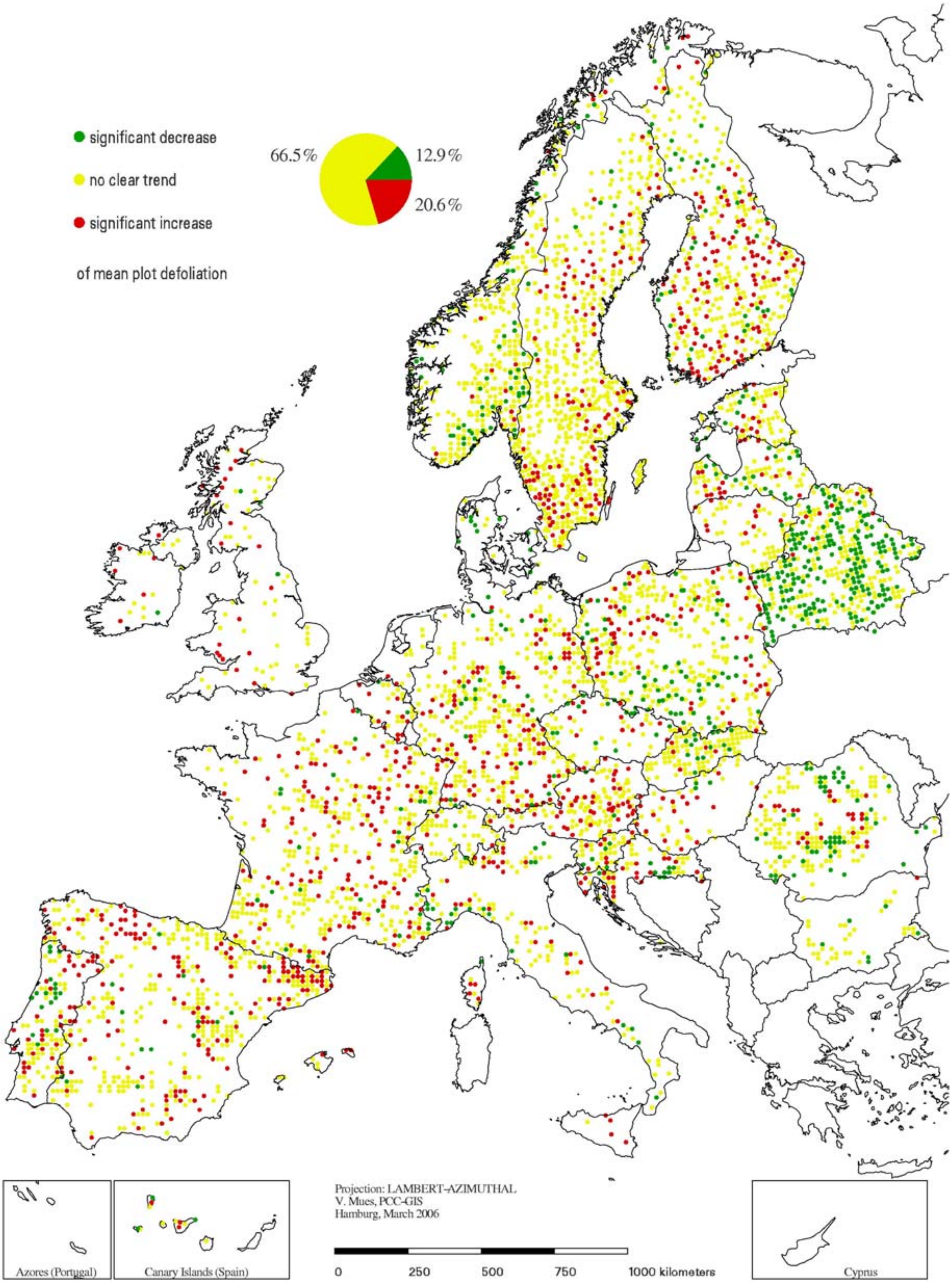


Figure 2.2.2.2-3: Trends of mean plot defoliation of all main species over the years 1997 to 2005.

2.2.2.3 Pinus sylvestris

Pinus sylvestris constitutes the largest share of sample trees in both periods of investigation, 1990-2005 and 1997-2005. It is the only species which is present in all climatic regions. In the total of all regions, the portion of damaged trees shows a pronounced decrease from a peak at 46.2% in 1994 to 25.0% in 2005. This reflects mainly the recuperation in the Sub-Atlantic region - which represents by far the largest share of trees – and to a lower extent an extreme decrease in the share of damaged trees after 1992 in Latvia, i.e. in the Boreal (temperate) region (Figure 2.2.2.3-1). In the Boreal (temperate) region defoliation decreased also in the period from 1997-2005. As a result, the share of damaged trees of this period has with 9.4% its so far lowest value. The recuperation in the Sub-Atlantic and Boreal (temperate) regions is also reflected in Figure 2.2.2.3-2. The map shows the high number of recuperating plots after 1997 in Belarus. Many recuperating plots are also seen in Poland, Latvia and Estonia, as well as in parts of Finland and Germany. Especially Poland and Lithuania have attributed the recuperation largely to reduced air pollution. The pie diagram shows that the share of recuperating plots (17.3%) is larger than that of the plots showing a deterioration (15.4%), which is largely due to the results reported from Belarus.

The recuperation of *Pinus sylvestris* is absent or less pronounced in other climatic regions. An example is the Mediterranean (higher) region. It represents only a small portion of the total *Pinus sylvestris* sample trees, but here the share of not defoliated trees decreased from 85.9% in 1990 to 36.9% in 2005 (Figure 2.2.2.3-1).

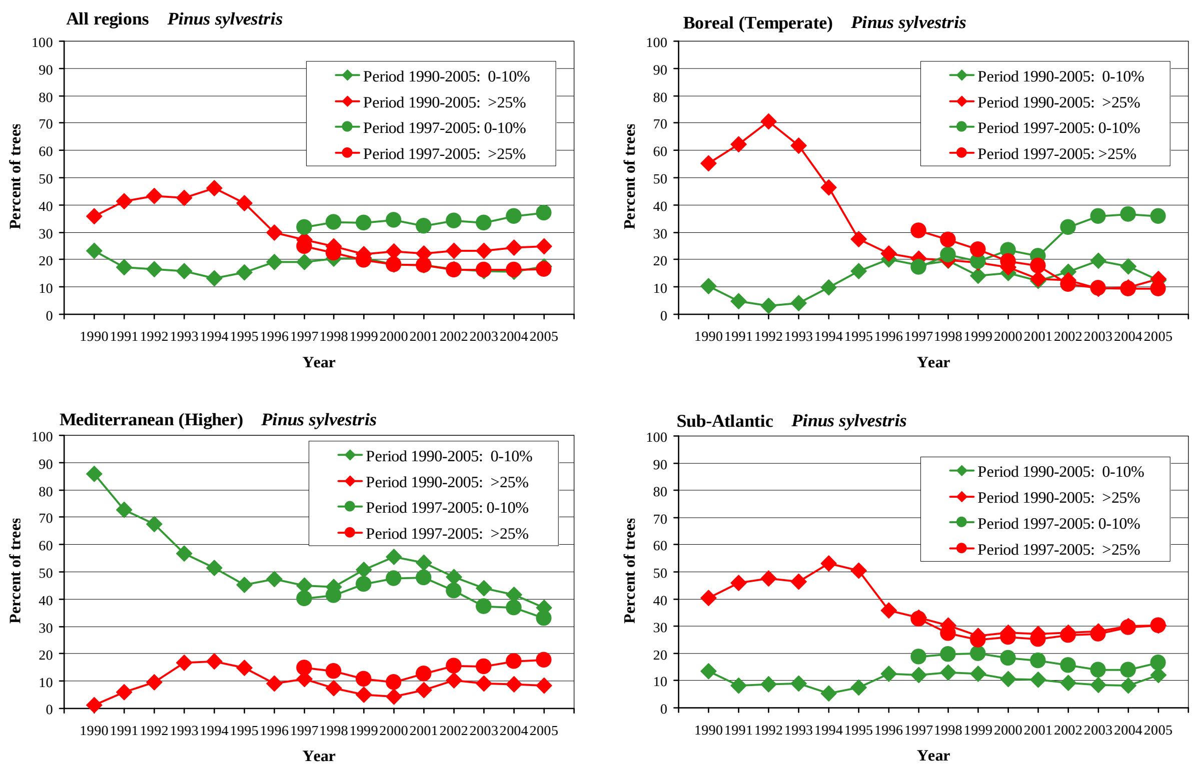


Figure 2.2.2.3-1: Shares of trees of defoliation 0-10% and >25% in two periods (1990-2005 and 1997-2005).

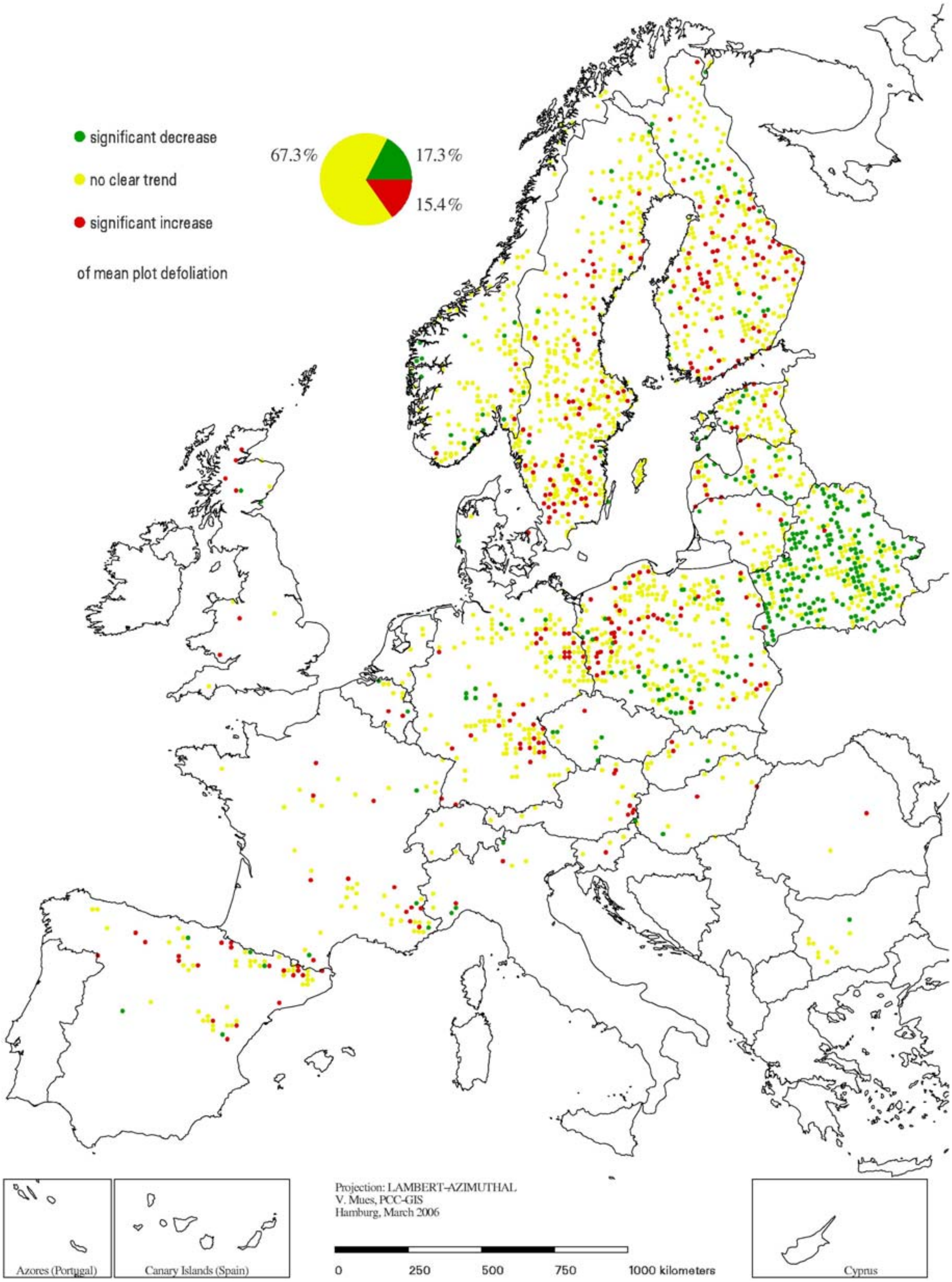


Figure 2.2.2.3-2: Trend of mean plot defoliation (slope of linear regression) of *Pinus sylvestris* over the years 1997 to 2005.

2.2.2.4 Picea abies

In both periods of observation, *Picea abies* constitutes the second largest share of trees behind *Pinus sylvestris*. In the period 1990-2005, the share of damaged trees in the total of all regions decreased from its peak of 38.2% in 1994 to 32.6% in 2005 (Figure 2.2.2.4-1). This development reflects largely the one in the Sub-Atlantic and Mountainous (south) regions, which comprise the largest and second largest share of *Picea abies* trees, respectively. These two regions – especially the Mountainous (south) region – show a sudden increase in defoliation from 2003 to 2004 with a subsequent decrease to nearly its old level in 2005. This pattern is interpretable as an effect of the dry and hot summer of 2003 and a recuperation from it in 2005. It is absent in the Boreal (temperate) region, where no unusual summer drought occurred.

In the 1997-2005 sample of *Picea abies* in the Sub-Atlantic and Mountainous (south) regions crown condition deteriorated. This is hardly reflected in the share of damaged trees, but is obvious from the decrease in not defoliated trees. Figure 2.2.2.4-2 shows the spatial distribution and the shares of plots with decreasing and increasing defoliation. Of all plots in the map, 18.9% showed a distinct increase in defoliation, whereas only 11.1% of them showed a distinct decrease.

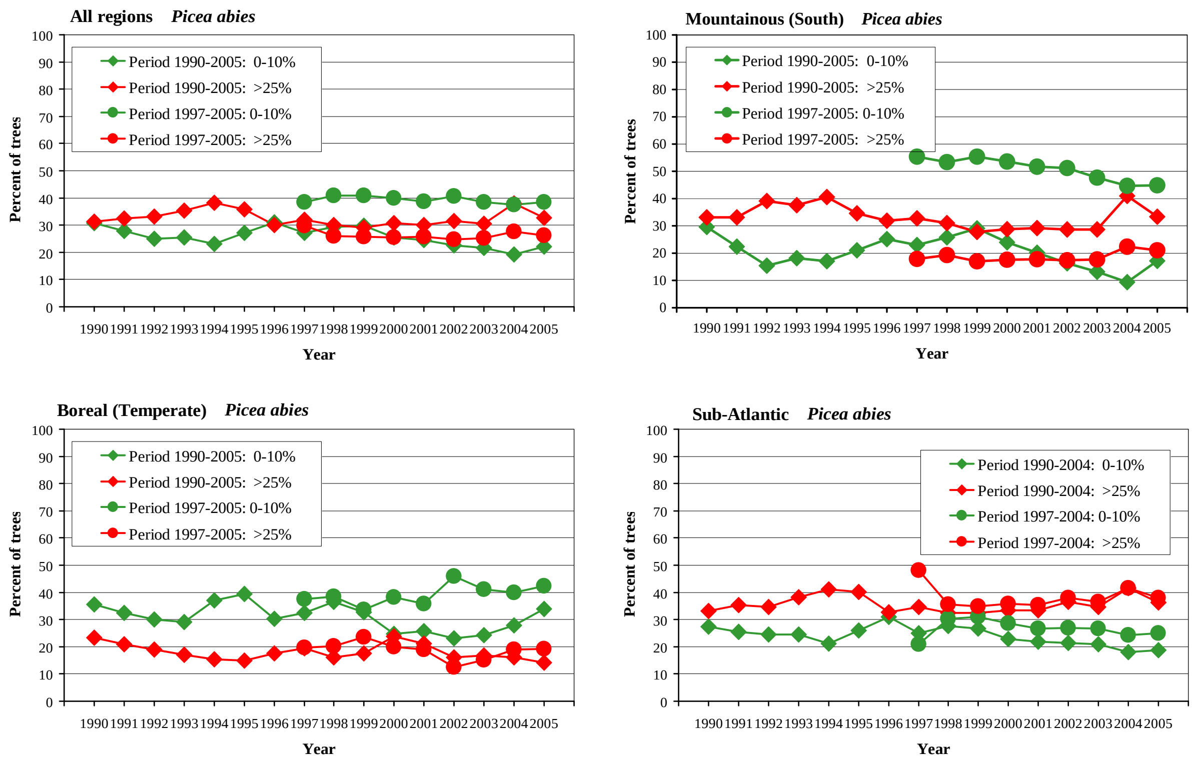


Figure 2.2.2.4-1: Shares of trees of defoliation 0-10% and >25% in two periods (1990-2005 and 1997-2005).

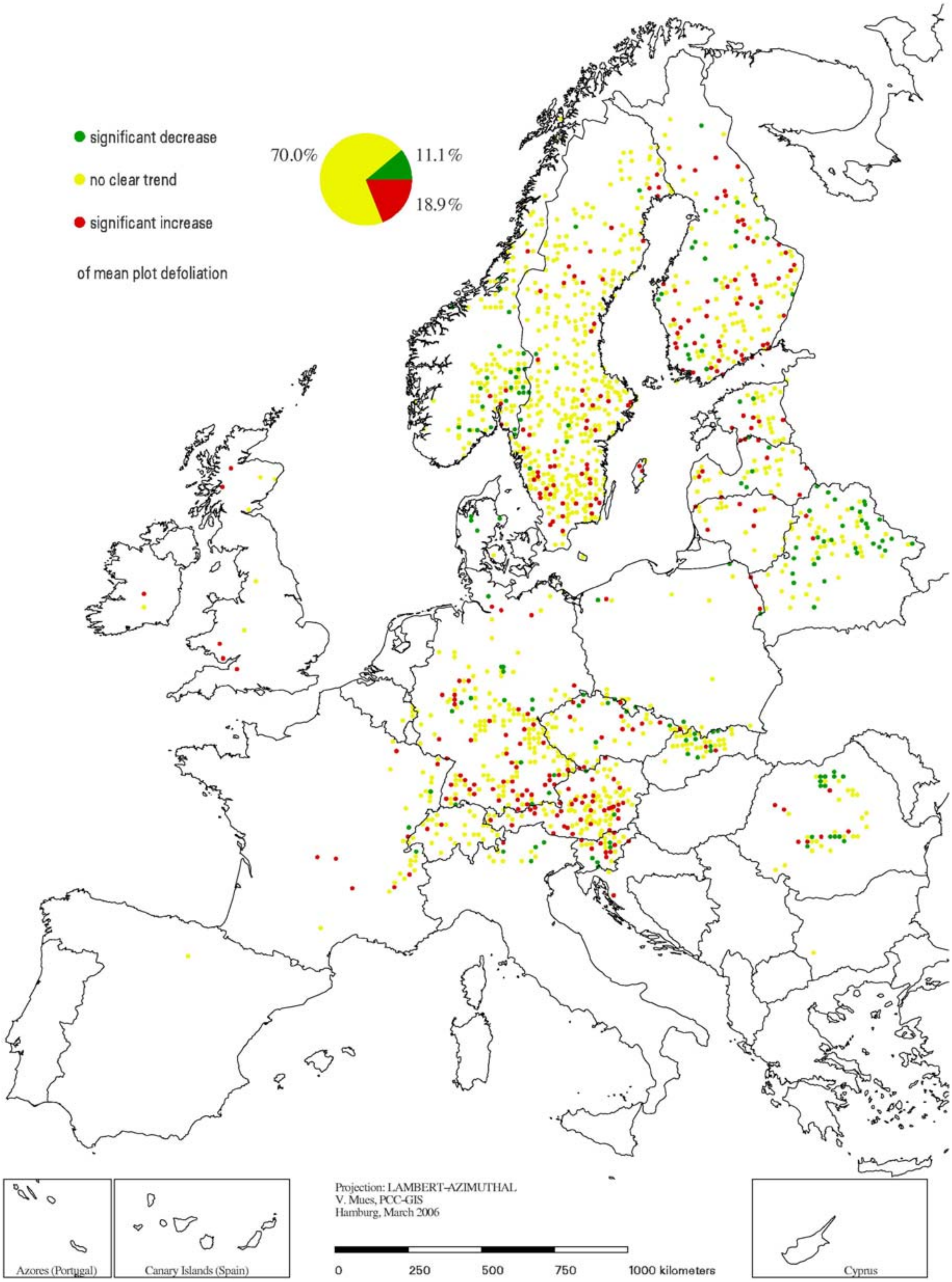


Figure 2.2.2.4-2: Trend of mean plot defoliation (slope of linear regression) of *Picea abies* over the years 1997 to 2005.

2.2.2.5 Fagus sylvatica

Fagus sylvatica constitutes the largest portion of the broadleaved species. In both periods of observation (1990-2005 and 1997-2005) crown condition across all regions deteriorates slightly. This becomes particularly obvious in the decrease of the share of not defoliated trees between 1990 and 2005 (Figure 2.2.2.5-1). The dry and hot summer of 2003 caused an increase in the defoliation in 2004. The subsequent decrease in defoliation indicates a recuperation of the trees in 2005. This reflects in particular the development of crown condition in the Sub-Atlantic and Mountainous (south) regions which comprise together more than half of the *Fagus sylvatica* trees. Both the drought damage and the recuperation from it are especially pronounced in the Atlantic (North) region, where the share of damaged trees increased by 16.6 percent points from 29.2% in 2003 to 45.8% in 2004, and decreased again to 32.0 % in 2005. Another obvious increase in defoliation occurred in the 1990-2005 sample in the Mountainous (south) region. There, the share of damaged trees tripled approximately from 11.8% in 2002 to 32.5% in 2003 which reflects largely the high fructification in the eastern Slovak Republic.

The overall deterioration of crown condition of *Fagus sylvatica* over the whole period of 1997-2005 observed particularly in the Atlantic (north), in the Sub-Atlantic and in the Mountainous (south) region is discernable in Figure 2.2.2.5-2. The map shows the spatial distribution of the trends since 1997 across Europe. The share of plots with increasing defoliation is 20.4% against a share of 9.7% of plots showing decreasing defoliation.

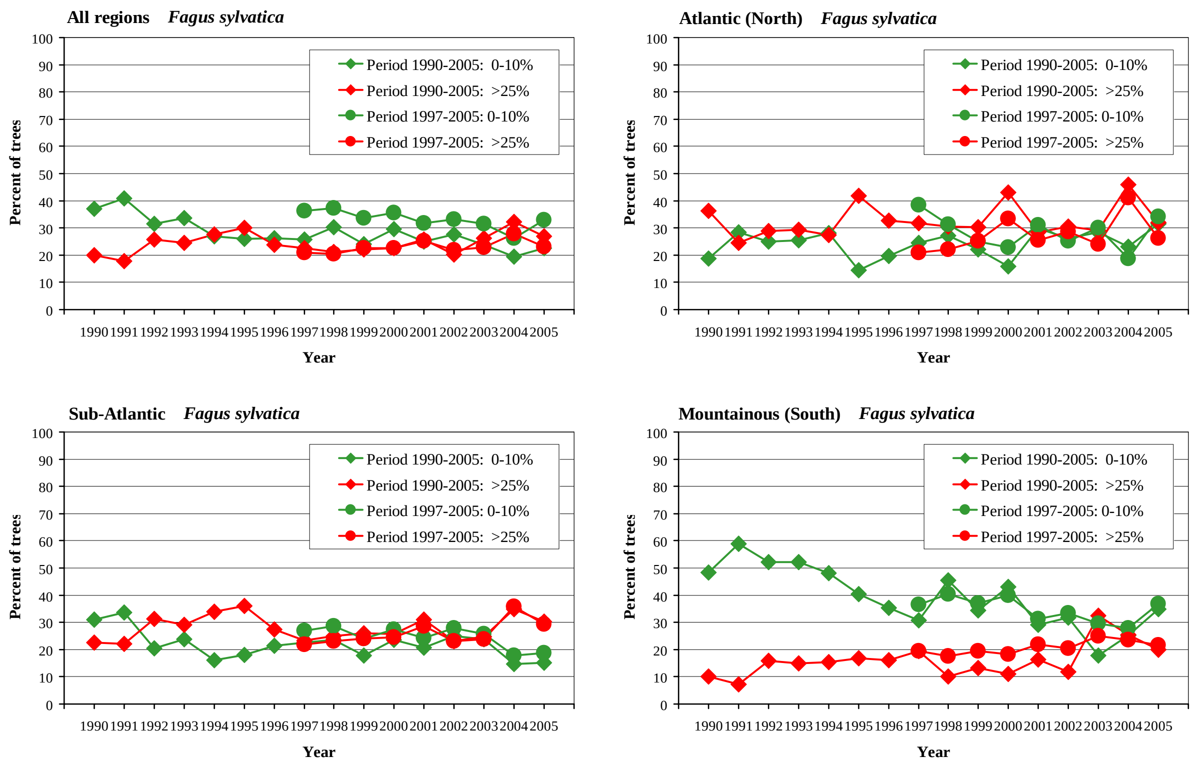


Figure 2.2.2.5-1: Shares of trees of defoliation 0-10% and >25% in two periods (1990-2004 and 1997-2005).

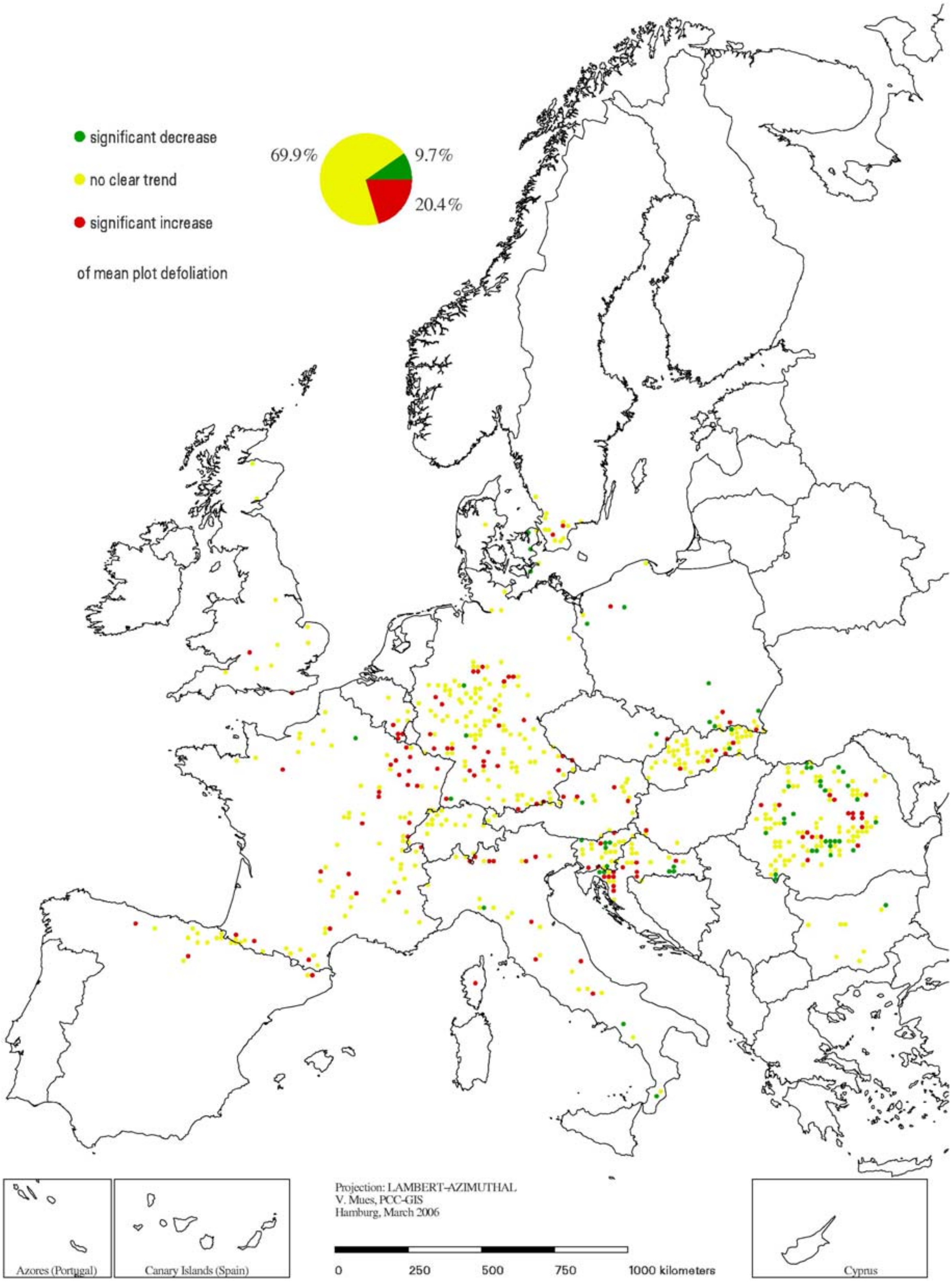


Figure 2.2.2.5-2: Trend of mean plot defoliation (slope of linear regression) of *Fagus sylvatica* over the years 1997 to 2005.

2.2.2.6 Quercus robur and Q. petraea

In the species group *Quercus robur* and *Quercus petraea*, the share of damaged trees across all regions recovered from its peak at 46.5% in 1994. After a steady state from 1999 onwards, it increased markedly in 2003 because of the summer heat and drought. This reflects mainly the development of crown condition in the Sub-Atlantic region which comprises the largest share of the sample trees of this species group. There, the share of damaged trees of the time series 1990-2005 increased by 10.1 percent points from 32.6% in 2002 to 42.7% in 2005, so far without any recuperation (Figure 2.2.2.6-1). A deterioration of crown condition in 2003 and 2004 is also visible in the Atlantic (North) region. The subsequent decrease in defoliation in 2005 reflects partly a recuperation of the trees in Denmark and northern Germany. In the Continental region, defoliation has been highly variable without a clear trend.

Of the 1997-2005 sample, nearly half of the trees with increasing defoliation is situated in France (Figure 2.2.2.6-2). Of all plots in the map, 20.1% show increasing and 9.4% of all plots show decreasing defoliation.

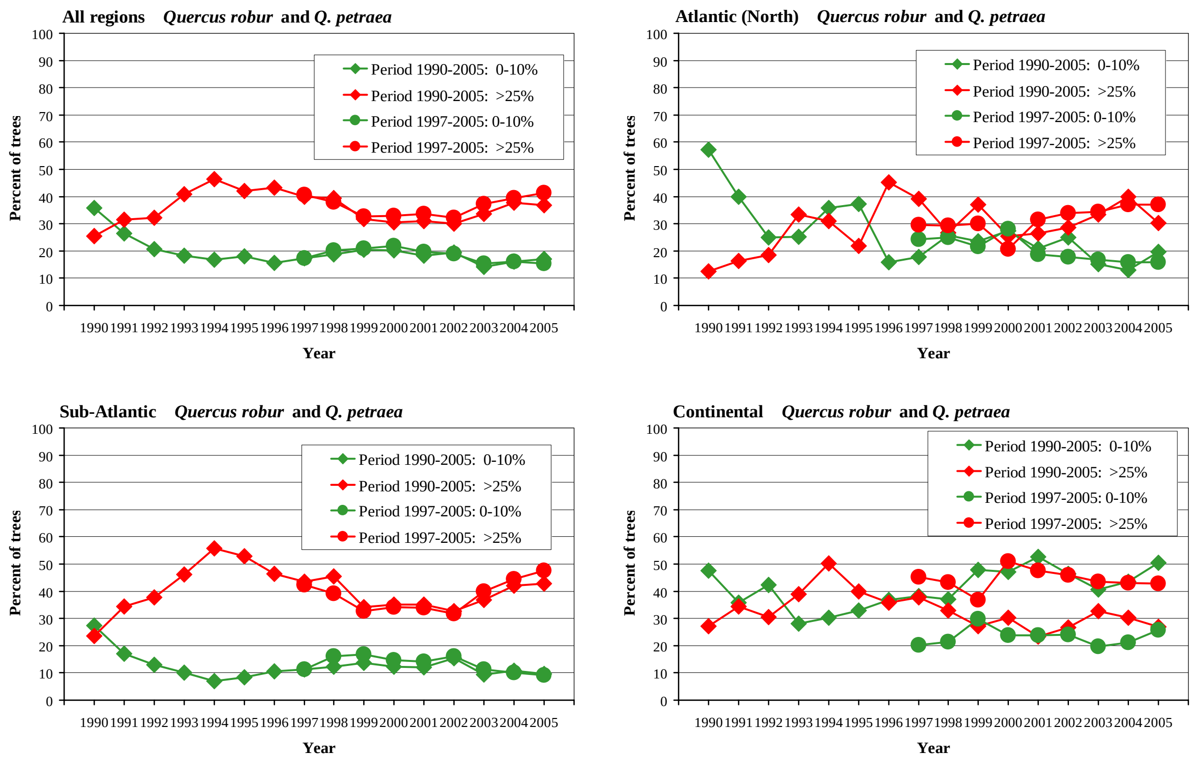


Figure 2.2.2.6-1: Shares of trees of defoliation 0-10% and >25% in two periods (1990-2005 and 1997-2005).

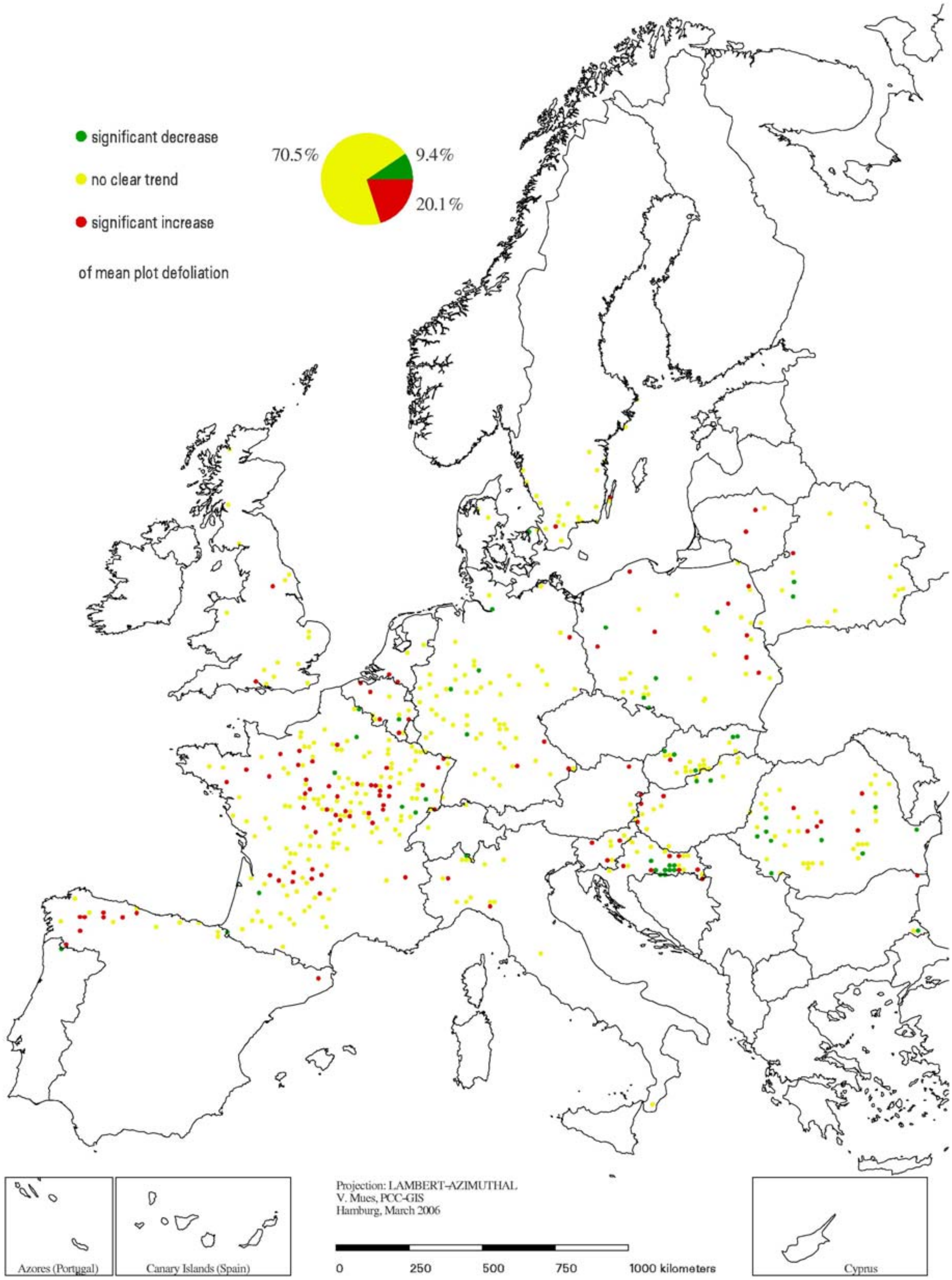


Figure 2.2.2.6-2: Trend of mean plot defoliation (slope of linear regression) of *Quercus robur* and *Quercus petraea* over the years 1997 to 2005.

2.2.2.7 Quercus ilex and Q. rotundifolia

Across all regions, *Quercus ilex* and *Quercus rotundifolia* shows an increase in the share of damaged trees to a peak of 28.1% in 1995. This deterioration was followed by a clear recuperation to 13.4% in 1998 (Figure 2.2.2.7-1). Since then the share of damaged trees of both samples (1990-2004 and 1997-2004) undulated around 20% until the year 2004. The subsequent sharp increase in 2005 is explained by exceptional summer drought. It is particularly obvious in the Mediterranean (Higher) region, where the share of damaged trees of the 1997-2005 sample reached 34.0%. In Portugal, after dry summers already in 2003 and 2004, the summer of 2005 was the driest for the last 50 years. Defoliation was caused by water deficit followed by insects and fungi outbreaks in trees weakened by insufficient water supply. Forest fires occurred also more frequently. Furthermore, Spain and France report unusual summer drought in recent years as the main cause of increasing defoliation.

A comparison of the maps in Figures 2.2.2.7-2 and 2.1.2.1-1 confirms that many of the plots with increasing defoliation are situated at higher altitudes. Of all plots on the map, 32.1% show increasing defoliation against only 6.5% with decreasing defoliation.

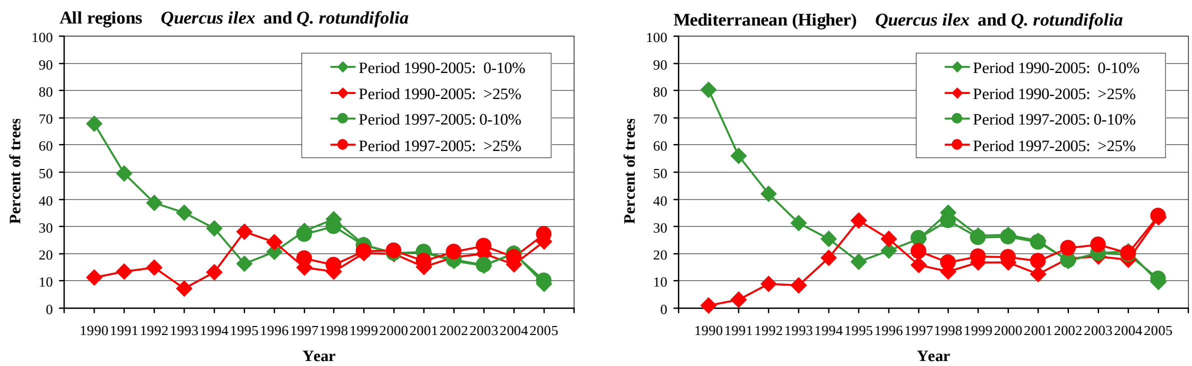


Figure 2.2.2.7-1: Shares of trees of defoliation 0-10% and >25% in two periods (1990-2005 and 1997-2005).

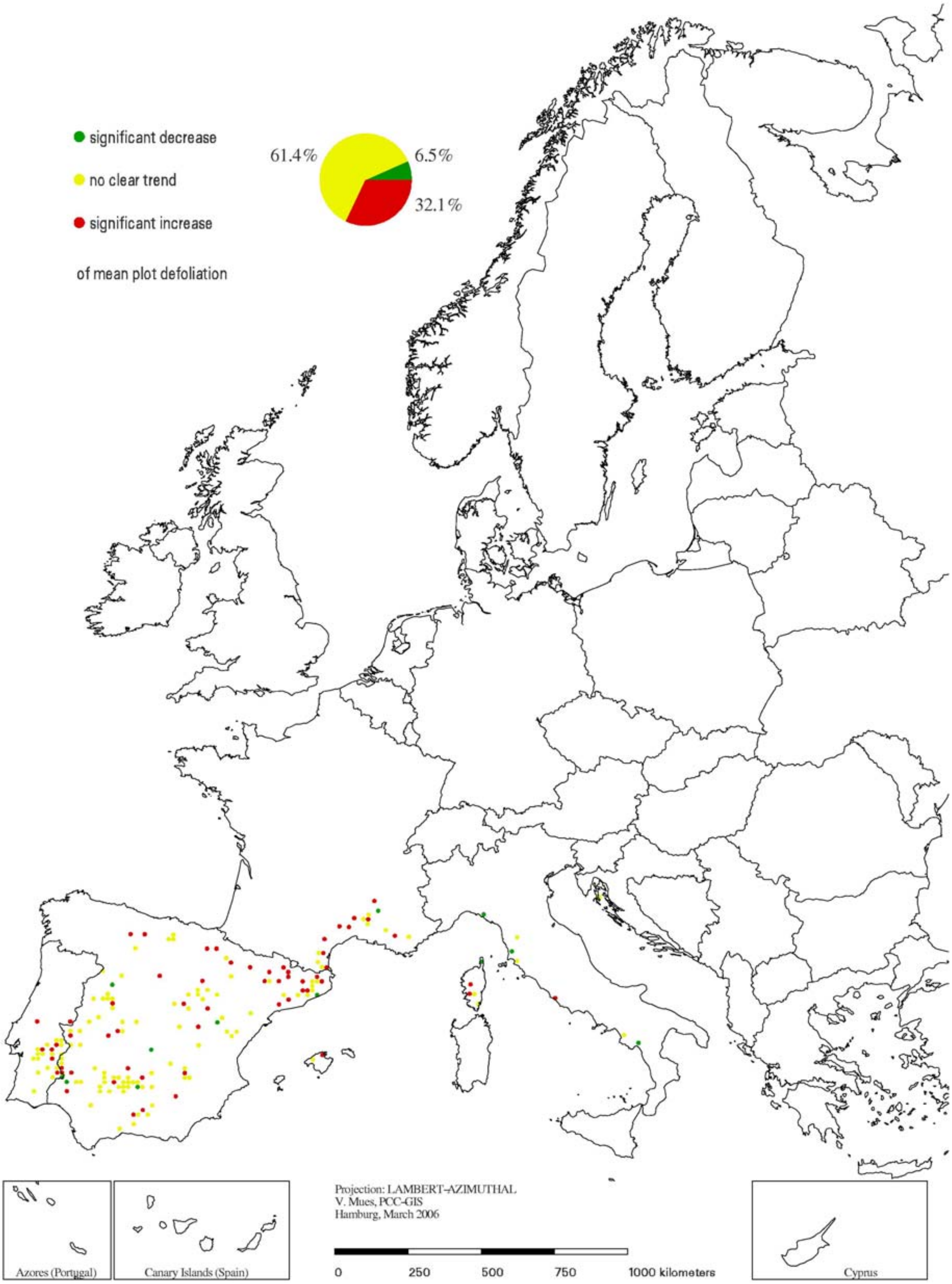


Figure 2.2.2.7-2: Trend of mean plot defoliation (slope of linear regression) of *Quercus ilex* and *Quercus rotundifolia* over the years 1997 to 2005.

2.2.2.8 Pinus pinaster

Over the entire period of observation, the share of damaged trees of *Pinus pinaster* across all regions changed only slightly (Figure 2.2.2.8-1). Despite this, defoliation of this species increased due to a continuous decrease in the share of not defoliated trees. This share fell from 68.1% in 1990 to 38.4% in 2004. This development reflects largely the one in the Mediterranean (Lower) and Mediterranean (Higher) regions, in which more than half of the sample trees are situated. In the Mediterranean (Higher) region, the share of damaged trees was nearly halved from 77.5% in 1990 to 42.6% in 2005.

The map in Figure 2.2.2.8-2 shows that the plots with increasing mean defoliation are scattered across the whole habitat, while a number of recuperating plots is concentrated in Portugal. The share of deteriorating plots is with 28.2% clearly larger than the share of improving plots with 13.0%.

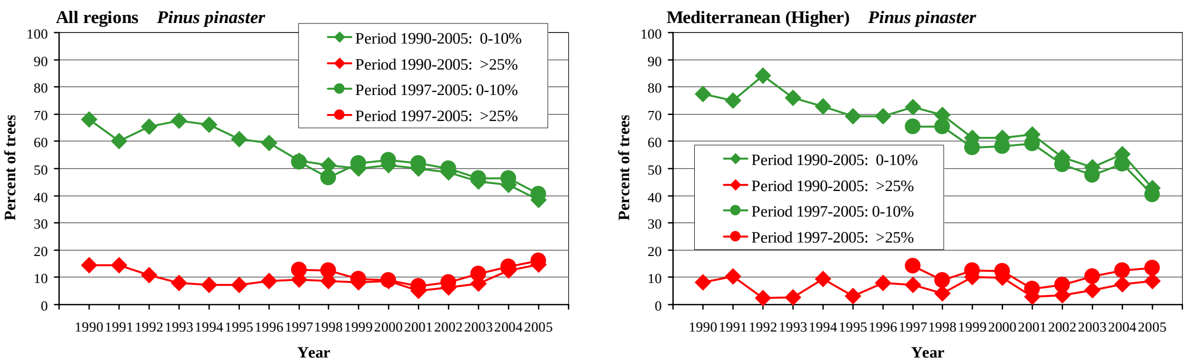


Figure 2.2.2.8-1: Shares of trees of defoliation 0-10% and >25% in two periods (1990-2005 and 1997-2005).

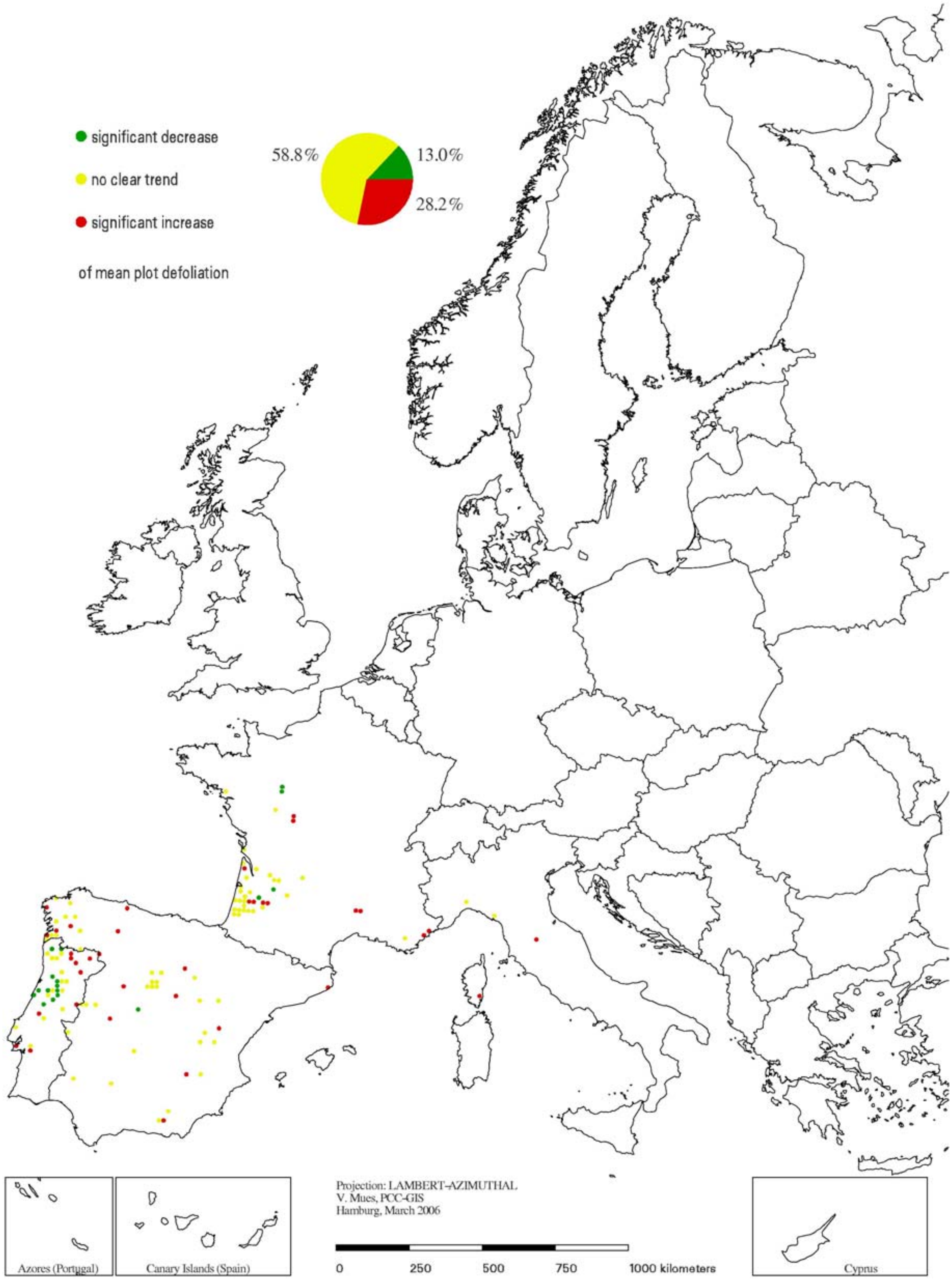


Figure 2.2.2.8-2: Trend of mean plot defoliation (slope of linear regression) of *Pinus pinaster* over the years 1997 to 2005.

2.2.3 Mortality

One of the problems in evaluation of mortality arises from the different ways of treating dead trees i.e. trees completely defoliated. In some countries trees with defoliation scores of 100% are removed, in other countries dead trees are kept in the database and are repeatedly reported as dead.

To avoid trees to be counted and qualified more than once as being dead, only trees that in a given year showed defoliation of 100% and in the subsequent year disappeared were considered as dead and included into the calculation of the mortality. As a sample suitable to reflect spatial and temporal changes in tree mortality, the time span from 2000 to 2005 was considered. By subdividing this sample into the time periods 2000 to 2002 and 2003 to 2005 the question was pursued if after extreme drought in 2003 a significant increase in the mortality of trees could be observed. The annual mortality as defined above and expressed in number of the dead trees and their share related to all trees sampled lies in all years below 0.5%. The increase in the year after the drought (2004) is negligible (Table 2.2.3-1 and Figure 2.2.3-1). The increase is larger in 2005, but given the small share of dead trees this must not necessarily be related to the drought.

Table 2.2.3-1: Annual mortality in 2000 to 2005.

Year	No. of sample trees	No. of dead trees	Mortality (%)
2000	13 2200	351	0.27
2001	13 2342	365	0.28
2002	13 1741	402	0.31
2003	13 1387	381	0.29
2004	13 5372	444	0.33
2005	13 3840	530	0.40

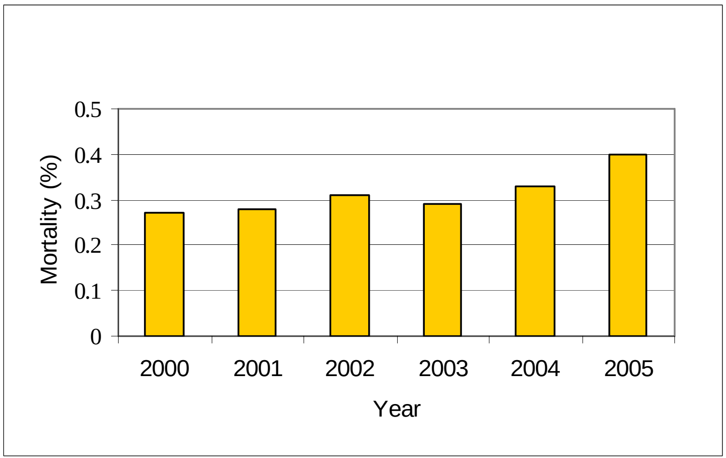


Figure 2.2.3-1: Development of the annual mortality between 2000 and 2005

In order to check if mortality increased in regions from which summer drought in 2003 was reported, it was mapped for the two periods 2000-2002 and 2003-2005 (not figured). Table 2.2.3-1 and Figure 2.2.3-1 comprise trees from all plots whose mortality dynamics range from only one tree scored as completely defoliated and disappeared up to all or almost all trees dying from one to the next assessment year. The different number of dead trees on plots was accounted for in the legend categories of the maps.

The overwhelming majority of plots experienced in both time periods only a slight mortality rate ranging from 1 to 5 trees per plot. The share of these plots is hardly different before (91.1%) and after the drought in 2003 (90.9%). The share of plots with more than 20 dead trees decreased in the time period 2003 to 2005 as compared to 2000-2002 from 3.5 to 1.8%. The spatial distribution of the plots (more or less affected by mortality) is similar in both maps. However, southern France shows an increase in the number of plots with 1 to 5 dead trees. Regions showing an increase in the number of dead trees per plot are southern Sweden as well as Spain and Bulgaria. Mortality in southern Sweden was caused by wind throw and an outbreak of *Gremmeniella abietina* (fungi affecting buds). Due to extended periods of drought mortality of trees (mainly with *Quercus* species and *Pinus halepensis*) increased in Spain in 2004 and 2005.

2.2.4 Further damage symptoms and their causes

Until 2004, the presence of the following damage types was reported (Chapter 2.1.3.1):

Game and grazing, insects, fungi, abiotic agents, direct action of man, fire, known regional air pollution, and other factors (T1-T8).

In 2005, a new system for the assessment of damage causes on Level I and Level II plots was implemented. The following 17 countries reported data according to the new method:

Austria, Belarus, Belgium (Flanders), Cyprus, Czech Republic, Finland, France, Italy, Latvia, Lithuania, Luxemburg, Norway, Poland, Slovak Republic, Spain, Sweden, United Kingdom.

The new method aims at providing information on the impact of damage factors on crown condition. It gives more detailed information on symptoms, causes and extent of the damage as follows:

- <u>Symptom description</u>
  Symptoms are divided into broad categories, e.g. wounds, necroses and deformations. Each symptom can be described more in detail. For instance, wounds are divided into cracks, debarking, and others. In addition, symptoms observed in the crown can be allocated to different parts of the crown (lower crown, upper crown, patches).

- <u>Determination of the cause</u>
  The damage causes are described in a hierarchical system. In the first step the previous categories (T1-T8) are maintained. However, in each category, a more detailed determination is possible. The most detailed level of the hierarchical system comprises the scientific names of the organisms involved.

- <u>Extent of damage</u>
  The extent of the damage is given as the percentage of the affected part of the tree (e.g. % of leaves eaten by defoliators).

In the following evaluation all trees submitted in tables prescribed for the detailed assessment of damage types are included into calculations. Of the 133 840 trees assessed for defoliation in 2005, about 66% (88 334 trees) were examined using the new damage type system. As different i.e. multiple damage types could be specified for a single tree the number of observations in tables presented below is much larger than 88 334.

Table 2.2.4-1 lists the most frequently assessed symptoms for each of the three parts of the trees. For each symptom the number of observations is given, i.e. the frequency with which the particular symptom was reported. Of the total number of observations, nearly one third were made on needles and leaves. Over 23% of the observations were made on branches, shoots and buds. Only 0.4% of observations refer to the stem and collar.

In 2005 nearly 15% of the observations refers to missing or devoured leaves and needles, followed by dead or dying branches and shoots. Discolouration constitutes the third largest share of observations (7.8%). That “missing or devoured leaves and needles” is a frequently observed symptom is not surprising: it reflects that defoliators are a quite common and widespread group of organisms in European forests. Moreover this symptom is easy to detect by the observers during crown condition assessment and may therefore be reported more frequently than other symptoms.
The shares of observations of all other symptoms are smaller. Deformations of needles and leaves comprise 4.5%, wounds on branches account for 4.2% of all observations. It is worth mentioning that the dozen of symptoms specified in Table 2.2.4-1 covers nearly all observations reported. Those symptoms on needles and leaves summarised as “other symptoms” account for only 1.2 % of the observations.

Table 2.2.4-1: Numbers and percentages of observations of symptoms in each part of the trees.

Affected part	Symptom	Number of observations	Percent
Needles and leaves	Partly or totally devoured/missing	18772	15.4
	Deformations	5428	4.5
	Light green to yellow discolouration	5526	4.5
	Red to brown discolouration (necrosis)	4061	3.3
	Signs of insects	2367	2.0
	Other signs	1512	1.3
	Signs of fungi	1126	0.9
	Microfilia	2050	1.7
	Other symptoms	1516	1.2
	Subtotal	42358	34.8
Branches, shoots and buds	Dead/dying	16372	13.5
	Wounds (debarking, cracks etc.)	5074	4.2
	Decay/rot	1948	1.6
	Resin flow (conifers)	1652	1.3
	Broken	1657	1.4
	Necrosis/necrotic parts	1213	1.0
	Other symptoms	447	0.4
	Subtotal	28363	23.4
Stem and collar	Various symptoms	591	0.4
Missing		50107	41.4
	Total	121419	100.0

Table 2.2.4-2 describes the affected part of the tree more in detail. The subtotals of the observations, however, are not the same as in Table 2.2.4-1 as the number of missing values vary among the evaluated parameters.

Table 2.2.4-2: Numbers and percentages of observations of tree parts affected.

Affected part		Number of observations	Percent
Needles and leaves	Broadleaves	19223	15.8
	Older needles	6005	4.9
	Needles of all ages	3864	3.2
	Current needle year	2763	2.3
	Subtotal	31855	26.2
Branches, shoots and buds	Current year shoots	879	0.7
	Twigs diameter < 2 cm	11506	9.5
	Branches diameter 2 <10 cm	5180	4.3
	Branches diameter => 10 cm	737	0.6
	Varying size	2428	2.0
	Top leader shoot	517	0.4
	Buds	91	0.1
	Subtotal	21338	17.6
Stem and collar	Main trunk or bole within the crown	1571	1.3
	Trunk between the collar and the crown	9475	7.8
	Whole trunk	939	0.8
	Roots (exposed) and collar (=< 25 cm)	3509	2.9
	Subtotal	**15494**	12.8
	Subtotal all three parts	68687	56.6
Dead tree		2677	2.2
No assessment		921	0.8
No symptoms on any part of trees		40856	33.6
Missing		8278	6.8
	Total	121419	100.0

The parameter “affected part” could be evaluated for 121419 observations (Table 2.2.4-2). Needles and leaves are reported most frequently as part of trees affected by damage agents (26.2%) followed by damage on branches, shoots and buds (17.6%). Stem and collar as damaged tree parts were found on 12.8% of all observations. The proportion of dead trees is surprisingly high (2.2%). No assessment was explicitly coded only in one country with 921 observations (0.8%) whereas other countries left out the specification completely when affected part could not be assessed resulting in 8278 missing values (6.8% of all observations).

The information specifying the location of the damage in the crown (mandatory only on Level II) was reported for 1 095 trees (Table 2.2.4-3).

Table 2.2.4-3: Numbers and percentages of observations for parameter “location in crown”

	Location in crown	Number of observations	Percent
Lower crown		681	62.2
Patches		357	32.6
Upper crown		57	5.2
	Total	1095	100.0

In the table below the most frequent causes of damage are compiled with information on number and percentages found. Only factors with a frequency 0.9% and more are presented separately.

Table 2.2.4-4: Numbers and percentages of observations of causes.

Cause	Number of observations	Percent
Defoliators	8273	6.8
Drought	5741	4.7
Dieback and canker fungi	3994	3.3
Stem, branch and twig borers	3532	2.9
Decay and root rot fungi	1300	1.1
Competition	1271	1.1
Needle cast and needle rust fungi	1132	0.9
Subtotal	25243	20.8
Investigated but unidentified	18768	15.4
Other causes	16004	13.2
Missing	61404	50.6
Total	121419	100.0

The largest share (6.8%) refers to defoliators. This is in line with the national reports on forest condition, where insects are often quoted as important damage causes. In 4.7% of all observations drought was found as a factor impairing the health of the trees. Different fungi groups occurring on leaves, needles and roots are also identified as causes of tree damage. In very few cases the individual damage agents were specified by their scientific names.

In this chapter some preliminary results of the new method for the assessment of damage causes are presented. These results indicate that this new method was implemented successfully and has proven to be operational in various forest types and on a large number of plots. Compared to the old method it provides more detailed information on the causes of the observed damage and allows to link these damage symptoms to certain damage factors. A major improvement is the availability of data on the severity of the stress factors and not only on their occurrence, increasing the potentials for cause – effect relationships. Keeping record of causal factors over the years will provide an interesting tool for quantifying their impact on tree health as well as their role in stand dynamics. It provides also new potentials for the assessment of combinations of stress factors and cumulative stresses.

3. INTENSIVE MONITORING

3.1 Introduction

The intensive monitoring aims to assess causal relationships on the forest ecosystem scale. For this purpose, more than 860 intensive monitoring (Level II) plots were selected in the most important forest ecosystems of 30 participating countries. Mandatory and hence to be carried out on all plots are annual assessments of crown condition, assessments of soil condition every ten years, bi-annual foliage chemistry surveys and forest growth studies every five years. Under the programme BioSoil a new soil survey is planned to be carried out on a limited number of Level II plots. Ground vegetation is assessed every five years on 715 plots. On 513 plots, atmospheric deposition is assessed continuously. Also continuously assessed are ambient air quality on 170 plots, soil solution chemistry on 242 plots and meteorology on 206 plots. Phenology is assessed several times per year on 64 plots. The complete methods of the intensive monitoring are laid down in the "Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests" (ANONYMOUS, 2004).

Results of the intensive monitoring have been presented in annual Technical Reports since 1997 (e.g. DE VRIES et al., 2003). Chapter 3.2 of the present report describes bulk and throughfall deposition as measured by the countries on their Level II plots until the year 2003. In Chapter 3.3, the measured depositions are compared with those depositions calculated with models by the Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe. Chapter 3.4 describes the effects of depositions on ground vegetation as assessed on Level II plots. Chapter 3.5 presents the approach and results of the application of dynamic models on Level II data aimed to estimate the future effects of depositions on forest soils.

3.2 Deposition and its trends

3.2.1 Introduction

Following the approach already described by LORENZ et al. (2005) for the calculation of deposition data from 1996 to 2001, deposition and its trends during the years 1998 to 2003 are presented in this section. Depositions, critical loads of depositions and exceedances of critical loads were presented by DE VRIES et al. (2002). ULRICH (2003) found linear trends in nitrogen, sulphur, calcium and magnesium concentration between 1992 and 2002 for the French intensive monitoring network "Renecofor". Mean concentrations of nitrogen and sulphur bulk depositions and their trends were presented by LORENZ et al. (2004).

A study of the temporal development and spatial variability of nitrate (N- NO_3^-), ammonium (N- NH_4^+) and sulphate (S- SO_4^{2-}) deposition on Level II plots from 1998 to 2003 is presented in this section. In addition, depositions of calcium (Ca), sodium (Na), and chlorine (Cl) as well as the amount of precipitation are taken into account whenever needed for a sound interpretation of the results.

3.2.2 Methods

The Level II data used were collected and analysed according to the ICP Forests Manual (ANONYMOUS 2004). The data employed for statistical analyses were checked and validated by the Forest Intensive Monitoring Coordinating Institute (FIMCI). Open field (bulk) deposition is measured in order to reflect the local air pollution situation. For assessments of air pollution effects on forests deposition under canopy throughfall and in some cases stemflow are measured. Deposition under canopy is mostly larger than in the open field as wet deposition is additionally polluted by dry deposition washed off the foliage. With respect to element fluxes in the forest canopy, two major processes can be observed during the passage of the deposition through the canopy:

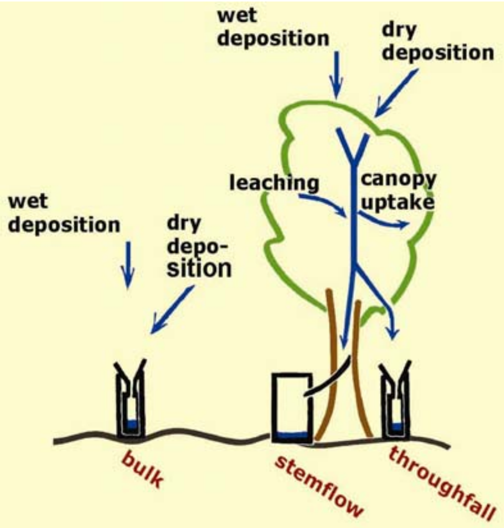


Figure 3.2.2-1: Deposition measurement in forests.

1. Leaching: The solution of an element, mostly of nutrient cations, from the tree crown into the precipitation water, which leads to an enrichment of the particular element in the throughfall deposition compared to bulk deposition.
2. Canopy uptake: The absorption of an element, mostly nitrogen compounds, from the precipitation water by the leaves which leads to decreased deposition of the particular element in the throughfall deposition compared to bulk deposition.

Both effects have to be taken into account when interpreting the results of this study related to throughfall deposition.

The study is based on the Level II data on bulk deposition measured in the open field and on throughfall deposition in order to describe the deposition under canopy. Due to the fact that stemflow data were available only for 17 plots continuously from 1998 to 2001 those measurements could not be taken into consideration which leads most probably to an underestimation of the throughfall deposition on these sites. A correction for sea salt impact was not calculated.

The variables subjected to the statistical analyses are bulk and throughfall deposition data expressed in terms of annual deposition in kg ha^{-1} a^{-1}. The time span for trend analyses was 1998 to 2003. This is a trade-off between the needs for high numbers of plots in order to cover a wide range of deposition situations and for the length of the time span. In fact, real trend analysis begins to make sense only for periods of at least 10 years and, thus, the present study must be understood as a case of descriptive analyses.

From the approximately 500 sites on which deposition is measured within ICP Forests, only those sites were selected which have been operational for the whole period 1998-2003, with a maximum of 1 month of missing data per year (s. Table 3.2.2-1). Deposition in missing periods was replaced by the respective average daily deposition of the remaining year.

For mapping and quantifying temporal developments, the slope of plot specific linear regression over the years of observation was used. Thus, with the years of assessment as predictor and annual deposition as target variable for each plot, linear relationships were obtained. The slopes of the linear equations were statistically tested and depicted in maps according to the following classification:

- Significant decrease: negative slope, error probability lower or equal 5% (green)
- Decrease: negative slope, error probability greater than 5% (light green)
- Significant increase: positive slope, error probability lower or equal 5% (red)
- Increase: positive slope, error probability greater than 5% (orange)
- no slope, same deposition in each year (grey)

In order to get information if trends for a particular ion are due to trends in precipitation the trends of deposition water amount were mapped as well. It must be stressed that conclusions about temporal changes in ion deposition based on such short time series can only be made with great reservations and do not have final character or validity.

In order to describe the high variability of deposition, the plot-wise mean deposition for a three years period (2001 to 2003) was mapped instead of deposition of a single year. The period 2001 to 2003 gives the most recent picture of the deposition situation. By selecting measurements from only 3 years a higher number of plots could be taken into account than in case of a longer time span (Table 3.2.2-1). For the mapping of mean deposition, percentile classes were chosen comprising the whole range of values found. The percentiles were calculated for the combination of bulk and throughfall values in order to permit a comparison between bulk and throughfall maps due to uniform threshold values.

Table 3.2.2-1: Number of plots which fulfilled the selection criteria.

No. of observations		Na^+	Cl^-	Ca^{2+}	N- NH_4^+	N- NO_3^-	S- SO_4^{2-}
Trend 1998 – 2003	Bulk	208	209	208	208	209	202
	Throughfall	239	240	239	239	240	233
Mean 2001 – 2003	Bulk	233	233	233	232	233	225
	Throughfall	265	265	265	264	265	267

3.2.3 Results

It must be clearly stated here that the throughfall deposition evaluated in this study does not reflect the total deposition. Neither the stemflow deposition nor the interactions between the canopy and the wet deposition are taken into account. The results are to be interpreted as a descriptive study in order to present the field measurements. All statements about the deposition quantities are intended to give a relative view of the deposition situation on the evaluated plots. No interpretations on absolute level are made.

3.2.3.1 Mean Annual Deposition 2001 to 2003

For ammonium, nitrate and sulphur as the most important anions in the acidification process the mean annual deposition in the period 2001 to 2003 was calculated in bulk as well as in throughfall deposition. To enable a sound interpretation of the results, in addition, calculations for sodium, chloride and calcium were done. Thus, Figure 3.2.3-1 shows the mean annual sodium (Na^+) bulk deposition in order to get an impression on which plots probably sea spray is an important source of sodium and sulphate deposition. Many of those plots which are in the class with highest sodium depositions are located close to the coast and seem to be influenced by sea spray effects.

Some of the plots on which relatively high sulphur bulk depositions were measured (Figure 3.2.3-2) also relatively high depositions of sodium are observed (Figure 3.2.3-1), e.g. at the west coast of the UK, in the south west of Norway or in Italy and Greece. On the other hand there are also plots with relatively high sulphur deposition in the Czech Republic, Slovakia, the west of Germany, and the North of Italy on which the relatively high sulphur deposition can not be linked to sea spray due to large distances to the coast and surrounding plots with lower sulphur deposition. Thus, the combined interpretation of sodium and sulphur depositions permits an identification of plots with relatively high sulphur depositions which are most probably of anthropogenic origin.

For the mean annual throughfall deposition of sulphate (Figure 3.2.3-3) a higher number of plots with relatively high deposition values were observed. These are located in Central Europe, the United Kingdom and the south of Sweden and Norway. The classification of the values used for the mapping of sulphur bulk and throughfall deposition is uniform. The share of plots in the classes with relatively high sulphur deposition is higher for throughfall than for bulk deposition.

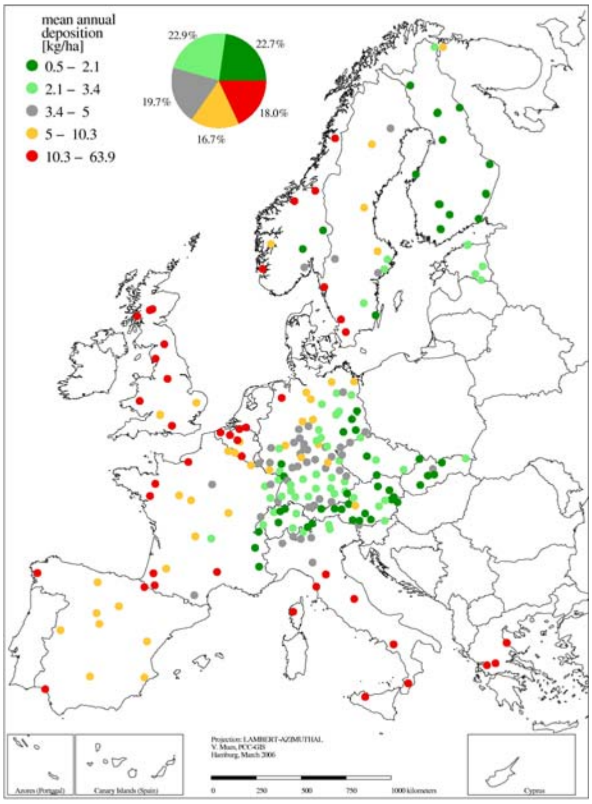


Figure 3.2.3-1: Mean annual sodium (Na^+) bulk deposition 2001 to 2003.

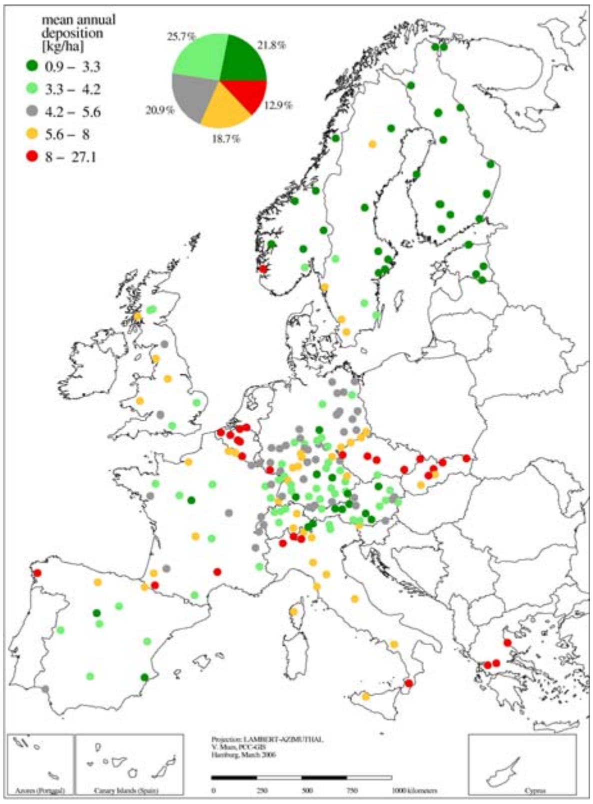


Figure 3.2.3-2: Mean annual sulphate (S- SO_4^{2-}) bulk deposition 2001 to 2003.

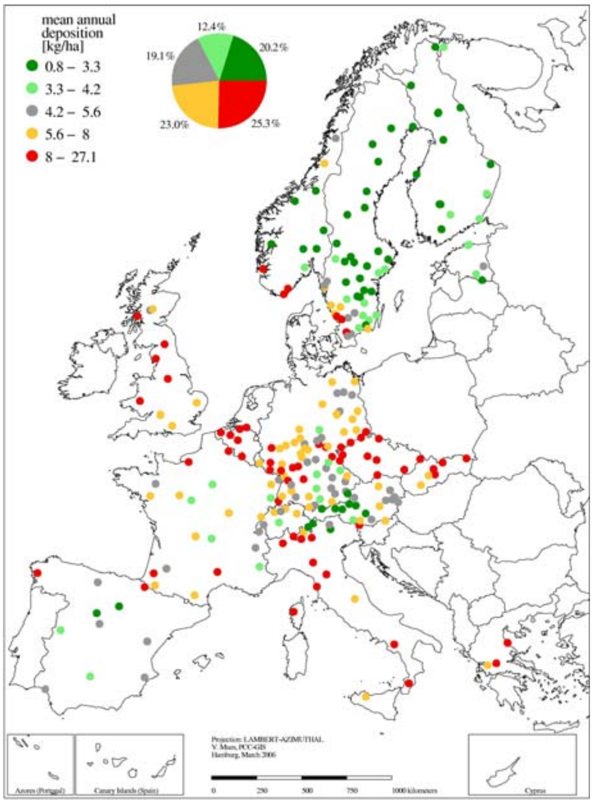


Figure 3.2.3-3: Mean annual sulphate (S- SO_4^{2-}) throughfall deposition 2001 to 2003.

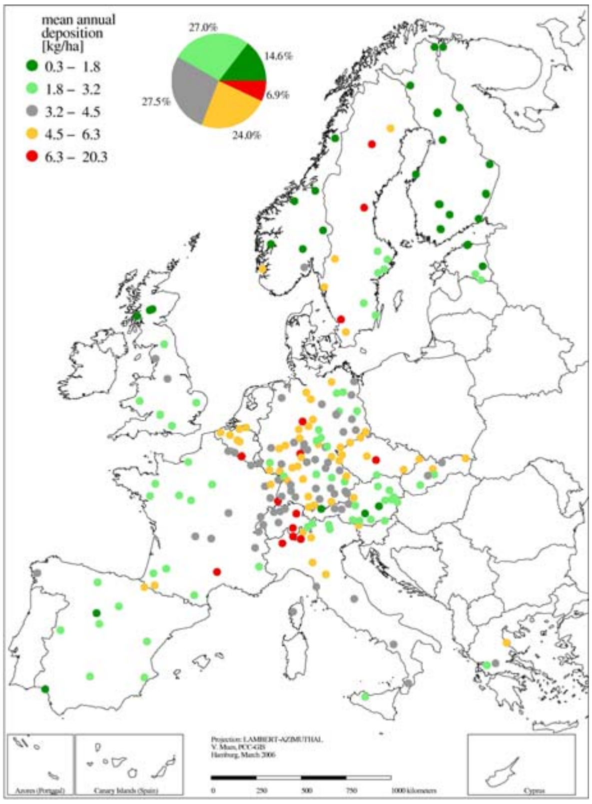


Figure 3.2.3-4: Mean annual nitrate (N- NO_3^-) bulk deposition 2001 to 2003.

As traffic is a major source of nitrate depositions relatively high values for the mean annual nitrate bulk deposition (Figure 3.2.3-4) are measured in Central Europe. But also in Sweden and in northern Italy relatively high values are found.

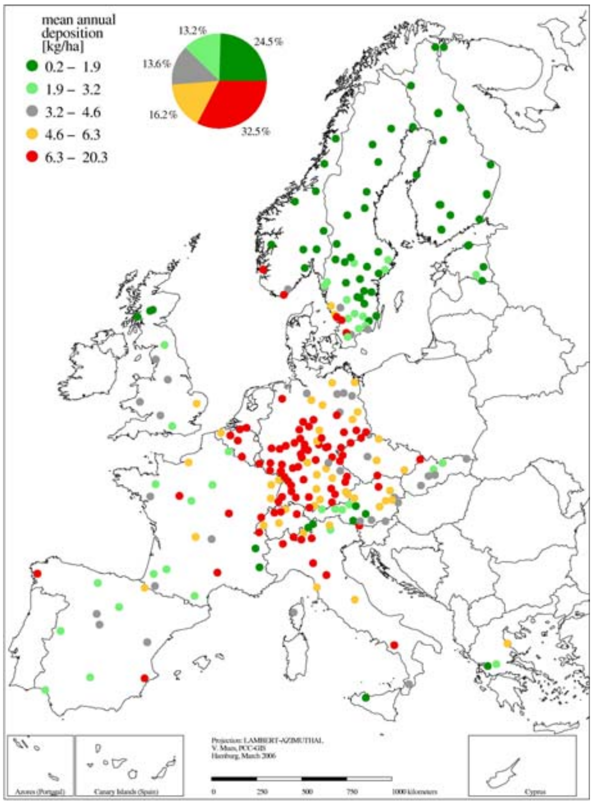


Figure 3.2.3-5: Mean annual nitrate (N- NO_3^-) throughfall deposition 2001 to 2003.

As already described for sulphur the amount of nitrate is relatively higher in throughfall (Figure 3.2.3-5) than in bulk deposition on the evaluated plots. Whereas for bulk deposition only 6.9% were found in the highest deposition class, for throughfall deposition the share of plots in the highest nitrate deposition class (6.3 to 20.3 kg ha^{-1} a^{-1}) is 32.5%. On most plots for which high bulk deposition values were calculated also high throughfall deposition values were found but there are also some exceptions. E.g. in northern Sweden high nitrate bulk deposition and relatively low nitrate throughfall deposition are observed for the same plots. This could be an indication for N-uptake during the rain passage through the canopy (Chapter 3.2.2).

Similar to the findings for nitrate the mean annual depositions of ammonium are high on plots in Central Europe and in case of bulk deposition also in Sweden (Figure 3.2.3-6). For nitrate two observations can be made which are described above also for ammonium: Throughfall deposition is higher than bulk deposition on most plots and there are also plots with the opposite relation (Sweden and northern England).

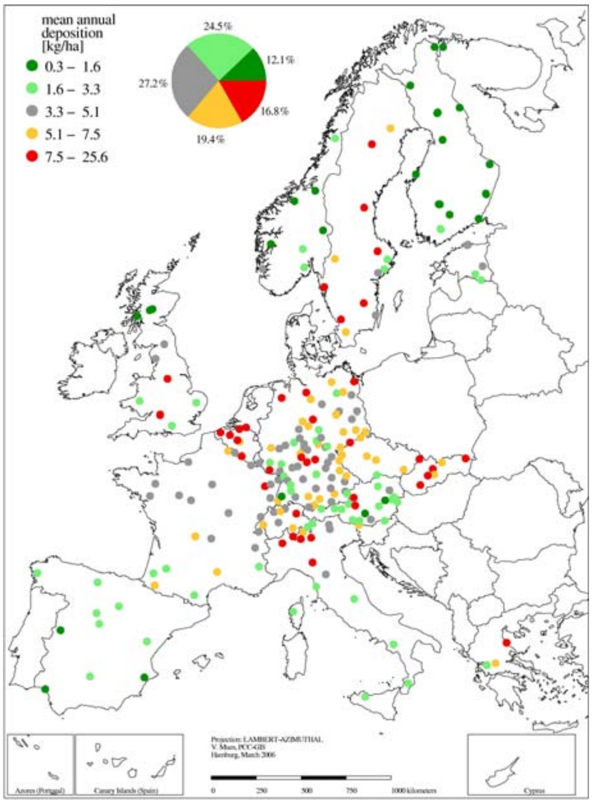


Figure 3.2.3-6: Mean annual ammonium (N- NH_4^+) bulk deposition 2001 to 2003.

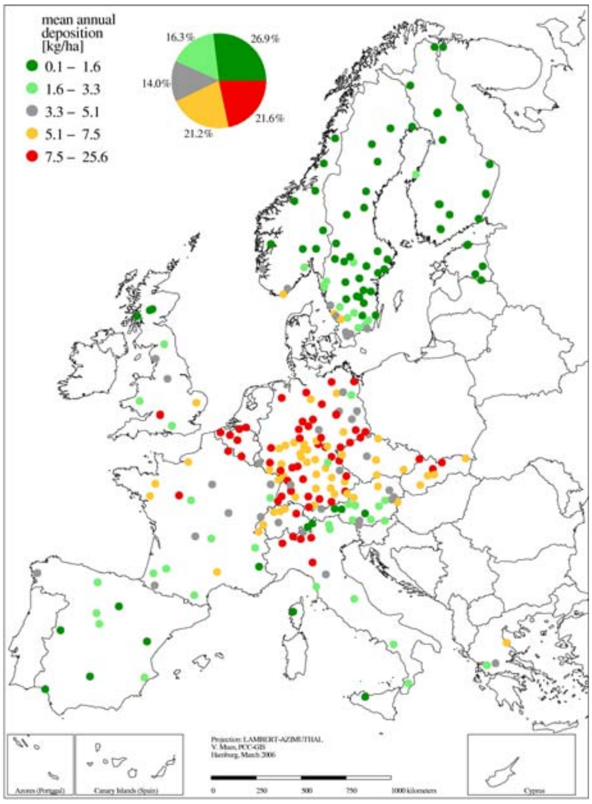


Figure 3.2.3-7: Mean annual ammonium (N- NH_4^+) throughfall deposition 2001 to 2003.

3.2.3.2 Trends

Mean annual deposition shows a reduction for sulphate and a less clear development for ammonium and nitrate deposition from 1998 to 2003 (Figure 3.2.3-8). Sulphur throughfall deposition decreases from almost 9.3 kg ha^{-1} a^{-1} in 1998 to 5.8 kg ha^{-1} a^{-1} in 2003. The reduction of bulk deposition from 6.5 to 4.3 kg ha^{-1} a^{-1} is at a relatively lower level but consistent with the reduction in throughfall deposition. As further results show the deposition situation is of high variation on the examined Level II plots and the results of this study cannot be ex-

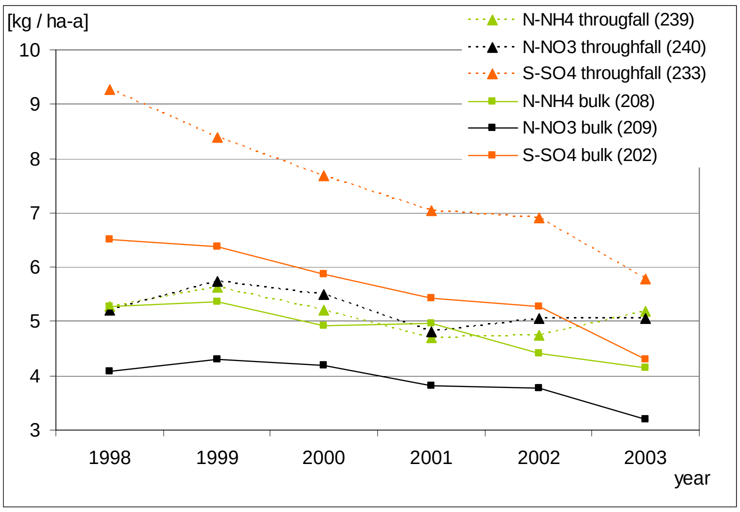


Figure 3.2.3-8: Mean annual deposition of sulphate, nitrate and ammonium in bulk and throughfall deposition.

trapolated to entire Europe. This is also true due to the fact that the Level II plots are not representative for Europe but a selection of typical forest types all over Europe.

The mean depositions of nitrogen compounds are of low variability at relatively low level. Nevertheless, especially in Central Europe there are some plots with relatively high nitrogen deposition. Especially in bulk deposition a decrease is observed. Two very interesting observations can be made for the year 2003 which was characterised by a very hot and dry summer in Central Europe. Whereas throughfall deposition for nitrate and especially for ammonium increased from 2002 to 2003 a decrease for the other deposition compounds can be observed. A possible explanation for this could be the main source for ammonium, namely intensive agriculture and cattle breeding. Gaseous emissions due to intensive cattle breeding can be expected to be higher with higher temperatures.

In order to permit a sound interpretation of the development of deposition and due to the fact that the amounts of bulk deposition and throughfall deposition depend on the amount of wet deposition it is a basic need to know the trend of precipitation. The plot specific trends of the amount of water in bulk deposition are not figured. Mean annual precipitation decreased on more than 80% of the evaluated plots in opposite to the period 1996 to 2001 (on less than 30% of the plots). This reflects most probably the very dry summer 2003 in Central Europe.

Following the described positive correlation between the amount of precipitation and deposition one should expect decreasing deposition on most plots during the evaluation period. This expectation is fulfilled e.g. in northern Finland where statistically significant decrease of precipitation coincides with statistically significant decrease in nitrate bulk deposition (Figure 3.2.3-9). The opposite relation can be observed for a plot in eastern Austria where a significant increase in nitrate bulk deposition coincides with a (not significant) decrease in precipitation.

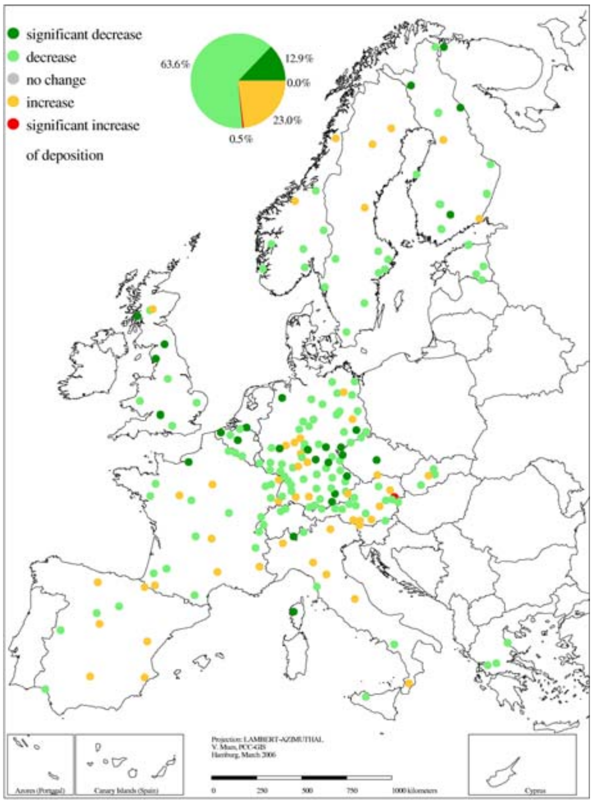


Figure 3.2.3-9: Trends of nitrate (N- NO_3^-) in bulk deposition 1998 to 2003.

Most probably due to the dry summer in 2003 on most plots in Central Europe the amount of water in bulk deposition, the precipitation, decreased during the observed period. This decrease was statistically significant only on some plots in Scandinavia, the UK, the north of France and on Sicily. The trends in bulk deposition of nitrate (Figure 3.2.3-9) and of ammonium (Figure 3.2.3-12), in general, reflect this decrease by a respective decrease in deposition. The opposite can be observed for nitrate and ammonium throughfall deposition on a number of plots in Central Europe: throughfall deposition increased from 1998 to 2003 (Figure 3.2.3-10 and Figure 3.2.3-11). The contrary observations for bulk and throughfall deposition are most probably caused by the relatively high amount of dry deposition in throughfall deposition. The filtering effect of trees seems to be even more important and effective in dry years.

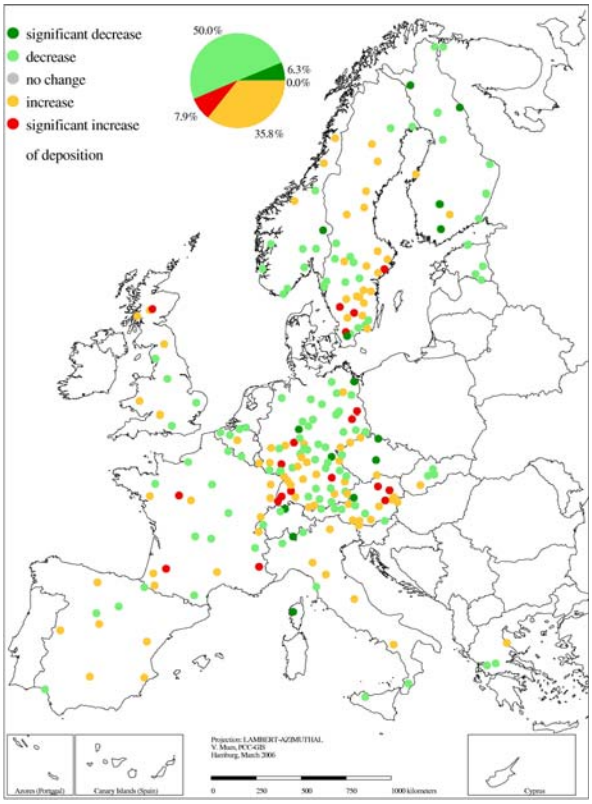


Figure 3.2.3-10: Trends of nitrate (N- NO_3^-) in throughfall deposition 1998 to 2003.

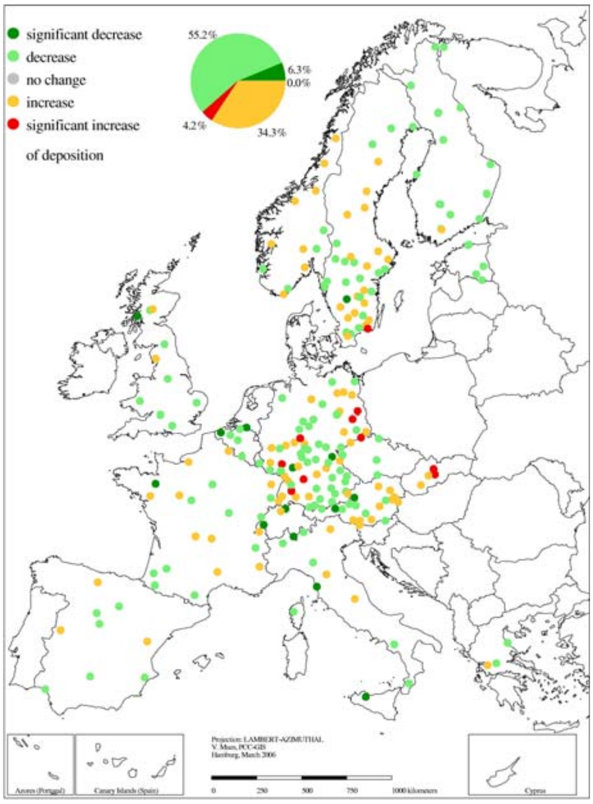


Figure 3.2.3-11: Trends of ammonium (N- NH_4^+) in throughfall deposition 1998 to 2003.

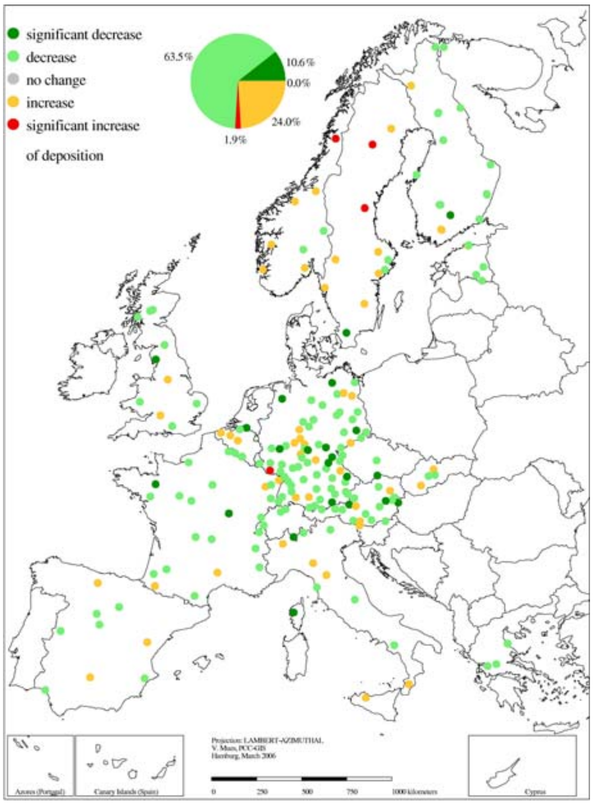


Figure 3.2.3-12: Trends of ammonium (N-NH_4^+) in bulk deposition 1998 to 2003.

The only exceptions from the positive correlation between precipitation and deposition in bulk deposition were found for ammonium in northern Sweden and Norway and on one plot in western Germany (Figure 3.2.3-12) where a significant increase in deposition was observed although precipitation decreased during the evaluation period (not figured). Interestingly, this increase in bulk deposition did not coincide with a respective increase in the throughfall deposition which might be explained by N-uptake.

The same observation - increase in bulk but decrease in throughfall deposition – is made for sulphur in the north of Sweden (Figure 3.2.3-13 and Figure 3.2.3-14). Most plots show a decrease in bulk deposition as well as in throughfall deposition which may reflect the decrease in wet deposition / precipitation.

The highest frequency of plots with statistically significant decrease in deposition was found for sulphur throughfall deposition with 30.9% (Figure 3.2.3-13), on 59.7% of the plots a decrease was found but not significantly.

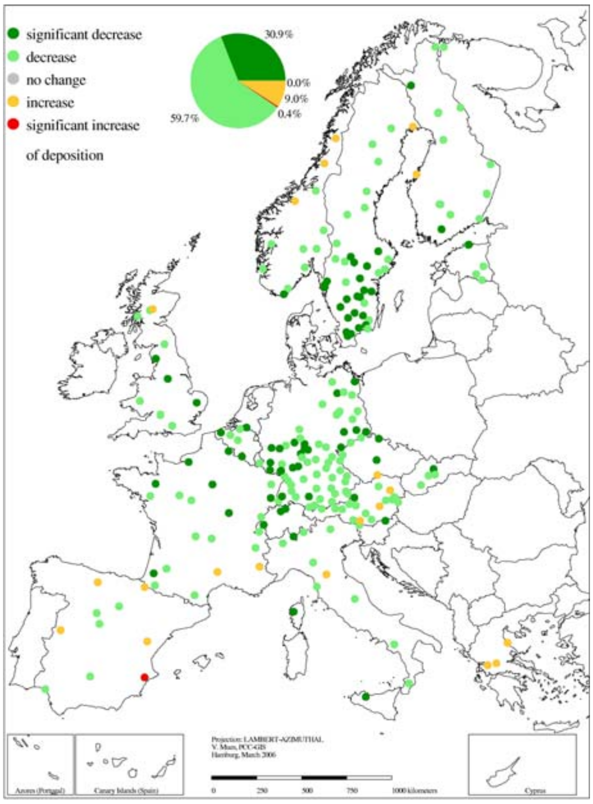


Figure 3.2.3-13: Trends of sulphate (S- SO_4^{2-}) in throughfall deposition 1998 to 2003.

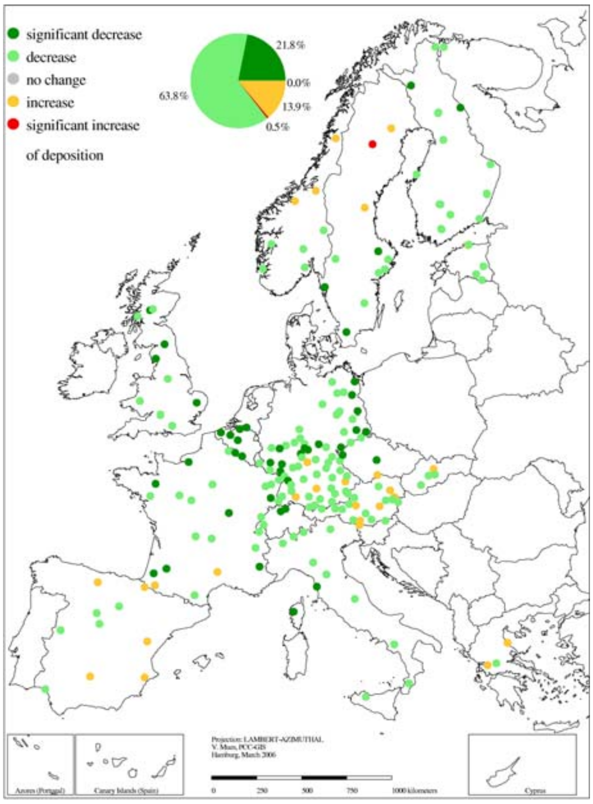


Figure 3.2.3-14: Trends of sulphate (S- SO_4^{2-}) in bulk deposition 1998 to 2003.

3.3 Evaluation of ground vegetation with special respect to deposition effects

3.3.1 Introduction

Ground vegetation is a major component of forest ecosystems. It is linked to nutrient cycling and interacts directly with other biotic and abiotic components. Vegetation layers contain and determine large parts of the biological diversity of forest ecosystems.

Ground floor vegetation assessments are mandatory at all Level II plots. Repetitions are foreseen at least every five years. Data from a larger number of plots are available from 1994 onwards. First evaluations of these data were published by DE VRIES (2002 and 2003). These evaluations were focussing on the present state of the ground floor vegetation and its relation to environmental influences.

Hypothesis
The current evaluation of vegetation relevés from Level II plots is based on an enlarged data set including data up to the year 2003. The underlying hypothesis of this study is that nitrogen deposition is related to the species composition of the ground vegetation. In addition it was of specific interest to find out whether the repeated ground vegetation assessments allow for a detection of changes in vegetation composition that might be driven by changing environmental conditions.

Plots evaluated
For the current evaluation, information from vegetation relevés was available for a total of 720 sites for the years from 1994 to 2003. Vegetation assessments were carried out by national experts at one marked plot or on a series of marked subplots per monitoring site. In 2002, it was decided to use a common sampling area of 400 m^2. Prior to this year the use of deviating national standards was allowed within the monitoring programme. Therefore a wide variety of different plot sizes were used (Figure 3.3.1-1).

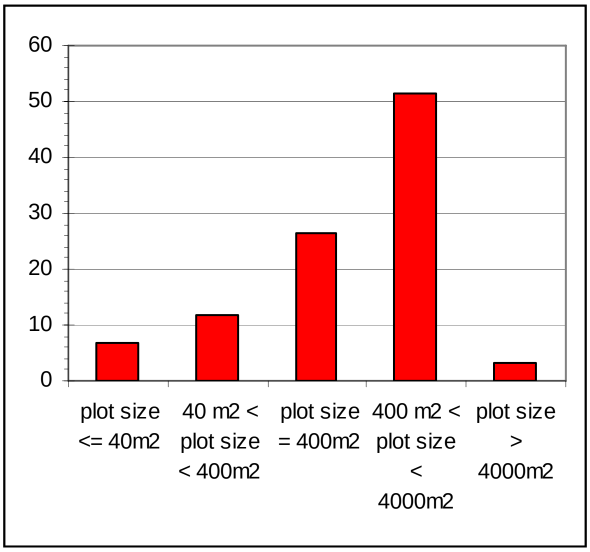


Figure 3.3.1-1: Percentage of plots with different plot sizes. n = 720 plots (in case of repeated surveys per plot, the last one was taken).

Due to repeated surveys at a number of plots, the total number of vegetation relevés was 1460. All intra-annual repetitions and all subplot information per plot were merged into one composite relevé, resulting in maximally one relevé per plot and year. Among those were 243 plots respectively relevés which had been sampled only once, while other plots had been sampled up to five times (Table 3.3.1-1).

Table 3.3.1-1: Number of vegetation surveys per plot.

number of surveys per plot	number (percentage) of concerned Level II plots	number (percentage) of vegetation relevés
1	243 (34%)	243 (17%)
2	359 (50%)	718 (49%)
3	55 (8%)	165 (11%)
4	9 (1%)	36 (2%)
5	26 (4%)	130 (9%)
6	28 (4%)	168 (12%)
total	720 (100%)	1460 (100%)

Vegetation surveys are available for different years (Table 3.3.1-2). For 1994, there were data from 26 plots available. In 1995, a total number of 113 plots had been surveyed, however, 26 of them were repetitions of the pervious year. A first peak is reached in 1998 with 283 relevés. The highest number of relevés was available for the year 2000.

Table 3.3.1-2: Number of relevés sampled at Level II monitoring plots per year.

year	number of relevés
1994	26
1995	113
1996	84
1997	43
1998	283
1999	157
2000	298
2001	137
2002	56
2003	263
total	1460

Fencing

38.4% of the plots were fenced and 61.6% were unfenced. A differentiated evaluation with respect to fencing was not conducted. DE VRIES et al. (2002 and 2003) showed that there was no significant effect of the fencing on ground vegetation composition at Level II plots at that time.

Cover estimates, layers and species numbers

Species abundance for ground floor vegetation was assessed using different scales like BRAUN-BLANQUET (1964), LONDO (1976), straight percentage cover, or others. The different scales were transformed into cover percentages following the ICP Forests manual (PCC 1998 and later updates).

Total percentage cover for moss, herb and shrub layer was assessed for each plot. The moss layer included terricolous bryophytes and lichens. The herb layer included all vascular plants below a height of 0.5 m. The height of the shrub layer was defined between 0.5 and 5 m. If individuals of herbaceous species or dwarf shrubs (e.g. *Pteridium aquilinum* or *Vaccinium myrtillus*) grew higher than 0.5 m, they were also assigned to the herb layer. A comparable approach was chosen for slightly lignified shrubs like *Rubus mult. spec*.

Within the ground floor layer of the 1460 vegetation relevés, a total of 2003 vascular plant species was identified. Additionally, 91 unidentified taxa were registered. The frequency distribution of the species was typically J-shaped, with a few very abundant and many rare species. Table 3.3.1-3 presents the 25 most abundant species identified at the monitoring sites. The overall mean cover gives an estimate of the average abundance of each species. There are species that occur in many relevés, but have a low mean cover, like e.g. rowan (*Sorbus aucuparia*). Other species like blueberry (*Vaccinium myrtillus*) occur rather frequently and have a high mean cover.

Table 3.3.1-3: Frequency and over-all cover of the 25 most abundant vascular plant species on 720 Level II monitoring sites in Europe (in case of repeated surveys, only the last relevé was taken).

	species	frequency	mean cover [%]
1	*Vaccinium myrtillus*	504	17.7
2	*Deschampsia flexuosa*	420	11.3
3	*Sorbus aucuparia*	404	0.4
4	*Dryopteris carthusiana*	324	2.1
5	*Picea abies*	302	1.1
6	*Vaccinium vitis-idaea*	300	8.3
7	*Oxalis acetosella*	298	9.4
8	*Luzula pilosa*	261	0.5
9	*Maianthemum bifolium*	259	2.6
10	*Rubus idaeus*	257	6.5
11	*Quercus robur*	219	1.0
12	*Pinus sylvestris*	213	0.3
13	*Melampyrum pratense*	193	1.0
14	*Trientalis europaea*	193	1.0
15	*Calluna vulgaris*	191	2.0
16	*Fagus sylvatica*	191	2.2
17	*Calamagrostis arundinacea*	170	4.5
18	*Dryopteris filix-mas*	170	1.7
19	*Athyrium filix-femina*	162	2.5
20	*Solidago virgaurea*	150	0.5
21	*Betula pendula*	147	0.2
22	*Frangula alnus*	146	0.3
23	*Anemone nemorosa*	133	6.9
24	*Fragaria vesca*	128	1.8
25	*Dryopteris dilatata*	127	3.4

Most relevés had species numbers below 30 species. The highest frequency was recorded for the class of 10 – 20 species per plot (Figure 3.3.1-2); the recorded maximum is 128 species within one relevé.

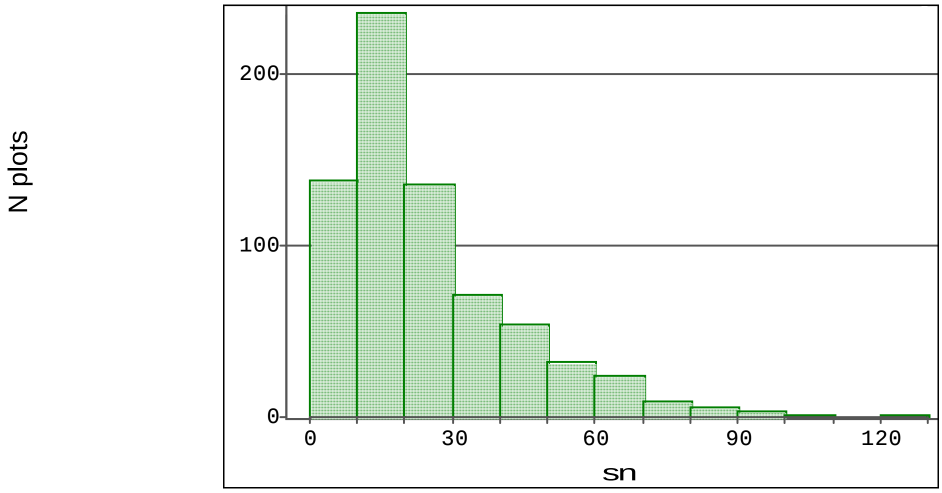


Figure 3.3.1-2: Frequency distribution of species numbers (sn) per plot (in case of repeated surveys, the last one was taken).

Soil and deposition data

Intensive Monitoring at Level II plots includes, among others, deposition measurements (LORENZ et. al 2005) as well as a soil survey (DE VRIES et. al 2000). The soil survey for most of the Level II plots was carried out in 1995. Deposition data were used for the years 1991 (6 plots) until 2001. Parameters used are listed in Tab. 3.3.3-4.

3.3.2 Diversity measures and vegetation structure at plot level

Since there is a narrow relationship between plot size and number of species growing on a plot, a simple comparison of species numbers per plot is heavily biased by differing plot sizes and is therefore not presented as map. In addition to species number, which is one of the major indicators for local (α) biodiversity, there are other more sophisticated estimates. A number of these indices, like Simpson index or Shannon-Wiener diversity are based on species number as a major component and thus, like species number itself, heavily depend on plot area and are therefore also not presented.

Only evenness (PIELOU 1969), which focuses at the relative abundance of all species at a plot, is almost unbiased by different sampling areas. Evenness was calculated for all Level II relevés at the basis of the cover percentages. Evenness values can vary between 0.01 (one species strongly predominating) and 1.0 (all species have the same share of cover). Evenness (J’) was calculated as:

$$J' = D' / \mathrm{ld}(S)$$

$D' = -\Sigma\, p_i * \mathrm{ld}(p_i)$ (= Shannon-Wiener diversity)

$p_i = cov_i / \Sigma\, cov_i$

cov_i: cover of individual taxa

S: total species number

The mean evenness for 1492 relevés was 0.6 (Figure 3.3.2-1).

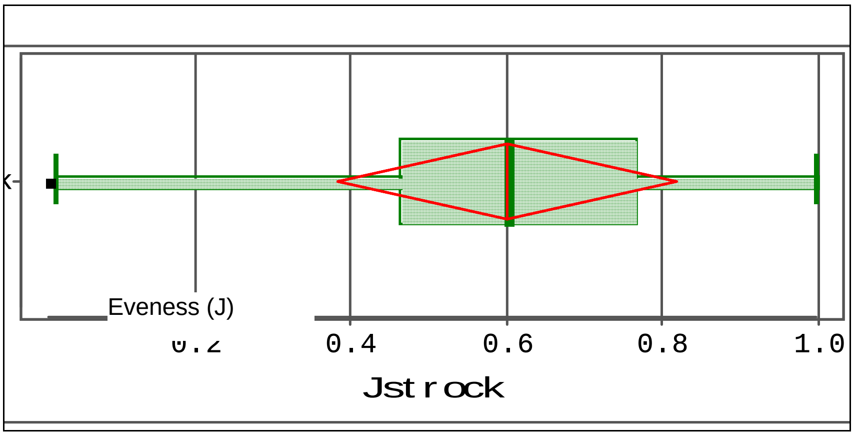


Figure 3.3.2-1: Box whisker plot for plot-wise evenness values (box: median, 25th, 75th percentile, whisker: mean plus/minus standard deviation, end of stalks: minimum, maximum); n = 1452 relevés (relevés with one species excluded).

The geographical distribution of evenness values (Figure 3.3.2-2) shows some small- to medium-scale clustering. This may originate from local, regional or country-specific forest management practices as well as from regional plant-sociological peculiarities. A general spatial trend over the whole of Europe cannot be observed.

The total herb layer cover is an important structural feature of forest ecosystems. High covers of the herb layer were observed on plots in eastern Germany, across Poland and in the Baltic states (Figure 3.3.2-3). The dense ground vegetation at these plots is mainly explained by a low coverage of the tree layer that mainly consists of *Pinus sylvestris*. *Pinus sylvestris* naturally has transparent crowns and enables rather dense undergrowth. Mean cover of the shrub layer (Figure 3.3.2-4) was as well high on plots in Eastern Europe, but as well in the south-west of Europe. The geographic distribution of moss abundance delivers a quite different picture (Figure 3.3.2-5): a distinct spatial trend can be observed from plots with sparse moss layers in the southern regions to dense moss layers on the plots in Scandinavia and north-eastern Europe.

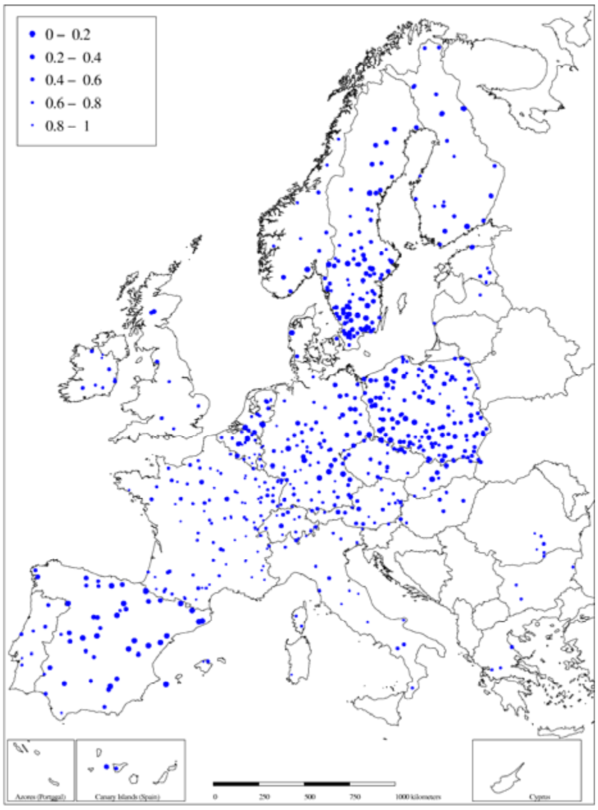


Figure 3.3.2-2: Evenness (J') of ground vegetation at Level II plots in Europe.

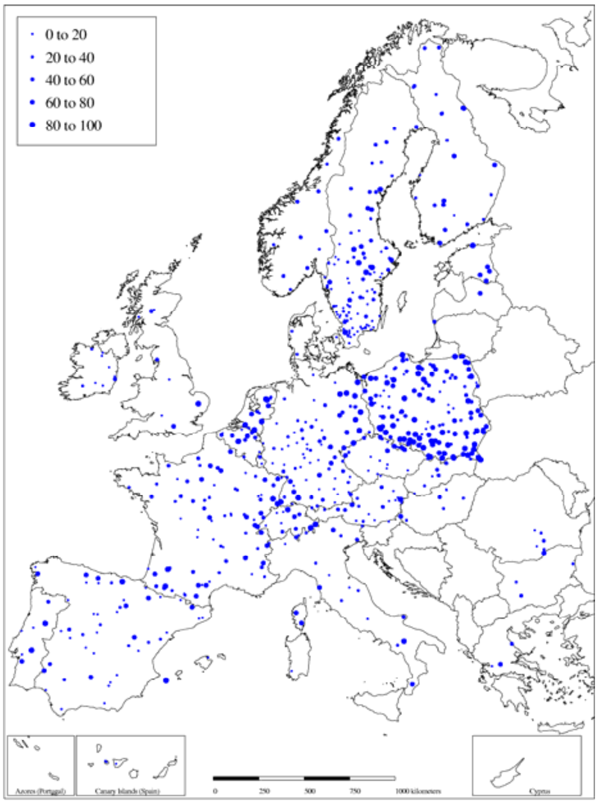


Figure 3.3.2-3: Mean % cover of the herb layer.

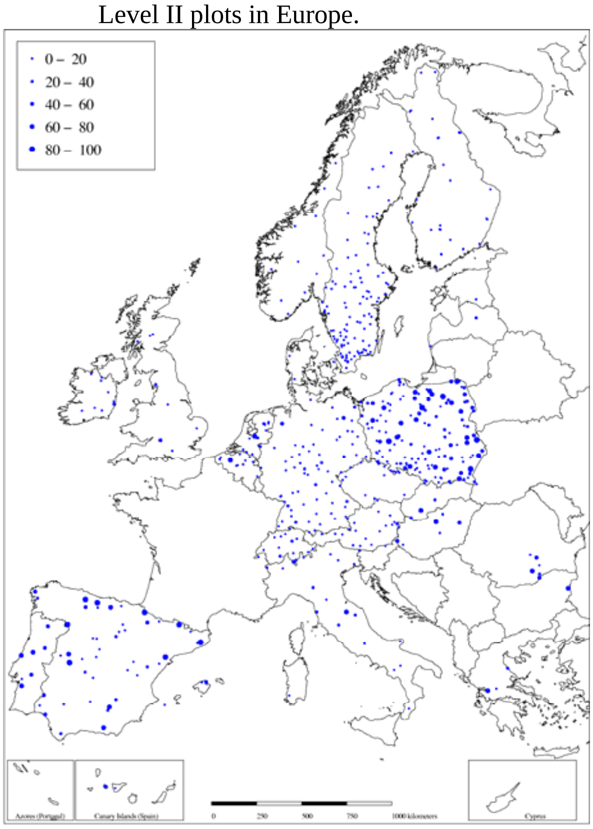


Figure 3.3.2-4: Mean % cover of the shrub layer.

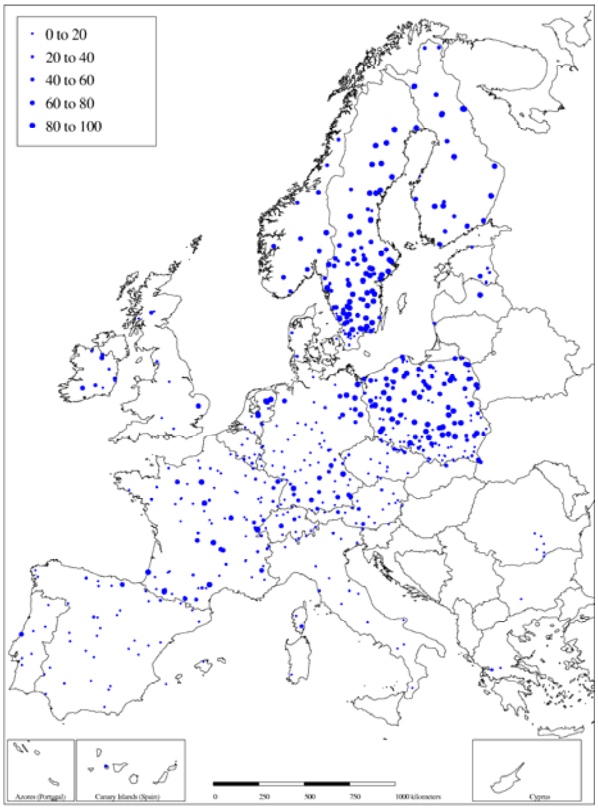


Figure 3.3.2-5: Mean % cover of the moss layer.

3.3.3 Floristic composition of ground floor vegetation and its relation to soil condition and deposition

The complete trans-national data set

Similarities of the floristic composition can be classified e.g. by cluster analysis (cf. WILDI 1986) or treaded by ordination techniques (TER BRAAK 1987). Both approaches aim to reduce the high dimensionality of the floristic space (here in total over 2000 species, each representing an axis in a multidimensional space). Within this study, ordination techniques were applied, because plot-related scores derived from an ordination can directly be used as predictors (explanatory variables) in interference models like multiple regression analyses. These analyses were applied in order to find main determinants for the floristic composition. Since the vegetation relevés from across Europe cover extremely wide biogeographical and ecological gradients, detrended correspondence analysis (DCA, detrended by segments), which is a unimodal response model, was used. CANOCO (TER BRAAK and ŠMILAUER 1998) in combination with EXCEL and SAS was used for the multivariate analysis and for subsequent evaluations. Species' cover values were square-root transformed for the DCA. Rare species that occurred in less than 5 relevés were excluded. To avoid bias from different numbers of repetitions, only the last relevé of each plot was used, resulting in a total number of 720 relevés and plots.

The DCA results in a first axis that explains 3.1% of the total variance (eigenvalue of 0.875 from a total sum of eigenvalues (inertia) = 28.3). The following three axes explain smaller proportions of the total variance: 2.6%, 2.3% and 2.0% respectively. The explained variance of the first four DCA axes sums up to 10%, which means that 90% of the total variance is not covered by the first four DCA axes. This is surely a result of a highly heterogeneous floristic composition of ground floor vegetation across the plots in Europe. Floristically, the first axis is on one side characterised by species dominating dry Mediterranean scrublands (maquis) represented e.g. by species of the *Cistaceae* family. On the other side shade tolerating undergrowth species of nemoral and boreal forests characterize the first axis (like *Deschampsia flexuosa* or *Vaccinium myrtillus* on acidic and *Anemone nemorosa* on calcareous soils). The spatial distribution of the scores of the first DCA axis (Figure 3.3.3-1) reveals distinctly higher scores for many plots on the Iberian Peninsula as compared to plots north of the Pyrenees. This can be interpreted as a border effect, which shows that a considerable number of plant taxa could not transcend the Pyrenees as a natural barrier after the last ice-age.

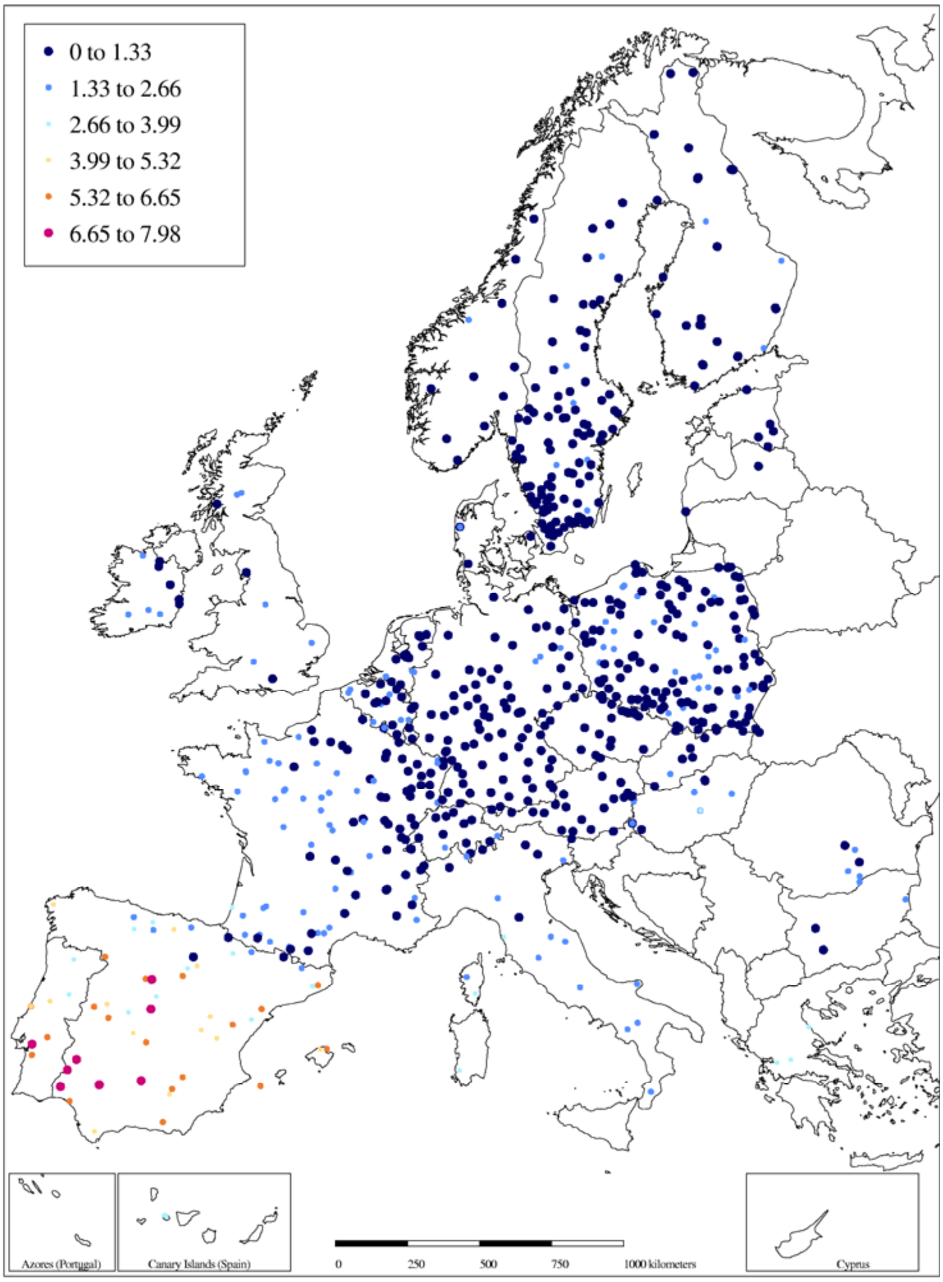


Figure 3.3.3-1: First DCA axis of an ordination with 720 Level II plots in Europe.

Plots in the nemoral forest zone of Europe

In the further evaluation a reduction of the high floristic variability within the data set was carried out as a first step as it was not the main objective to depict biogeographical aspects, but instead to search mainly for influences of nitrogen depositions onto the floristic composition of the ground vegetation. Therefore, all plots south of 46° latitude were excluded. In order to eliminate as well the floristically deviant influence of boreal and sub-alpine climates all plots north of 61° latitude and above 750 m a.s.l. were excluded from further analyses. It became clear that for detecting influences of environmental conditions on ground floor vegetation, the excluded plots need to be evaluated separately.

After this reduction a total of 488 plots remained for the application of a second DCA (sum of all eigenvalues = 15.02). The percentage of explained variance on the first axis now increased to 4.3%, the second to fourth axis explain decreasing shares of the total variance (2.5%, 2.2%, 1.8% respectively).

Table 3.3.3-1 provides an insight into the species with the highest loadings on the 1st DCA axis. Highest scores were reached by species typically occurring on acidic soils like some species from the blueberry genus (*Vaccinium mult. spec*.). At the other end of the axis species with the lowest scores like arum (*Arum maculatum*), dog's mercury (*Mercurialis perennis*), or oxlip (*Primula elatior*) are listed. These species typically grow on calcareous soils. These results show that the acidity status of the plots is the main factor that determines ground floor vegetation composition across the nemoral zone European forests (cf. EWALD 2003).

Table 3.3.3-1: Species of the ground floor vegetation with highest and lowest scores on the 1st DCA axis of 488 plots from the nemoral zone of Europe.

Species	DCA 1 score	Species	DCA 1 score
Vaccinium vitis-idaea	*6.1609*	*Vicia sepium*	*-0.1651*
Vaccinium uliginosum	6.1594	*Ranunculus ficaria*	-0.4019
Empetrum nigrum	5.9426	*Arum maculatum*	-0.4473
Carex ericetorum	5.5999	*Euonymus europaeus*	-0.5002
Calluna vulgaris	5.2408	*Acer campestre*	-0.5644
Melampyrum sylvaticum	4.9799	*Sonchus oleraceus*	-0.6393
Carex nigra	4.9359	*Quercus cerris*	-0.6479
Linnaea borealis	4.889	*Mercurialis perennis*	-0.6542
Betula sp.	4.8739	*Cardamine bulbifera*	-0.6761
Hypericum perfoliatum	4.7989	*Ranunculus auricomus*	-0.6962
Sorbus intermedia	4.798	*Cardamine pratensis*	-0.7195
Festuca ovina	4.776	*Alliaria petiolata*	-0.7346
Monotropa hypopitys	4.7315	*Primula elatior*	-0.7371
Vaccinium myrtillus	4.6717	*Cyclamen purpurascens*	-0.7441
Amelanchier grandiflora	4.6441	*Hypericum hirsutum*	-0.7716

For the species characterizing the second and third axis it was hardly possible to give any simple ecological interpretation. However, on the fourth axis species like climbing corydalis (*Ceratocapnos claviculata*), bifid hemp-nettle (*Galeopsis bifida*), or chickweed (*Stellaria media*) (Table 3.3.3-2) reached high scores. For these species there is considerable evidence from the literature (e.g. LETHMATE et al. 2002, DE VRIES et al. 2003) that they are favoured by high availability of soil nitrogen. Thus, it can be interpreted that plots with high scores on the fourth axis are characterized by the availability of soil nitrogen. On the fourth axis there are also species with high scores that are not specifically linked to nitrogen availability, but which might for other reasons occur in areas with elevated nitrogen deposition. Within the interpretation of the fourth axis, pseudo correlations have thus to be taken into account, related to species, like e.g. planted Douglas fir (*Pseudotsuga menziesii*) or black cherry (*Prunus serotina*) in The Netherlands or Flanders. Also crowberry (*Empetrum nigrum*) may more accidentally coincide with areas of high N deposition loads. Such pseudo correlations cannot be separated statistically, but have to be taken into account when interpreting the DCA results. Species with low scores on the 4th axis (Table 3.3.3-2) seem not to contain any specific common information with respect to nitrogen availability.

Table 3.3.3-2: Species of the ground floor vegetation best characterising (with highest and lowest scores) the 4th DCA axis of 488 plots from the nemoral part of Europe.

Species	DCA 4 scores	Species	DCA 4 scores
Empetrum nigrum	4.5847	*Orthilia secunda*	-0.4666
Ceratocapnos claviculata	4.424	*Sorbus aria*	-0.4961
Pseudotsuga menziesii	4.1899	*Pulmonaria obscura*	-0.5129
Amelanchier grandiflora	4.0857	*Gymnocarpium dryopteris*	-0.5533
Senecio sylvaticus	4.0665	*Galium boreale*	-0.6704
Epilobium spec.	3.8963	*Melampyrum sylvaticum*	-0.6858
Galeopsis bifida	3.7711	*Vicia cracca*	-0.6863
Prunus serotina	3.732	*Campanula rotundifolia*	-0.7114
Equisetum arvense	3.6021	*Polygonatum odoratum*	-0.7203
Poa angustifolia	3.6004	*Hypericum perfoliatum*	-0.7414
Picea spec.	3.5981	*Galium verum*	-0.793
Calamagrostis canescens	3.5689	*Linnaea borealis*	-0.8453
Fallopia dumetorum	3.5542	*Viola mirabilis*	-0.8502
Conyza canadensis	3.495	*Viola palustris*	-0.8535
Rubus plicatus	3.4527	*Hepatica nobilis*	-0.8814
Impatiens noli-tangere	3.4445	*Carex brizoides*	-0.938
Stellaria media	3.4398	*Geranium sylvaticum*	-0.9541
Impatiens parviflora	3.4118	*Equisetum sylvaticum*	-0.976

Due to its integrated sampling approach the Level II data set provides the opportunity to relate the scores on the different DCA axes to measured environmental parameters such as soil and deposition information. Correlation analyses were thus applied to statistically substantiate the ecological interpretation of the DCA scores. Results show that in spite of the low amount of the total variance explained by the first DCA axis, it reveals a significant relationship with pH_{CaCl2} values of the organic soil layer ($r = 0.789$, Table 3.3.3-3 and Figure 3.3.3-2). In addition, there are a number of soil parameters that provide significant relations like base saturation in the upper mineral layer (basesat, 0 to 10 cm depth), or the cation exchange capacity (CEC). It has to be taken into account that these soil parameters are significantly inter-correlated. The second and third axes show weaker relationships with the amount or organic carbon respectively carbon and nitrogen contents in mineral layers of the Level II sites. A weaker relationship between the 2nd DCA axis and ammonium deposition can be interpreted as a sign that NH_4 deposition may have effects on the floristic composition of the ground floor vegetation. This finding is underlined by the strong correlation between total nitrogen and ammonium deposition and the scores of the fourth axis (Table 3.3.3-3 and Figure 3.3.3-3) of the detrended correspondence analysis. This finding is based on a larger group of species with high scores on the 4th DCA axis. Even if pseudo correlations between geographical distributions of some species and anthropogenically caused deposition patterns are taken into account, the findings strongly suggest that there are a number of ground vegetation species that more specifically occur on plots due to higher nitrogen deposition. Thus, nitrogen deposition partly determines ground vegetation composition at the investigated plots. This interpretation is underpinned by the fact that there are hardly any other relationships of the 4th axis with any other soil related factors, except the C/N ratio within the organic layer. Just this parameter was also found to be correlated negatively with N deposition by AUGUSTIN et al. (2005).

Table 3.3.3-3: Correlation coefficients between DCA axes and key parameters of soil solid phase and deposition. For a detailed explanation of the key factors see Table 3.3.3-4.
All records from nemoral forest region; n = 488 plots. For plots with more than one record, the last record has been chosen in order to avoid pseudo-replication.
: (Prob > |r|) ≤ 0.05, **: (Prob > |r|) ≤ 0.01, *: (Prob > |r|) < 0.0001.*

		DCA axis 1	DCA axis 2	DCA axis 3	DCA axis 4
Soil solid phase	**C** (n = 461)	-0.2462***	-0.0971*	-0.2481***	0.0174
	N (n = 471)	-0.4094***	0.0029	-0.2379***	0.0662
	BCE (n = 469)	-0.4659***	0.1004*	-0.0327	-0.0554
	CEC (n = 467)	-0.4357***	0.0709	-0.1883***	-0.034
	Basesat (n = 464)	-0.6439***	0.1692**	0.1205**	0.0171
	C_{org} (n = 465)	0.1516**	-0.2889***	-0.2115***	-0.0027
	C/N_{min} (n = 461)	0.3752***	-0.2479***	0.0342	-0.0560
	C/N_{org} (n = 465)	0.2199***	-0.0534	0.0421	-0.2205***
	pH_o (n = 472)	-0.7893***	-0.0022	0.0020	-0.0075
	pH_{m01} (n = 472)	-0.4661***	0.1736***	0.1481**	-0.0485
Annual throughfall deposition	**xN_{depo}** (n = 224)	-0.1228	-0.1969**	-0.0150	0.5204***
	xNH_4-N_{depo} (n = 224)	-0.0610	-0.2748***	0.0586	0.5140***
	xNO_3-N_{depo} (n = 224)	-0.2431**	-0.0031	-0.1105	0.4218***

Table 3.3.3-4: Parameters characterising the soil solid phase and throughfall nitrogen deposition.

domain	parameter	unit	explanation
soil solid phase	**C**	g kg^{-1}	organic carbon concentration in the upper 10 cm of the mineral soil layer; different layers (0 – 5 cm, 5 – 10 cm, 0 – 20 cm) have been merged.
	N	g kg^{-1}	total nitrogen concentration in the upper 10 cm of the mineral soil layer; different layers (0 – 5 cm, 5 – 10 cm, 0 – 20 cm) have been merged.
	BCE	cmol (+) kg^{-1}	sum of basic exchangeable cations in the upper 10 cm of the mineral soil layer.
	CEC	cmol (+) kg^{-1}	cation exchangeable capacity of the upper 10 cm of the mineral soil layer
	Basesat	%	base saturation of the upper 10 cm of the mineral soil layer
	C_{org}	g kg^{-1}	organic carbon concentration of the organic layer.
	C/N_{min}		C/N ratio of the upper 10 cm of the mineral soil layer
	C/N_{org}		C/N ratio of the organic layer.
	pH_o		pH value in 0.01 molar $CaCl_2$ of the organic layer; in cases where pH of the organic layer was missing, it was substituted according to the empirical relationship: $pH_O = -1.0145 + (1.5425\ pH_{m0\text{-}10}) + (0.2068\ pH_{m0\text{-}10}^2)$
	pH_{m01}		pH value in 0.01 molar $CaCl_2$ of the upper 10 cm of the mineral soil layer; if only a value of the upper 5 cm are given, the respective value for 10 cm depth has been calculated according to empirical regressions: $ph_{m0\text{-}10} = 0.3449 + (0.9415 * pH_{m0\text{-}5})$ or: $pH_{m0\text{-}10} = 0.0593 + (0.9769 * pH_{m5\text{-}10})$; if only $pH_{0\text{-}20}$ is given, it has been equalled to $pH_{0\text{-}10}$; if measurements in different years have been conducted, the latest datum was taken; in cases of moor soils pH of upper h-horizon was equalled to the upper mineral horizon; if only pH of the organic layer was given and value of the mineral layer was missing, the empirical relationship was used: $pH_{m0\text{-}10} = 4.6856 - (1.0375 * pH_O) + (0.2068 * pH_O^2)$.

domain	parameter	unit	explanation
annual throughfall deposition	**xN_{depo}**	kg ha^{-1} a^{-1}	mean annual N throughfall deposition as sum of NH_4-N deposition and NO_3-N deposition; calculated for all years available before 2001; only for plots with at least 273 days per year sampled; if sampling period was shorter than 365 days, missing periods were completed by mean values derived from the remaining days.
	xNH_4-N_{depo}	kg ha^{-1} a^{-1}	mean annual NH_4-N throughfall deposition; calculated for all years available before 2001; only for plots with at least 273 days per year sampled; if sampling period was shorter than 365 days missing periods were completed by mean values derived from the remaining days.
	xNO_3-N_{depo}	kg ha^{-1} a^{-1}	mean annual NO_3-N throughfall deposition; calculated for all years available before 2001; only for plots with at least 273 days per year sampled; if sampling period was shorter than 365 days missing periods were completed by mean values derived from the remaining days.

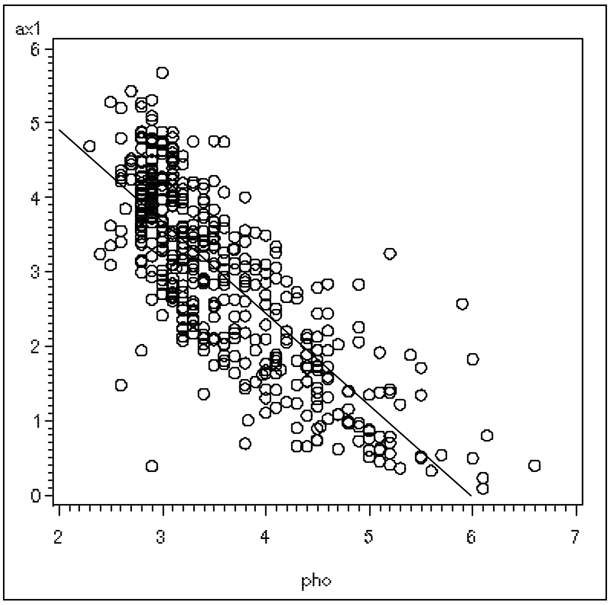


Figure 3.3.3-2: Relationship between the 1st DCA axis and pH_{CaCl2} in the organic layer; R^2 = 0.623, (Pr > F) < 0.0001, n = 472 plots.

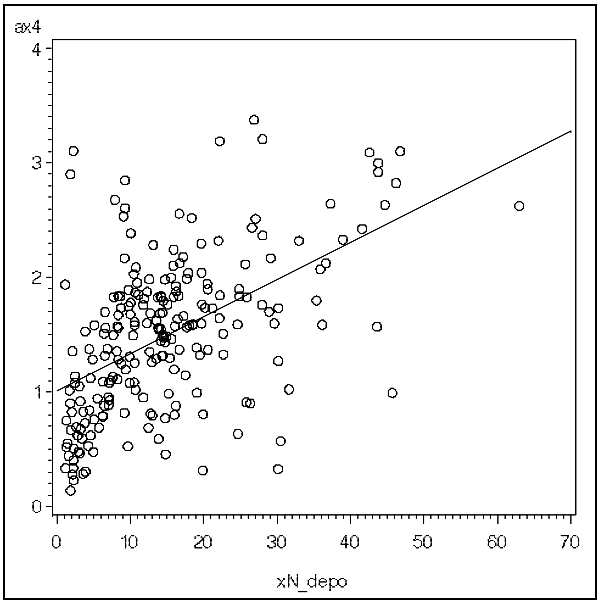


Figure 3.3.3-3: Relationship between the 4th DCA axis and annual N throughfall deposition; R^2 = 0.271, (Pr > F) < 0.0001, n = 224 plots.

The plot related scores of the 4th DCA axis show spatial trends (Figure 3.3.3-4). High scores, indicating a vegetation composition that reflects high nitrogen availability occur mainly in regions that are known to receive high nitrogen deposition. This trend is particularly obvious for Western Europe and Southern Scandinavia. The high scores for the plots in Scotland and Ireland can probably not be explained by high N deposition rates, since some abundant species with a prevalence for the Atlantic climate (e.g. *Drypoteris dilatata*, *Galium saxatile*, *Galium palustre*) gain also higher scores on the 4th DCA axis.

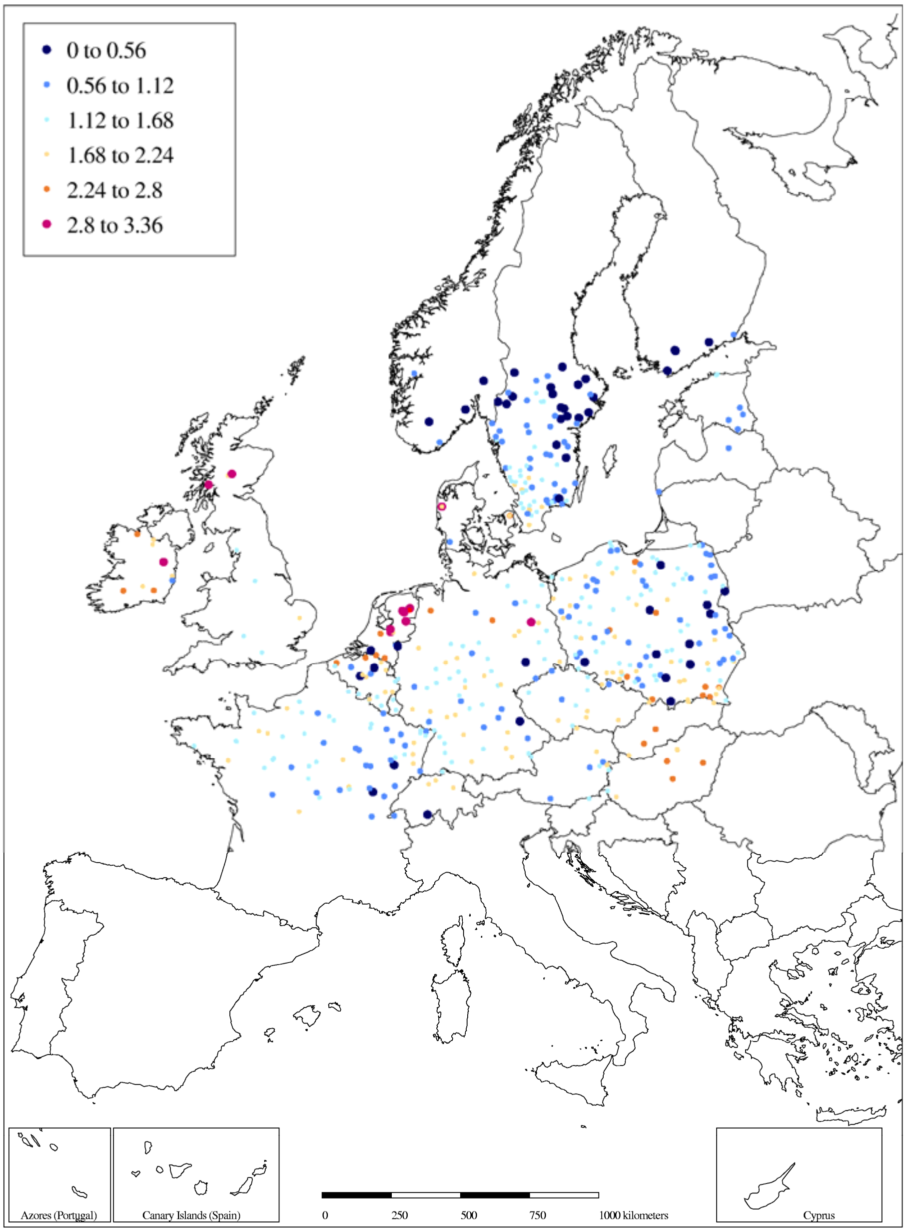


Figure 3.3.3-4: Scores of the 4th DCA axis at Level II plots within the nemoral zone of Europe.

3.3.4 Application of ecological indicator values

Indicator values according to ELLENBERG (1992) attributed to individual plant species deliver derived estimates for ecologically important site conditions. Of particular interest within the context of forest monitoring under the umbrella of ICP Forests are indicator values for soil reaction (R) and availability of soil nitrogen (N). Mean indicator values (mR, mN) per relevé were calculated from all plants species within a vegetation relevé. Weighting by cover degrees did not improve the results, thus unweighted means were used. Additionally, mean indicators for radiation (light, mL) and moisture (mF) were calculated.

There have been discussions about the applicability of the indicator values with respect to their geographical range. Also, modifications have been proposed (e.g. ERTSEN et al. 1998). For some parts of Europe alternative systems have been developed since long (ZOLYOMI et al. 1967, LANDOLT 1977, VEVLE 1985). Nonetheless, as shown for the transnational Level II data set, the original Ellenberg indicator values for soil conditions are closely related to measured soil parameters (cf. Table 3.3.4-2). The Level II data are a unique basis for testing the applicability of these indicators on a European scale. Results show that they seem to work sufficiently accurate over wide geographical scales, which justifies their use for the whole of Europe (even including the Canary Islands, which do phytogeographically belong to the Macaronesian flora region). A map with mean indicator values for soil reaction of Level II plots (and one for temperature indicator values, which are not considered here) was already published by DE VRIES et al. (2002).

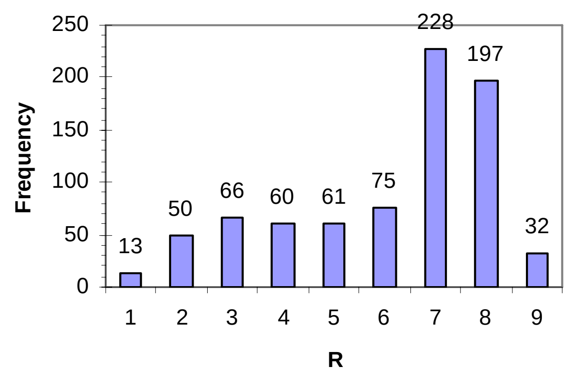


Figure 3.3.4-1: Frequency distribution for all R indicating plants found at the Level II monitoring sites irrespective of their local abundance or over-all frequency. Number of unranked and indifferent species: 1222.

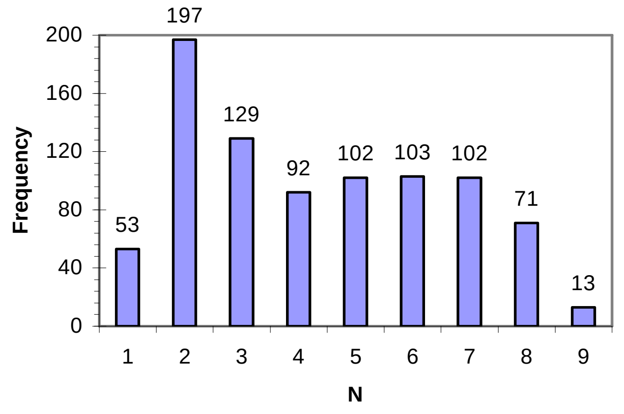


Figure 3.3.4-2: Frequency distribution for all N indicating plants found at the Level II monitoring sites irrespective of their local abundance or over-all frequency. Number of unranked and indifferent species: 1142.

Figure 3.3.4-1 and Figure 3.3.4-2 reflect the frequency of all R and N indicators derived from all plants found at any site and point in time at any Level II permanent plot in Europe. Both distributions reflect almost exactly the frequency distribution of all 2726 species originally ranked by ELLENBERG (1992), even if there is a high amount of unranked and indifferent species. As stated by other authors (e.g. EWALD 2003) much more species grow on calcareous soils than on acidic soils (Figure 3.3.4-1). Within the N gradient from poor to rich soils more species occur on nitrogen poor soils. This has led to the hypotheses that N eutrophication might endanger biodiversity in the long run (e.g. ELLENBERG 1983).

When regarding the development of mean R and N indicator values per plot along the time scale the overwhelming majority of plots show no or only small changes (Figure 3.3.4-3). Extreme changes of the mean indicator values might be the results of heavy disturbances between two assessments or probably assessment errors (e.g. plots not identical at the assessments).

A comparison of differences between mean indicator values for available soil nitrogen for the first and the last assessment at all respective plots is given in Figure 3.3.4-4. The mN values of 50% of all plots remain almost constant. A slightly higher number of plots show increasing mean indicator values for nitrogen (98 plots corresponding to 27% of all plots) as compared to plots with decreasing mN values (84 plots corresponding to 22% of all plots). A t-test for paired data did however not reveal a significant difference between mN values of the first and the last assessment (mean increase: 0.02, n = 475, (Pr > |t|) = 0.294). A systematic statistical evaluation of changes with classical time series analysis and longitudinal approaches is to consider as soon as longer time series with more repetitions become available.

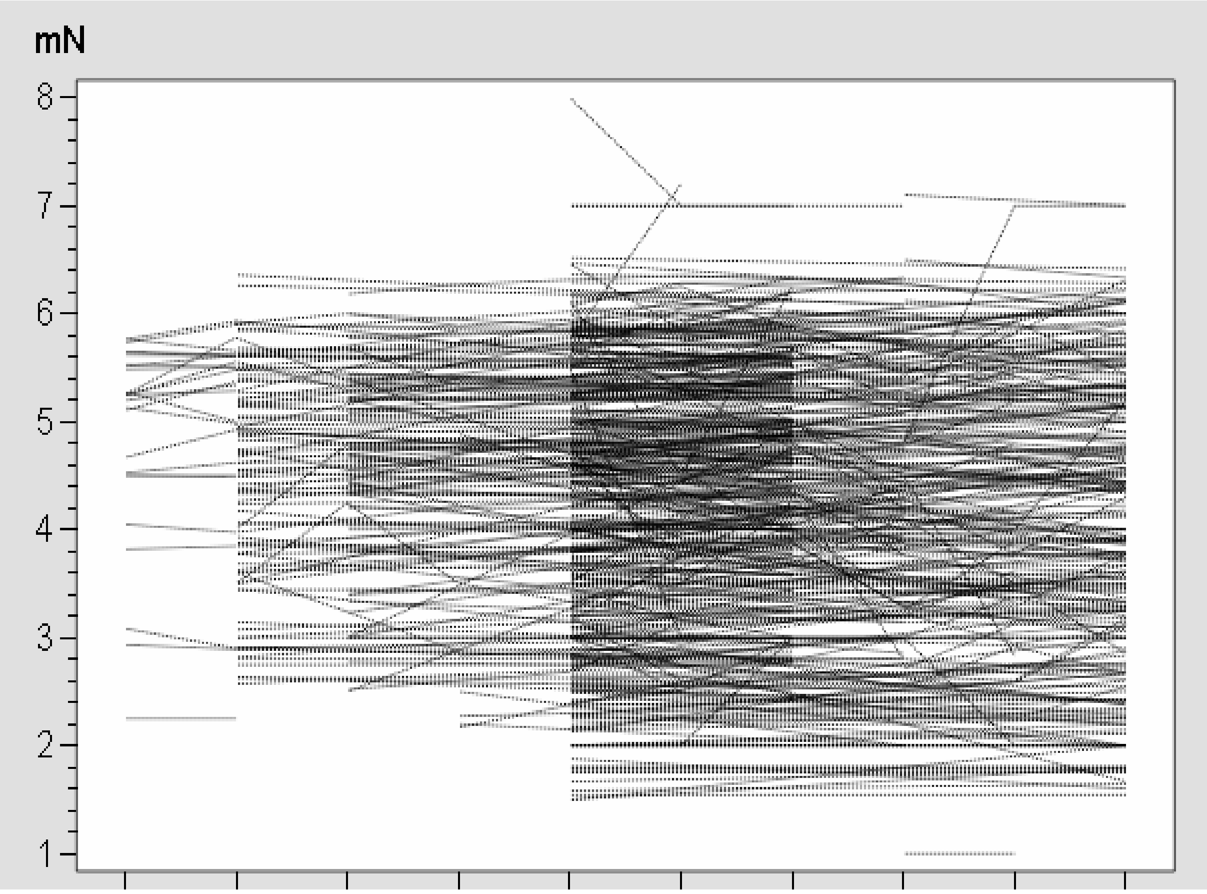


Figure 3.3.4-3: Development of mean N indicator values of the herb layer at each Level II plot in Europe with at least one repetition; n = 475 plots.

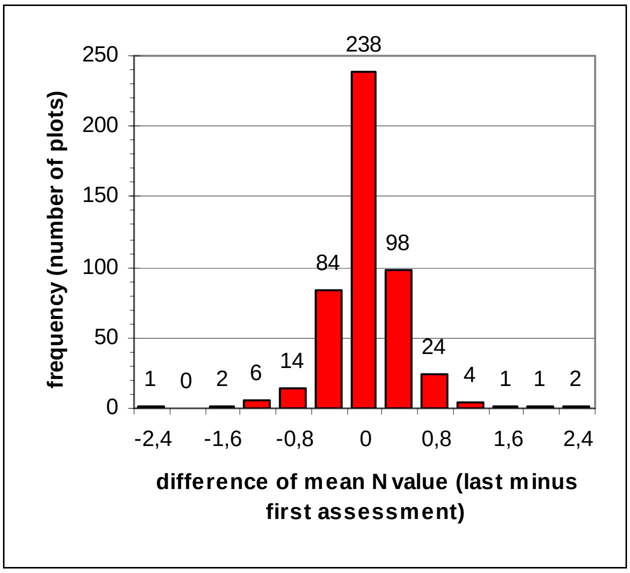


Figure 3.3.4-4: Summarised differences between the plot related mean indicator values for soil nitrogen (mN) at the respective first and at the last assessment; n = 475 plots.

Mean indicator values do not vary independently. Table 3.3.4-1 shows the intercorrelation structure of indicator values from 488 plots of the nemoral zone of Europe (numbers of intercorrelation pairs differ slightly due to plots, for which no specific mean indicator value could be calculated). The intercorrelations reflect the ecological ties between certain ecosystem features. For instance, in stands with better water supply a decrease of light on the forest floor is often observed, due to a denser crown layer (in case of wet and very wet soils this relationship is reversed, therefore the respective relationship is week). The similar relationship exists between mL and mR respectively mN values. On soils rich in basic cations or rich in available nitrogen tree crowns grow denser resulting in less light reaching the forest floor. A very strong relationship with a correlation coefficient of r = 0.795 exists between the mean indicator value of soil reaction and available nitrogen. This relationship, which exists over a wide range of the gradient from very acid to alkaline soils has often been found (e.g. ELLENBERG 1992, SEIDLING and ROHNER 1993) and was already described by SCHÖNHAR (1952). This relationship is physically based on a usually poor nitrogen supply on acidic soils due to impeded mineralization processes.

Table 3.3.4-1: Correlation coefficients of mean indicator values calculated from 488 plot form the nemoral zone of Europe; (): number of valid cases, *(Prob > |r|) ≤ 0.05, **: (Prob > |r|) ≤ 0.01, ***: (Prob > |r|) < 0.0001.*

	mF	mR	mN
mL	-0.1413** (475)	-0.3880*** (482)	-0.4759*** (484)
mF		0.0166 (470)	0.1843*** (473)
mR			0.7954*** (481)

The close correlation between mR and mN values can be corroborated by a correlation approach between measured soil and deposition parameters and indicator values (Table 3.3.4-2). Not only the negative relationship between light indicator values and all soil parameters closely related to soil acidity status, but also the mR and mN values reveal comparatively close relationships with these measured parameters. With an r of 0.765 the relationship between mR and the pH in the organic layer is specifically tight (Figure 3.3.4-5). This is interestingly in the same order of magnitude than the relationship between the 1st DCA axis and the same soil parameter (cf. Table 3.3.3-3).

Mean nitrate throughfall deposition shows a statistically significant relation with mean nitrogen indicator values (relationships with bulk N deposition are distinctively weaker and are not displayed here). Based on the evaluation of Ellenberg indicators, ground vegetation thus partly reflects atmospheric inputs. The higher mN values on plots with high nitrogen deposition might be due to a beneficial effect of nitrogen deposition on nitrogen indicating plant species.

Table 3.3.4-2: Correlation coefficients for mean indicator values calculated from 488 plots from the nemoral zone of Europe and measured environmental factors of the soil solid phase and mean annual throughfall deposition; n = 488 plots. *(Prob > |r|) ≤ 0.05, **: (Prob > |r|) ≤ 0.01, ***: (Prob > |r|) < 0.0001.*

		mL	mF	mR	mN
soil solid phase	C	-0.2411*** (461)	0.1324** (448)	0.1390** (456)	0.2254*** (457)
	N	-0.3308*** (471)	0.1329** (458)	0.3328*** (466)	0.3759*** (467)
	BCE	-0.2364*** (469)	-0.0345 (456)	0.5311*** (464)	0.3412*** (465)
	CEC	-0.2918*** (467)	0.0679 (454)	0.4250*** (462)	0.3619*** (463)
	base	-0.2246*** (464)	-0.0544 (451)	0.7555*** (459)	0.5028*** (460)
	C_{org}	-0.0959* (465)	0.1724** (452)	-0.2624*** (459)	-0.1525** (461)
	C/N_{min}	0.2201*** (461)	0.0077 (448)	-0.4249*** (456)	-0.3314*** (457)
	C/N_{org}	0.1100* (465)	-0.0586 (452)	-0.1708** (459)	-0.2338*** (461)
	pH_o	-0.3439*** (472)	-0.0249 (459)	0.7648*** (466)	0.5697*** (468)
	pH_{m01}	-0.2064*** (472)	-0.1660** (459)	0.5795*** (466)	0.3426*** (468)
mean annual throughfall deposition	xN_{depo}	0.2423** (224)	0.1740* (213)	0.0795 (219)	0.2402** (220)
	$xNH_4\text{-}N_{depo}$	0.2901*** (224)	0.1833** (213)	0.0384 (219)	0.1794** (220)
	$xNO_3\text{-}N_{depo}$	0.0970 (224)	0.1073 (213)	0.1776** (219)	0.3196*** (220)

The close correlation between mN values and the measured pH of the organic soil layer within the Level II data supports earlier findings by ELLENBERG (1992) and SEIDLING and ROHNER (1993). This relationship depends on a complex interplay between nitrification processes and availability of base cations within soils. Results for the Level II plots (Figure 3.3.4-6) show an almost linear increase from very acidic to slightly acidic soils and a more flat progression at higher pH values indicating decreasing nitrification rates at more calcareous soils which was also described earlier (e.g. RUNGE 1965, KRIEBITZSCH and BÜHMANN 1978).

The distribution of the plotwise values (Figure 3.3.4-6) shows a large variation and there is a large number of plots that deviate from the general mN-pH_O relationship. In the further evaluation it was of interest to explore reasons for these deviations and to find out whether additional nitrogen supply, e.g. through nitrogen deposition, was related to these deviations. The question of interest was whether nitrogen deposition could be related to plots with low pH but unexpected high mN values.

Therefore the residuals from the mN - pH_O relationship were regressed against soil and deposition parameters. The closest relationship in terms of the correlation coefficient was found for total N throughfall deposition. Results for a quadratic regression were slightly better as compared to a linear regression. Correlations for nitrate and ammonium were slightly weaker as compared to total deposition.

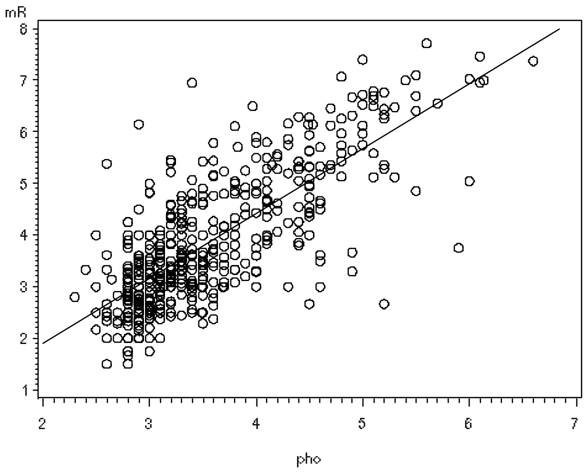


Figure 3.3.4-5: Relationship between mean indicator values for soil reaction and pH_{CaCl2} in the organic layer for n = 466 plots, R^2 = 0.5849, regression: mR = -0.6260 + 1.2602 pH_O.

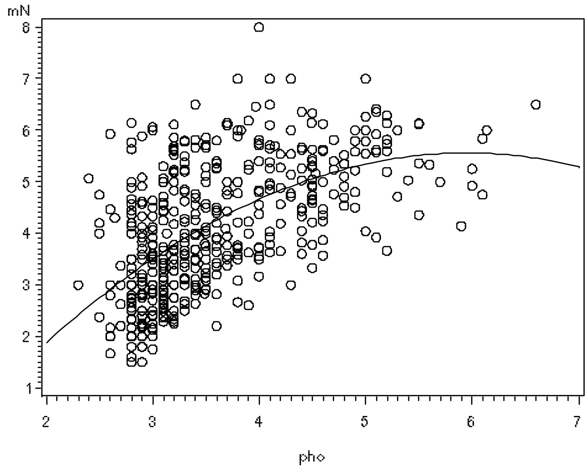


Figure 3.3.4-6: Relationship between mean indicator values for nitrogen and pH_{CaCl2} in the organic layer for n = 468 plots, R^2 = 0.3443, regression: mN = -2.7799 + 2.8000 pH_O + 0.2352 pH_O^2,

Figure 3.3.4-7 illustrates the relationship between the residuals from the quadratic regressions model mN on pH_O and atmospheric total N throughfall deposition. This relationship may still include a considerable amount of variation from different sources, like e.g. historical or recent mechanical disturbances, is however distinctively closer than the relationship between mean N indicator values and total N deposition (cf. Table 3.3.4-2).

The results show that on plots with acid soils nitrogen availability for ground vegetation is usually comparatively low. There are, however, a number of plots with acid soils were indicators of the ground vegetation suggest unexpected high nitrogen availability. These high mean indicators are correlated with higher nitrogen deposition.

Table 3.3.4-3: Correlation coefficients for residuals from the linear and quadratic regression models of mean N indicator values on pH_O on one side (indicator values are derived from the vegetation relevés; all records from nemoral forest region, if more than one record per plot is taken, the last record has been chosen) and key factors characterising the soil solid phase (organic layer and upper mineral layer) and mean throughfall deposition on the other side; *: (Prob > |r|) ≤ 0.05, **: (Prob > |r|) ≤ 0.01, ***: (Prob > |r|) < 0.0001.

		residuals of mN on pH_O	
ecological domains	environmental factors	from linear regression model	from quadratic regression model
soil solid phase	C	0.1310** (457)	0.1382** (457)
	N	0.2003*** (467)	0.2132*** (467)
	BCE	0.0081 (465)	0.0804 (465)
	CEC	0.1182* (463)	0.1763** (463)
	Basesat	0.1059* (460)	0.1132* (460)
	C_{org}	-0.0976* (461)	-0.0880 (461)
	C/N_{min}	-0.1704** (457)	-0.1590** (457)
	C/N_{org}	-0.2031*** (461)	-0.2107*** (461)
	pH_o	0.0000 (468)	-0.0000 (468)
	pH_{m01}	-0.0485 (468)	-0.0048 (468)
mean annual throughfall deposition	xN_{depo}	0.4000*** (210)	0.4310*** (210)
	$xNH_4\text{-}N_{depo}$	0.3644*** (210)	0.3899*** (210)
	$xNO_3\text{-}N_{depo}$	0.3860*** (210)	0.4194*** (210)

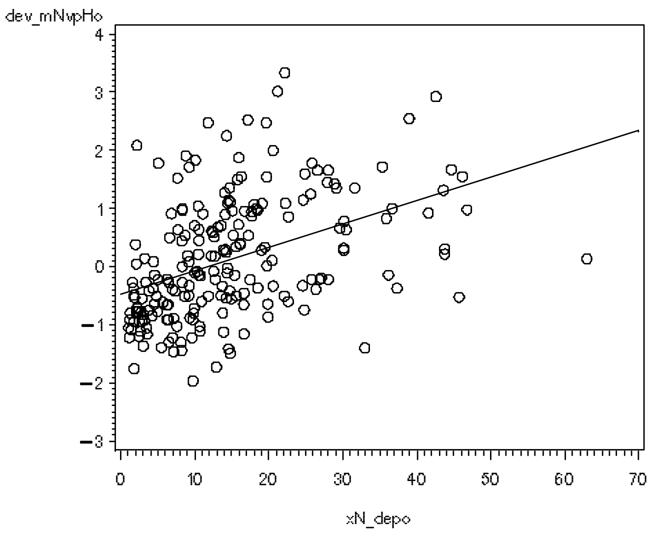


Figure 3.3.4-7: Residuals from the quadratic regression model between mean N indicator values and pH in the organic layer on the ordinate and mean annual total N throughfall deposition on the abscissa; R^2 = 0.186, n = 210.

3.3.5 Floristic changes along the time scale

Level II plots with repeated surveys of ground floor vegetation can be used to evaluate potential changes in ground vegetation composition. As the time series are of different length and as the starting points vary considerably, all repeatedly surveyed plots have been brought in sequences and analysed jointly by detrended correspondence analysis (DCA). Eventually triggering weather extremes can therefore not be considered. Anthropogenic and natural disturbances are not comprehensively acquired within the Level II data base;

these drivers for floristic dynamics can therefore as well not be differentiated from other influences like gradual changes of environmental factors.

For 106 plots at least three repetitions were available. Again, plots south of 46° latitude were excluded due to their strongly deviant floristic composition, leaving a total of 97 plots with 427 relevés. The eigenvalues of the DCA sum up to a total of 15.7, which is in the same order of magnitude than the approach covering 488 plots the nemoral zone (see subchapter above).

Results of the DCA reveal a 1st axis explaining 4.0% of the total floristic variance. Again this axis is loaded by species that are characteristic for the soil acidity status of the plots. The 2nd and 3rd axis explain 3.0% and 2.0 % respectively of the total floristic variance. Again, the 4th axis (explaining 1.8% of the total floristic variance) specifically lists species that show influences of nitrogen deposition on the ground floor vegetation. In general thus, this DCA based on plots with repeated surveys corroborates the findings of the DCA presented above showing that ground vegetation can be used to differentiate plots with more acidic or neutral acidity status and to differentiate plots with differing nitrogen availability.

The 1st and 4th axes of the DCA are the ones that carry the most relevant ecological information. Thus, all relevés were plotted in relation to their scores on these axes (Figure 3.3.5-1). Relevés belonging to the same plot were connected by lines. The resulting trajectories indicate whether the vegetation composition of the evaluated plots reflect changing acidity or nitrogen status of the plots over time. Results show that related to both axes there is hardly any general trend. This may be explained by the fact that either (i) time series are still rather short and start at times in which nitrogen deposition has already taken place for years and decades, so that a possible change of ground vegetation has already taken place before the assessments started, or (ii) the main determining factors for ground vegetation are site and stand specific (e.g. anthropogenic or natural disturbances) and did not change consistently over time.

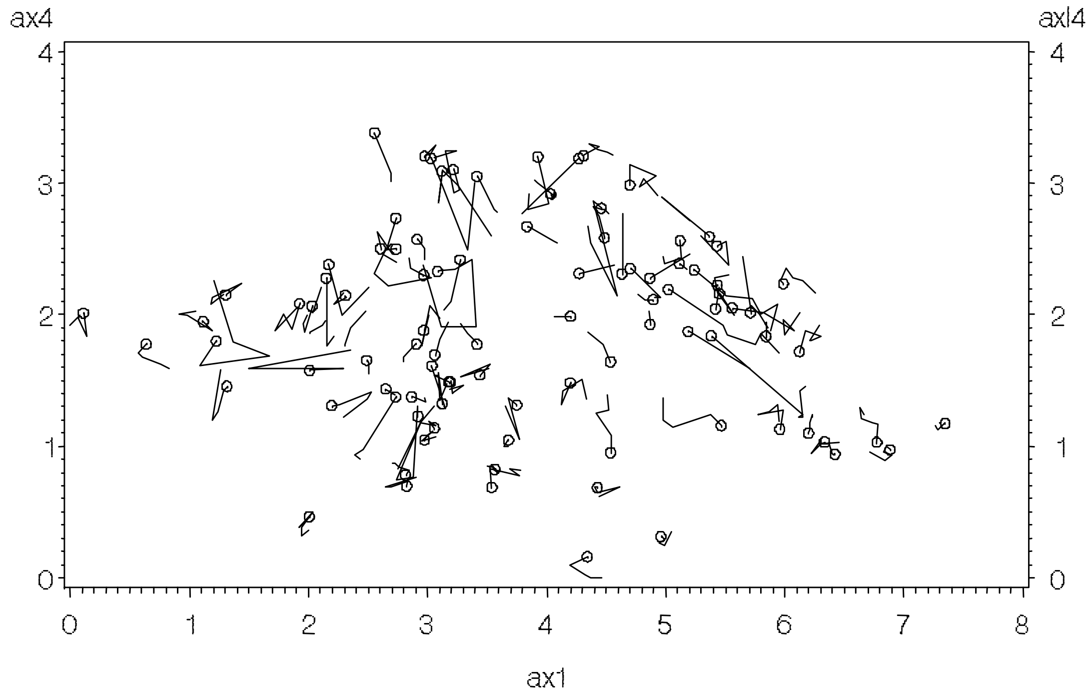


Figure 3.3.5-1: DCA-scores of the first and the fourth axes of serial vegetation relevés from permanent Level II plots. All relevés belonging to a series are successively interconnected by a trajectory; the temporally last point is marked by a circle.

3.3.6 Conclusions

Ground vegetation constitutes a considerable part of forest ecosystem diversity. Level II plots, albeit case studies, offer insight into cause effect relations of the most important forest ecosystems in Europe. The monitoring data offer detailed structural and species-specific information on the status and dynamic of this important ecosystem compartment at a European scale. Descriptive statistics of plain and derived parameters like cover degrees or diversity indices describe respective properties with a considerable broad geographical and ecological coverage, even if the results can statistically not be considered as area-representative. The measurement of a large amount of environmental parameters, both anthropogenic and natural, at identical sites, allows for interference studies, which may contribute to a better understanding of floristic and ecosystem processes.

Multivariate ordination (detrented correspondence analysis; DCA) of the floristic composition of vegetation relevés from all European Level II plots reveal a phytogeographical gradient which distinguishes relevés from the Iberian Peninsula as floristically most deviant.

A separate DCA with relevés from the nemoral zone of Europe, excluding Mediterranean, boreal and high-altitude forests reveals soil acidity on its first axis as the most differentiating ecological factor. The fourth DCA axis significantly correlates with nitrogen deposition in Europe indicating a fertilising effect of nitrogen deposition on the ground vegetation composition of the plots. This effect is corroborated by the fact that plots with high scores on the fourth axis are mostly located in regions with high nitrogen deposition.

Ellenberg indicator values for soil acidity and nitrogen support the results of the ordination as well. Soil parameters and nitrogen deposition are both significantly related to mean Ellenberg indicators per plot.

A strong correlation between soil pH and mean nitrogen indicators of the vegetation supports earlier findings whereas nitrogen availability is at least partly determined by the acidity status of the soil. Plotwise residuals from this general relation were significantly linked to nitrogen deposition showing that unexpected high nitrogen availability – mostly occurring at plots with low soil pH - is linked to atmospheric nitrogen inputs.

The analysis of changes in ground vegetation species composition over time was conducted by simple comparisons of mean Ellenberg indicators for nitrogen as well as with a DCA that aimed to check for changes in plotwise DCA scores over time. Both approaches did not reveal significant results, even though the number of plots with increasing mean nitrogen indictors was slightly higher compared to the number of plots with decreasing mean indicators. In general it is assumed that (i) the time interval was too short to detect changes and that (ii) the first assessments were made at times at which ground vegetation was already adapted to the nitrogen inputs. A systematic statistical evaluation of changes with classical time series analysis and longitudinal approaches is to consider as soon as longer time series with more repetitions become available.

3.4 Dynamic models for acidification and eutrophication

3.4.1 Introduction

All eight protocols to the Convention on Long-range Transboundary Air Pollution of the United Nations Economic Commission for Europe (UNECE) entered into force now. The most recent was on 17 May 2005 the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (Gothenburg Protocol). This Protocol aims to cut further emissions of sulphur, nitrogen oxides, volatile organic compounds (VOCs) and ammonia up to 2010. Reduction targets for all four pollutants are set for each country individual and nearly equal to the national emission ceilings (NEC) given by the NEC-Directive of the EU (2001/81/EG). In total by 2010, Europe's sulphur emissions should be cut by 63%, its NOx emissions by 41%, its VOC emissions by 40% and its ammonia emissions by 17% compared to their 1990 levels (Press Release UNECE/ENV/05/P04).

Since the first UNECE protocols on reducing emissions of sulphur (signed in 1985) and nitrogen (1988) have come into force, ever-increasing resources have been directed to develop effect-based approaches to control air pollution. With the implementation of the second Sulphur Protocol (1994) and, more recently, the Gothenburg-Protocol critical loads have been applied as guidelines for abatement strategies. Critical loads have been compared to actual deposition load values and an Average Accumulated Exceedance (AAE) of critical loads can be computed (see Mapping Manual 2004, Chapter 8).

In the last two decades, Europe observed the first results of the emission reduction but at the same time, critical loads of acidity and of nutrient nitrogen for forest, non forest vegetation and water ecosystems were still exceeded (Figure 3.4.1-1). The area of unprotected forest ecosystems amounts to only 10 percent by acidity but 50 percent due to nutrient Nitrogen (Figure 3.4.1-2). Results and methods are described in the CCE Report 2005 (POSCH et al. 2005).

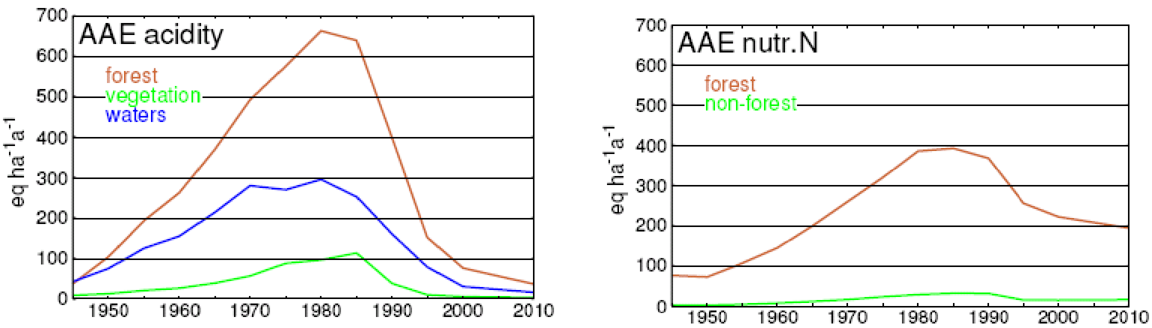


Figure 3.4.1-1: Average Accumulated Exceedance by acidity (left) and nutrient nitrogen (right).

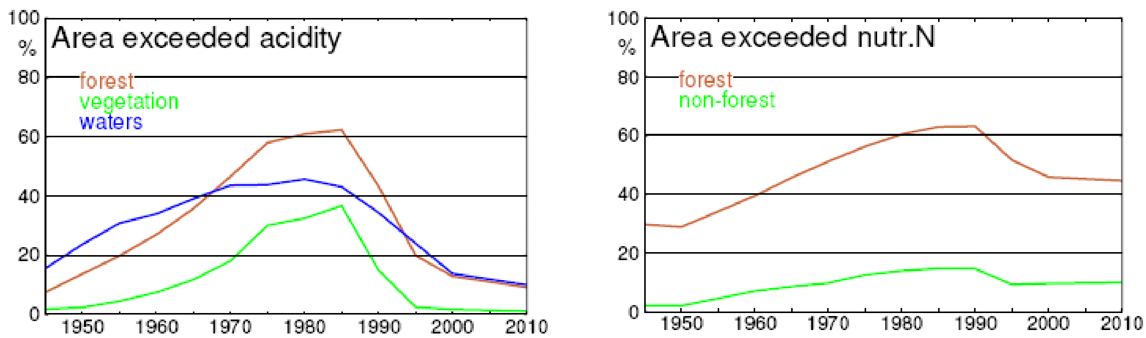


Figure 3.4.1-2: Ecosystem area exceeded by acidity (left) and nutrient nitrogen (right).

However, recently enacted measures are becoming effective. Additional commitments have brought about proof that the degree of acid critical load exceedance is falling. It is predicted to fall further in the future. To the contrary, the emission of nitrogen oxides and ammonia still remains on a high level and will be furthermore the main contributor of acidification and especially responsible for an unacceptable level of eutrophication.

3.4.2 Application of dynamic models at Level II plots

Air pollution is seen as an important factor for forest damage in several European countries. Long-term deposition of air pollutants is one of the main factors in processes linked to defoliation. It is monitored and assessed annually on a European scale. But will a decrease of deposition and reduced critical load exceedances result in forest ecosystem recovery? And if so, what’s the time scale for coming under sustainable conditions?

To answer this dynamic modelling is necessary, because critical loads do not provide any information on time scales. Dynamic models are needed to assess time delays of recovery in regions cease being exceeded and time delays of damage in regions where critical loads continue to be exceeded (Mapping Manual 2004, Chapter 6). Studies based on mapping of critical loads of acidity and eutrophication and environmental monitoring supported by dynamic modelling show that recovery from pollutant stress will often be very slow and may sometimes even take decades or hundreds of years.

Therefore under the Convention in the ICP Modelling and Mapping as well as in other ICPs dynamic models have been developed and are applied to show the effects of acid deposition on soils and to derive targets for emission reduction with respect to acidification processes. The most common models are:

<u>VSD</u>
The Very Simple Dynamic (VSD) soil acidification model has been developed as the (minimal) extension of the Simple Mass Balance (SMB) steady-state model and is available for European use. In 2005, the Coordination Center on Effects (CCE) issued a call for dynamic modelling data and 14 countries submitted national results of applying the VSD model (POSCH et al. 2005).

<u>SAFE</u>
Soil Acidification in Forest Ecosystems (SAFE) is a dynamic soil chemistry model, developed with the objective of studying the effect of acid deposition on soil and ground water. It can be used to study the acidification and recovery processes and how they are affected by deposition rates, soil parameters and hydrological variations. SAFE includes process-oriented descriptions of cation exchange reactions, chemical weathering of minerals, leaching and accumulation of dissolved chemical components and solution equilibrium reactions.

Under development are also models focused on the biogeochemical modelling of nitrogen, and on modelling of acidification and eutrophication impacts on biodiversity for application in support of the Convention (e.g. BERN model).

Following the recommendations of the last year’s Executive Report efforts were directed towards the application of the VSD and SAFE model to a larger number of Level II plots. In correspondence with this the Level II data were tested for generating inputs for dynamic models.

From these tests arose, that based on the ICP Forests data exclusively the SAFE model was not applicable and the VSD model could be used at a selected number of plots only. As minimum model input a complete set of mandatory <u>and</u> some optional data is required and additional information on soil texture and mineral content should be available (Figure 3.4.2-1).

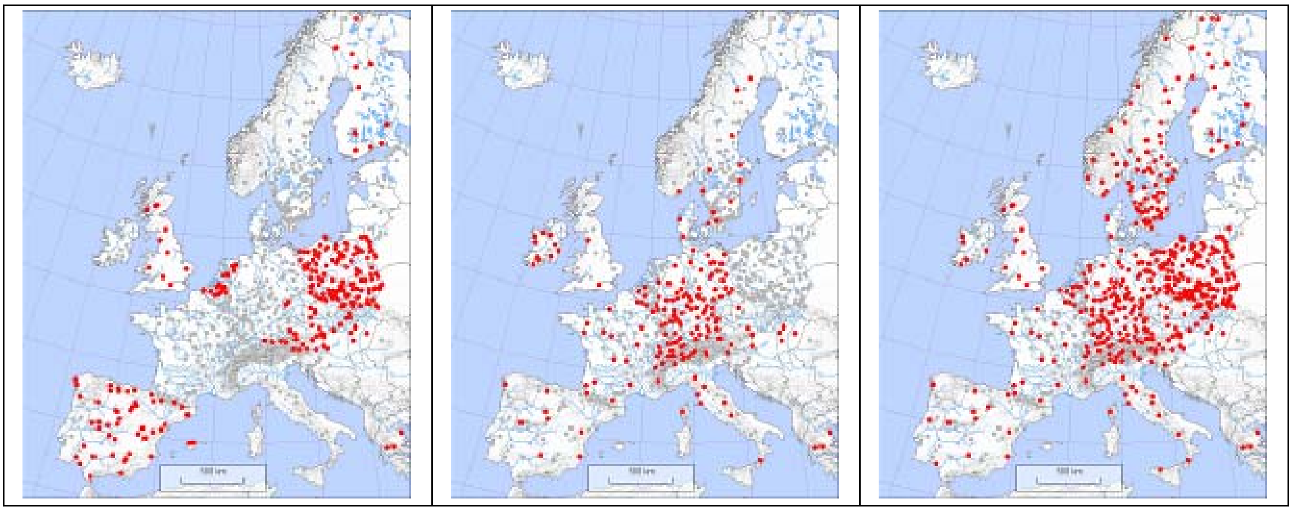


Figure 3.4.2-1: Availability of texture data (left), precipitation (centre) and bulk deposition (right) at Level II plots necessary for dynamic modelling, red dots show plots where data are present.

For dynamic modelling based on ICP Forests data 37 plots with sufficient input parameters were selected (Figure 3.4.2-2). Restrictions of model application on different Level II plots are mainly caused by missing input data, both mandatory and optional.

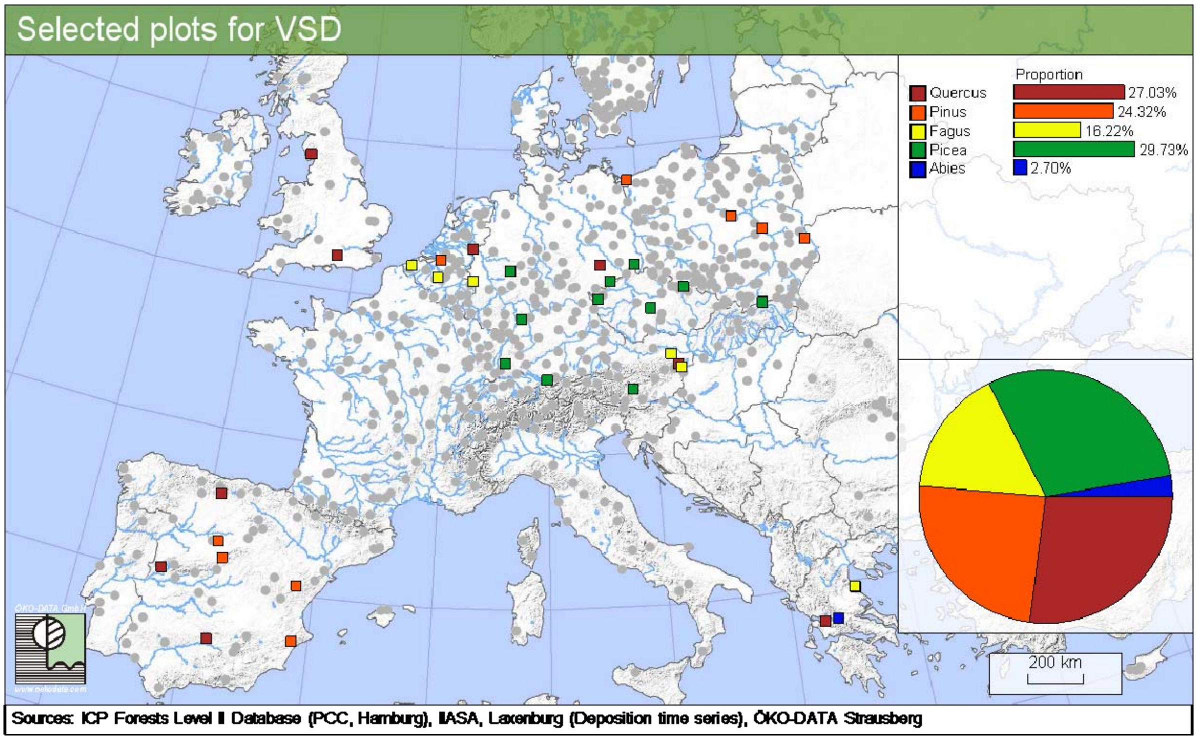


Figure 3.4.2-2: Level II plots selected for dynamic modelling with the VSD model.

Additional – as an example - a combination of ICP Forests data and specific forest research and monitoring studies in Germany were selected for running the SAFE model, resulting finally in 8 plots for SAFE applications (Figure 3.4.2-3).

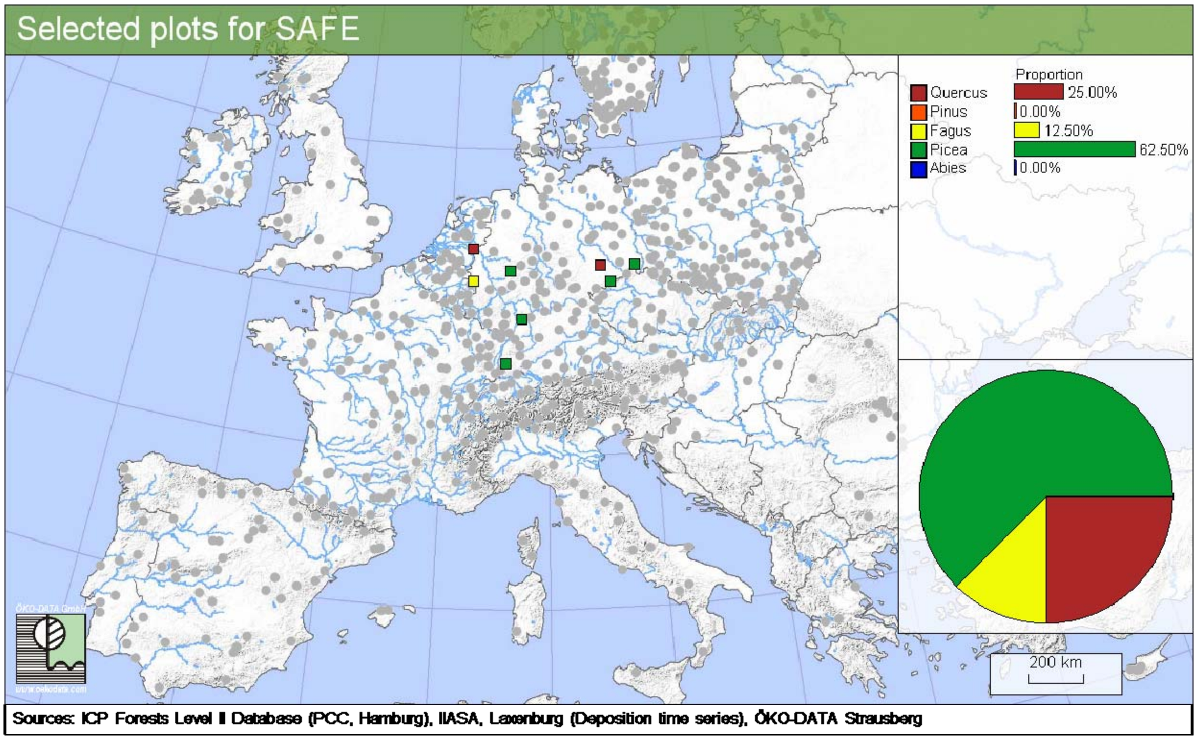


Figure 3.4.2-3: Level II plots selected for SAFE application.

3.4.3 Dynamic model results

Dynamic soil chemistry models such as VSD show the effects of acid deposition and forestry measures on the soil solution over time. The key processes included in the model are element fluxes in deposition, nutrient uptake by trees, nutrient cycling including mineralization, weathering processes for base cations and aluminium, and leaching of elements to groundwater. Also equilibrium reactions within the soil solution are taken into account. The calculations rely on Level II data and historical deposition rates available from literature. Future deposition scenarios based on the UNECE Gothenburg Protocol were applied as calculated by the International Institute for Applied Systems Analysis (IIASA). The depicted plots are not representative for Europe, but were selected for reasons of data availability. The application of dynamic models to a larger number of Level II plots is intended in the future.

The specific site and stand conditions on each plot have to be taken into account in order to assess the effects of measured deposition. Dynamic models have been applied to 37 Level II plots. These models specifically estimate the reaction of the soil solution based on soil, meteorological and deposition data.

Results of the dynamic model VSD are demonstrated in Figure 3.4.3-1 to 3.4.3-3. The pH value is chosen as accepted chemical indicator of acidification.

For the years 1900, 1990 and 2030 VSD results at the selected 37 Level II plots showing the change of pH, first an effect of acidification and than a recovery.

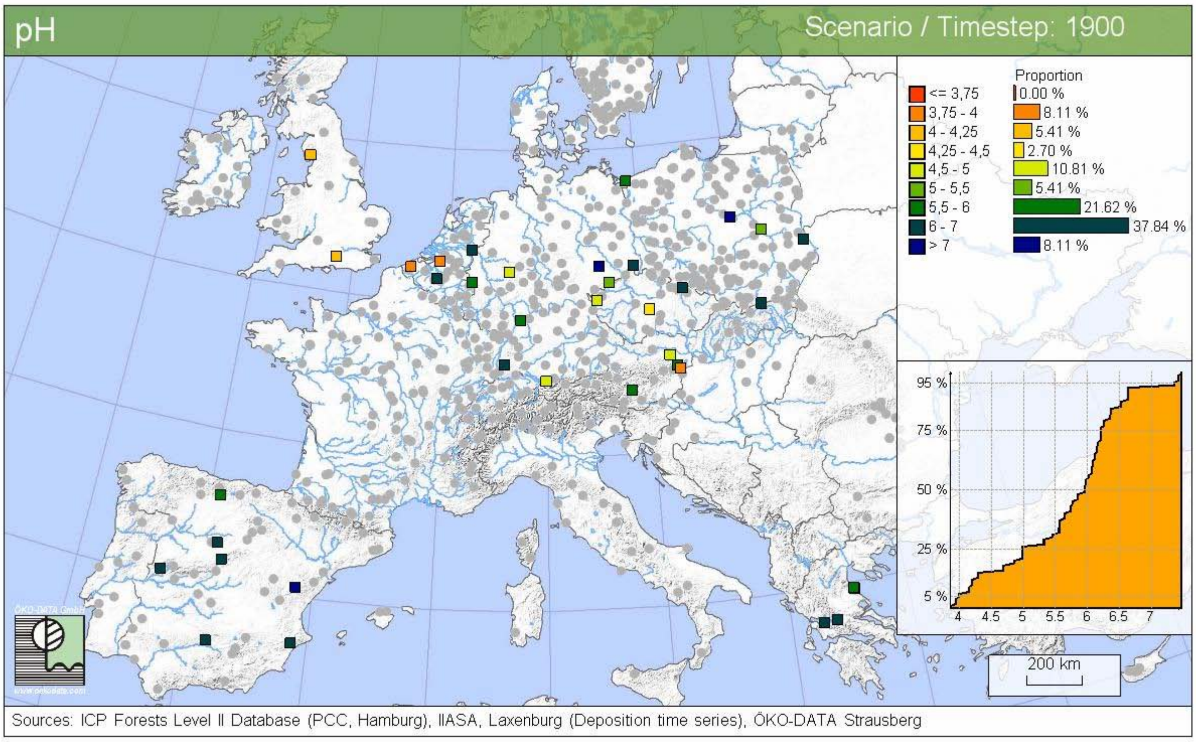


Figure 3.4.3-1: pH values at Level II plots for the year 1900. The pH value is a common chemical indicator for acidification, low values indicate acid conditions.

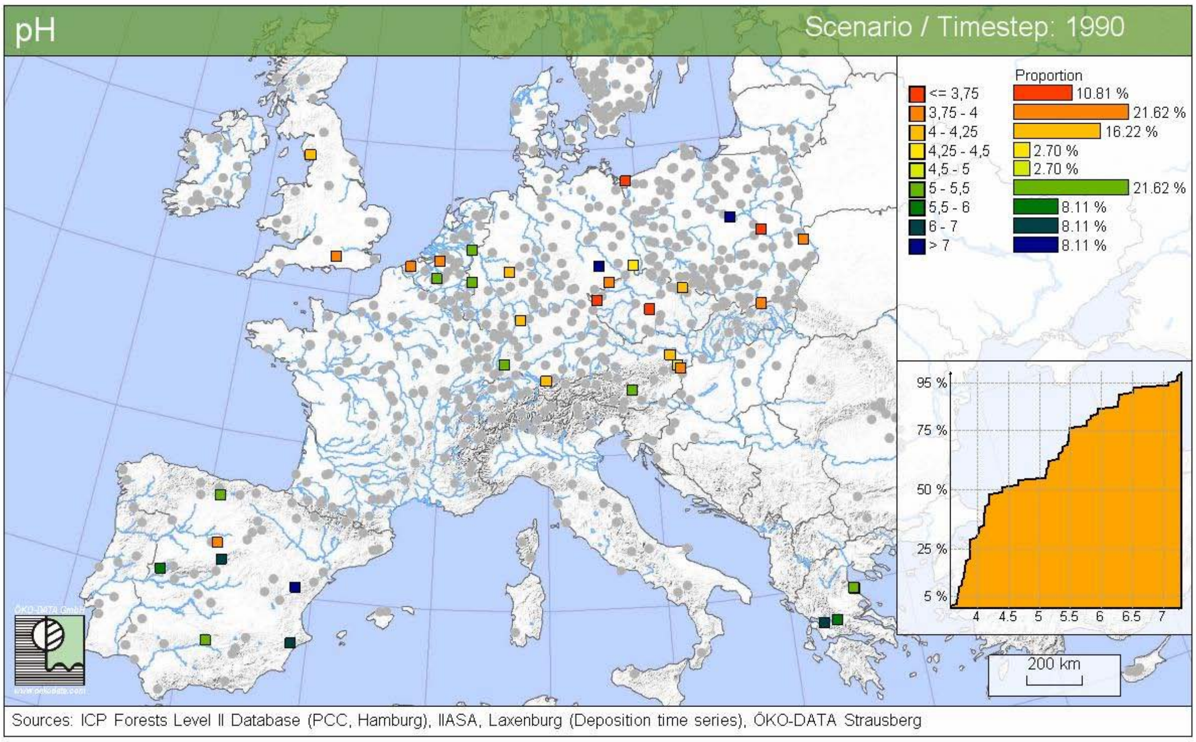


Figure 3.4.3-2: pH values at Level II plots for the year 1990. The pH value is a common chemical indicator for acidification, low values indicate acid conditions.

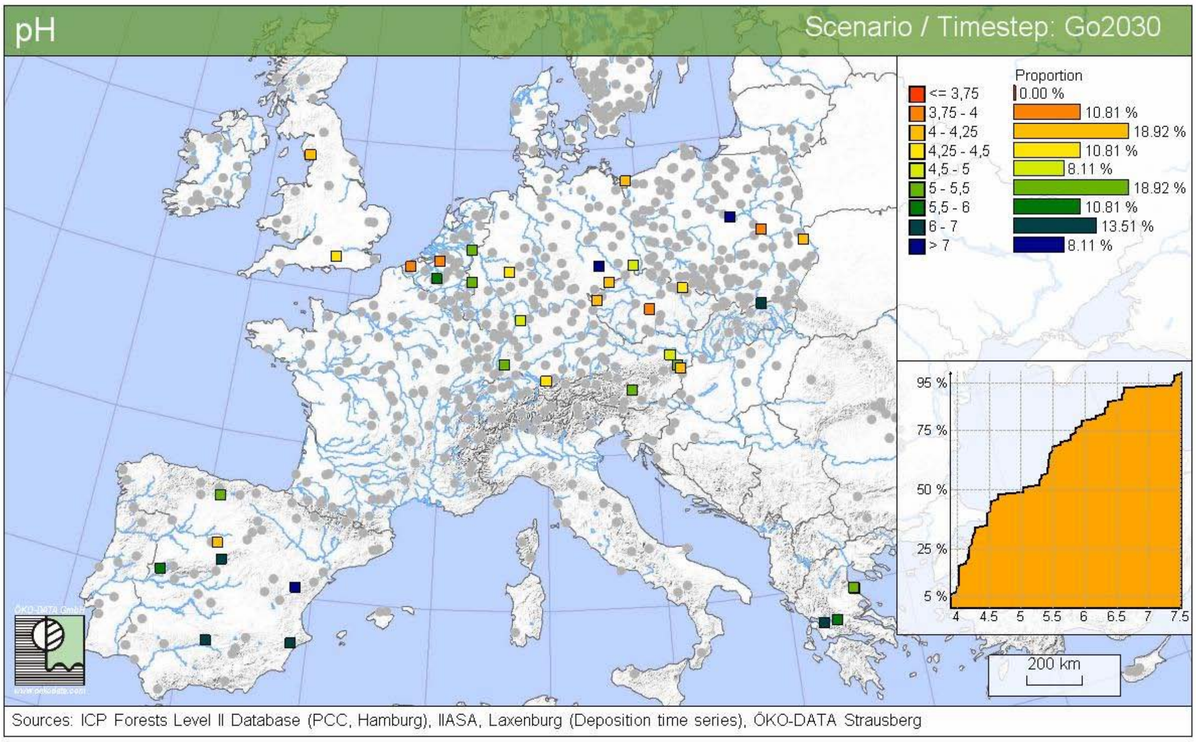


Figure 3.4.3-3: pH values at Level II plots for the year 2030. The pH value is a common chemical indicator for acidification, low values indicate acid conditions.

Many of the depicted plots show an increase of acidification between 1900 and 1990 and a subsequent slight recovery until 2030. Such a development is in general confirmed by measurements and has as well been reported from partner programmes of ICP Forests, showing that across Europe, the area with critical loads exceedances was largest in the 1990s.

The partial recovery that is observed since then is a success of emission reductions. The results presented are based on the assumption of further emission reductions following the UNECE Gothenburg Protocol. In 2050, soils with pH values below 4 can be expected for the examined plots nearly in the range of 1900, but above pH 5 are at this time just 50 percent of the calculated sites instead of about 70 percent in 1900 (Figure 3.4.3-4).

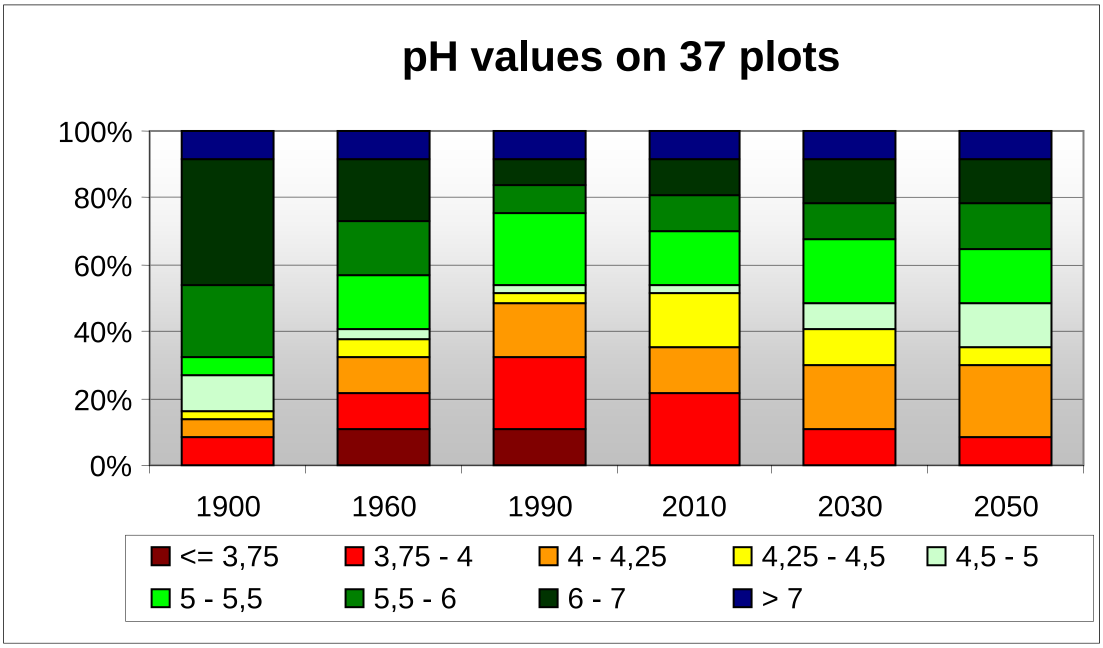


Figure 3.4.3-4: Frequency of pH values over time at 37 Level II plots, located in Spain (7), United Kingdom (2), Germany (8), Poland (6), Greece (4), Austria (4), Belgium (3) and Hungary (1).

The plot wise results show that the ecosystem reaction is not uniform, but instead depends on specific site and stand conditions (see Figure 3.4.3-5). Plots with a very constant pH value are mostly located on calcareous parent material which is a natural buffer for acidic inputs. Sensitive soils show a marked decrease in pH and only a partial recovery.

A full recovery is observed on plots were pH increases to historical levels after emission reductions have become effective. It has to be taken into account that dynamic models focus on the chemistry of soil solution which is closely linked to atmospheric deposition and thus reacts rather quickly to changing inputs. The recovery of the soil solid phase is much slower and can take many decades.

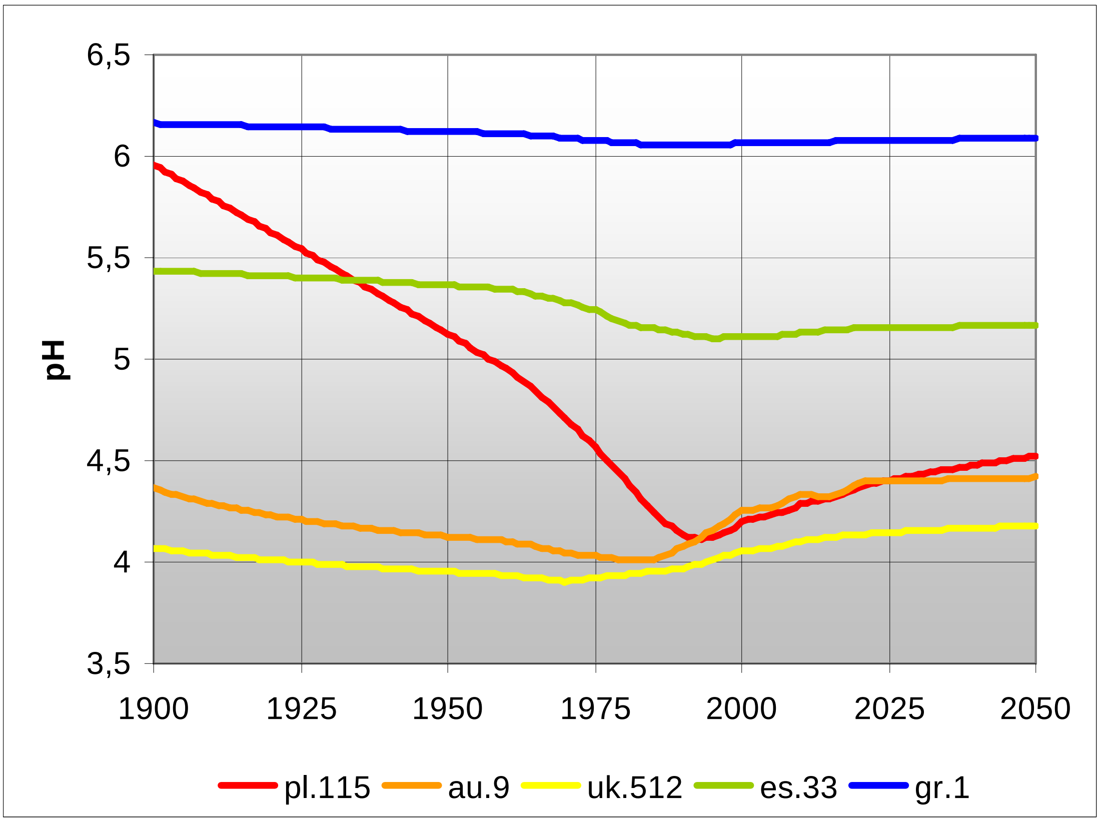


Figure 3.4.3-5: Time series of pH-value for selected Level II plots in Poland, Austria, United Kingdom, Spain and Greece.

The plots shown in Figure 3.4.3-5 are characterized by the following items.

- pl.115**:** Spruce, Texture: Medium, CEC 3.2 $cmol_c/kg$,
  Deposition 1760eq/(ha a) S, 800 eq/(ha a) ox. N, 890 eq/(ha a) red. N
- au.9: Beech, Texture: Medium, CEC: 12.8 $cmol_c/kg$,
  Deposition 264 eq/(ha a) S, 335 eq/(ha a) ox. N, 254 eq/(ha a) red. N
- uk.512: Oak, Texture: Fine, CEC: 11.2 $cmol_c/kg$,
  Deposition 550 eq/(ha a) S, 176 eq/(ha a) ox. N, 259 eq/(ha a) red. N
- es.33: Oak, Texture: Medium, Actual base saturation: 51%, CEC: 7.8 $cmol_c/kg$,
  Deposition 285 eq/(ha a) S, 200 eq/(ha a) ox. N, 130 eq/(ha a) red. N
- gr.1: Oak, Texture: Medium, CEC: 12.8 $cmol_c/kg$,
  Deposition 381 eq/(ha a) S, 121 eq/(ha a) ox. N, 175 eq/(ha a) red. N

Single layer models, like VSD, are neglecting the dependencies of the chemical status between different soil layers. Multilayer models as SAFE take care of these dependencies. For this reason, and also because of the much more sophisticated weathering module, results of SAFE are more reliable and comparable with measurements.

Model results applying SAFE demonstrate that due to reduced emissions after the implementation of the Gothenburg Protocol at some Level II plots a recovery can be expected, at other plots critical pH conditions will remain (Figure 3.4.3-5). The model application was funded by the forest departments of North Rhine-Westphalia and Saxony.

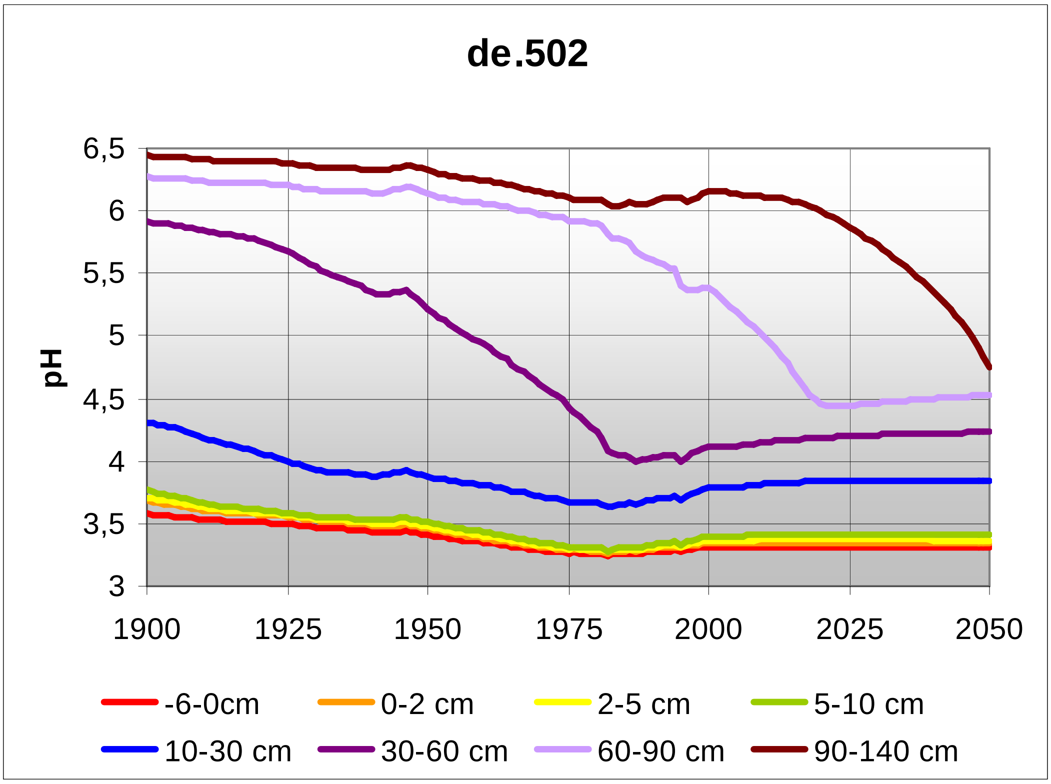


Figure 3.4.3-6: Dynamic acidification effects modelled with the multilayer model SAFE at the German Level II Plot 502: Tannenbusch, 130 year old oak with 25 % 75 year old beech, Gleyic Cambisol, sand (P=900mm, T=9°C),
Deposition 900 eq/(ha a) S, 600 eq/(ha a) ox. N, 1570 eq/(ha a) red. N.

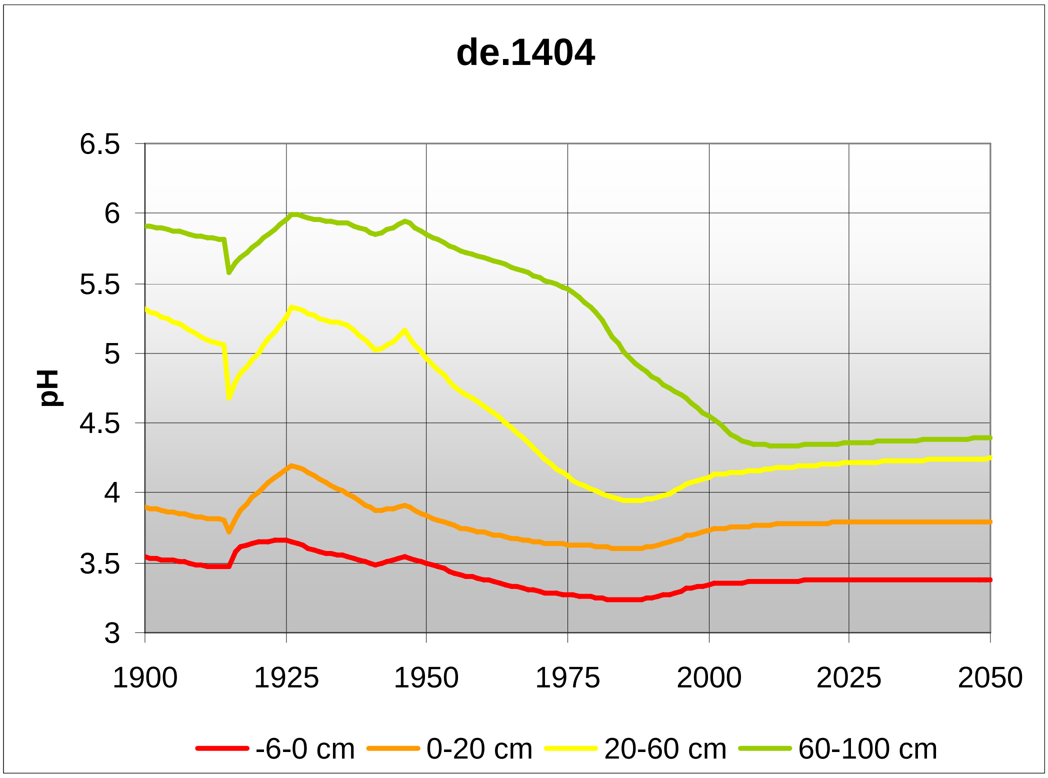


Figure 3.4.3-7: Dynamic acidification effects modelled with the multilayer model SAFE at the German Level II Plot 1404: Bautzen, 90 year spruce, Cambisol, silt, (P=900mm, T=8°C),
Deposition 1280 eq/(ha a) S, 1070 eq/(ha a) ox. N, 1260 eq/(ha a) red. N.

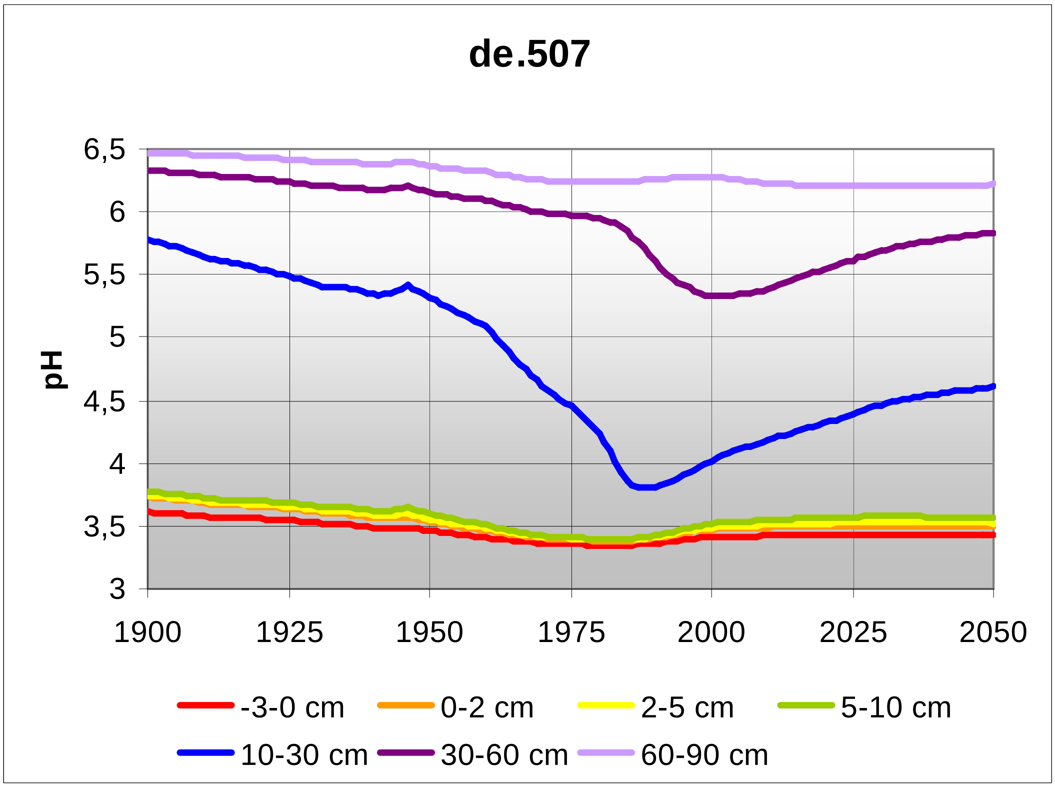


Figure 3.4.3-8: Dynamic acidification effects modelled with the multilayer model SAFE at the German Level II Plot 507: Monschau, 140 year beech, Gleysol, loam (P=1050mm, T=8°C), Deposition 720 eq/(ha a) S, 570 eq/(ha a) ox. N, 590 eq/(ha a) red. N.

The German Level II sites 502 and 1404 in Figure 3.4.3-6 and Figure 3.4.3-7 show the development of the acid frontier induced by acidic deposition. Plot 502 is a slow reacting site (a damage delay time is obvious) with high storage capabilities, while the Saxony site 1404 shows an extreme fast response to acid deposition. The third Level II plot 507 shows an expected recovery after implementation of the Gothenburg protocol (Figure 3.4.3-8).

3.4.4 Further development and tests for BERN-model application combining dynamic model results with vegetation changes

Level-II-data were selected for testing the biodiversity model “Bioindication for Ecosystem Regeneration towards Natural conditions” (BERN model, SCHLUTOW and HÜBENER 2005) in order to comprehend the vegetation changes in the past and future.

The BERN-model database contains the natural plant communities of middle Europe with their ecological niche widths of base saturation, pH, C/N-ratio in the soil and the climate conditions where their potential occurrence is possible. The BERN-model functions as an add-on-model to analyse and interpret biodiversity changes based on the results of modelled times series for base saturation and C/N-ratio.

Until now, BERN is a static model, which means that time lag effects are neglected. Due to the retardation of vegetation changes the observed vegetation effects may differ from the model outcome (not figured). Further evaluations and modelling based on a larger number of sites with an appropriate data basis are to be done in order to increase the experience with and the interpretability of biodiversity models.

4. NATIONAL SURVEY REPORTS IN 2005

Reports on the results of the national crown condition surveys at Level I of the year 2005 were received from 31 countries. For these countries, the present chapter presents summaries. Besides that, numerical data on crown condition in 2005 was received from 32 countries. These results are tabulated in Annex II. In Annex II-1 basic information on the forest area and survey design of the participatory countries is given. The distribution of the trees over the defoliation classes for all species is given in Annex II-2. Annexes II-3 and II-4 contain the data for conifers and for broadleaved trees, respectively. The annual changes in crown condition are presented for all species in Annex II-5, for the coniferous trees in Annex II-6, and for broadleaved trees in Annex II-7. Graphical presentations of the results are given in Annex II-8. It has to be noted, however, that it is not possible to directly compare the national survey results of individual countries. The sample sizes and survey designs may differ substantially and therefore conflict with comparisons. Gaps in the Annexes, 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.

4.1 Northern Europe

4.1.1 Estonia

Forest condition in Estonia has been systematically assessed since 1988. In 2005, 2 167 trees, 573 *Picea abies*, 1478 *Pinus sylvestris* and 116 broadleaved trees were assessed on 92 permanent Level I sample plots in the period from July to October.

The most defoliated tree species in the past years has been *Pinus sylvestris*. An improvement of crown condition was observed in the period 1994–2000. Subsequently, a certain decline was observed until 2003. Since then deceasing defoliation has been observed for this tree species. In 2005, 49.3% of the *Pinus sylvestris* were not defoliated (defoliation class 0), 45.5% of the trees were slightly (defoliation class 1), 4.7% of the trees were moderately (defoliation class 2) and only 0.5% of the trees were severely defoliated or dead (defoliation classes 3 and 4). The reduced defoliation is a result of an ending outbreak of the shoot blight caused by *Ascocalyx abietina*.

Defoliation increased for *Picea abies* from 1996 to 2002 and remained on the same level since then. In 2005, 61.6% of the *Picea abies* were not defoliated (defoliation class 0), 31.8% of the trees were slightly (defoliation class 1), 4.4% of the trees were moderately (defoliation class 2) and only 2.2% of the trees were severely defoliated or dead (defoliation classes 3 and 4).

In general, the health status of deciduous species was markedly better than that of conifers.

Lophodermium pinastri (521 trees damaged) and *Ascocalyx abietina* (534 trees damaged) were the most important reasons for biotic damage of trees.

4.1.2 Finland

The 2005 forest condition survey was conducted on 609 sample plots arranged on 16 x 16 km and 24 x 32 km grids. During the summers 2004 and 2005, over 150 new plots were added to the survey. The present network also includes 110 peat land plots. No notable changes were observed in the average defoliation level of any tree species between the years 2004 and 2005.

Of the 11 535 trees assessed in 2005, 57% of the conifers and 62% of the broadleaves were not suffering from defoliation (leaf or needle loss 0-10%). The proportion of slightly defoliated (11 - 25%) conifers was 34%, and that of moderately defoliated (over 25% defoliation) 9 %. For broadleaves the corresponding proportions were 31% and 7%, respectively. In general, the average tree-specific degree of defoliation was 9.2% (9.1% in 2004) in *Pinus sylvestris*, 17.8% (18.0 in 2004) in *Picea abies* and 10.9% (11.5% in 2004) in broadleaves (mainly *Betula* spp.). On mineral soils, the average defoliation was 9.5% (9.3%) in *Pinus sylvestris*, 17.9% (18.1%) in *Picea abies* and 11.4% (12.0%) in broadleaves, and on peatlands 8.2% (8.2%), 16.8% (17.0%) and 9.4% (9.3%), respectively. A total of 13 trees (0.1%) died during 2004-2005 (0.1 % in 2003/2004).

In 2005 the most extensively reported disease was *Chrysomyxa ledi*. It was common in a belt running across central Finland. The most severe damage was caused by storms, even though there was no single storm but several local gales. Snow caused damage in many areas in winter 2004/2005. Moose remains a major threat for young plantations. Voles were abundant in 2005 and caused damage in plantations, too. In spring especially, brownish *Pinus sylvestris* were eye-catching along the roadsides where salt used for de-icing the roads had damaged the trees. *Juniper* spp. were again heavily infected by *Stigmina juniperina*. According to the inventories, *Gremmeniella abietina* and *Tomicus* species were the most abundant damaging agents in pines and *Chrysomyxa ledi* in spruces.

No correlation was found between the defoliation pattern of conifers or broadleaves and the modelled sulphur or nitrogen deposition at the national level in 2005 (the model calculation for 2005 is based on estimated deposition for the year 2002 by EMEP/Finnish Meteorological Institute).

4.1.3 Latvia

The forest condition survey of 2005 in Latvia was carried out on 349 permanent sample plots on the national 8 x 8 km grid net. Eight sample plots were completely destroyed during the hurricane of January 2005. The main species assessed were *Pinus sylvestris, Picea abies,* and *Betula* spp.

Of all tree species, 19.7% of the assessed trees were not defoliated, 67.2% were slightly defoliated and 13.1% moderately defoliated to dead (defoliation classes 2-4).

The mean defoliation of conifers was slightly higher (20.4%) than the defoliation of broadleaves (18.7%). For *Pinus sylvestris* a slight yet statistically significant increase in mean defoliation, reaching 20.5 %, was observed compared to 2004. 2005 was the first year with increasing pine defoliation after a long period of crown condition improvement since 1993. The deterioration in 2005 was due to a large-scale outburst of the European pine sawfly *Neodiprion sertifer* in the northwestern and northern regions of Latvia. The total area affected by the pest was about 15 000 ha (in 2004 about 800 ha). In the most critical regions appropriate protection measures were taken.

The mean defoliation of *Picea abies* (20.2%) and *Betula* spp. (18.9%) was slightly lower than in 2004, although the changes were statistically insignificant. The percentage of damaged *Picea abies* (defoliation classes 2-4) decreased to 17.6% - the lowest value since 2000. However, since 2001 defoliation has been practically constant with annual variations below 1 percent point. For *Betula* spp., the proportion of trees in defoliation classes has varied periodically with no significant changes over the past four years.

In addition to the substantial storm damage from January 2005, visual observation revealed damage on 18.3% of the trees assessed. Compared to previous years, this index has increased by about 10 percent points. This increase is partly explained by a more thorough recording of the damage following the revised assessment methods. The proportion of damaged trees is similar for both conifers and broadleaved trees. For *Pinus sylvestris*, damage was recorded on 19.5% of the trees assessed, for *Picea abies* and *Betula* spp. the values were 14.7% and 16.1%, respectively. For *Pinus sylvestris* the most common damage causes were *Neodiprion sertifer* and the needle cast *Lophodermium pinastri*. *Picea abies* was most commonly damaged by deer and unfavourable abiotic factors. For *Betula* spp., foliar pests were the most commonly recorded damage types.

4.1.4 Lithuania

The 2005 forest condition survey was carried out on 262 sample plots of the transnational (16 × 16 km) and national (8 × 8 km) grid nets. In total, 6 315 sample trees representing 15 tree species were assessed. The main tree species were *Pinus sylvestris, Picea abies, Betula pendula, Betula pubescens, Populus tremula, Alnus glutinosa, Alnus incana, Fraxinus excelsior*, and *Quercus robur.*

Mean defoliation of all tree species was 20.3%, and thus 1.3 percent points lower than in 2004 (21.6%) and 0.9 percent points lower than in 2003 (21.2%). 14.1% of all sample trees were not defoliated (defoliation class 0), 74.9% were slightly defoliated and only 11.0% were assessed as moderately defoliated, severely defoliated or dead (defoliation classes 2-4). Mean defoliation of conifers was 19.6% (20.4% in 2004). The change in mean defoliation of broadleaves was statistically significant. It was 22.0% and by 2.1 percent points lower than in 2004 (24.1%).

Pinus sylvestris accounted for more than 50% of all sample trees and its condition thus significantly influences the overall mean values. Mean defoliation of *Pinus sylvestris* was 19.7% (20.2% in 2004). Since 1998, mean defoliation of *Pinus sylvestris* did not exceed 21.0%.

Mean defoliation of *Picea abies* was 19.3 (21.0% in 2004). In 2005, mean defoliation of *Quercus robur* was 31.4% (31.3% in 2004) and the share of trees in defoliation classes 2 -4 was 34.6% (47.6% in 2004). *Alnus incana*, *Alnus glutinosa* and *Populus tremula* had the lowest mean defoliation of all tree species. Mean defoliation of *Alnus incana* was 18.2% (24.2% in 2004), mean defoliation of *Alnus glutinosa* was 18.5% (19.1% in 2004) and *Populus tremula* had a mean defoliation of 18.6% (22.7% in 2004).

10.9% of all sample trees had some kind of identifiable damage symptoms. The most frequent damage was caused by insects (2.5%), abiotic agents (2.1%), fungi (1.8%) and direct action of man (1.1%). The share of trees with insect damage was 4.2 percent points lower than in 2004 (6.7%). *Populus tremula* (48.9%) and *Quercus robur* (45.8%) were the tree species with the highest proportion of damaged trees. *Pinus sylvestris* (6.2%) and *Alnus glutinosa* (7.2%) were the tree species with the lowest share of damaged trees.

The condition of Lithuanian forests can be considered as relatively stable, as mean defoliation of all tree species has varied only slightly since 1996.

4.1.5 Norway

With respect to all tree species, 44.2% of the trees assessed in 2005 were not defoliated and 90.2% were not discoloured. This reflects a general improvement compared to the year before. The mortality remained at 0.3%. Average crown density was 82.6% showing a decrease by 0.7 percent points as compared to 2004.

For *Picea abies*, average crown defoliation increased from 15.1 % to 16.1 % in 2005 compared to 2004, and for *Pinus sylvestris* from 14.5 % to 16.0 % in 2005. The crown defoliation for *Betula* spp. was recorded to 21.3 %, representing a decrease by 1.3 percent points compared to the result in 2004.

Of the coniferous trees, 47% were rated not defoliated, representing the same level as in 2004. But, for *Picea abies* there was an increase in the share of not defoliated trees by 0.9 percent points and for *Pinus sylvestris* a decrease by 2.2 percent points compared to 2004. An increase for *Betula* spp. by 6.4 percent points to 34.8% in 2005 was observed in the class of not defoliated trees.

15% of *Picea abies* showed signs of discolouration, after 18% in 2004. For *Pinus sylvestris*, 4.7% were assed as discoloured, reflecting the same level as compared to 2004. In *Betula* spp., a decrease in discoloured trees was observed from 9% in 2004 to 5.7% in 2005.

No serious attacks of pests or pathogens were recorded in 2005. In general, the observed crown condition results from an interaction between climate, pests, pathogens and general stress. The results of the 2005 assessments confirm the status of the crown condition recorded over the last few years.

4.1.6 Sweden

The national forest condition survey was carried out on 784 plots of the transnational Level I grid. In total, 11 443 conifers and broadleaved sample trees were assessed. Included in the calculations are also 7 386 sample trees (*Picea abies* and *Pinus sylvestris*) on 3 232 sample plots of the National Forest Inventory. The results from the national forest condition survey concern only forest of thinning age or older. The main tree species are *Picea abies*, *Pinus sylvestris*, *Betula pendula*, *Betula pubescens*, *Fraxinus excelsior*, and *Quercus robur*.

The proportion of trees with more than 25% defoliation is in *Picea abies* 27.9 % (25.6 % in 2004) and in *Pinus sylvestris* 11.4 % (10.0% in 2004). The increased defoliation is mainly seen as increased mortality rate, + 1.2 percent points, mainly due to wind thrown trees. In *Betula* spp. a slight increased defoliation was recorded and the proportion of trees with more than 25% is 8.5% (7.0% in 2004). The share of discoloured *Picea abies* trees has in 2005 slightly decreased to 9.7%. In *Pinus sylvestris* discolouration is still rare, with less than 2%.

The severe storm in January 2005, which affected large parts of southern Sweden, has strongly influenced the forest condition in 2005. It will probably also have a significant affect on the condition in coming years due to the risk of increasing populations of bark beetles. About 75 million m^3 timber, mainly *Picea abies* but also to a large part *Pinus sylvestris* trees were felled by the storm. In southern Sweden (Götaland) 6.8% of the *Picea abies* trees and 3.6% of the *Pinus sylvestris* trees were wind thrown. A relatively low rate (less than 5% for *Ips typographus*) of insect attacks on wind thrown trees indicated low populations in spring 2005. However, a large amount of suitable substrate has increased the populations in the meantime. Among defoliators no extensive outbreaks were found, and less than 1% of the broadleaved trees were moderately or severely affected by defoliators. Attacks of *Dendroctonus micans* were detected on 0.8% of *Picea abies* in southern Sweden (Götaland). Among fungi damage (root rot excluded) no indication of any outbreak was found. The excessive outbreak of *Gremmeniella abietina,* which arose in 2001, still influences the tree health on *Pinus sylvestris*. New infections are now however at a low level.

4.2. Central Europe

4.2.1 Austria

The crown condition assessment in Austria is restricted to the transnational grid of 16 x 16 km since 2003. The transnational grid in 2005 comprised 136 plots with about 3 500 sample trees.

In 2005, crown condition for all tree species, compared to results of the previous year, deteriorated. Around 15% of the sample trees, i.e. 1.7 percent points more than in 2004 were classified as damaged (defoliation classes 2-4). The share of coniferous species classified as damaged increased by approximately 2 percent points and the share of broad-leaved species decreased by about 1 percent point. The mortality rate, calculated as the percentage of trees that died between two surveys, was 0.4%, and thus the highest value ever found in all years.

As regards the most common coniferous species, crown condition of *Picea abies* and *Larix decidua* deteriorated, and crown condition of *Pinus sylvestris* slightly improved. Reliable information on the development of broadleaved species, esp. *Quercus* sp., cannot be given due to the small sample size. The remarkable deterioration of crown condition of *Larix decidua* is probably due to strong infestation with *Coleophora laricella* and *Adelges geniculatus & laricis* in many parts of Austria. Because of the high amount of precipitation during the summer of 2005, several micro fungi, some of them leading to premature leaf shedding, were observed on broadleaved species. The swarming of bark beetles started very early this year. A surprisingly high activity of bark beetles occurred in alpine regions located higher than 1 000 m above sea level.

The impact of atmospheric sulphur deposition on forests has been assessed since 1983 on the Austrian Bio Indicator Grid comprising 760 sample plots. The main indicator tree species for foliar analysis is *Picea abies* (about 90%). The annual sampling allows a precise evaluation of the temporal and regional development of the impact of sulphur. Despite the reduction of SO_2 emissions in Austria since the 1980ies, the legal threshold value is still exceeded on 8% of the plots. These plots are mainly located near large national emitters, but also in areas affected by transboundary sulphur emissions from neighbouring countries.

4.2.2 Croatia

86 sample plots on the 16 x 16 km grid network were included in the forest condition survey in 2005, and 87 plots in 2004. The percentage of trees of all species within defoliation classes 2-4 in 2005 (27.1%) was higher as compared to the year 2004 (25.2%). For broadleaves the share of trees in classes 2-4 was 17.8 % in 2004 and 19.2 in 2005. For conifers, the percentage of damaged trees shows an increase from 70.6 % in 2004 to 79.5% in 2005. Although the percentage of moderately to severely damaged conifers is high, it does not have a stronger impact on the overall percentage of trees of all species due to the low representation of coniferous trees in the sample (268 coniferous trees vs. 1778 broadleaves in the 2005 survey).

Abies alba remains the tree species with the highest share of damaged trees. 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 continued with 83.3% of moderately to severely damaged trees in 2003, 86.5% in 2004 and 88.5% in the year 2005.

The lowest damage of *Quercus robur* was recorded in 1988 (8.1%), the highest in 1994 (42.5%), and the share of damaged tress has been fairly constant in the following years with around 25-30% until the year 2000. Afterwards it decreased to values below 20% (15.4% in 2003, 18.5% in 2004). In 2005, an increase was recorded with 22.1% of moderately to severely damaged oak trees.

For *Fagus sylvatica*, the share of trees in defoliation classes 2-4 remained low since the start of the observations. The highest value was recorded in the year 2001 when it was 12.5%. Later it dropped to lower values: 5.1% in 2003, 7.5% in 2004 and 7.0% in 2005.

In Croatia, the last two years were wet years. According to the Meteorological and Hydrological Service of Croatia, the year 2004 was very warm (on 45% of the area) or warm (also 45% of the area) and rainy (50% of the area) or normal (45% of the area). These conditions did not seem to have a beneficial effect on the defoliation of trees in Croatia. Overall, despite a relatively high degree of damage, forest condition in Croatia has remained stable in the course of the last few years with a slightly increasing trend.

4.2.3 Czech Republic

No important changes in defoliation since 2001 have been observed for *Picea abies*, which is the main tree species in the 60 years old and older stands. For *Picea abies* trees younger than 60 years, the share of trees in defoliation class 1 slightly increased in 2005. Simultaneously, the share of trees in the higher defoliation classes 2–4 increased. A slight increase of the share of trees in defoliation class 2 was as well observed for *Pinus sylvestris* and *Larix decidua* of both age categories. The most distinct changes were observed for *Abies alba* up to an age of 59 years where, compared to the previous year, mean defoliation increased from below 10% to 35.0%. Just as in the preceding year, an improvement was observed for the older *Abies alba* stands. Here, the share of trees in defoliation class 1 increased at the expense of a decreasing share of trees in higher damage classes.

Compared to the previous year, no important changes occurred for the main deciduous species (*Quercus* spp. and *Fagus sylvatica*) of both age categories.

During the summer season 2005, forest stands in some forest regions, mainly in western and northern Bohemia, were sporadically damaged by strong winds and storms. Drought damage occurred for *Pinus sylvestris* and *Pinus nigra* on exposed sites of the central Bohemia.

In 2005, the continuing emission reductions of main pollutants like solid substances, SO_2, CO, VOCs, were less distinct as compared to the previous years. Emissions of solid substances and nitrogen oxides (NO_x) have slightly increased in the last years.

4.2.4 Germany

Since 1984, the crown condition of forest trees has been recorded on an annual basis. The survey provides information on the health status of trees. The results of the 2005 nationwide crown condition assessment show a slight recovery in the crown condition of forest trees compared to the previous year. The previous year was characterised by the most severe crown defoliation since the beginning of surveys. This can be attributed to the extreme drought situation and heat wave in 2003.

The proportion of forest areas with visible crown defoliation (defoliation classes 2–4) now amounts to 29% which is still a comparatively high level. Of all main tree species, *Quercus* spp. showed the largest share of visible crown defoliation (51%) which is a serious worsening as compared to the previous year (45%). This is as well the highest level of defoliation since the beginning of the survey. There are large regional differences. Compared with the previous year the crown condition of oak trees shows the most severe deterioration in Hesse, Saarland, Bavaria and Thuringia. The 75 % proportion of damaged oak area that was reported from Baden-Württemberg in 2005 marks a new peak in long-term as well as in supra-regional comparisons.

For *Fagus sylvatica* 44% of the area was rated as damaged. This is a substantial recovery since 2004 (55%). Yet, it is still one of the highest levels since the launch of the surveys in 1984. The current condition also constitutes a serious deterioration as compared to the condition in the early 1990s. 31% of the area covered by *Picea abies* showed visible crown defoliation. 19% of the *Pinus sylvestris* trees were classified as damaged or dead. These conifers showed comparatively small changes as compared to 2004.

In 2005, forest condition was still influenced by the after-effects of the dry summer in 2003. Whereas the weather in northern and central Germany was beneficial for a recovery of the trees, this was not the case throughout the South. The mass outbreak of bark beetles in the previous years receded nationwide, but bark beetles continued to inflict damage on spruce trees in the South-West. This development was fostered by the warm and dry weather that prevailed. The mass outbreak of insect pests on oak trees also continued in southern and in central Germany, as well as in Lower Saxony.

The fact that the forests have already suffered from persistently high deposition and acid inputs over years and decades increases their susceptibility to additional stress factors and poses a long-term risk to the quality of soils and groundwater. Moreover, climate change poses new challenges to forests and forest management.

4.2.5 Poland

The 2005 forest condition survey was carried out on 1 298 permanent observation plots of the national gridnet, including 433 plots of the transnational 16 x 16 km grid. Each plot consists of 20 marked dominant trees.

Forest condition improved compared to the previous year. 12.2% of all sample trees were without any symptoms of defoliation, indicating an increase by 3.9 percent points as compared to 2004. The proportion of damaged trees (defoliation classes 2-4) decreased by 3.9 percent points to a currant level of 30.7% of all trees. The share of damaged trees decreased by 3.7 percent points for conifers and by 4.5 percent points for broadleaves.

In 2005, improvements were specifically observed for *Abies alba* stands, where the share of trees with a defoliation above 25% decreased by 13.8 percent points. *Quercus* spp. also showed slight improvements. The share of trees with defoliation above 25% decreased by 6.6 percent points.

29.6% of the conifers were rated as damaged (defoliation classes 2-4). *Abies alba* remained the species with the highest defoliation (50.9% of the trees in defoliation classes 2-4).

For broadleaves, the proportion of trees in defoliation classes 2-4 amounted to 34.1%. As in the previous year, the highest defoliation amongst broadleaved trees was observed in *Quercus* spp. stands. In 2005, a share of 46.9% of all *Quercus* spp. trees was in damage classes 2-4.

In 2005, discolouration (classes 1-4) was observed on 3.6% of the conifers and 1.5% of the broadleaves.

4.2.6 Slovak Republic

The 2005 national crown condition survey was carried out on 108 Level I plots of the 16 x 6 km grid net. The assessments covered 4 993 trees, 4 111 of which being assessed as dominant or co-dominant trees according to Kraft. Of the 4 111 assessed trees, 22.9% were damaged or dead (defoliation classes 2-4). The respective figures were 35.3% for conifers and 13.6% for broadleaves. Compared to 2004, the share of trees defoliated more than 25% decreased by 3.8 percent points. Mean defoliation for all tree species together was 22.3%, with 26.2% for conifers and 19.2% for broadleaves. Compared to 2004, an improvement in mean defoliation was observed for *Carpinus betulus* only. Statistically significant improvements were not observed for any species.

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

From the beginning of the forest condition monitoring in 1987 until 1996 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 the crown condition survey, damage types were assessed. 41.9 % of all sampling trees (4 993) had some kind of damage symptoms. The most frequent damage was caused by insects (18.8%) and fungi (15.1%) at tree stems. Additional damage causes were logging activities (13.3%), and abiotic agents (5.6%). Epiphytes had the most important influence on defoliation. 69% of trees damaged by epiphytes revealed defoliation above 25%. In addition, abiotic agents had a direct link to defoliation.

4.2.7 Slovenia

The 2005 national forest condition survey encompassed a total of 1056 trees on 44 sample plots. The sampling scheme and the assessment methods were the same as in the previous forest condition surveys. In 2005, the grid was revised for potential new sampling plots which might need to be included (e.g. afforestation). Eight locations were checked, but only two new plots were included.

The mean defoliation of all tree species was estimated to 23.3%, while the proportion of trees with more than 25% unexplained defoliation attained 30.6%. Despite the fact that, when compared to the previous assessment, the share of damaged trees has increased (in 2004 the mean defoliation was 23.3 % and the proportion of trees with more than 25% unexplained defoliation was 29.3%) the change has not been proven statistically significant ($p > 0.05$).

As already reported in the past years there are significant differences in defoliation between conifers and broadleaves. 28.1% of sampled coniferous trees were defoliated less than 10%, 38.1% of them between 10 and 25 %, 27.3% between 26 and 60%, and 6.5% of them were severely defoliated or dead. On the other hand, 30.1% of broadleaves were considered unaffected at all, 40.1% of them were damaged slightly, 23.7% of them were defoliated moderately and the defoliation of 4.8% trees was higher than 60%. To summarise, in comparison to the survey in 2004, the distribution of damage proportions has changed slightly, but the changes are not significant.

By considering only individual tree species, the following conclusions may be drawn. The mean defoliation of *Picea abies* remained almost the same as in 2004, while the share of damaged trees (defoliated more than 25%) decreased by 5.8 percent points. However, the change was not proven statistically significant ($p > 0.05$). In comparison to the situation of the last year, *Fagus sylvatica* remained almost unchanged. While its mean defoliation increased by 0.2 percent points, the share of damaged trees decreased by 0.7 percent points.

4.2.8 Switzerland

In 2005, the Swiss national forest health inventory was carried out on 48 plots of the 16 x 16 km grid using the same sampling and assessment methods as in the previous years.

Forest condition in 2005 was still affected by the drought of 2003. So far, the largest annual increase in defoliation had been recorded in 2004 as a delayed response to the drought. Crown condition in 2005 had only slightly (but not significantly) recovered in comparison to 2004. In 2005, 28.1% (2004: 29.1%, 2003: 14.9%) of the trees had more than 25% unexplained defoliation (i.e. subtracting the known causes such as insect damage, or frost damage), and 39.2% (2004: 41.0%, 2003: 24.4%) of the trees had more than 25% total defoliation. It should be noted that the Swiss values also include all dead trees and that the proportion of dead trees is constantly rising in Swiss forests (2005: 8.4%, 2004: 7.5%, 2003: 6.7%). Although too few trees are assessed annually for a statistical analysis of tree mortality, it was striking that between 2003 and 2004 11 trees out of the roughly 1050 trees assessed had died and between 2004 and 2005 6 more trees died. These mortality trees were found on several plots and included various species (50% were deciduous trees). The mortality rates following the drought were higher than the ‘normal’ annual mortality rate of 0.3 to 0.4 percent.

On the Swiss Level II plots, the situation was similar. Following the large increase in defoliation on most plots in 2004 a slight decrease or stabilization was reported in 2005. Mortality rates for all plots combined were 1% between 2003 and 2004 and 0.55% between 2004 and 2005, but varied highly between plots. At one *Pinus sylvestris* plot, mortality since 2003 has surpassed 30%. In some parts of Switzerland, bark beetle induced mortality of *Picea abies* has continued in 2004 and to a lesser degree in 2005. On *Fagus sylvatica* few defoliators had been reported in the aftermath of the drought, but severe insect induced defoliation of *Quercus* spp., in particular *Operophtera brumata* species, has continuously increased since 2001.

4.3 Southern Europe

4.3.1 Cyprus

The annual assessment of crown condition was conducted on 15 Level I plots, during the period August - October 2005. The assessment covered the main forest ecosystems of Cyprus, and a total of 360 trees of *Pinus brutia*, *Pinus nigra* and *Cedrus brevifolia* were assessed. Defoliation, discolouration and the agents causing damage to the trees were recorded.

From the total number of trees assessed, 20% of them were not defoliated, 69.2% were slightly defoliated and 10.8% were moderately defoliated. A comparison with the survey results of the previous year shows a slight improvement with a decrease by 2.5 percent points of the trees being in class 0 (not defoliated) and by 1.4 percent points of the trees being in class 2 (moderately defoliated). On the other hand, an increase by 3.9 percent points in class 1 (slightly defoliated) has been observed. Among the years 2001 to 2005 there are no significant changes in the defoliation percentage in each class.

For the results of 2005 in *Pinus brutia*, 20% of the sample trees showed no defoliation, 67% were slightly defoliated and 13% were moderately defoliated. In *Pinus nigra*, 19.4% of the sample trees showed no defoliation while the rest 80.6% of them were slightly defoliated. In *Cedrus brevifolia*, 20.8% of the sample trees showed no defoliation and 79.2% of them were slightly defoliated.

From the total number of sample trees inspected, 42.5% showed signs of insect attack and 7.5% showed signs of attack by “other agents” (lichens and dead branches). Compared to the previous years’ results, there is an increase by 0.5 percent points of sample trees showing signs of insect attack and an increase by 1.1 percent points for other agents. The preliminary analysis shows that sucking and defoliator insects are the major biotic factors causing defoliation during the year 2005. No damage was attributed to any of the known pollutants. However, the poor edaphic conditions on which the forests grow, and the adverse drought conditions prevailing in Cyprus should be considered as additional factors contributing to the defoliation of trees.

Forest fires are a serious problem for the forests in Cyprus due to drought conditions, low precipitation and high temperatures prevailing in the island. However, due to the effective system and infrastructure in preventing and suppressing forest fires, the annual burnt area is kept small. During 2005, twenty-eight forest fires damaged 28.9 ha of State forests. 12.5 ha were coniferous forest, 13.5 ha were broadleaved forest and 2.9 ha were other forest cover types. The main causes of fires were: carelessness of forest visitors and farmers, malicious, unknown and natural causes. Forest fire did not cause any damage to the Level I plots in 2005.

4.3.2 Greece

When all tree species are taken together, 83.7% of the trees were not or slightly defoliated, 13.3% of the trees were moderately defoliated, 1.5% were severely defoliated and 1.5% were dead. For the conifers, 48.5% showed no defoliation, 36.5% were slightly, 12.2% were moderately and 0.8% and 1.9% were severely defoliated and dead, respectively. For the broadleaves, 38.7% showed no defoliation, 43.4% were slightly, 14.6% were moderately and 2.4% and 0.9% were severely defoliated or dead, respectively.

A comparison of defoliation results between 2005 and 2002 (year of the previous assessment) shows that for the sample of all species, the share of moderately and severely defoliated trees and dead trees decreased by 3.3, 0.8 and 0.5 percent points, respectively, whereas an increase by 2.1 and 2.5 percent points was observed for the share of not defoliated and slightly defoliated trees, respectively.

A comparison of the 2005 survey results with those of the 2002 shows a slight improvement in the condition of conifers and mainly of the broadleaved species. From the total number of trees assessed, about 25.5% showed signs of insect attack and 8.3%, 1.9%, and 19.5%, showed signs of adverse effects by abiotic, human and “other agents”, respectively. No damages were attributed to any of the known pollutants. The insect damages registered in 2005 were mainly old damages of the previous years.

2003 and 2004 were rainy years with heavy winters and exceptionally wet and humid summers. 2005 was extremely rainy and a lot of floods occurred during winter and spring in widespread areas all over the country.

4.3.3 Italy

The number of Level I plots in Italy (6573 trees on 238 plots) was in 2005 slightly lower than in 2004 (17 plots less), because of assessment problems in some regions. Thereby, the main results as far as defoliation and discolouration are concerned, as well as the frequency of biotic and abiotic damage agents, according to the new assessment form are presented.

Defoliation data are reported according to the usual categorical system: most (74.4%) is included in the classes 1 to 4; the 32.9% is included in the classes 2 to 4. 41.0% of conifers and 20.1% of broadleaves are without any defoliation (class 0). The conifers falling in the defoliation classes 2 to 4 are 22.8%, for broadleaves 36.5%. Analyzing the sample by defoliation and by age class (<60 and ≥60 years) it can be observed that, among the young

conifers (< 60 years), the share of trees belonging to the classes 2-4 is highest for *Pinus sylvestris* (33.3%) and *Pinus halepensis* (29.7%). Among the old conifers (≥60 years) for *Pinus cembra* (40.4%) the highest share of trees in classes 2-4 was followed by *Larix decidua* (35.6%) and *Picea abies* (25.8%). The share of damaged trees (classes 2-4) was even higher among the young trees (<60 years) for *Castanea sativa* (56.3%), *Quercus pubescens* (53.3%), *Ostrya carpinifolia* (31.7%) and *Fagus sylvatica* (26.5%). Also among the old broadleaves the share of damaged trees was relatively high for some species (*Castanea sativa*, 61.0%; *Quercus petraea*, 44.4%; *Fagus sylvatica*, 31.1%).
Discoloration is absent in 92.8% of conifers and 93.6% of broadleaves. Among the young conifers (< 60 years) 43.1% of the *Pinus halepensis* trees present discoloration in the classes 2-3, all other tree species showed lower discolouration.

Starting from 2005, the new methodology for a deeper assessment of damage factors (biotic and abiotic) was introduced. In conifers, most of the observed symptoms were attributed to insects (14.3% of the whole sample); the conifers affected to fungi are the 6.7% of the total. Abiotic agents are the 4.9% of the sample from which 17.3% of the trees with abiotic damage were affected by "snow/ice".
For broadleaves, most symptoms are attributable to insects (39.9%), mostly "defoliators" (79.6%). Fungi infest 11.7% of the sample. They are especially: "decay and root rot fungi" (14.2%), and "blight" (10.6%). Abiotic agents infest 4.5% of the sample, of which "hail" (26.2%) and "heat/sun scald" (16.6%) were assessed most frequently.

4.3.4 Portugal

In 2005, the forest condition survey was conducted on 119 forest plots including 3 570 trees, of which 69% had an age less than 60 years. 97% of the trees assessed were broad-leaves. Considering the results from 1988 to 2005, the share of both damaged broadleaves and conifers shows a peak in 1990, and decreases until 2002. However, since 2003 again a slight increase in the proportion of damaged trees has been observed.

With respect to the most important tree species in Portugal, *Quercus suber* shows the severest situation, reaching the peak of its share of damaged trees (52.7%) in 1991. In the same year, *Quercus ilex* L. showed its maximum of damaged trees (46.2%). The share of damaged trees was generally far lower for *Pinus pinaster* with a maximum of 26.3% in 1990, and in *Eucalyptus globulus* Labill. with 7.3% in 1991.

The bad crown condition of several tree species in the years 1990 and 1991, and recently in 2003, 2004 and 2005, has to be interpreted in connection with attacks by fungi and insects as well as by forest fires, triggered by a sequence of dry years, specially in 1989 until 1991, and 2003 until 2005. In fact, 2003 was the worst year on what concerns forest fires, since systematic data records exist. 423 276 ha were burned, 283 063 of which (67%) were forest stands (8% of the total Portuguese forest). 2005 was the driest year of the last 50 years. This had a negative impact on the condition of forest trees as well.

4.3.5 Spain

Results of the forest condition survey in 2005 showed that 21.5% of all assessed trees were rated as damaged or dead (defoliation classes 2-4). Compared to the previous year, the share of damaged trees increased significantly. For the class of undamaged trees, the lowest share of trees was observed since the beginning of the surveys in 1987. The worsening affected more strongly the broadleaves, but also conifers showed a worsening, reaching the highest defoliation since 1987. The percentage of dead trees remained practically unchanged.

The four most important species in the survey are *Pinus sylvestris, Pinus halepensis, Quercus ilex and Quercus pyrenaica*. In 2005, *Quercus pyrenaica* was, out of the four species, the one which had the best results. For the first time since 2000, the share of undamaged trees increased for this tree species. *Pinus sylvestris* worsened slightly, with a reduction in the number of healthy trees and a corresponding increase in the share of damaged trees. These two species were hardly affected by the drought that occurred in 2005. In contrast, the two more xeric species *Quercus ilex* and in particular *Pinus halepensis* showed a more serious worsening. For the latter species, 25% of the trees were classified as damaged, which is the worst result since the beginning of the inventories in 1987.

The most frequently registered damaging factors were abiotic ones, specifically drought, followed by insects, mainly defoliators and fungi. Drought and water shortage specifically affected eastern, south-eastern and central regions and caused damage mainly at *Quercus* spp. and *Pinus halepensis* plots. As regards insects, the noticeable increase in spring defoliators at plots with broadleaves is remarkable. Most damages were caused by the combined action of several *Lepidoptera* species. Alder stands suffered defoliation by *Agelastica alni*. In mountain pine forests of central Spain damage by *Diprion pini* was again increasing. Among fungi, foliar fungi diseases in *Eucalyptus* stands, mainly in the eastern part of the Cantabric coast, and a frequent appearance of *Spaheropsis sapinea* in *Pinus radiata* stands are worth mentioning.

The importance of atmospheric pollution for forest condition is a factor which can not be quantified directly, as it is frequently disguised by other processes which are more apparent. However, its contribution to degradation processes in forests (in combination with other agents), can not be denied.

4.4 Western Europe

4.4.1 Belgium

Flanders

The crown condition survey in the northern part of Belgium was conducted on 72 plots in a 4 x 4 km grid in 2005. The main tree species are *Quercus robur* and *Pinus sylvestris*. *Fagus sylvatica*, *Quercus rubra*, *Pinus nigra subsp. Laricio* and *Populus* spp. are as well represented.
The share of damaged trees was 21.3%. Discolouration was observed on 6.2% of the sample trees. During the last 10 years, the mortality rate fluctuated between 0 and 0.5%. In 2004/2005, 0.2% of the trees died.

Compared to previous surveys, defoliation increased in coniferous stands while the crown condition of broadleaves remained stable. 22.6% of the broadleaves and 19.2% of the conifers were rated as damaged. Discolouration increased as well and was higher for broadleaves (7.0%) than for conifers (4.6%).

Pinus sylvestris remains the species with the lowest defoliation (15.0%). The most severely damaged species were *Populus* spp. with 46.3% of the trees in defoliation classes 2-4. The crown condition of *Pinus nigra* is still high, with 35.0% of the trees being damaged. The crown condition of *Pinus nigra* and *Quercus rubra* showed a significant worsening.

Quercus robur (23.2%) has a higher share of damaged trees than *Q. rubra* (19.4%). Especially young *Q. rubra* trees revealed a lower defoliation.

One year after the mast year in 2004 there was hardly any seed production in *Fagus sylvatica* in 2005. The condition of the trees was significantly better than in the year before. 18.8% of the trees show moderate to severe leaf loss.

Especially in *Quercus rubra* stands there was more insect damage compared to the year before. In *Quercus robur,* insect damage remained constant but more trees suffered from *Microsphaera alphitoïdes* infection. In the north eastern part of Flanders, there was a high infestation of *Thaumetopoea processionea*, resulting in defoliation of oak trees.

Locally infection by the fungus *Discosporium populeum* in *Populus* was continuing, resulting in dying and dead trees for the third consecutive year. The infection by this weakening parasite started after several years of a severe *Melampsora larici-populina* infestation.

Wallonia

The 2005 survey comprised 1 398 trees (504 conifers and 894 broadleaves) on 60 plots, on the regional 8 x 8 km systematic grid.

Since 2002, mean defoliation of *Fagus sylvatica* increased continuously and was about 27% in 2005; sessile oak showed also an increase in 2005, while the defoliation of *Quercus robur* was lower as compared to the previous year.

The high defoliation for *Fagus sylvatica* is most likely a consequence of beetle damage during 2000-2002, of dry weather conditions and high temperatures in the period from June to October 2003, which induced an intensive fructification in 2004 with a consecutive lack of foliage in 2005. Such an intensive fructification in 2004 had the same impact on *Quercus petraea* defoliation. The other species showed minor changes, both for broadleaves and conifers.

Discolouration has decreased both for broadleaves and conifers since the high level of 2003, but about 13% of the trees showed more than 25% of discolouration in 2005, which was still higher than before 2003. Discolouration at conifers mostly occurred at old *Pinus sylvestris* and *Picea abies*.
Among broad-leaved species, young stands showed hardly any discolouration. At older stands, the high discolouration was most intensive for *Fagus sylvatica* and *Quercus petraea* with respectively 28% and 15 % of the trees moderately or severely discoloured.

4.4.2 Denmark

The Danish Level I forest condition survey in 2005 showed that most tree species had satisfactory health, based on both EU/ICP Forests plots (22) and national plots (26). In total, 1152 trees were assessed. In general, the average defoliation scores of *Picea abies, Fagus sylvatica* and *Quercus* spp. were slightly lower than in previous years. Most other tree species were also in good health, although *Fraxinus excelsior* and *Picea sitchensis* showed elevated defoliation in some areas.

Within the crown condition survey in 2005, 78% of all coniferous trees and 67% of all deciduous trees were rated as undamaged. 17% of all conifers and 25% of all deciduous trees showed warning signs of damage, and 5% of all conifers and 8% of all deciduous trees were rated as damaged. The period of very good forest health in Denmark has now lasted for more than 5 years, in spite of storms and dry summers which have had some negative impact.

The mean defoliation of *Picea abies* was 6% in 2005, and the share of damaged trees remained at only 5%. As in the previous three years, more than 80% of the monitored spruces were in the lowest defoliation class. However, a storm in January 2005 did cause extensive damage to many spruce stands, including some observation plots.

The health condition for beech (*F. sylvatica*) continued to improve in 2005, with a mean defoliation of 9%, the lowest since monitoring began. The amount of damaged trees was only 5%. Since 2000 none of the monitored beech trees have been in the two highest damage classes.

In 2005 the mean defoliation of oak (*Q. robur* and *Q. petraea*) decreased to 17% after a couple of years with 20% average defoliation. The share of damaged trees fell to 16% in 2005 (from 21% in 2004). The health of oak is still significantly better than in the 1990'ies. Some damage due to the outbreak of defoliators in 1996-1997 can still be seen in oak forests in Denmark, mainly killing of trees by *Armillaria gallica*.

4.4.3 France

In 2005, the French forest condition survey included 10 129 trees on 509 permanent points. The growing season was characterized by the third consecutive dry summer, especially in the Southern part of the country. Nevertheless, temperatures were closer to the long term average as compared to summer 2003. At the national level, several species showed slight increases in defoliation. Broadleaves remained at a higher defoliation level than conifers. The amount of discoloured trees in general decreased, remaining at a relatively low level. Less than 10% of the trees were judged discoloured. The only exceptions were the Jura and the North-eastern Plaines with 26% and 13% of the broadleaved trees, respectively, being discoloured and the Pyreneans and Mediterranean regions with 19% and 16% of the conifers rated as discoloured. The 2005 growing season was marked by a mortality rate that remained relatively high.

Since 2002, the species that worsened most at the national level in terms of defoliation have been *Castanea sativa*, *Fagus sylvatica*, *Quercus ilex*, *Quercus petraea*, as well as *Picea abies*. Nevertheless, these tendencies mask a regional variability.

Identifiable damage was reported from one third of the trees. Among all reported damage types, insects were mostly mentioned (15% of the trees) with caterpillars, *Coroebus bisfasciatus* on *Quercus* spp. and *Orchestes fagi* on *Fagus sylvatica* affecting crown condition. As concerns fungi, an increase in *Microsphaera alphitoides* on *Quercus robur* was observed. *Cryphonectria parasitica* was reported from 14% of the *Castanea sativa*. *Melampsora* spp. affected *Populus* spp.. Drought and other abiotic damage were mentioned from 10-35% of the trees depending on the tree species, mainly from *Fagus* *sylvatica*, *Quercus ilex*, *Quercus pubescens*, *Castanea sativa*, *Populus* spp. and *Betula* spp. and as well as from *Pinus halepensis* and *Pinus sylvestris*.

These results are considered as evidence for the importance of the European network for monitoring annual changes in forest crown condition.

4.4.4 Ireland

The annual assessment of crown condition was conducted on the Level I plots in Ireland between June 28th and September 19th 2005. Overall mean percent defoliation and discolouration was 16.0% and 6.5% respectively. This represents a slight disimprovement in crown condition of Irish forests between the 2004 and 2005 survey of approximately 1 percent point for defoliation and of 1.3 percent points for discolouration. Defoliation levels recorded in 2005 were similar to the long term average of 15.6% and discolouration in 2005 was also close but below the long term 16 year average of 8.0%. In terms of species, defoliation decreased in the order of *Picea abies* (24.5%) > *Pinus contorta* (16.7%) > *Picea sitchensis* (13.6%), while the trend in discolouration was in the order of *Pinus contorta* (12.2%) > *Picea sitchensis* (3.4%) > *Picea abies* (0%). These results do not vary significantly from those recorded in the 2004

The trends in crown density among species are similar to last year's survey. In 2004, *Picea abies* had the highest defoliation levels as was observed in 2003 and 2002 also. This was the result of a combination of defoliation levels decreasing in *Pinus contorta* and increasing somewhat in both spruce species since 2001. *Pinus contorta* had the highest discolouration levels of the three species in 2003, which was also the observation in the 2004 survey. There has been a recent increase in discolouration of *Pinus contorta* in the Irish crown condition survey.

The number of trees with absolutely no damage (i.e. 0% defoliation and 0% discolouration) increased in 2005 by 6 percent points to 22% of trees in the survey. An additional 27% of trees had such low levels of defoliation and discolouration that the causes of damage were indiscernible. These figures represent a slight decrease, some 5 percent points, in the number of trees recorded in this category in 2004. Of the remaining trees where causes of damage could be identified, approximately 33% of trees had less than 25% defoliation and less than 4% of trees had greater than 25% discolouration. Exposure continued to be the greatest single cause of damage to the sample trees in 2003 with over one third of sample trees showing some damage attributable to the abiotic environment. The instances of observed aphid damage however were much decreased since the 2002 outbreak, in particular for Sitka spruce, with only 5% of tress affected in 2005. The aphid responsible for damaging more than 20% of the sample trees in 2002 was *Elatobium abietinum* but this insect pest has a typically sporadic occurrence depending on the prevailing environmental conditions in a given year (Less than 3% of trees were affected by aphids in the 2001 survey.) Other damage types (shoot die-back, top-dying, nutritional problems, and grazing damage) accounted for damage in a very small percentage of the trees. Damage due to grazing was again apparent in 2005; recorded on the young spruce trees at Ballinglen on the east coast of Ireland. No instances of damage directly attributable to atmospheric deposition were recorded in the 2005 survey.

4.4.5 The Netherlands

Over the last three years, more than 75% of the conifers in the Netherlands showed a defoliation below 10%. This high percentage however mostly depends on *Pinus sylvestris* which constitutes the largest part of this sample. Defoliation of *Pseudotsuga menziesii* on the other hand has increased over the last three years. In this period, most trees moved from defoliation class 1 (10%-25%) to defoliation class 2 (25%-60%). In 2005, 92% of the trees were in class 2 compared to only 8% in 2003.

The defoliation of *Quercus* spp. in the Netherlands was considerably higher compared to the mean of all broadleaves. In 2003, 48% of the assessed trees were in defoliation class 1. In 2005 however, 49% of the *Quercus* were in defoliation class 2. This shift mainly occurred for the trees older than 60 years and was even more pronounced for the sample of trees older than 100 years.

4.4.6 United Kingdom

Climatic conditions during the 2005 growing season and the preceding winter were variable, being drier than average in the south of the UK and wetter than average in the north. In spite of this difference, tree growth across the entire country was generally good and there was an overall improvement in crown condition this year. Broadleaves and conifers displayed a similar pattern of change, with the percentage of trees in class 0 (0-10% defoliation) having increased by approximately 5 percent points since 2004. Following an upturn in condition in 2004, the conifers have therefore registered consecutive years of improvement in crown density for the first time since 1995.

The improvement in the condition of the broadleaves in 2005 largely reflected a marked increase in the crown density of *Fagus sylvatica*, with the proportion of trees in defoliation class 0 for this species rising from 27.5% in 2004 to 38.3% in 2005. As in previous cases of such rapid recovery, this change was attributable to much-reduced mast formation, with fruiting being absent or scarce on 96.7% of the assessed trees this year. Discolouration of beech was more evident than in 2004, however, due largely to an increase in both the incidence and severity of attacks by the beech leaf miner *Rhynchaenus fagi*. The condition of *Quercus robur* was largely unchanged since last year and continued to display marked regional variation.

Following a marked improvement in crown condition last year, the crown density of *Picea sitchensis* displayed a further slight increase in 2005 as the species continued to recover from the severe aphid-induced defoliations which it suffered in 2002 and 2003. Although attacks by the green spruce aphid (*Elatobium abietinum*) were recorded in 50.9% of plots they were minor in extent and insect damage was only adjudged to be common or abundant on 3.9% of the surveyed trees. *Pinus sylvestris* exhibited its greatest improvement in condition since 1993, with an increase in mean crown density of 1.6 percent points compared with last year. Following a marked improvement in 2004, needle retention of this species was once again good in 2005 with 62.8% of assessed trees retaining their needles for 3 or more years. Concomitantly, damage due to the pine shoot beetle (*Tomicus piniperda*) was reduced this year being evident in only 32% of plots and generally of low severity.

4.5 South-Eastern Europe

4.5.1 Bulgaria

In 2005, the forest condition survey was carried out at 139 plots on a grid net of 16 x 16 km, 8 x 8 km and 4 x 4 km. A total of 4 817 sample trees was assessed, 2 585 of them conifers and 2 232 broadleaves. For all species, there was a slight recovery of crown condition. The share of moderately to severely damaged trees (defoliation classes 2-4) decreased compared to the 2004 results. The share of trees without visible defoliation increased from 19.8% in 2004 to 22.4% in 2005.

For conifers, the percentage of damaged trees slightly increased. As compared to the previous year, trees without visible defoliation decreased by 5.2 percent points. The share of severely defoliated trees remained almost the same and that of dead trees increased by 1.3 percent points.

For *Abies alba*, *Picea abies* and *Pinus sylvestris*, some of the damages were caused by needle-rust, canker and root rot fungi including *Lophodermium pinostri, Genangium ferruginosum, Heterobasidion annosum* and *Armilaria mellea*.

Defoliation of broadleaves (*Quercus* spp. and *Fagus sylvatica*) was lower in 2005 as compared to 2004. The share of the trees without any defoliation increased by 10.7 percent points, compared to the 2004 results. The share of severely defoliated *Quercus* trees decreased. *Quercus* trees were attacked by defoliating insects including *Operophthera brumata* and pathogens such as *Nectria* spp., *Stereum rugosum* and *Hypoxilon mediterraneum*. Beech stands suffered under mining insects such as *Rhynchaenus fagi*.

Abiotic agents like weather extremes (snow, ice) and anthropogenic factors such as silvicultural operations at nearby trees were identified as damage causes. Nevertheless, no specific damage factor was observed for more than half of the trees.

4.5.2 Hungary

The crown condition assessment in Hungary revealed on the average a slightly worse situation as compared to the previous year. This is mainly due to a continuing *Lymantria dispar* gradation. Some colder days had eased the situation during late spring killing a lot of caterpillars. In spite of this, defoliation by the caterpillars was recognized on a quarter of million hectares mainly in the *Quercus cerris, Q. petraea* and *Q. robur* forests.

Chemical control was carried out on more than 40 thousand hectares. Gradation collapsed in different places due to the lack of nourishment. On the other hand, despite all efforts the infestation spread from North of lake Balaton to the North-Hungarian mountains and it is expected to remain constantly strong in South-West Hungary in the future too.

The rest of the forests, untouched by the caterpillars, showed less defoliation as compared to 2004. This is mainly due to an increased precipitation. The benefit of increased humidity is reflected in the decreasing defoliation of *Pinus sylvestris* and *Pinus nigra*. This tendency was followed by *Picea abies* too, which also showed a higher resistance against bark beetles (mainly *Ips typhographus*).

After a year with elevated defoliation, *Fagus sylvatica* was in 2005 the tree species with lowest defoliation, although some older beech stands still seem to suffer from the drought of 2003.

Effects of leaf miners (*Parectopa robiniella* and *Phillonoricter robiniella*) on *Robinia pseudoacacia* were lower as compared to the previous year.

4.5.3 Romania

In 2005, 100 718 trees were assessed on the national monitoring network (4 x 4 km) which comprised 4 132 permanent plots. From the total number of sample trees, 8.1% were rated as damaged (defoliation classes 2-4). The respective shares were 4.7%, for conifers and 9.3% for broadleaves. In 2005, the forest health status in Romania significantly improved as compared to the previous years (2003 and 2004); the shares of damaged trees decreased by 4.5 percent points for conifers and by 3.6 percent points for broadleaves.

Among the main tree species, *Picea abies* (4.0%), *Fagus sylvatica* (5.5%) and *Abies alba* (6.4%) had the lowest shares of damaged trees (defoliation classes 2-4), and *Quercus frainetto* (26.4%), *Quercus robus* (18.6%), *Robinia pseudoaccaia* (17.2%), *Quercus cerris* (15.9%) and *Quercus pedunculiflora + Q. pubescens* (14.5%), had the highest shares. As compared to the previous year (2004) a reduction in the shares of damaged trees was registered for *Picea abies* (1.7 percent points), *Fagus sylvatica* (2.3 percent points), *Abies alba* (5.2 percent points), *Quercus robur* (3.3 percent points), *Q. frainetto* (8.6 percent points), *Q. cerris* (5.3 percent points), *Q. pedunculiflora + Q. pubescens (*1.0 percent points) and *Robinia pseudoaccaia* (17.5 percent points).

This situation can be explained by favourable weather conditions that led to a shift from defoliation class 2 to class 1 for many trees. As compared to 2002 – 2004, precipitation was higher in 2005. In the southern and south-eastern part of the country the improvement of tree crown condition lasted already since 2003.

4.5.4 Serbia

In 2005, the total number of trees assessed on all sampling plots was 2 995, comprising 338 conifers and 2 657 broadleaved trees. Among the conifers, *Abies alba* had the lowest share of damaged or dead trees (11.6%), whereas *Pinus nigra* had the highest share (47.8%). Taking the total sample of conifers, 21.3% of the trees were damaged or dead (defoliation classes 2-4).

The broadleaved trees were on average in a better condition, with 15.7% of the trees assessed as damaged or dead. *Quercus petraea* had the highest share of trees in defoliation classes 2-4 (35.3%), and *Carpinus betulus* had the lowest share in these classes (2.6%).

Moderate or severe discolouration was detected on 9.2% of the conifers and on 5.3% of the broadleaves.

Defoliation above 25% does not always indicate a reduction of vitality caused by the effect of adverse agents (climate stress, insect pests, and pathogenic fungi). In some cases elevated defoliation indicates a temporary phase in the natural variability of crown density.

The monitoring of forest condition will be continued on the 16 x 16 km grid and in some regions on a denser national grid 4 x 4 km including the plots newly established in 2004 on which the changes of crown condition were assessed in 2005 as well.

4.6 Eastern Europe

4.6.1 Belarus

The forest condition survey in Belarus in 2005 was carried out on 1 212 permanent observation plots of the national network. The assessments covered as main tree species *Pinus sylvestris*, *Picea abies*, *Quercus robur*, *Betula* spp., *Fraxinus excelsior*, and *Alnus glutinosa*. The lowest defoliation was observed for *Pinus sylvestris*, with 7.2% of the trees in defoliation classes 2-4 (8.5% in 2004). The respective shares were 6.5% for *Alnus glutinosa*, 6.8% for *Betula* spp., and 9.6% for *Picea abies* (11.4% in 2004). Highest defoliation was observed for *Qercus robur* (27.3%; 33.1% in 2004) and *Fraxinus excelsior* (27.4%; 25.4% in 2004).

Damage symptoms were identified at 17.5% of all trees. For individual tree species the shares of damaged trees were as follows: *Pinus sylvestis:* 10.5%, *Picea abies* : 19.2%, *Quercus robur:* 50.3%, *Betula* spp.: 35.1% and *Alnus glutinosa*: 25.9%. The most frequent damage type was insect damage, which was observed on 30.0% of all damaged trees (fungi: 18.1%; human activities: 13.3% and abiotic factors: 12.6).

4.6.2 Republic of Moldova

The forest condition survey in 2005 was carried out on a national 2 x 2 km grid in Moldova and included a total number of 14 575 trees of which 26.5% were rated as damaged (defoliation classes 2-4). 91% of the trees did not show any discolouration or were only slightly discoloured.

The most defoliated broadleaved tree species were *Quercus pubescens* and *Quercus pedunculiflora* with 36.7% of the trees in defoliation classes 2-4, followed by *Robinia pseudoacacia (*32.6%) and *Quercus robur (*35.2%). 45.6% of the *Pinus* spp. and 20.3% of the assessed *Fraxinus* spp. trees were classified as damaged or dead.

26.7% of all trees showed signs of easily identifiable damage. The majority of the damages was caused by insects (78.9% of all damaged trees). 53.0% of the trees damaged by insects were included in defoliation classes 2-4.

4.6.3 Ukraine

In 2005, 26 720 sample trees were assessed on 1 329 forest monitoring plots in 19 administrative regions of Ukraine (covering around 75% of the country). Mean defoliation of conifers was 11.6% and for broadleaves it was 12.2%.

For the sample of common sample trees, being assessed in 2004 and 2005 (26 325 trees) a very minor overall improvement was observed. Mean defoliation of all species in 2005

(12.0%) was lower than in 2004 (12.9%). Changes are characterised by a decrease of tree shares in defoliation classes 1 and 2 and an increase in classes 0 and 4. However, changes in classes 1 and 4 were not significant. A statistically significant improvement in tree crown condition was registered for *Quercus robur*. The share of trees in class 1 increased by 2.5 percent points, corresponding to a decrease in classes 2 and 3 by 2.7 percent points. The same tendency was observed for *Fagus sylvatica* and *Fraxinus excelsior*. For *Pinus sylvestris* an increase in the share of trees in class 0 and a decrease in classes 1 and 2 were observed. In contrast to this, the share of *Picea abies* trees in the classes 0 and 1 decreased and the share of trees in class 2 increased.

The overall improvement in tree crown condition can be explained by better weather conditions in 2005 and by a decreasing impact of defoliating insects.

4.7 Northern America

4.7.1 Canada

Natural Resources Canada's Canadian Forest Service (CFS) does not have a national monitoring program for forest health. In 1995, the Canadian Council of Forest Ministers put in place a framework of Criteria and Indicators (C&I) for sustainable forest management. This framework is compatible with the Montréal Process and shares the themes identified in the Global Forest Resources Assessment that are also common to the Ministerial Conference for the Protection of Forests in Europe and the other international C&I processes. The indicators in this framework, revised in 2003 are used for national reporting on sustainable forest management, including forest health. A report on the latest status of these indicators will be published in 2006. Canada, along with the provinces is putting in place a new plot-based National Forest Inventory, to generate much of the information for reporting on C&I and forest condition. Other information is gathered through regionally based surveys or through partner agencies. Forest health is tracked using an indicator measuring the areas of forest disturbed by fire, insects, disease and timber harvest and the areas of forest with impaired function due to ozone or acid rain.

Ozone

A Canada wide standard of 62 ppb for the 30-year average of the annual fourth highest daily maximum 8-hour average ozone concentration was endorsed as a numerical target to be achieved by 2010. Trends in this standard for 1993-2002 averaged across western and eastern Canada show little overall change or slight decreases in some areas with values ranging between 52 and 53 ppb in western Canada and 68-77 ppb in eastern Canada. In general three major areas in Canada have consistent episodic ozone events every summer. These are southern British Columbia, the Windsor-Quebec corridor and southern Atlantic Canada. There is limited information on the impacts of these episodic events on forest ecosystems in the respective areas. Studies in these areas have been primarily limited to single or few immature trees. Extensive, long term studies of the impact on ecosystem structure and function are being done in partnership with the US Forest Service, academic institutions and other countries in the Aspen Free-Air Carbon Dioxide Enrichment (FACE) experiment on 32 ha of forest land in northern Wisconsin.

In 1998, the Canada-wide acid rain strategy established the long term goal of remaining below the critical loads of acidifying compounds. A critical load is the highest deposition of acidifying compounds that will not cause changes leading to long term harmful effects on the overall structure or function of an ecosystem. Critical loads have been developed for some forest soils in Canada. The working group under the New England Governors and the Eastern Canadian Premiers have mapped the extent of exceedance of the critical loads for soils in eastern Canada, under a no harvest scenario. Areas where critical loads are exceeded, cover almost 52% of eastern Canada. In some cases this exceedances would be greater if nutrient depletions associated with harvesting were considered. Work is underway to improve accuracy of critical load estimates and exceedances and to understand the linkage with biological effects. Research in Quebec (OUIMET et al. 2001 Focus 1: 119-134), where many research plots are located on nutrient poor sites, revealed that critical load exceedance is associated with a 30% reduction in forest growth. The conclusions from this research were that further reductions in national and international sulphate and nitrate emission rates were required to protect forest soils from excessive acidification. Models developed for south central Ontario predicted that soil acidification will continue even with proposed reductions in sulphur emissions and that nutrient removals through harvesting will exacerbate the condition (WATMOUGH et al 2004 critical loads Ontario report no 2, Environmental and resource studies Trent University).

Fire

Neither the area burned nor the number of fires in Canada show particular trends between 1975 and 2003. Most fires are caused by human error while the largest areas burned result from lightning strikes. An average of the data from 1993-2003 indicates that 7591 fires have burned a total of 1.1 million hectares annually although year to year variation is large.

Insects

From 1975 to 2003, the annual area disturbed by insects declined. Insect outbreaks tend to be cyclical with outbreaks occurring in peak years in certain areas of the country. Spruce budworm and forest tent caterpillar are two insects that have been tracked nationally since 1975. Forest tent caterpillar has had three outbreaks since 1975. Recent newcomers on the insect pest list include: the large aspen tortrix (*Choristoneura conflictana*) which, has caused significant damage in Alberta since 2002; the spruce bark beetle (*Dendroctonus rufipennis*) which, has affected about 400 000 ha in the Yukon and continues to expand; and, the mountain pine beetle (*Dendroctonus ponderosae*) which, by the end of 2004, was estimated to have destroyed approximately 230 million m3 of timber, covering an area of 4 million ha.

Climate Change Impacts on the Productivity and Health of Aspen (CIPHA)

Trembling aspen (*Populus tremuloides*) is of significant ecological importance as the most widely distributed tree species in North America and for its value as a carbon stock and a commercial species for fiber. In 2000, the CFS together with Environment Canada and other partners initiated CIPHA to investigate the dieback and reduced growth observed since the 1990's with this species in areas of the southern boreal forest and the aspen parkland in western Canada. The objectives of this network of long term research plots, in 72 aspen stands, along a regional climate gradient are: i) to provide early detection of climate change impacts; ii) understand how climatic variation, insects and other factors have affected health and growth of aspen forests in western Canada iii) predict future changes in biomass, productivity and health of aspen forests in western Canada; iv) provide a framework for linking research and monitoring. Some results from this monitoring research are starting to be published.

Tree ring analysis showed that between 1951 and 2000, there were several cycles of reduced growth. Most of the variation was explained by interannual variation in a climate moisture index in combination with insect defoliation. Continued annual monitoring of forest health and dieback within the CIPHA plot network coupled with re-sampling of tree rings in these stands will serve to elucidate the long term impacts of a severe drought in the region between 2001 and 2003. This work has demonstrated the potential for extending such plot-based field sampling across a wide range of forest types over large areas, to become a valuable tool for the validation of national and global scale models of forest responses (HOGG et al. 2005. Can J. For. Res. 35: 610-622).

Defoliation histories based on tree ring analyses and records of past insect outbreaks pointed to several factors contributing to the observed dieback. Defoliation by forest tent caterpillar (*Malacosoma disstria*) and drought between 1960 and 80 led to reduced growth and predisposed some stands to secondary damage by wood-boring insects and fungal pathogens. That global change may increase the severity of these stressors, underscores the need for long term monitoring (HOGG et al. 2002. Can. J. For. Res. 32:823-832).

A study to determine the biotic and abiotic agents affecting trembling aspen showed that large aspen tortrix and poplar peniophora (*Peniophora polygonia*) were the most common pests occurring on 15 and 13% of live trees respectively. Tree age, climate moisture index, number of years of forest tent caterpillar defoliation and incidence of Armillaria root disease accounted for a significant proportion of the variation in trembling aspen health and mortality (BRANDT et al. 2003. For Ecol & Manage 178: 287-300).

4.7.2 USA

Background Information

Since 2002, USDA Forest Service has been working develop a systematic approach to critical loads and levels. This activity has involved both researchers and forest managers. One of the pivotal facets of the program has been partnership with Canada and Mexico. Additionally, reliance on ICP agencies, in particular ICP Forests, has advanced this work. USA Forest Service is in the process of developing nine ICP Forests demonstration Level II sites within the USA. In the last year, four of these nine sites have become increasingly operational and active in critical loads and levels research.

Main results

During 2005, field measurements were continued at Riverside (CA), Kings River (CA), Glacier Lakes Ecosystem Study Site (GLEES, WY), and Otter Creek Wilderness (WV). Data from these is being used to calculate critical loads for nitrogen and sulphur using a simple mass-balance approach. Additional work on critical levels for ozone is on-going at Riverside and Kings River in California and GLEES in Wyoming.

A critical loads map for New England has been developed under the New England Governors' & Eastern Canadian Premiers' Forest Mapping Group for Critical Loads of Sulfur and Nitrogen. This study has been evaluating current ecological indicators (crown health, growth and mortality) at the plot level as a comparison between sensitivity and current health status using the US Forest Inventory Analysis database.

A national critical loads map for the USA (see Figure) has also been developed by the Southern Research Station's Global Change Research Program. This one kilometre resolution map utilizes published data for runoff (United States Geological Survey), a national forest cover dataset (USGS/USFS, 25 tree classes), and soil information (Miller and White, 1998). This map is presented as preliminary result and will be refined through collection of site specific data sets.

Outlook

During 2006, the described activities will continue at all sites. The draft national critical loads map for sulphur and nitrogen will be evaluated and improved. Work on critical loads mapping in the North-eastern States will also continue. Work is also continuing to work cooperatively with the USDA Forest Service FIA and Forest Health Monitoring (FHM) programs. In February of 2007, a fourth Critical Loads and Levels Research Workshop will be held in Riverside, California in cooperation with the North American Forestry Commission.

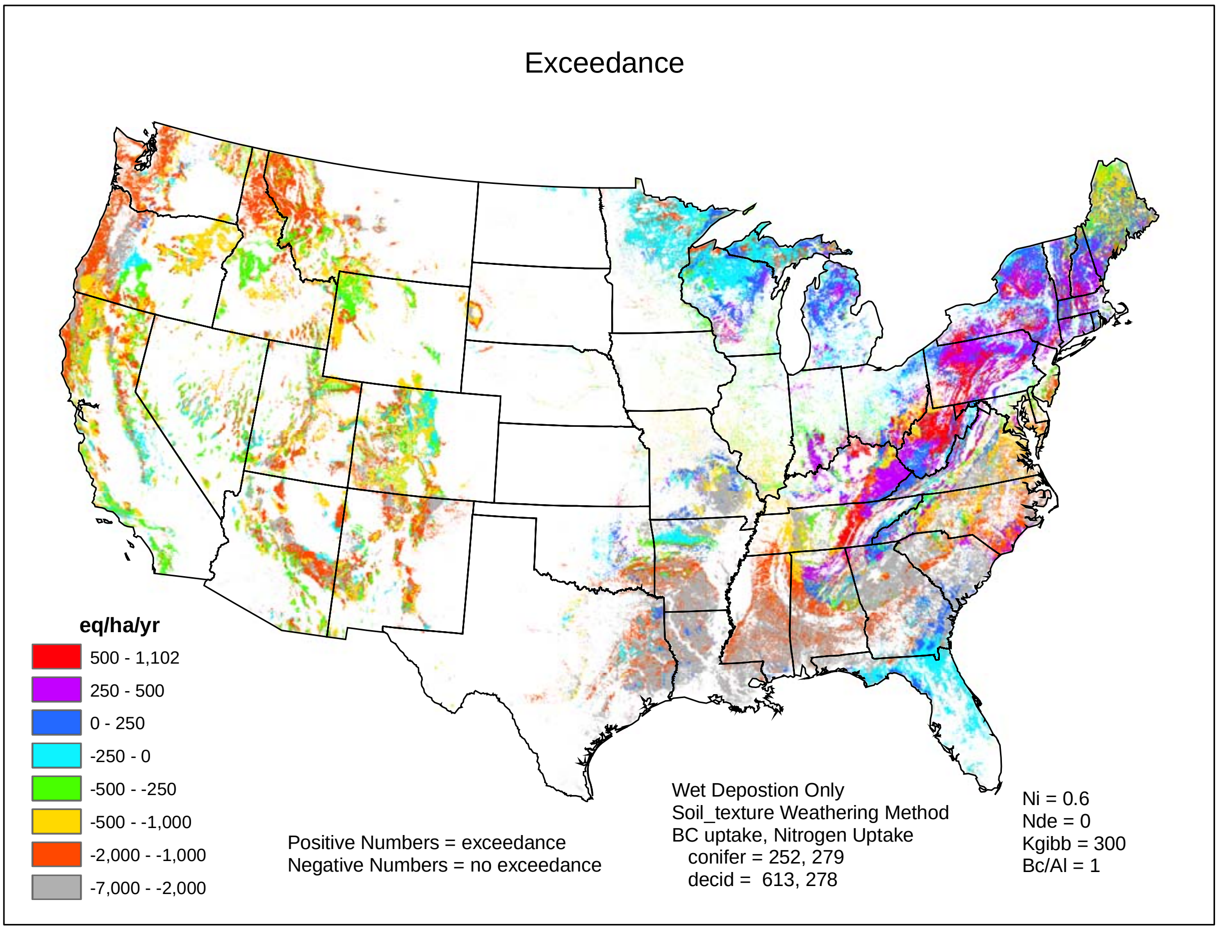


Figure 4.7.2-1: Draft Continental Critical Loads Map Calculated by Simple Mass Balance Approach using Published Data (source: USDA Southern Global Change Research Program)

5. REFERENCES

Augustin, S., Bolte, A., Holzhausen, M., Wolff, B. (2005): Exceedance of critical loads of nitrogen and sulphur and its relation to forest conditions. Eur J Forest Res 124: 289-300.

Brandt et al. (2003): For Ecol & Manage 178: 287-300.

Braun-Blanquet, J. (1964): Pflanzensoziologie. Grundzüge der Vegetationskunde. 3. Aufl, Springer, Berlin Wien New York, 865 S.

Chappelka, A.H., Freer-Smith, P.H. (1995): Predeposition of trees by air pollutants to low temperatures and moisture stress. Environmental Pollution 87: 105-117.

Cronan, C.S., Grigal, D.F., (1995): Use of calcium/aluminium ratios as indicators of stress in forest ecosystems. Journal of Environmental Quality 24: 209-226.

De Vries, W. (2000): Intensive monitoring of forest ecosystems in Europe. Evaluation of the programme in view of its objectives and proposal for the scientific evaluation of the data. A strategy document. UN/ECE and EC, Geneva and Brussels, 45 pp.

De Vries, W., G.J. Reinds, H. van Dobben, D. de Zwart, D. Aamlid, M Posch, J. Auee, J.C.H. Voogd and E. Vel (2002): Intensive Monitoring of Forest Ecosystems in Europe. Technical Report 2002. UN/ECE and EC, Geneva and Brussels, 105 pp.

De Vries W, Reinds GJ, van Dobben H, de Zwart D, Aamlid D, Neville P, Posch M, Auée J, Voogd JCH, Vel EM (2002): Intensive Monitoring of Forest Condition in Europe: Technical Report 2002. UN/ECE and EC, Geneva and Brussels, 175 p

De Vries, W.; Reinds, G. J.; Posch, M.; Sanz, M. J.; Krause, G. H. M. ; Calatayud, V.; Renaud ; J. P. ; Dupouey, J. L.; Sterba, H.; Vel, E. M. ; Dobbertin, M. ; Gundersen, P.; Voogd, J. C. H. (2003): Intensive Monitoring of Forest Ecosystems in Europe. Technical Report. UN/ECE and EC, Geneva and Brussels, 161 pp.

De Vries, W.; Reinds, G. J.; van der Salm, C.; Draaijers, G.P.J.; Bleeker, A.; Erisman, J.W.; Auee, J.; Gundersen, P.; Kristensen, H.L.; Van Dobben, H.; De Zwart, D.; Derome, J.; Voogd, J.C.H.; Vel, E. M. (2001): Intensive Monitoring of Forest Ecosystems in Europe. Technical Report. UN/ECE and EC, Geneva and Brussels, 177 pp.

Diekmann, M.: (2003): Species indicator values as an important tool in applied plant ecology a review. Basic Appl. Ecol. 4: 493-506.

Ellenberg, H. jun. (1983): Gefährdung wildlebender Pflanzen in der Bundesrepublik Deutschland. Versuch einer ökologischen Betrachtung. Forstarchiv 54: 127-133.

Ellenberg, H. (1992): Zeigerwerte der Gefäßpflanzen ohne *Rubus*. Scripta Geobotanica 18: 9-166.

Ertsen, ACD; Alkemade, JRM; Wassen, MJ (1998): Calibrating Ellenberg indicator values for moisture, acidity, nutrient availability and salinity in the Netherlands. Plant Ecology 135: 113-124.

Ewald, J. (2003): The calcareous riddle: why are there so many calciphilous species in the Central European flora? Folia Geobotanica 38: 357-366.

Fischer, R., de Vries, W., Barros, M., van Dobben, H., Dobbertin, M., Gregor, H.-D., Larsson, T.-B., Lorenz, M., Mues, V., Nagel, H.D., Neville, P., Sanchez-Pena, G. and de Zwart, D. (2002): The Condition of Forests in Europe. 2002 Executive Report. UNECE and EC, Geneva, Brussels. 32 p.

Fischer, R.; Barbosa, P.; Bastrup-Birk, A.; Becher, G.; Dobbertin, M.; Ferretti, M.; Goldammer, J.G.; Haußmann, T.; Lorenz, M.; Mayer, P.; Mues, V.; Pettricione, B.; Raspe, S.; Roskams, P.; Sase, H.; Stofer, S; Wulff, S. (2004): The Condition of Forests in Europe. 2004 Executive Report. UN/ECE and EC, Geneva and Brussels, 54 p.

Freer-Smith, P.H., (1998): Do pollutant-related forest declines threaten the sustainability of forests. Ambio 27: 123-131.

Hogg et al. (2002): Can. J. For. Res. 32:823-832.

Hogg et al. (2005): Can J. For. Res. 35: 610-622.

ICP Modelling & Mapping (ed., 2004): Manual on Methodologies and Criteria for Modelling and Mapping Critical Loads & Levels and Air Pollution Effects, Risks and Trends. Federal Environmental Agency (Umweltbundesamt) Berlin, UBA-Texte 52/04 (download via internet: www.icpmapping.org)

Kriebitzsch, W-U.; Bühmann H. (1978): Stickstoff-Mineralisation im Boden eines Eichen-Buchen-Waldes und eines Kiefernforstes in der nordwestdeutschen Tiefebene. Forstwiss Cbl 108: 255-270.

Landolt, E. (1977): Ökologische Zeigerwerte zur Schweizer Flora. Veröff Geobot Inst ETH Stiftung Rübel 64: 1-208.

Lethmate, J., Ebke, K., Pollmann, W. (2002): Zur Ausbreitung des Rankenden Lerchensporns *Ceratocapnos claviculata* (L.) Liden. Osnabrücker Naturwiss Mittlg 28: 117-135.

Londo, G. (1976): A decimal scale for relevés of permanent quadrats.Vegetatio 33: 61-64.

Lorenz, M. ; Becher, G. (1994): Forest Condition in Europe. 1994 Technical Report. UN/ECE and EC, Geneva and Brussels, 174 pp.

Lorenz, M., Becher, G., Mues, V., Fischer, R., Becker, R., Calatayud, V., Diese, N., Krause, G.H.M., Sanz, M., and E. Ulrich, (2005): Forest Condition in Europe. Technical Report 2005. UN/ECE, Geneva, 99 pp + Annexes.

Lorenz, M.; Mues, V.; Becher, G.; Seidling, W.; Fischer, R.; Langouche, D.; Durrant, D.; Bartels, U. (2002): Forest Condition in Europe. 2002 Technical Report. UN/ECE and EC, Geneva and Brussels, 160 pp.

Lorenz, M.; Mues, V.; Becher, Müller-Edzards, Ch..; Luyssaert, S.; Raitio, H.; Fürst, A.; Langouche, D. (2003): Forest condition in Europe. 2003 Technical Report. UN/ECE and EC, Geneva and Brussels, 113 pp + Annexes.

Ouimet et al. (2001). Focus 1: 119-134.

Pielou, EC (1969): An introduction to mathematical ecology. Wiley, New York.

Posch, M., Slootweg, J. and J.-P. Hettelingh, (2005): European Critical Loads and Dynamic Modelling. CCE status report 2005, National Environmental Assessment Agency, Bilthoven, Netherlands, RIVM Report No. 259101016, ISBN No. 90-6960-128-1.

Runge, M. (1965): Untersuchungen über die Mineralstoffnachlieferung an nordwestdeutschen Waldstandorten. Flora 155: 353-386.

Schlutow, A., Hübener, P. (2005): Ermittlung von aktuellen Regenerierungspotenzialen naturnaher Ökosysteme mittels Bioindikation. Archives of Nature Conservation and Landscape Research 44(3):27-78.

Schönhar, W. (1952): Untersuchungen über die Korrelation zwischen der floristischen Zusammensetzung der Bodenvegetation und der Bodenazidität sowie anderen Bodenfaktoren. Mitt Ver forstl Standortskartierung 2: 1-23.

Seidling, W. (2005): Ground floor vegetation assessment within the intensive (Level II) monitoring of forest ecosystems in Germany: change and challenges. Eur J Forest Res 124: 301-312.

Seidling, W., Rohner, M-S. (1993): Zusammenhänge zwischen Reaktions-Zeigerwerten und bodenchemischen Parametern am Beispiel von Waldbodenvegetation. Phytocoenologia 23: 301-317.

ter Braak, CJF. (1987): Ordination. In : RHG Jongman, CJF ter Braak, OFR van Tongeren (eds): Data analysis in community and landscape ecology. Pudoc, Wageningen, 91-173.

ter Braak, CJF., Šmilauer, P. (1998): CANOCO reference manual and user's guide to CANOCO for WINDOWS. Microcomputer Power, Ithaca, 352 p.

Ulrich, E. (2003): RENECOFOR – 11ème bilan annuel, année 2002: Office National des Forêts, Direction Technique, 12 pp.

Vevle, O. (1985): Økologiske faktortall for norske karplantar. Utarbeidd på grunnlag av „Zeigerwerte der Gefäßpflanzen Mitteleuropas“. Bø (Telemark Distriktshøgskole), 35 p.

Walter, H. and H. Lieth. 1960-1967: Klimadiagramm-Weltatlas. 9000 Klimadiagramme, 33 Hauptkarten, 22 Nebenkarten. G. Fischer. Jena.

Walter, H., E. Harnickel, D. Müller-Dombois, D., (1975): Klimadiagramm-Karten der einzelnen Kontinente und die ökologische Klimagliederung der Erde. G. Fischer, Stuttgart, 36 pp. + 9 maps.

Watmough et al. (2004). Critical loads Ontario report no 2, Environmental and resource studies Trent University.

Wildi, O. (1986): Analyse vegetationskundlicher Daten. Veröff. Geobot. Inst. ETH Stfg. Rübel 90: 1-226.

Williamson, MH. (1981): Island populations. Oxford University Press, Oxford.

Zolyomi, B.; Barath, Z.; Fekete, G.; Jakucs, P.; Karpati, I.; Kovacs, M.; Mate, I. (1967): Einreihung von 1400 Arten der ungarischen Flora in ökologische Gruppen nach TWR-Zahlen. Fragm Bot Mus Hist Nat Hung 4: 101-142.

Annex I-1
Climatic regions

The **Boreal** region comprises Finland, the central and northern parts of Sweden, Estonia except the coastal regions and some plots in northern and central Norway. The climate is mainly cold with a short vegetation period. In the northernmost parts the climate changes to arctic conditions. The Boreal region is dominated by *Picea abies* and *Pinus sylvestris*. In 2005, 19.2% of the plots of the European survey were located in the Boreal region.

The **Boreal (Temperate)** region covers most parts of southern Sweden and Norway, the whole of the Baltic countries Latvia and Lithuania, the coastal regions of Estonia and the whole of Belarus. This region contains a higher proportion of deciduous tree species, compared to the colder Boreal region. 15.4% of the assessed trees were in the Boreal (Temperate) region.

The **Atlantic (North)** region comprises the United Kingdom, Ireland, Denmark, the Netherlands, the southern coasts of Sweden and Norway, north-west Germany, northern Belgium and France. The climate is characterised by mild winters, a relatively uniform distribution of precipitation over the year and long transitional seasons. The forests consist of *Picea abies*, *Pinus sylvestris*, *Picea sitchensis, Quercus robur* and *Fagus sylvatica*. 5.6% of the plots were situated in this region.

The **Atlantic (South)** region comprises central and south-western France, the atlantic coast of Spain and the northern parts of Portugal. The climate is warm, with high precipitation in winter, but very little frost and snow. There is a higher proportion of oak species, dependent on warmer summers, than in the Atlantic (North) region. Also frequent are *Castanea sativa, Pinus pinaster, Pinus radiata* and *Pinis sylvestris.* 4.6% of the plots were located in this region.

The plots of the **Sub-Atlantic** region are located in Poland, the Czech Republic, the western parts of Slovakia, northern Austria and Switzerland, eastern and southern Germany, southern Belgium, central-eastern France, and the whole of Luxembourg. The climate is typically temperate and characterised by large temperature differences between summer and winter, with a gradient from the western parts to the eastern parts. If the whole region is considered, the forests are very heterogeneous, dominated by *Picea abies, Pinus sylvestris* and *Fagus sylvatica*. In this region 18.5% of all plots were located.

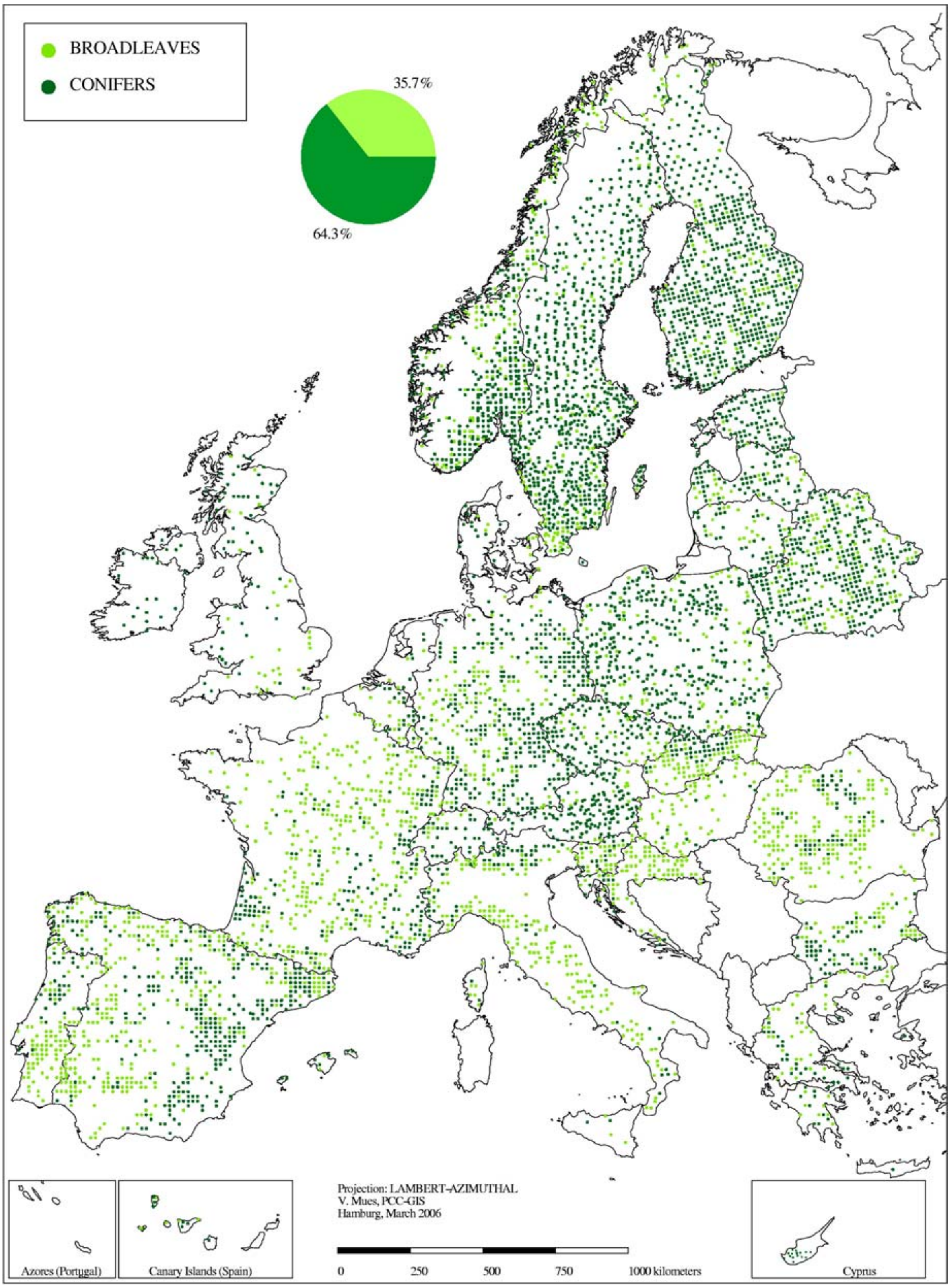
The **Continental** region consists of the Republic of Moldova, large parts of Romania, eastern and northern Bulgaria and nearly all Hungary. The climate is typically continental with warm and dry summers, and low temperatures in winter. The forests are characterised by oak species, *Fagus sylvatica, Robinia pseudoacacia, Carpinus betulus, Picea abies* and *Abies alba.* In 2005, 4% of the sample plots were located in this region.

The **Mountainous (South)** region comprises plots on several mountain ridges. They share steep climatic gradients and consequently complex geobotanical structures, depending on altitude and exposition. They comprise the Alpine system (Pyrenees, Alps, Tatras, Carpathians and the Balkan), the Appenin, the Vosges, and in Germany the Black Forest and the Bavarian/Bohemian Forests. The dominant species are *Picea abies, Fagus sylvatica, Larix decidua, Pinus nigra, Pinus sylvestris* and *Abies alba*. This climatic region comprises 11.6% of all sample plots.

The **Mountainous (North)** region was introduced to account for the peculiarities of the mountainous climate in northernmost Europe in comparison to that in the other parts of Europe. This region is located only in Norway. It is characterised by large seasonal variations in climate, but with a generally shorter vegetation period. The plots at lower altitudes on the Atlantic coast are influenced by the Gulf stream and have a more temperate climate. The most frequently occurring species are *Betula pubescens*, *Picea abies* and *Pinus sylvestris*. 5% of the sample plots were located in the Mountainous (North) region.

The Mediterranean region as a whole is divided in the **Mediterranean (Higher)** and **Mediterranean (Lower)** regions. The higher areas (6.5% of the plots) are situated between 400 m and ca. 1000 m altitude in Portugal, Spain, southern France, Italy, Slovenia, Croatia, Romania and Greece with humid climate. The Mediterranean (Lower) regions (9.6% of the plots) cover Cyprus and lower parts of the countries mentioned above. The climate is characterised by hot and dry summers and frequent drought periods in summer. Both Mediterranean regions are dominated by *Pinus halepensis, Pinus nigra, Pinus pinaster, Quercus ilex, Quercus cerris* and *Quercus pubescens.*

Annex I-2
Braodleaves and conifers (2005)



Annex I-3

Species assessed (2005)

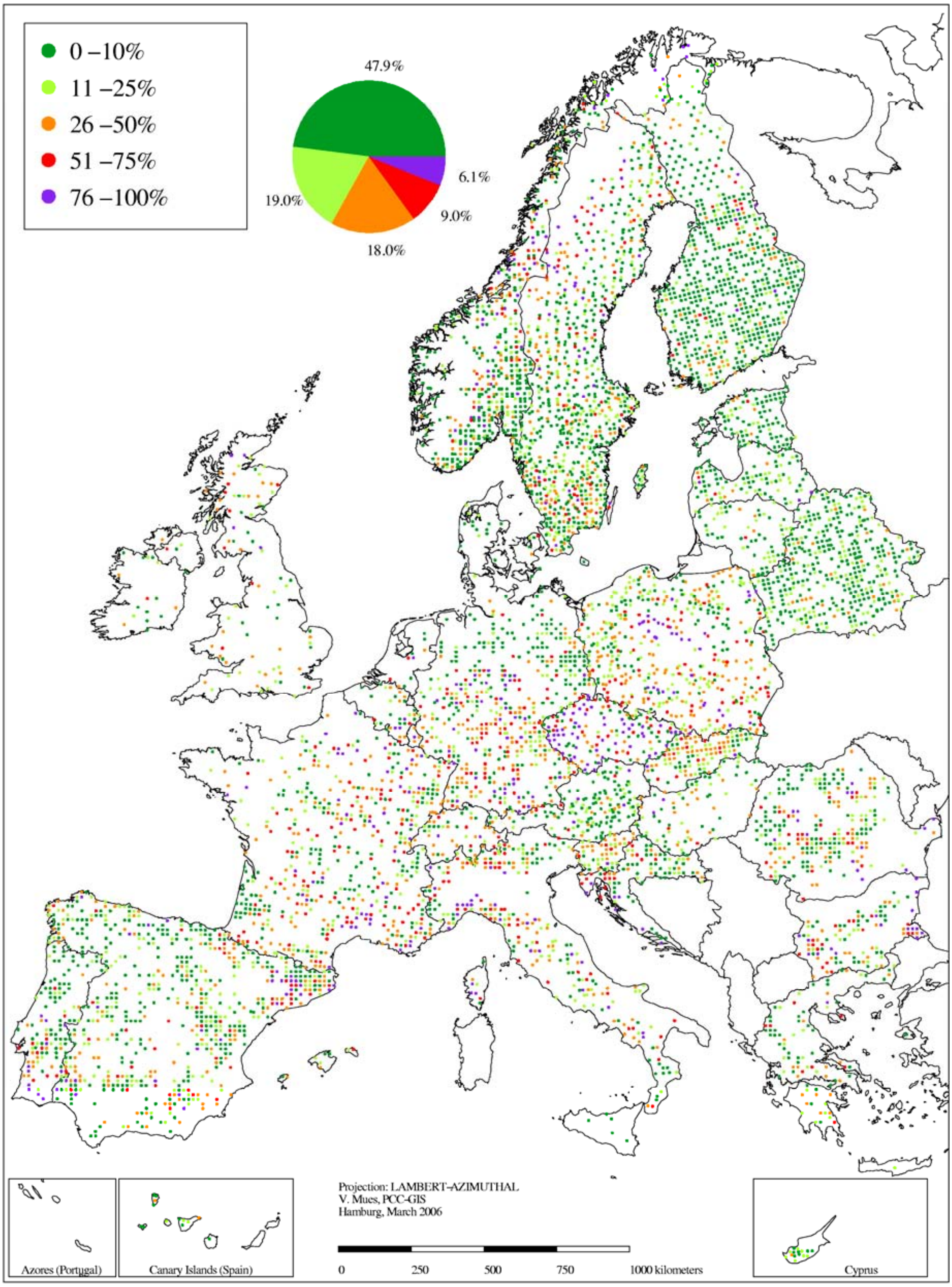
Species	Observed trees		Observed plots	
	Number	%	Number	%
Pinus sylvestris	37180	27.78	1925	18.30
Picea abies	26582	19.86	1549	14.72
Fagus sylvatica	11898	8.89	666	6.33
Quercus robur	5009	3.74	441	4.19
Betula pubescens	4859	3.63	748	7.11
Quercus ilex	3833	2.86	223	2.12
Betula pendula	3683	2.75	665	6.32
Quercus petraea	3438	2.57	351	3.34
Pinus pinaster	3279	2.45	173	1.64
Pinus nigra	2878	2.15	166	1.58
Pinus halepensis	2657	1.99	135	1.28
Abies alba	2147	1.60	210	2.00
Quercus pubescens	1936	1.45	159	1.51
Carpinus betulus	1718	1.28	232	2.20
Quercus suber	1593	1.19	90	0.86
Quercus cerris	1505	1.12	133	1.26
Eucalyptus spp.	1439	1.08	65	0.62
Castanea sativa	1275	0.95	148	1.41
Larix decidua	1233	0.92	181	1.72
Populus tremula	1068	0.80	260	2.47
Alnus glutinosa	1017	0.76	139	1.32
Fraxinus excelsior	980	0.73	194	1.84
Quercus pyrenaica	963	0.72	54	0.51
Picea sitchensis	902	0.67	46	0.44
Quercus frainetto	812	0.61	43	0.41
Robinia pseudoacacia	735	0.55	66	0.63
Quercus rotundifolia	633	0.47	36	0.34
Acer pseudoplatanus	564	0.42	160	1.52
Pseudotsuga menziesii	540	0.40	47	0.45
Populus hybrides	473	0.35	23	0.22
Pinus pinea	454	0.34	37	0.35
Quercus faginea	395	0.30	50	0.48
Pinus brutia	378	0.28	19	0.18
Ostrya carpinifolia	365	0.27	60	0.57
other broadleaves	339	0.25	75	0.71
Pinus radiata	322	0.24	16	0.15
Tilia cordata	309	0.23	74	0.70
Juniperus thurifera	279	0.21	22	0.21
Abies cephalonica	269	0.20	13	0.12
Alnus incana	225	0.17	39	0.37
Prunus avium	224	0.17	101	0.96
Quercus coccifera	208	0.16	16	0.15
Pinus contorta	190	0.14	15	0.14
Abies borisii-regis	178	0.13	9	0.09
Olea europaea	174	0.13	21	0.20
Acer campestre	165	0.12	69	0.66

Species	Observed trees		Observed plots	
	Number	%	Number	%
Quercus rubra	153	0.11	21	0.20
Pinus uncinata	146	0.11	13	0.12
Tilia platyphyllos	130	0.10	19	0.18
Fraxinus angustifolia	126	0.09	14	0.13
Fraxinus ornus	125	0.09	43	0.41
Fagus moesiaca	121	0.09	6	0.06
Acer platanoides	117	0.09	43	0.41
Populus nigra	108	0.08	10	0.10
Platanus orientalis	89	0.07	5	0.05
Alnus cordata	85	0.06	4	0.04
Pinus cembra	82	0.06	9	0.09
Larix kaempferi	72	0.05	9	0.09
Sorbus aucuparia	66	0.05	29	0.28
Pinus strobus	63	0.05	8	0.08
Sorbus aria	49	0.04	31	0.29
Juniperus oxycedrus	49	0.04	17	0.16
Salix caprea	46	0.03	29	0.28
Juniperus phoenicea	46	0.03	10	0.10
Populus canescens	45	0.03	5	0.05
Ulmus glabra	45	0.03	23	0.22
Acer monspessulanum	44	0.03	13	0.12
Acer opalus	44	0.03	17	0.16
Juniperus communis	43	0.03	7	0.07
Populus alba	42	0.03	10	0.10
Salix spp.	41	0.03	10	0.10
Phillyrea latifolia	39	0.03	9	0.09
Cupressus sempervirens	37	0.03	6	0.06
Other conifers	37	0.03	8	0.08
Cedrus atlantica	32	0.02	4	0.04
Salix alba	30	0.02	6	0.06
Sorbus torminalis	27	0.02	22	0.21
Arbutus unedo	27	0.02	8	0.08
Ulmus minor	24	0.02	9	0.09
Cedrus brevifolia	24	0.02	1	0.01
Arbutus andrachne	22	0.02	2	0.02
Buxus sempervirens	21	0.02	3	0.03
Quercus macrolepsis	21	0.02	1	0.01
Quercus trojana	20	0.01	3	0.03
Corylus avellana	19	0.01	10	0.10
Quercus fruticosa	19	0.01	1	0.01
Fagus orientalis	15	0.01	1	0.01
Juglans regia	14	0.01	6	0.06
Pistacia terebinthus	11	0.01	2	0.02
Pinus leucodermis	11	0.01	1	0.01
Alnus viridis	10	0.01	2	0.02
Sorbus domestica	10	0.01	9	0.09
Ilex aquifolium	9	0.01	6	0.06
Pyrus communis	9	0.01	6	0.06
Ulmus laevis	9	0.01	5	0.05

Species	Observed trees		Observed plots	
	Number	%	Number	%
Tsuga spp.	9	0.01	1	0.01
Cercis siliquastrum	8	0.01	1	0.01
Cupressus lusitanica	8	0.01	1	0.01
Ceratonia siliqua	7	0.01	2	0.02
Cedrus deodara	4	0.00	1	0.01
Prunus serotina	3	0.00	1	0.01
Abies grandis	3	0.00	1	0.01
Pinus mugo	3	0.00	1	0.01
Thuya spp.	3	0.00	1	0.01
Malus domestica	2	0.00	1	0.01
Prunus padus	2	0.00	2	0.02
Salix fragilis	2	0.00	2	0.02
Pistacia lentiscus	2	0.00	1	0.01
Chamaecyparis lawsonia	2	0.00	1	0.01
Carpinus orientalis	1	0.00	1	0.01
Salix cinerea	1	0.00	1	0.01
Salix eleagnos	1	0.00	1	0.01
Picea omorika	1	0.00	1	0.01
Taxus baccata	1	0.00	1	0.01
All species	133840	100.00	10522	100.00

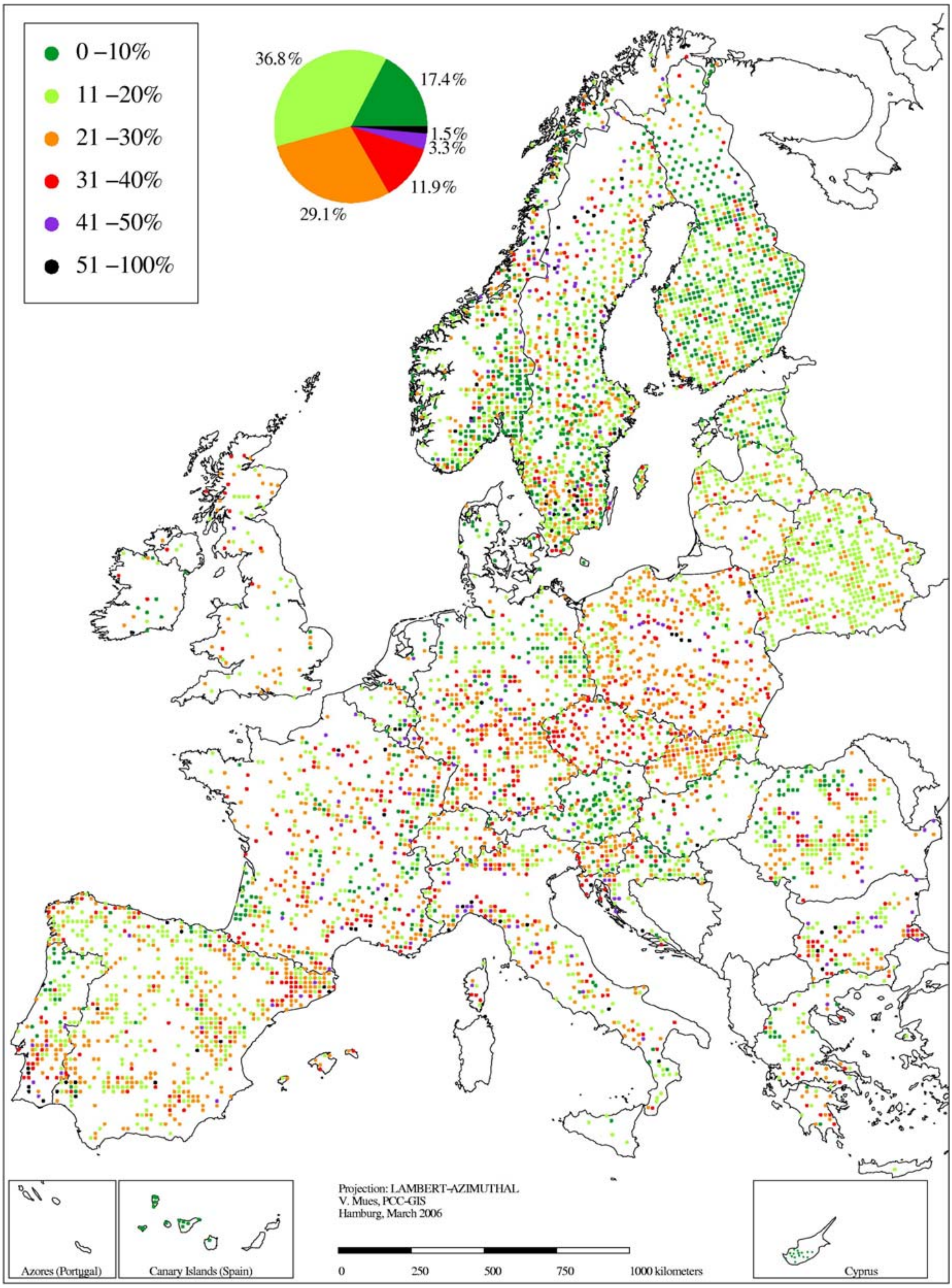
Annex I-4
Percentage of trees damaged (2005)

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.



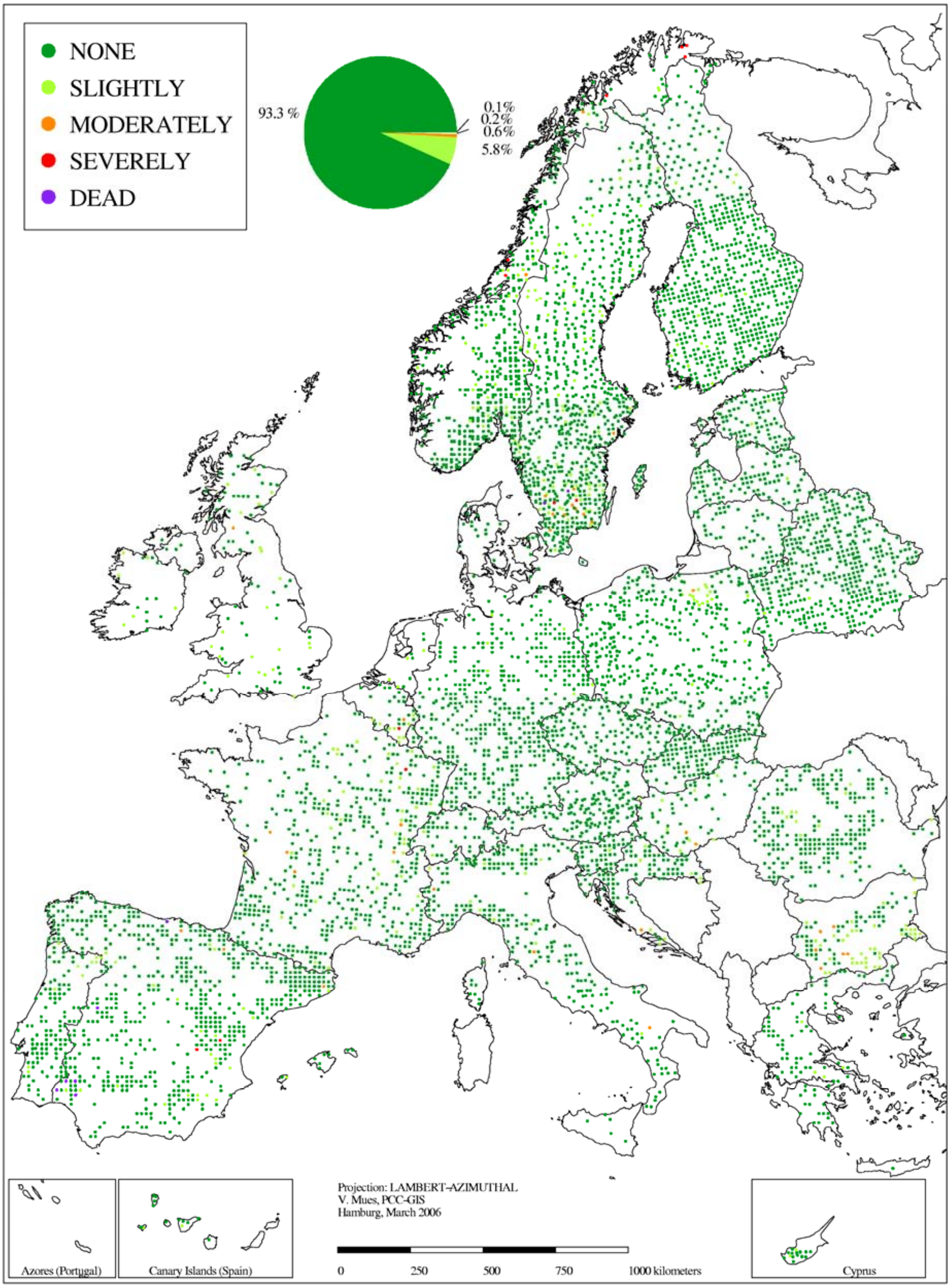
Annex I-5
Mean plot defoliation of all species (2005)

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.



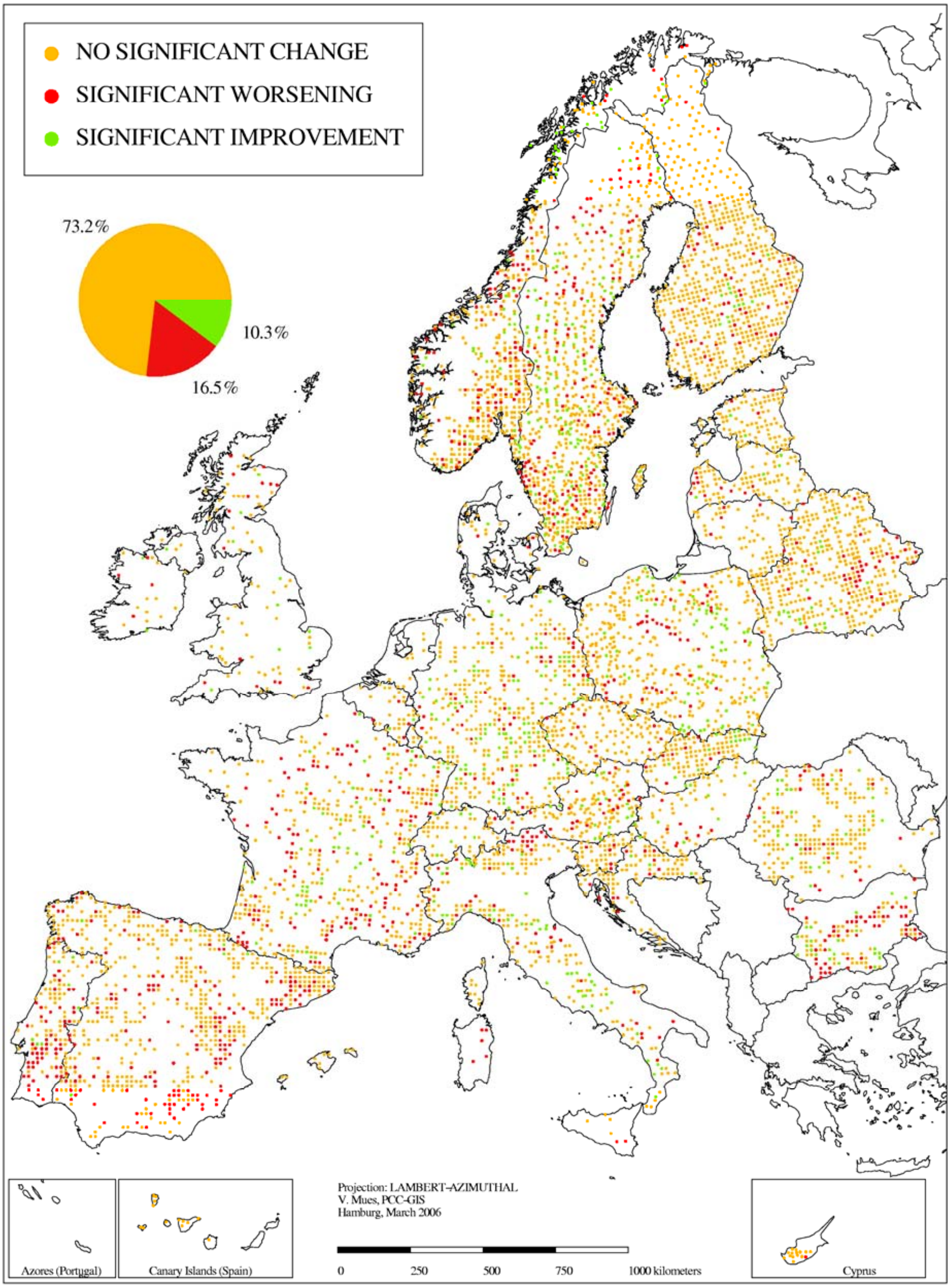
Annex I-6
Plot discolouration (2005)

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 I-7

Changes in mean plot defoliation (2004-2005)



Annex I-8

Development of defoliation of most common species (1990-2005).

Picea abies

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%
1990	526	52.3	28.3	19.4
1991	524	54.8	22.7	22.5
1992	525	49.5	30.7	19.8
1993	521	47.8	21.7	30.5
1994	522	39.7	26.2	34.1
1995	503	42.6	28.6	28.8
1996	495	49.5	30.1	20.4
1997	475	51.6	26.3	22.1
1998	497	52.3	27.6	20.1
1999	507	56.0	24.7	19.3
2000	489	53.1	26.0	20.9
2001	490	61.9	21.6	16.5
2002	466	64.0	22.3	13.7
2003	466	61.8	21.9	16.3
2004	465	62.4	21.7	15.9
2005	444	61.5	24.1	14.4

SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%
1990	3822	27.4	39.5	33.1
1991	3767	25.5	39.1	35.4
1992	3826	24.6	40.7	34.7
1993	3781	24.6	37.2	38.2
1994	3778	21.1	37.8	41.1
1995	3833	25.9	34.0	40.1
1996	3835	31.0	36.4	32.6
1997	3855	25.1	40.4	34.5
1998	4674	27.6	39.9	32.5
1999	4651	26.7	40.9	32.4
2000	4651	22.9	43.6	33.5
2001	4444	21.9	44.8	33.3
2002	4509	21.3	42.1	36.6
2003	4563	21.0	44.5	34.5
2004	4540	18.0	40.4	41.6
2005	4495	18.7	45.1	36.2

BOREAL (TEMP.)	Number of trees	0-10%	>10-25%	>25%
1990	405	35.6	41.2	23.2
1991	599	32.4	46.6	21.0
1992	595	30.1	50.9	19.0
1993	594	29.0	54.0	17.0
1994	531	37.1	47.5	15.4
1995	547	39.5	45.5	15.0
1996	585	30.4	52.0	17.6
1997	545	32.5	48.1	19.4
1998	551	36.5	47.5	16.0
1999	552	32.8	49.6	17.6
2000	549	24.8	51.3	23.9
2001	540	25.7	53.2	21.1
2002	540	23.1	60.8	16.1
2003	522	24.3	58.8	16.9
2004	518	27.8	56.2	16.0
2005	518	33.8	51.9	14.3

MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	1715	29.6	37.3	33.1
1991	1727	22.4	44.5	33.1
1992	1697	15.4	45.5	39.1
1993	1674	18.2	44.2	37.6
1994	1708	17.1	42.3	40.6
1995	1803	21.1	44.3	34.6
1996	1778	25.2	42.9	31.9
1997	1726	23.0	44.2	32.8
1998	2151	25.8	43.2	31.0
1999	2131	29.1	43.1	27.8
2000	2076	24.0	47.2	28.8
2001	2016	20.2	50.6	29.2
2002	1994	16.3	55.0	28.7
2003	2011	13.2	58.1	28.7
2004	1955	9.4	49.6	41.0
2005	1937	17.2	49.4	33.4

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	6485	30.7	38.0	31.3
1991	6634	27.8	39.8	32.4
1992	6660	24.9	41.9	33.2
1993	6584	25.4	39.2	35.4
1994	6553	23.0	38.8	38.2
1995	6700	27.1	37.2	35.7
1996	6707	30.9	39.0	30.1
1997	6615	27.2	40.9	31.9
1998	7887	29.4	40.5	30.1
1999	7855	29.8	41.0	29.2
2000	7779	25.4	43.9	30.7
2001	7504	24.4	45.5	30.1
2002	7523	22.7	45.7	31.6
2003	7568	21.7	47.7	30.6
2004	7484	19.2	42.8	38.0
2005	7400	22.0	45.4	32.6

Pinus sylvestris

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%
1990	588	50.2	41.8	8.0
1991	591	51.3	37.2	11.5
1992	581	55.1	32.7	12.2
1993	592	50.0	39.4	10.6
1994	591	45.7	42.5	11.8
1995	576	44.3	45.8	9.9
1996	577	38.1	51.0	10.9
1997	573	47.5	46.2	6.3
1998	573	54.1	39.4	6.5
1999	647	46.4	43.7	9.9
2000	643	44.0	45.6	10.4
2001	648	42.4	48.5	9.1
2002	648	46.5	43.8	9.7
2003	647	48.8	41.6	9.6
2004	639	55.5	38.2	6.3
2005	639	54.0	40.5	5.5

MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1990	541	85.9	12.8	1.3
1991	541	72.8	21.3	5.9
1992	564	67.4	23.0	9.6
1993	564	56.6	26.6	16.8
1994	540	51.5	31.3	17.2
1995	549	45.2	39.9	14.9
1996	541	47.4	43.4	9.2
1997	540	45.0	44.3	10.7
1998	540	44.4	48.2	7.4
1999	603	50.6	44.3	5.1
2000	602	55.5	40.2	4.3
2001	604	53.3	40.1	6.6
2002	603	48.0	41.6	10.4
2003	601	44.1	46.9	9.0
2004	601	41.6	49.6	8.8
2005	599	36.9	54.8	8.3

MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	739	66.9	21.2	11.9
1991	742	51.1	32.3	16.6
1992	758	39.4	40.7	19.9
1993	743	36.9	41.2	21.9
1994	731	29.5	40.7	29.8
1995	747	31.7	54.9	13.4
1996	754	35.5	49.5	15.0
1997	763	34.3	55.7	10.0
1998	829	39.6	50.0	10.4
1999	918	48.4	41.7	9.9
2000	904	35.6	51.7	12.7
2001	895	37.5	49.5	13.0
2002	896	26.2	54.7	19.1
2003	896	23.1	59.0	17.9
2004	899	20.7	61.7	17.6
2005	895	22.0	60.1	17.9

BOREAL (TEMP.)	Number of trees	0-10%	>10-25%	>25%
1990	960	10.4	34.4	55.2
1991	1154	4.9	32.8	62.3
1992	1130	3.1	26.3	70.6
1993	1156	4.0	34.2	61.8
1994	1099	9.9	43.8	46.3
1995	1079	15.9	56.6	27.5
1996	1117	20.0	57.8	22.2
1997	1096	18.0	61.7	20.3
1998	1115	19.5	60.7	19.8
1999	1134	14.2	67.0	18.8
2000	1068	15.0	67.8	17.2
2001	1121	12.3	74.9	12.8
2002	1133	15.5	72.0	12.5
2003	1131	19.6	71.0	9.4
2004	1134	17.5	72.7	9.8
2005	1124	12.4	74.7	12.9

SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%
1990	8491	13.5	46.2	40.3
1991	8534	8.2	45.8	46.0
1992	8538	8.6	43.9	47.5
1993	8549	8.9	44.6	46.5
1994	8011	5.4	41.5	53.1
1995	7838	7.5	42.1	50.4
1996	7838	12.4	51.7	35.9
1997	7815	12.1	54.8	33.1
1998	8210	12.9	56.8	30.3
1999	8205	12.5	61.0	26.5
2000	8216	10.5	61.9	27.6
2001	8195	10.4	62.4	27.2
2002	8059	9.1	63.2	27.7
2003	8103	8.5	63.4	28.1
2004	8139	8.1	61.9	30.0
2005	8120	12.1	57.5	30.4

CONTINENTAL	Number of trees	0-10%	>10-25%	>25%
1990	149	46.3	18.1	35.6
1991	157	56.0	25.5	18.5
1992	158	62.6	20.3	17.1
1993	162	63.0	16.0	21.0
1994	162	59.9	17.3	22.8
1995	166	69.3	12.0	18.7
1996	168	66.7	14.3	19.0
1997	168	64.9	14.9	20.2
1998	181	62.4	21.0	16.6
1999	180	68.4	17.2	14.4
2000	170	65.9	14.7	19.4
2001	170	68.8	15.9	15.3
2002	170	61.2	18.2	20.6
2003	169	53.3	26.0	20.7
2004	168	57.8	20.2	22.0
2005	166	56.6	18.1	25.3

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	11630	23.1	41.1	35.8
1991	11877	17.2	41.5	41.3
1992	11887	16.6	40.0	43.4
1993	11924	15.9	41.6	42.5
1994	11292	13.2	40.6	46.2
1995	11113	15.3	44.0	40.7
1996	11154	19.1	51.0	29.9
1997	11115	19.2	53.6	27.2
1998	11608	20.4	54.6	25.0
1999	11847	20.6	57.3	22.1
2000	11764	18.3	58.7	23.0
2001	11794	17.9	59.8	22.3
2002	11670	16.4	60.3	23.3
2003	11708	15.9	60.9	23.2
2004	11741	15.5	60.2	24.3
2005	11705	17.4	57.6	25.0

Fagus sylvatica

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	420	18.8	45.0	36.2	1990	123	65.9	21.1	13.0
1991	420	28.3	47.2	24.5	1991	95	57.9	28.4	13.7
1992	420	25.0	46.2	28.8	1992	119	59.7	31.1	9.2
1993	420	25.5	45.2	29.3	1993	119	62.2	31.1	6.7
1994	425	28.2	44.3	27.5	1994	80	33.8	54.9	11.3
1995	423	14.4	43.8	41.8	1995	120	59.2	35.0	5.8
1996	404	19.8	47.5	32.7	1996	96	33.3	52.1	14.6
1997	420	24.5	43.8	31.7	1997	120	29.2	54.1	16.7
1998	420	27.1	42.4	30.5	1998	120	27.5	60.8	11.7
1999	431	22.0	47.8	30.2	1999	121	35.5	55.4	9.1
2000	436	15.8	41.1	43.1	2000	126	42.9	47.6	9.5
2001	461	29.7	41.9	28.4	2001	127	48.8	46.5	4.7
2002	459	26.1	43.4	30.5	2002	128	28.9	57.8	13.3
2003	463	28.3	42.5	29.2	2003	128	27.3	60.2	12.5
2004	472	23.1	31.1	45.8	2004	128	15.6	71.1	13.3
2005	497	31.4	36.6	32.0	2005	130	16.2	69.2	14.6
SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	2371	31.1	46.3	22.6	1990	976	48.3	41.7	10.0
1991	2429	33.6	44.3	22.1	1991	994	59.0	33.8	7.2
1992	2446	20.4	48.4	31.2	1992	1001	52.2	31.9	15.9
1993	2424	23.8	47.1	29.1	1993	1014	52.2	32.9	14.9
1994	2385	16.2	49.8	34.0	1994	950	48.0	36.7	15.3
1995	2420	18.0	46.0	36.0	1995	1010	40.4	42.7	16.9
1996	2434	21.4	51.2	27.4	1996	1004	35.4	48.5	16.1
1997	2476	22.5	54.2	23.3	1997	1011	30.7	49.9	19.4
1998	2684	23.5	51.5	25.0	1998	1053	45.4	44.5	10.1
1999	2718	17.8	56.3	25.9	1999	1158	34.4	52.3	13.3
2000	2731	23.6	50.6	25.8	2000	1204	43.1	45.9	11.0
2001	2721	20.6	48.4	31.0	2001	1193	29.0	54.7	16.3
2002	2724	24.9	52.0	23.1	2002	1200	31.8	56.4	11.8
2003	2742	23.9	51.4	24.7	2003	1202	17.8	49.7	32.5
2004	2757	14.6	50.5	34.9	2004	1195	25.2	49.4	25.4
2005	2763	15.1	54.7	30.2	2005	1188	34.9	45.2	19.9

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	4014	37.0	43.0	20.0
1991	4063	40.9	41.2	17.9
1992	4090	31.4	42.8	25.8
1993	4108	33.6	42.0	24.4
1994	3947	27.0	45.4	27.6
1995	4126	25.9	44.0	30.1
1996	4091	26.2	49.9	23.9
1997	4162	25.8	51.6	22.6
1998	4416	30.2	48.7	21.1
1999	4567	24.1	53.9	22.0
2000	4636	29.6	47.9	22.5
2001	4639	25.0	49.2	25.8
2002	4648	27.6	52.3	20.1
2003	4677	23.9	50.0	26.1
2004	4693	19.4	48.5	32.1
2005	4719	22.7	50.4	26.9

Quercus ilex and *Q. rotundifolia*

MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%
1990	652	80.4	18.7	0.9	1990	2326	65.0	21.5	13.5
1991	652	56.1	40.8	3.1	1991	2308	47.2	36.3	16.5
1992	653	42.0	49.1	8.9	1992	2323	38.2	45.7	16.1
1993	653	31.2	60.4	8.4	1993	2298	36.4	56.9	6.7
1994	653	25.4	56.1	18.5	1994	2294	31.4	57.4	11.2
1995	671	17.1	50.7	32.2	1995	2277	16.6	56.4	27.0
1996	665	21.1	53.5	25.4	1996	2278	20.5	54.7	24.8
1997	665	25.6	58.5	15.9	1997	2278	29.0	56.2	14.8
1998	657	35.0	51.6	13.4	1998	2278	31.9	54.4	13.7
1999	770	26.6	56.5	16.9	1999	2896	21.8	56.2	22.0
2000	764	27.0	56.2	16.8	2000	2914	17.6	60.8	21.6
2001	765	24.7	62.8	12.5	2001	2914	19.4	65.2	15.4
2002	765	17.3	64.4	18.3	2002	2918	17.6	64.4	18.0
2003	766	20.2	60.7	19.1	2003	2919	14.1	66.1	19.8
2004	766	20.9	61.3	17.8	2004	2916	20.3	64.4	15.3
2005	770	9.5	57.0	33.5	2005	2888	8.8	69.1	22.1

Quercus ilex and *Q. rotundifolia*

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	3074	67.8	20.9	11.3
1991	3064	49.4	37.2	13.4
1992	3080	38.6	46.6	14.8
1993	3055	35.1	57.8	7.1
1994	3027	29.3	57.4	13.3
1995	3052	16.3	55.6	28.1
1996	3034	20.6	55.1	24.3
1997	3034	28.3	56.9	14.8
1998	3026	32.8	53.8	13.4
1999	3820	23.4	56.4	20.2
2000	3852	20.2	59.8	20.0
2001	3853	20.4	64.5	15.1
2002	3857	17.4	63.8	18.8
2003	3859	15.6	64.4	20.0
2004	3855	20.2	63.7	16.1
2005	3832	8.9	66.5	24.6

Pinus pinaster

ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1990	467	44.3	17.8	37.9	1990	426	77.5	14.3	8.2
1991	461	38.6	27.8	33.6	1991	380	75.0	14.7	10.3
1992	482	53.3	26.6	20.1	1992	370	84.1	13.5	2.4
1993	451	59.0	31.9	9.1	1993	370	75.9	21.4	2.7
1994	423	60.3	31.0	8.7	1994	432	72.9	17.8	9.3
1995	420	57.1	36.2	6.7	1995	432	69.3	27.5	3.2
1996	420	54.5	34.3	11.2	1996	432	69.2	22.9	7.9
1997	410	60.3	32.9	6.8	1997	427	72.6	20.1	7.3
1998	410	52.7	39.3	8.0	1998	432	69.6	26.2	4.2
1999	598	52.9	43.1	4.0	1999	511	61.2	28.8	10.0
2000	600	49.0	40.2	10.8	2000	482	61.2	29.0	9.8
2001	592	41.7	53.2	5.1	2001	481	62.4	34.7	2.9
2002	593	41.3	48.8	9.9	2002	482	54.2	42.5	3.3
2003	565	37.0	57.0	6.0	2003	482	50.6	44.0	5.4
2004	563	32.9	52.9	14.2	2004	472	55.3	37.3	7.4
2005	504	35.3	54.8	9.9	2005	473	42.9	48.4	8.7
MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	1712	71.4	18.6	10.0	1990	2654	68.1	17.5	14.4
1991	1699	61.7	27.6	10.7	1991	2589	60.1	25.4	14.5
1992	1698	64.1	25.6	10.3	1992	2599	65.3	23.8	10.9
1993	1582	67.7	23.5	8.8	1993	2452	67.5	24.6	7.9
1994	1638	65.7	27.8	6.5	1994	2542	66.0	26.8	7.2
1995	1480	59.2	32.2	8.6	1995	2381	60.9	31.9	7.2
1996	1449	57.0	34.6	8.4	1996	2350	59.3	32.0	8.7
1997	1433	43.6	45.9	10.5	1997	2333	52.9	38.0	9.1
1998	1427	44.2	45.8	10.0	1998	2332	51.2	40.2	8.6
1999	1661	42.9	47.4	9.7	1999	2886	50.0	41.8	8.2
2000	1661	46.5	45.4	8.1	2000	2859	51.1	40.3	8.6
2001	1653	47.7	46.3	6.0	2001	2842	50.1	44.8	5.1
2002	1649	48.4	45.7	5.9	2002	2840	48.5	45.3	6.2
2003	1459	45.9	44.6	9.5	2003	2622	45.2	47.1	7.7
2004	1427	43.9	41.7	14.4	2004	2579	44.1	43.5	12.4
2005	1281	36.2	44.0	19.8	2005	2375	38.4	46.9	14.7

Quercus suber

MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	1403	39.1	19.2	41.7	1990	1442	38.9	18.9	42.2
1991	1382	26.6	29.7	43.7	1991	1419	26.7	29.2	44.1
1992	1449	29.6	37.7	32.7	1992	1487	29.6	37.2	33.2
1993	1401	46.1	44.5	9.4	1993	1438	47.6	43.3	9.1
1994	1397	39.2	47.0	13.8	1994	1434	40.7	45.8	13.5
1995	1398	19.4	54.3	26.3	1995	1435	21.3	53.1	25.6
1996	1400	32.9	52.1	15.0	1996	1437	33.9	51.5	14.6
1997	1403	34.3	53.2	12.5	1997	1440	35.8	52.0	12.2
1998	1403	26.8	58.2	15.0	1998	1440	28.1	57.2	14.7
1999	1511	23.4	56.9	19.7	1999	1548	24.5	56.3	19.2
2000	1533	21.2	62.0	16.8	2000	1570	22.4	61.2	16.4
2001	1534	22.0	59.6	18.4	2001	1571	22.5	59.4	18.1
2002	1557	22.1	60.4	17.5	2002	1594	22.5	60.2	17.3
2003	1541	19.4	54.4	26.2	2003	1578	19.8	54.5	25.7
2004	1557	20.9	52.4	26.7	2004	1594	21.6	52.2	26.2
2005	1500	3.8	60.1	36.1	2005	1534	4.2	60.3	35.5

Quercus robur and *Q. petraea*

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	322	57.2	30.4	12.4	1990	269	66.5	8.6	24.9
1991	323	39.9	43.7	16.4	1991	257	55.3	13.2	31.5
1992	323	25.1	56.3	18.6	1992	237	49.4	27.8	22.8
1993	326	25.2	41.4	33.4	1993	238	51.7	34.9	13.4
1994	316	35.8	33.2	31.0	1994	197	55.3	33.5	11.2
1995	331	37.2	41.0	21.8	1995	239	40.2	48.1	11.7
1996	328	15.9	39.0	45.1	1996	237	32.9	49.4	17.7
1997	335	17.9	43.0	39.1	1997	238	34.5	52.1	13.4
1998	335	25.7	47.7	26.6	1998	240	33.8	44.5	21.7
1999	335	23.6	39.4	37.0	1999	280	35.4	53.5	11.1
2000	337	27.3	47.2	25.5	2000	278	30.6	57.9	11.5
2001	341	20.8	52.8	26.4	2001	281	20.3	60.8	18.9
2002	342	24.9	46.4	28.7	2002	282	20.6	62.7	16.7
2003	338	15.1	51.5	33.4	2003	298	22.1	62.5	15.4
2004	340	12.9	47.1	40.0	2004	299	20.4	58.9	20.7
2005	363	19.6	50.1	30.3	2005	302	21.9	60.9	17.2

SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	1634	27.3	49.2	23.5	1990	205	12.2	23.4	64.4
1991	1635	17.0	48.6	34.4	1991	212	26.9	39.6	33.5
1992	1624	13.1	49.1	37.8	1992	212	14.6	58.5	26.9
1993	1624	10.2	43.6	46.2	1993	214	18.7	34.1	47.2
1994	1630	6.9	37.3	55.8	1994	197	11.2	55.8	33.0
1995	1631	8.5	38.6	52.9	1995	210	21.0	45.2	33.8
1996	1608	10.6	43.0	46.4	1996	209	12.9	30.6	56.5
1997	1627	11.2	45.4	43.4	1997	209	17.2	26.8	56.0
1998	1693	12.2	42.4	45.4	1998	238	19.3	35.3	45.4
1999	1723	13.8	52.1	34.1	1999	243	18.5	39.5	42.0
2000	1725	12.3	52.7	35.0	2000	241	18.3	44.8	36.9
2001	1729	12.1	52.7	35.2	2001	244	18.4	45.1	36.5
2002	1735	15.4	52.0	32.6	2002	246	13.8	46.8	39.4
2003	1737	9.4	53.8	36.8	2003	247	15.4	45.3	39.3
2004	1744	10.7	47.3	42.0	2004	267	19.1	39.7	41.2
2005	1746	9.6	47.7	42.7	2005	266	21.4	30.8	47.8

Quercus robur and ***Q. petraea***

CONTINENTAL	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	166	47.6	25.3	27.1	1990	2633	35.8	38.8	25.4
1991	178	35.9	29.8	34.3	1991	2640	26.4	42.2	31.4
1992	177	42.4	27.1	30.5	1992	2609	20.7	47.0	32.3
1993	177	28.2	32.8	39.0	1993	2615	18.3	40.9	40.8
1994	185	30.3	19.5	50.2	1994	2559	16.8	36.7	46.5
1995	185	33.0	27.0	40.0	1995	2643	18.1	39.8	42.1
1996	190	36.8	27.4	35.8	1996	2619	15.7	41.1	43.2
1997	191	38.2	24.1	37.7	1997	2651	17.2	42.9	39.9
1998	207	37.1	30.0	32.9	1998	2764	18.7	41.9	39.4
1999	207	47.8	25.1	27.1	1999	2839	20.5	47.7	31.8
2000	208	47.1	22.6	30.3	2000	2868	20.2	49.3	30.5
2001	205	52.7	23.9	23.4	2001	2879	18.2	50.9	30.9
2002	205	46.4	26.8	26.8	2002	2889	19.5	50.4	30.1
2003	204	40.7	26.5	32.8	2003	2902	14.1	52.3	33.6
2004	264	43.6	26.1	30.3	2004	2998	16.0	46.3	37.7
2005	264	50.4	22.7	26.9	2005	3029	17.1	46.1	36.8

Abies alba

SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	385	11.2	27.5	61.3	1990	335	21.5	30.1	48.4
1991	385	10.1	23.9	66.0	1991	348	22.7	34.2	43.1
1992	386	9.8	23.1	67.1	1992	347	14.7	43.5	41.8
1993	382	8.1	26.7	65.2	1993	347	11.2	30.8	58.0
1994	385	7.8	22.9	69.3	1994	343	15.5	39.7	44.8
1995	402	8.0	30.8	61.2	1995	359	14.8	37.6	47.6
1996	401	9.7	35.4	54.9	1996	366	13.7	32.8	53.5
1997	392	11.5	35.7	52.8	1997	360	10.3	40.8	48.9
1998	432	11.6	34.5	53.9	1998	342	16.4	38.9	44.7
1999	429	10.5	37.5	52.0	1999	347	13.8	42.1	44.1
2000	430	9.3	36.0	54.7	2000	383	17.5	43.1	39.4
2001	419	10.3	29.6	60.1	2001	374	16.0	46.3	37.7
2002	459	15.9	32.2	51.9	2002	425	13.4	49.7	36.9
2003	459	13.7	38.3	48.0	2003	439	10.0	44.6	45.4
2004	459	14.2	37.9	47.9	2004	440	11.1	47.1	41.8
2005	458	19.0	42.8	38.2	2005	449	16.0	51.9	32.1

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	748	15.6	28.9	55.5
1991	761	16.0	28.6	55.4
1992	761	13.8	32.9	53.3
1993	757	9.5	29.2	61.3
1994	756	12.4	31.2	56.4
1995	785	11.1	34.1	54.8
1996	795	11.8	35.0	53.2
1997	780	11.4	39.4	49.2
1998	802	14.6	36.8	48.6
1999	804	12.9	39.6	47.5
2000	817	13.1	39.4	47.5
2001	793	13.0	37.5	49.5
2002	884	14.7	40.6	44.7
2003	898	11.9	41.4	46.7
2004	903	12.6	42.5	44.9
2005	911	17.7	47.2	35.1

Picea sitchensis

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	294	61.2	28.6	10.2	1990	294	61.2	28.6	10.2
1991	285	45.9	30.2	23.9	1991	285	45.9	30.2	23.9
1992	286	45.8	29.7	24.5	1992	286	45.8	29.7	24.5
1993	287	33.4	29.3	37.3	1993	287	33.4	29.3	37.3
1994	266	35.7	39.1	25.2	1994	266	35.7	39.1	25.2
1995	259	39.0	33.6	27.4	1995	259	39.0	33.6	27.4
1996	265	52.1	29.8	18.1	1996	265	52.1	29.8	18.1
1997	269	61.4	24.5	14.1	1997	269	61.4	24.5	14.1
1998	288	51.7	29.5	18.8	1998	288	51.7	29.5	18.8
1999	266	72.9	16.2	10.9	1999	266	72.9	16.2	10.9
2000	267	65.9	22.5	11.6	2000	267	65.9	22.5	11.6
2001	262	62.3	22.1	15.6	2001	262	62.3	22.1	15.6
2002	266	49.6	31.6	18.8	2002	266	49.6	31.6	18.8
2003	245	61.3	26.9	11.8	2003	245	61.3	26.9	11.8
2004	250	60.4	20.8	18.8	2004	250	60.4	20.8	18.8
2005	251	63.0	21.1	15.9	2005	251	63.0	21.1	15.9

All species

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	2729	47.8	34.3	17.9	1990	1668	66.6	14.0	19.4
1991	2729	44.8	34.8	20.4	1991	1555	56.6	21.7	21.7
1992	2718	41.4	37.8	20.8	1992	1799	64.3	23.2	12.5
1993	2710	38.8	35.6	25.6	1993	1782	61.3	27.3	11.4
1994	2693	38.5	36.8	24.7	1994	1608	59.2	28.7	12.1
1995	2642	36.2	37.6	26.2	1995	1704	58.8	33.0	8.2
1996	2624	37.0	39.9	23.1	1996	1560	51.4	37.9	10.7
1997	2605	42.0	38.0	20.0	1997	1680	56.1	35.2	8.7
1998	2628	45.8	36.2	18.0	1998	1704	49.3	38.3	12.4
1999	2754	45.9	35.4	18.7	1999	2376	55.2	37.1	7.7
2000	2726	43.6	36.2	20.2	2000	2376	48.6	37.2	14.2
2001	2765	45.7	36.4	17.9	2001	2376	42.8	48.5	8.7
2002	2746	43.6	37.9	18.5	2002	2376	36.6	50.1	13.3
2003	2724	43.7	37.2	19.1	2003	2376	34.8	51.9	13.3
2004	2746	43.4	33.9	22.7	2004	2376	35.6	48.9	15.5
2005	2776	45.0	37.2	17.8	2005	2316	31.8	51.5	16.7
SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1990	18600	21.3	43.3	35.4	1990	3636	78.4	16.9	4.7
1991	18638	17.8	43.2	39.0	1991	3586	60.3	30.8	8.9
1992	18707	15.2	43.0	41.8	1992	3600	50.9	36.0	13.1
1993	18654	15.6	42.1	42.3	1993	3600	46.8	40.8	12.4
1994	18016	11.6	40.5	47.9	1994	3612	43.0	39.6	17.4
1995	18056	14.8	39.6	45.6	1995	3684	34.0	44.9	21.1
1996	18005	19.0	46.1	34.9	1996	3660	36.1	46.1	17.8
1997	18052	18.3	49.2	32.5	1997	3636	40.2	46.3	13.5
1998	19727	19.5	48.8	31.7	1998	3636	42.9	45.9	11.2
1999	19765	18.6	52.6	28.8	1999	4356	40.0	48.3	11.7
2000	19847	17.8	52.6	29.6	2000	4326	39.2	49.7	11.1
2001	19547	17.1	52.5	30.4	2001	4326	33.6	53.1	13.3
2002	19570	16.9	53.2	29.9	2002	4326	30.4	53.7	15.9
2003	19577	15.6	54.0	30.4	2003	4326	28.7	56.6	14.7
2004	19591	13.0	51.9	35.1	2004	4326	28.5	56.6	14.9
2005	19505	15.1	52.2	32.7	2005	4326	20.6	57.6	21.8
MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1990	8715	67.4	18.5	14.1	1990	5271	45.5	31.8	22.7
1991	8634	57.5	26.5	16.0	1991	5336	42.3	35.7	22.0
1992	8853	50.8	32.7	16.5	1992	5347	32.4	40.7	26.9
1993	8622	51.6	38.6	9.8	1993	5320	31.6	40.6	27.8
1994	8578	46.8	39.4	13.8	1994	5232	28.0	42.2	29.8
1995	8394	32.6	46.2	21.2	1995	5506	27.2	47.0	25.8
1996	8424	36.3	47.1	16.6	1996	5498	29.2	45.4	25.4
1997	8435	37.0	50.9	12.1	1997	5458	28.9	46.1	25.0
1998	8454	38.1	48.9	13.0	1998	6074	35.2	42.5	22.3
1999	10038	33.7	51.5	14.8	1999	6633	36.7	43.8	19.5
2000	10188	31.5	54.1	14.4	2000	6763	33.3	47.0	19.7
2001	10218	30.5	56.6	12.9	2001	6647	28.2	50.6	21.2
2002	10248	28.5	57.2	14.3	2002	6745	24.3	53.4	22.3
2003	9978	25.7	57.4	16.9	2003	6794	19.8	53.7	26.5
2004	9888	27.9	56.6	15.5	2004	6734	19.9	51.3	28.8
2005	9527	15.3	59.9	24.8	2005	6736	25.1	50.4	24.5

All species

BOREAL (TEMP.)	Number of trees	0-10%	>10-25%	>25%
1990	1920	28.9	34.1	37.0
1991	2424	22.6	37.7	39.7
1992	2396	18.7	37.5	43.8
1993	2420	20.1	41.9	38.0
1994	2257	27.1	43.7	29.2
1995	2262	34.4	46.2	19.4
1996	2368	31.8	50.1	18.1
1997	2297	30.0	53.5	16.5
1998	2326	30.4	53.6	16.0
1999	2348	25.2	57.9	16.9
2000	2256	18.8	61.1	20.1
2001	2325	18.0	65.9	16.1
2002	2340	19.7	66.7	13.6
2003	2293	21.4	65.9	12.7
2004	2290	21.3	65.8	12.9
2005	2263	21.5	65.2	13.3

CONTINENTAL	0-10%	>10-25%	>25%	0-10%
1990	1133	60.9	19.2	19.9
1991	1151	64.0	19.1	16.9
1992	1151	62.3	18.2	19.5
1993	1162	56.9	18.5	24.6
1994	1140	53.9	17.9	28.2
1995	1160	61.5	15.9	22.6
1996	1117	65.3	15.0	19.7
1997	1073	66.9	14.9	18.2
1998	1155	66.5	16.0	17.5
1999	1230	71.9	13.7	14.4
2000	1230	67.7	13.6	18.7
2001	1211	64.1	18.9	17.0
2002	1182	63.5	17.3	19.2
2003	1182	58.0	18.3	23.7
2004	1422	62.1	16.5	21.4
2005	1375	66.0	15.4	18.6

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1990	43672	42.9	32.1	25.0
1991	44053	36.5	35.8	27.7
1992	44571	32.2	38.1	29.7
1993	44270	31.6	39.5	28.9
1994	43136	28.6	39.3	32.1
1995	43408	26.7	41.6	31.7
1996	43256	29.3	44.9	25.8
1997	43236	29.8	47.1	23.1
1998	45704	31.2	46.1	22.7
1999	49500	30.9	48.4	20.7
2000	49712	28.7	49.7	21.6
2001	49415	26.8	51.9	21.3
2002	49533	25.2	52.8	22.0
2003	49250	23.1	53.6	23.3
2004	49373	22.9	51.6	25.5
2005	48824	21.2	52.7	26.1

Annex I-9
Development of defoliation of most common species (1997-2005).

Picea abies

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%
1997	1285	64.4	23.1	12.5	1997	8253	20.9	31.0	48.1
1998	1314	57.2	30.2	12.6	1998	7269	30.3	34.2	35.5
1999	1336	55.0	31.9	13.1	1999	7551	31.1	34.0	34.9
2000	1333	56.5	26.8	16.7	2000	7527	28.6	35.7	35.7
2001	1216	61.6	25.5	12.9	2001	7323	26.7	37.9	35.4
2002	1196	60.0	24.9	15.1	2002	7380	26.9	35.2	37.9
2003	1178	55.2	27.8	17.0	2003	7434	26.6	36.9	36.5
2004	1162	52.6	30.1	17.3	2004	7483	24.3	34.0	41.7
2005	1131	52.6	26.7	20.7	2005	7380	25.1	37.0	37.9
MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%
1997	116	40.5	41.4	18.1	1997	84	76.2	15.5	8.3
1998	116	26.7	42.3	31.0	1998	77	41.5	36.4	22.1
1999	128	27.3	45.4	27.3	1999	88	55.7	26.1	18.2
2000	128	25.8	51.5	22.7	2000	83	63.9	25.3	10.8
2001	116	31.0	42.3	26.7	2001	82	67.1	20.7	12.2
2002	103	35.0	47.5	17.5	2002	109	42.2	29.4	28.4
2003	116	44.8	36.2	19.0	2004	102	36.2	36.2	27.5
2004	115	47.8	33.9	18.3	2004	102	30.4	36.3	33.3
2005	122	51.6	27.9	20.5	2005	103	30.1	41.7	28.2
MOUNTAIN-OUS (NORTH)	Number of trees	0-10%	>10-25%	>25%	MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	735	44.8	21.5	33.7	1997	5372	55.4	26.7	17.9
1998	728	45.5	20.2	34.3	1998	5803	53.4	27.3	19.3
1999	724	48.9	22.9	28.2	1999	5927	55.4	27.6	17.0
2000	713	47.5	26.6	25.9	2000	6105	53.6	28.8	17.6
2001	791	53.6	18.7	27.7	2001	5994	51.7	30.5	17.8
2002	837	49.1	23.4	27.5	2002	5957	51.2	31.4	17.4
2003	862	54.2	20.5	25.3	2003	6001	47.7	34.6	17.7
2004	916	61.0	19.3	19.7	2004	5985	44.7	32.9	22.4
2005	974	58.6	19.5	21.9	2005	5632	44.9	34.0	21.1
BOREAL	Number of trees	0-10%	>10-25%	>25%	BOREAL (TEMPERATE)	Number of trees	0-10%	>10-25%	>25%
1997	5804	40.9	32.1	27.0	1997	4653	37.6	42.6	19.8
1998	5877	39.7	33.9	26.4	1998	4587	38.4	41.3	20.3
1999	5863	40.0	32.9	27.1	1999	4559	33.6	42.8	23.6
2000	5779	37.3	36.6	26.1	2000	4566	38.2	41.8	20.0
2001	5738	35.0	35.4	29.6	2001	4548	35.9	45.2	18.9
2002	5700	37.5	35.9	26.6	2002	4558	45.9	41.7	12.4
2003	5639	36.0	35.4	28.6	2003	4587	41.2	43.7	15.1
2004	6207	38.6	35.7	25.7	2004	4539	39.8	41.2	19.0
2005	6194	38.9	36.4	24.7	2005	4562	42.2	38.6	19.2
CONTINENTAL	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	551	33.9	30.7	35.4	1997	26908	38.4	31.7	29.9
1998	511	34.4	29.2	36.4	1998	26341	40.9	33.1	26.0
1999	502	37.2	31.1	31.7	1999	26728	40.9	33.3	25.8
2000	465	31.6	34.9	33.5	2000	26748	40.0	34.6	25.4
2001	463	42.5	29.4	28.1	2001	26320	38.8	35.5	25.7
2002	455	37.2	32.5	30.3	2002	26344	40.6	34.7	24.7
2003	447	33.5	33.5	32.9	2003	26415	38.5	36.2	25.3
2004	395	37.2	37.7	25.1	2004	26953	37.6	34.7	27.7
2005	430	48.9	30.9	20.2	2005	26575	38.5	35.2	26.3

Pinus sylvestris

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%
1997	1165	49.9	41.2	8.9
1998	1243	47.9	42.8	9.3
1999	1318	45.0	42.3	12.7
2000	1361	43.5	42.8	13.7
2001	1360	36.5	49.8	13.7
2002	1362	42.9	41.0	16.1
2003	1379	42.9	43.1	14.0
2004	1370	45.0	40.7	14.3
2005	1413	45.1	42.3	12.6

ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	216	59.3	24.5	16.2
1998	216	52.3	36.1	11.6
1999	217	43.7	42.9	13.4
2000	212	57.5	32.1	10.4
2001	211	51.7	33.6	14.7
2002	212	44.8	42.9	12.3
2003	210	48.6	35.7	15.7
2004	210	50.9	36.7	12.4
2005	212	58.0	27.4	14.6

SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%
1997	10366	18.8	48.5	32.7
1998	10650	19.8	52.9	27.3
1999	10676	20.0	54.9	25.1
2000	10684	18.2	55.9	25.9
2001	10678	17.3	57.4	25.3
2002	10546	15.7	57.7	26.6
2003	10587	14.0	58.9	27.1
2004	10639	14.0	56.5	29.5
2005	10613	16.7	52.9	30.4

MEDITERR. (HIHGER)	Number of trees	0-10%	>10-25%	>25%
1997	785	40.3	44.8	14.9
1998	786	41.3	45.0	13.7
1999	875	45.5	43.8	10.7
2000	872	47.7	42.7	9.6
2001	875	47.8	39.5	12.7
2002	876	43.1	41.3	15.6
2003	871	37.3	47.4	15.3
2004	872	36.9	45.9	17.2
2005	870	33.0	49.3	17.7

MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%
1997	138	49.3	35.5	15.2
1998	138	50.7	34.1	15.2
1999	155	49.0	31.6	19.4
2000	154	41.6	43.5	14.9
2001	154	38.3	46.1	15.6
2002	154	37.0	44.2	18.8
2003	155	31.6	49.0	19.4
2004	155	29.0	52.9	18.1
2005	156	35.3	46.1	18.6

MOUNTAIN-OUS (NORTH)	Number of trees	0-10%	>10-25%	>25%
1997	823	47.0	36.6	16.4
1998	823	44.7	39.4	15.9
1999	826	48.3	37.5	14.2
2000	825	52.8	36.5	10.7
2001	843	53.6	36.2	10.2
2002	841	49.5	38.6	11.9
2003	851	54.6	35.3	10.1
2004	871	62.9	28.7	8.4
2005	863	58.8	30.9	10.3

MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	2561	23.7	37.4	38.9
1998	2623	26.0	32.1	41.9
1999	2562	31.3	34.1	34.6
2000	2185	28.1	40.9	31.0
2001	2128	36.4	37.7	25.9
2002	2119	27.1	44.6	28.3
2003	2388	19.3	50.6	30.1
2004	2293	19.9	45.7	34.4
2005	2157	17.7	47.1	35.2

BOREAL	Number of trees	0-10%	>10-25%	>25%
1997	7815	65.0	28.2	6.8
1998	7823	65.7	28.7	5.6
1999	7807	65.6	28.5	5.9
2000	7837	65.9	29.3	4.8
2001	7904	59.7	32.3	8.0
2002	7955	58.4	35.5	6.1
2003	7931	55.6	37.4	7.0
2004	9536	59.6	34.9	5.5
2005	9803	61.9	33.1	5.0

BOREAL (TEMP.)	Number of trees	0-10%	>10-25%	>25%
1997	10654	17.3	52.1	30.6
1998	10679	21.8	50.9	27.3
1999	10631	19.3	57.1	23.6
2000	10576	23.4	57.2	19.4
2001	10650	21.3	60.9	17.8
2002	10611	31.9	57.1	11.0
2003	10610	35.9	54.5	9.6
2004	10576	36.7	53.9	9.4
2005	10592	36.0	54.6	9.4

CONTINENTAL	Number of trees	0-10%	>10-25%	>25%
1997	435	44.2	17.2	38.6
1998	449	50.2	12.2	37.6
1999	370	58.6	23.0	18.4
2000	503	55.9	26.2	17.9
2001	544	43.9	37.7	18.4
2002	500	44.0	32.6	23.4
2003	482	38.2	38.4	23.4
2004	451	35.0	41.5	23.5
2005	478	35.8	34.9	29.3

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	34958	31.9	43.1	25.0
1998	35430	33.8	43.8	22.4
1999	35437	33.6	46.5	19.9
2000	35209	34.4	47.5	18.1
2001	35347	32.2	49.9	17.9
2002	35176	34.2	49.6	16.2
2003	35464	33.5	50.3	16.2
2004	36973	36.0	47.7	16.3
2005	37157	37.2	46.4	16.4

Fagus sylvatica

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%
1997	965	38.5	40.6	20.9
1998	966	31.3	46.7	22.0
1999	993	24.9	49.8	25.3
2000	994	22.8	43.9	33.3
2001	1011	31.0	43.6	25.4
2002	1029	25.2	46.2	28.6
2003	1034	30.1	45.8	24.1
2004	1041	18.7	40.1	41.2
2005	1066	34.2	39.7	26.1

ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	252	35.7	43.7	20.6
1998	229	46.7	47.2	6.1
1999	230	42.2	51.7	6.1
2000	238	53.8	39.5	6.7
2001	239	59.4	38.1	2.5
2002	240	36.7	53.3	10.0
2003	239	31.4	53.5	15.1
2004	241	16.2	63.9	19.9
2005	243	30.9	49.3	19.8

SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%
1997	3184	27.0	51.1	21.9
1998	3366	28.5	48.4	23.1
1999	3503	24.0	52.0	24.0
2000	3434	27.5	48.1	24.4
2001	3458	24.3	47.1	28.6
2002	3489	27.8	49.1	23.1
2003	3513	25.8	50.5	23.7
2004	3534	17.8	46.3	35.9
2005	3528	18.8	51.8	29.4

MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1997	762	38.6	34.9	26.5
1998	787	36.0	35.7	28.3
1999	892	34.2	38.9	26.9
2000	893	33.7	41.9	24.4
2001	910	28.9	41.4	29.7
2002	874	30.1	44.0	25.9
2003	849	29.4	49.3	21.3
2004	853	26.3	48.7	25.0
2005	929	30.7	47.1	22.2

MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%
1997	617	47.5	31.9	20.6
1998	630	47.1	32.7	20.2
1999	828	36.8	37.5	25.7
2000	827	36.2	38.6	25.2
2001	833	28.5	39.9	31.6
2002	822	31.4	45.9	22.7
2003	790	31.6	48.1	20.3
2004	851	26.9	49.0	24.1
2005	827	40.4	41.2	18.4

MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	3433	36.5	44.0	19.5
1998	3527	40.3	42.1	17.6
1999	3643	36.9	43.6	19.5
2000	3869	39.8	41.9	18.3
2001	3665	31.3	46.8	21.9
2002	3717	33.4	46.2	20.4
2003	3755	29.6	45.3	25.1
2004	3612	28.0	48.5	23.5
2005	3663	36.8	41.6	21.6

CONTINENTAL	Number of trees	0-10%	>10-25%	>25%
1997	1636	48.0	32.9	19.1
1998	1754	46.7	34.7	18.6
1999	1448	51.1	26.5	22.4
2000	1436	49.4	27.6	23.0
2001	1576	48.3	28.2	23.5
2002	1636	51.8	30.1	18.1
2003	1559	50.2	31.8	18.0
2004	1509	49.1	35.5	15.4
2005	1543	53.2	32.9	13.9

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	10854	36.4	42.8	20.8
1998	11264	37.2	42.4	20.4
1999	11542	33.6	43.9	22.5
2000	11697	35.5	41.8	22.7
2001	11699	31.7	43.0	25.3
2002	11814	33.2	44.9	21.9
2003	11746	31.4	45.7	22.9
2004	11648	26.3	45.8	27.9
2005	11806	33.0	43.9	23.1

Quercus ilex and *Q. rotundifolia*

MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1997	865	25.8	53.4	20.8
1998	815	32.3	50.8	16.9
1999	936	25.9	55.0	19.1
2000	930	26.3	54.9	18.8
2001	931	24.3	58.4	17.3
2002	931	17.6	60.3	22.1
2003	933	20.2	56.5	23.3
2004	957	19.7	60.2	20.1
2005	962	10.8	55.2	34.0

MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%
1997	2567	27.9	55.3	16.8
1998	2552	29.5	54.7	15.8
1999	3190	21.4	56.4	22.2
2000	3211	17.2	60.2	22.6
2001	3225	19.1	64.2	16.7
2002	3212	17.4	63.6	19.0
2003	3186	13.9	64.8	21.3
2004	3188	19.7	63.0	17.3
2005	3156	9.2	66.4	24.4

MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	155	24.5	41.3	34.2
1998	155	25.2	64.5	10.3
1999	240	30.0	54.2	15.8
2000	281	31.7	56.9	11.4
2001	282	25.2	53.9	20.9
2002	281	22.4	44.1	33.5
2003	237	16.0	42.2	41.8
2004	281	19.6	48.7	31.7
2005	239	12.6	52.3	35.1

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	3677	27.2	54.6	18.2
1998	3612	30.0	54.2	15.8
1999	4456	23.0	56.0	21.0
2000	4512	20.3	58.5	21.2
2001	4528	20.6	62.0	17.4
2002	4514	17.8	61.5	20.7
2003	4446	15.8	61.3	22.9
2004	4516	19.9	61.4	18.7
2005	4448	10.0	62.8	27.2

Pinus pinaster

ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1997	1279	58.0	28.6	13.4	1997	475	65.5	20.2	14.3
1998	1283	41.8	41.7	16.5	1998	466	65.4	25.8	8.8
1999	1458	58.0	34.4	7.6	1999	544	57.7	29.8	12.5
2000	1409	58.4	33.2	8.4	2000	511	58.2	29.5	12.3
2001	1421	54.4	38.8	6.8	2001	510	59.2	35.1	5.7
2002	1401	52.3	38.3	9.4	2002	512	51.4	41.4	7.2
2003	1373	49.2	39.5	11.3	2003	512	47.6	42.0	10.4
2004	1372	48.1	38.3	13.6	2004	506	51.6	35.8	12.6
2005	1292	45.5	43.0	11.5	2005	505	40.4	46.1	13.5
MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	MOUNTAIN. (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	1546	42.6	45.6	11.8	1997	71	78.8	12.7	8.5
1998	1520	43.8	46.1	10.1	1998	69	71.1	15.9	13.0
1999	1754	42.9	47.4	9.7	1999	134	79.2	10.4	10.4
2000	1754	45.9	45.9	8.2	2000	130	76.9	13.1	10.0
2001	1746	46.4	47.0	6.6	2001	129	69.8	18.6	11.6
2002	1742	46.9	45.9	7.2	2002	129	58.2	30.2	11.6
2003	1552	43.8	45.0	11.2	2003	129	47.3	40.3	12.4
2004	1500	42.5	42.1	15.4	2004	128	50.0	41.4	8.6
2005	1354	35.2	42.9	21.9	2005	128	53.1	35.2	11.7
ALL REGIONS	Number of trees	0-10%	>10-25%	>25%					
1997	3371	52.4	34.9	12.7					
1998	3338	46.6	40.9	12.5					
1999	3890	51.9	38.8	9.3					
2000	3804	53.2	37.9	8.9					
2001	3806	51.9	41.4	6.7					
2002	3784	49.9	42.0	8.1					
2003	3566	46.5	42.3	11.2					
2004	3506	46.4	39.6	14.0					
2005	3279	40.7	43.2	16.1					

Quercus suber

MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	1434	33.9	53.1	13.0	1997	1502	36.7	50.8	12.5
1998	1434	26.9	57.6	15.5	1998	1501	29.6	55.6	14.8
1999	1541	23.4	56.9	19.7	1999	1632	25.6	55.1	19.3
2000	1563	21.5	61.8	16.7	2000	1654	22.9	61.0	16.1
2001	1564	22.2	58.6	19.2	2001	1654	22.8	58.9	18.3
2002	1587	22.3	59.5	18.2	2002	1678	22.6	59.6	17.8
2003	1571	19.4	54.1	26.5	2003	1638	20.0	54.4	25.6
2004	1587	20.6	52.9	26.5	2004	1655	21.8	52.5	25.7
2005	1529	3.9	60.3	35.8	2005	1593	5.5	59.9	34.6

Quercus robur and *Q. petraea*

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	1230	24.2	46.3	29.5	1997	1431	20.3	40.4	39.3
1998	1296	25.1	45.5	29.4	1998	1450	25.7	40.0	34.3
1999	1299	21.7	48.3	30.0	1999	1475	25.6	48.0	26.4
2000	1287	28.1	51.2	20.7	2000	1495	29.8	44.5	25.7
2001	1294	18.8	49.7	31.5	2001	1483	25.0	46.8	28.2
2002	1300	17.8	48.2	34.0	2002	1488	21.6	50.0	28.4
2003	1292	16.8	48.9	34.3	2003	1502	17.1	46.6	36.3
2004	1294	15.8	47.1	37.1	2004	1502	19.2	45.2	35.6
2005	1322	15.8	47.1	37.1	2005	1484	14.4	48.1	37.5
SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1997	2606	11.3	46.4	42.3	1997	213	16.0	44.6	39.4
1998	2666	16.0	44.7	39.3	1998	219	19.2	42.0	38.8
1999	2727	16.9	50.5	32.6	1999	221	24.9	44.3	30.8
2000	2736	14.7	51.2	34.1	2000	220	23.2	46.8	30.0
2001	2739	14.3	51.9	33.8	2001	224	17.4	51.3	31.3
2002	2748	16.0	52.3	31.7	2002	217	13.4	53.4	33.2
2003	2750	11.3	48.7	40.0	2003	213	10.3	53.5	36.2
2004	2764	10.0	45.6	44.4	2004	220	8.6	50.9	40.5
2005	2776	9.1	43.4	47.5	2005	214	9.3	49.1	41.6

Quercus robur **and** ***Q. petraea***

MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%
1997	515	21.4	40.5	38.1
1998	585	20.0	39.0	41.0
1999	632	23.9	43.7	32.4
2000	629	26.1	39.9	34.0
2001	630	27.3	45.4	27.3
2002	635	26.0	48.8	25.2
2003	628	23.7	50.0	26.3
2004	645	28.1	45.7	26.2
2005	688	28.8	41.8	29.4

MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	682	14.4	30.2	55.4
1998	726	14.5	36.0	49.5
1999	708	13.8	40.3	45.9
2000	778	14.3	40.6	45.1
2001	672	17.4	41.7	40.9
2002	661	12.6	46.4	41.0
2003	678	13.6	45.1	41.3
2004	752	16.4	40.6	43.0
2005	686	14.4	37.3	48.3

BOREAL (TEMPERATE)	Number of trees	0-10%	>10-25%	>25%
1997	308	15.9	43.2	40.9
1998	303	23.1	42.6	34.3
1999	289	14.9	48.8	36.3
2000	310	27.1	42.3	30.6
2001	312	22.1	48.7	29.2
2002	304	31.6	51.3	17.1
2003	307	18.2	48.6	33.2
2004	308	21.8	41.5	36.7
2005	310	25.2	44.8	30.0

CONTINENTAL	Number of trees	0-10%	>10-25%	>25%
1997	841	20.1	34.8	45.1
1998	850	21.5	35.3	43.2
1999	780	29.7	33.5	36.8
2000	813	23.9	25.2	50.9
2001	812	23.9	28.6	47.5
2002	651	24.0	30.1	45.9
2003	645	19.7	36.9	43.4
2004	678	21.2	35.7	43.1
2005	767	25.7	31.6	42.7

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	7836	17.2	42.1	40.7
1998	8105	20.3	41.6	38.1
1999	8140	21.0	46.3	32.7
2000	8276	21.9	45.1	33.0
2001	8174	19.6	46.8	33.6
2002	8010	19.0	48.7	32.3
2003	8022	15.3	47.4	37.3
2004	8169	16.0	44.5	39.5
2005	8253	15.4	43.3	41.3

Abies alba

SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%
1997	640	30.9	28.4	40.7
1998	647	29.4	29.1	41.5
1999	688	29.2	32.0	38.8
2000	647	29.5	29.8	40.7
2001	637	30.0	25.3	44.7
2002	679	32.8	27.4	39.8
2003	678	30.2	32.3	37.5
2004	682	29.8	33.0	37.2
2005	678	32.7	35.4	31.9

MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1997	125	30.4	17.6	52.0
1998	123	32.5	13.8	53.7
1999	141	31.2	17.7	51.1
2000	141	28.4	17.7	53.9
2001	128	24.2	18.8	57.0
2002	129	26.4	19.4	54.2
2003	128	25.0	19.5	55.5
2004	128	21.1	19.5	59.4
2005	130	23.1	17.7	59.2

MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	1055	35.4	33.7	30.9
1998	1046	34.4	35.7	29.9
1999	1070	32.6	38.5	28.9
2000	1109	34.8	38.1	27.1
2001	1057	36.9	38.6	24.5
2002	1079	34.9	38.0	27.1
2003	1128	31.1	37.4	31.5
2004	1127	35.1	35.0	29.9
2005	1118	35.8	40.4	23.8

CONTINENTAL	Number of trees	0-10%	>10-25%	>25%
1997	176	17.6	26.7	55.7
1998	181	16.0	30.9	53.1
1999	170	20.0	28.8	51.2
2000	164	15.2	33.5	51.3
2001	164	29.9	31.1	39.0
2002	166	28.3	36.2	35.5
2003	166	21.1	46.4	32.5
2004	171	28.1	32.2	39.7
2005	184	28.3	29.3	42.4

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	2060	32.2	31.0	36.8
1998	2060	31.4	32.1	36.5
1999	2131	30.8	34.1	35.1
2000	2098	31.6	33.6	34.8
2001	2020	33.6	32.5	33.9
2002	2086	33.4	33.3	33.3
2003	2135	30.1	35.3	34.6
2004	2145	32.3	33.2	34.5
2005	2147	33.8	36.3	29.9

Picea sitchensis

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	972	42.8	39.3	17.9	1997	995	44.1	38.4	17.5
1998	1017	36.5	37.6	25.9	1998	1039	37.8	36.9	25.3
1999	923	44.9	34.9	20.2	1999	945	46.2	34.1	19.7
2000	970	41.4	35.8	22.8	2000	992	42.7	35.0	22.3
2001	941	37.4	38.8	23.8	2001	963	38.5	38.2	23.3
2002	921	29.4	41.3	29.3	2002	943	30.2	41.2	28.6
2003	900	28.2	41.5	30.3	2003	922	29.2	41.2	29.6
2004	881	32.6	38.9	28.5	2004	902	33.5	38.7	27.8
2005	881	36.2	38.3	25.5	2005	902	37.7	37.4	24.9

All species

ATLANTIC (NORTH)	Number of trees	0-10%	>10-25%	>25%	ATLANTIC (SOUTH)	Number of trees	0-10%	>10-25%	>25%
1997	6919	46.0	37.5	16.5	1997	5720	45.0	31.6	23.4
1998	7109	42.8	39.4	17.8	1998	5724	42.9	35.2	21.9
1999	7190	42.0	39.9	18.1	1999	6336	49.3	35.8	14.9
2000	7247	43.2	38.0	18.8	2000	6215	48.8	34.6	16.6
2001	7137	40.7	39.7	19.6	2001	6215	45.7	39.9	14.4
2002	7159	38.9	39.0	22.1	2002	6196	39.6	42.5	17.9
2003	7120	37.9	40.3	21.8	2003	6136	35.6	41.2	23.2
2004	7109	35.1	39.7	25.2	2004	6096	34.5	41.6	23.9
2005	7188	38.1	39.1	22.8	2005	5976	32.0	43.9	24.1
SUB-ATLANTIC	Number of trees	0-10%	>10-25%	>25%	MEDITERR. (HIGHER)	Number of trees	0-10%	>10-25%	>25%
1997	28382	22.0	42.3	35.7	1997	7402	33.5	39.6	26.9
1998	28077	25.9	44.2	29.9	1998	7387	36.4	41.3	22.3
1999	28774	26.0	46.2	27.8	1999	8423	34.3	43.7	22.0
2000	28572	24.8	46.6	28.6	2000	8379	32.9	45.7	21.4
2001	28348	23.4	47.5	29.1	2001	8389	28.7	46.4	24.9
2002	28414	22.9	47.9	29.2	2002	8235	27.3	47.5	25.2
2003	28437	20.9	48.6	30.5	2003	8233	25.0	49.9	25.1
2004	28594	18.7	46.2	35.1	2004	8401	25.4	49.7	24.9
2005	28441	20.3	46.3	33.4	2005	8375	23.2	48.4	28.4
MEDITERR. (LOWER)	Number of trees	0-10%	>10-25%	>25%	MOUNTAIN-OUS (NORTH)	Number of trees	0-10%	>10-25%	>25%
1997	12101	35.3	46.6	18.1	1997	2632	42.7	34.3	23.0
1998	12099	34.8	46.5	18.7	1998	2673	42.7	33.7	23.6
1999	14446	31.4	49.0	19.6	1999	2672	43.9	34.7	21.4
2000	14542	29.5	50.9	19.6	2000	2686	46.6	35.8	17.6
2001	14604	28.1	52.4	19.5	2001	2864	48.9	32.4	18.7
2002	14691	26.6	53.3	20.1	2002	2975	44.9	34.8	20.3
2003	14266	24.2	53.6	22.2	2003	3025	47.9	33.0	19.1
2004	14323	26.0	52.9	21.1	2004	3302	51.4	28.7	19.9
2005	13888	19.5	53.0	27.5	2005	3425	53.0	28.7	18.3
MOUNTAIN-OUS (SOUTH)	Number of trees	0-10%	>10-25%	>25%	BOREAL	0-10%	>10-25%	>25%	0-10%
1997	17746	38.2	34.8	27.0	1997	15922	56.1	29.3	14.6
1998	18560	39.1	33.5	27.4	1998	15978	55.6	30.5	13.9
1999	19778	39.7	35.4	24.9	1999	15892	55.5	30.0	14.5
2000	20029	38.8	36.7	24.5	2000	15870	53.9	32.7	13.4
2001	19692	37.0	37.9	25.1	2001	15860	50.0	33.7	16.3
2002	19268	36.2	39.2	24.6	2002	15879	50.3	35.8	13.9
2003	19516	32.8	41.3	25.9	2003	15808	48.4	36.4	15.2
2004	19617	31.3	41.1	27.6	2004	18659	52.1	35.0	12.9
2005	18914	32.9	41.8	25.3	2005	19011	54.1	33.8	12.1
BOREAL (TEMP.)	Number of trees	0-10%	>10-25%	>25%	CONTINENTAL	Number of trees	0-10%	>10-25%	>25%
1997	19935	27.1	48.0	24.9	1997	6405	35.5	32.1	32.4
1998	19893	29.2	47.3	23.5	1998	6922	33.7	31.8	34.5
1999	19801	25.6	52.8	21.6	1999	6167	41.8	29.9	28.3
2000	19815	28.7	52.6	18.7	2000	6323	38.7	27.9	33.4
2001	19933	27.5	55.5	17.0	2001	6538	39.4	31.2	29.4
2002	19906	37.0	51.8	11.2	2002	6418	37.9	34.6	27.5
2003	19942	37.5	50.3	12.2	2003	6174	34.5	35.9	29.6
2004	19815	38.0	49.4	12.6	2004	6013	36.5	36.1	27.4
2005	19827	38.6	49.5	11.9	2005	6283	41.8	32.7	25.5

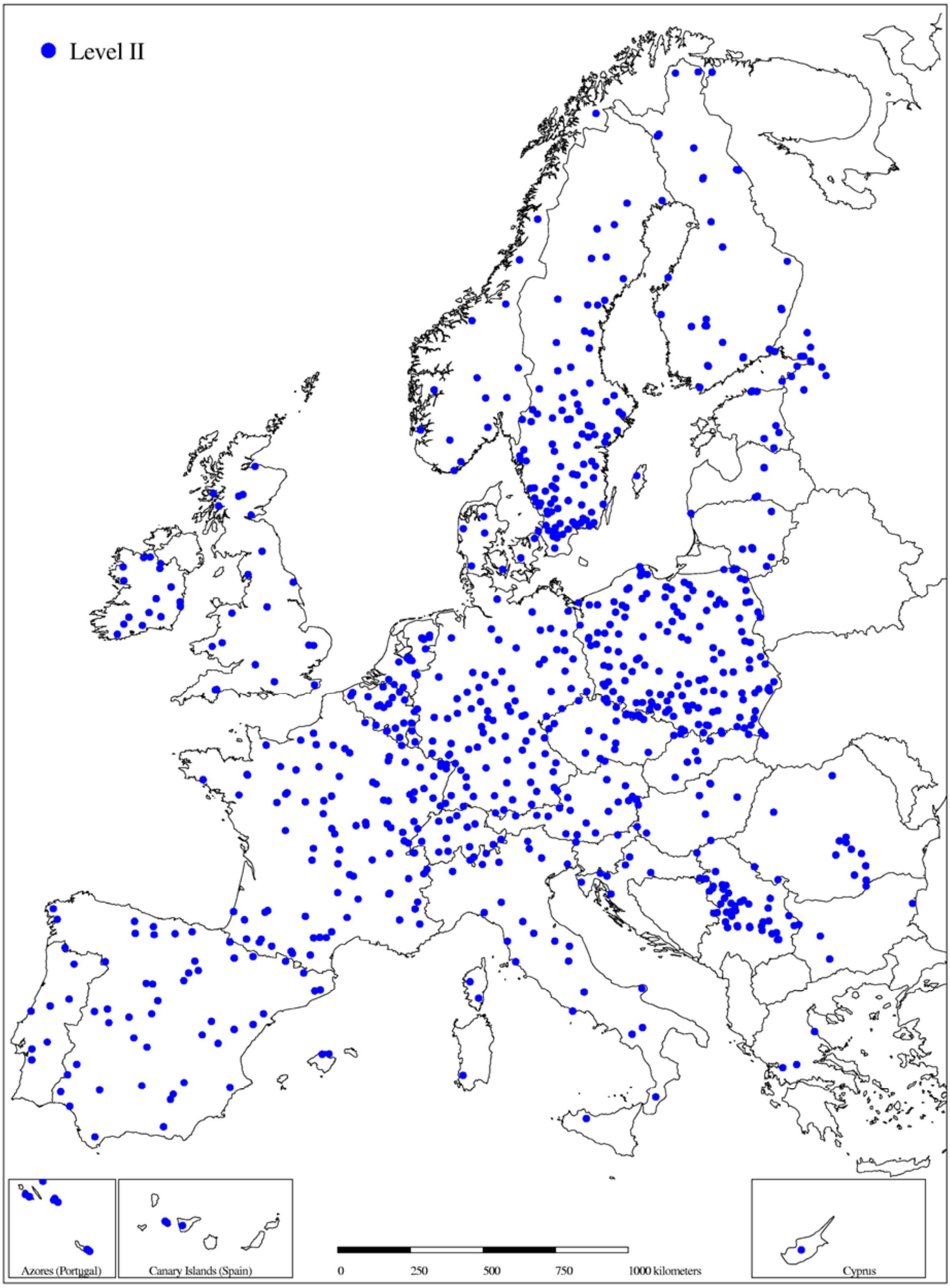
All species

ALL REGIONS	Number of trees	0-10%	>10-25%	>25%
1997	123164	35.1	39.3	25.6
1998	124422	36.2	39.8	24.0
1999	129479	35.9	41.9	22.2
2000	129678	35.5	42.5	22.0
2001	129580	33.6	44.1	22.3
2002	129141	34.1	44.6	21.3
2003	128657	32.2	45.1	22.7
2004	131929	32.7	43.8	23.5
2005	131328	33.3	43.5	23.2

	Period 1990 - 2005			Period 1997 - 2005		
Year	No. of trees N	Mean defoliation $\overline{X}$	Standard error $s_{\overline{X}} = s/\sqrt{N}$	No. of trees N	Mean defoliation $\overline{X}$	Standard error $s_{\overline{X}} = s/\sqrt{N}$
Pinus sylvestris						
1990	11630	24.3	0.15			
1991	11877	26.2	0.14			
1992	11887	26.9	0.14			
1993	11924	26.6	0.14			
1994	11292	27.7	0.14			
1995	11113	26.0	0.14			
1996	11154	23.3	0.13			
1997	11115	22.5	0.12	34958	20.7	0.08
1998	11608	21.9	0.12	35430	20.0	0.08
1999	11847	21.3	0.11	35437	19.3	0.07
2000	11764	21.9	0.12	35209	18.8	0.07
2001	11794	21.8	0.11	35347	19.2	0.07
2002	11670	22.4	0.12	35176	18.6	0.07
2003	11708	22.5	0.12	35464	18.7	0.07
2004	11741	22.7	0.12	36973	18.4	0.07
2005	11705	22.6	0.13	37157	18.3	0.07
Picea abies						
1990	6485	22.4	0.22			
1991	6634	22.5	0.21			
1992	6660	23.3	0.20			
1993	6584	24.3	0.22			
1994	6553	25.7	0.23			
1995	6700	24.6	0.23			
1996	6707	22.3	0.21			
1997	6615	22.9	0.20	26908	20.4	0.10
1998	7887	22.0	0.18	26341	19.2	0.10
1999	7855	21.8	0.18	26728	19.3	0.10
2000	7779	22.9	0.18	26748	19.4	0.10
2001	7504	22.7	0.17	26320	19.4	0.10
2002	7523	23.3	0.18	26344	19.1	0.10
2003	7568	23.2	0.18	26415	19.6	0.10
2004	7484	25.3	0.19	26953	20.3	0.10
2005	7400	23.3	0.18	26575	20.2	0.11
Quercus robur* and *Q. petraea						
1990	2633	21.0	0.34			
1991	2640	23.4	0.33			
1992	2609	24.1	0.32			
1993	2615	26.2	0.32			
1994	2559	27.6	0.34			
1995	2643	26.9	0.34			
1996	2619	27.9	0.36			
1997	2651	26.3	0.32	7836	27.1	0.20
1998	2764	25.9	0.31	8105	26.0	0.20
1999	2839	23.8	0.28	8140	24.2	0.18
2000	2868	23.5	0.28	8276	24.1	0.18
2001	2879	23.7	0.27	8174	24.6	0.18
2002	2889	23.3	0.27	8010	23.9	0.17
2003	2902	24.6	0.26	8022	25.9	0.17
2004	2998	26.6	0.30	8169	26.7	0.18
2005	3029	25.5	0.29	8253	26.9	0.18

	Period 1990 - 2005			Period 1997 - 2005		
Year	**No. of trees** N	**Mean defoliation** $\overline{x}$	**Standard error** $s_{\overline{x}} = s/\sqrt{N}$	**No. of trees** N	**Mean defoliation** $\overline{x}$	**Standard error** $s_{\overline{x}} = s/\sqrt{N}$
Fagus sylvatica						
1990	4014	17.9	0.22			
1991	4063	17.2	0.21			
1992	4090	20.8	0.23			
1993	4108	20.0	0.24			
1994	3947	21.6	0.22			
1995	4126	22.2	0.22			
1996	4091	21.1	0.21			
1997	4162	20.6	0.20	10854	19.3	0.15
1998	4416	19.5	0.20	11264	18.9	0.14
1999	4567	20.6	0.19	11542	19.8	0.14
2000	4636	20.5	0.21	11697	19.8	0.15
2001	4639	21.5	0.20	11699	20.8	0.14
2002	4648	20.0	0.19	11814	19.9	0.14
2003	4677	21.7	0.20	11746	20.3	0.14
2004	4693	24.2	0.22	11648	22.3	0.14
2005	4719	22.2	0.21	11806	20.4	0.14
Pinus pinaster						
1990	2654	13.2	0.30			
1991	2589	15.8	0.37			
1992	2599	14.0	0.33			
1993	2452	12.1	0.33			
1994	2542	12.5	0.31			
1995	2381	12.8	0.28			
1996	2350	14.6	0.36			
1997	2333	15.5	0.33	3371	16.3	0.31
1998	2332	15.8	0.32	3338	16.7	0.27
1999	2886	16.5	0.32	3890	15.8	0.27
2000	2859	17.8	0.38	3804	16.5	0.31
2001	2842	14.7	0.23	3806	14.4	0.21
2002	2840	15.4	0.24	3784	15.3	0.22
2003	2622	16.1	0.27	3566	16.4	0.25
2004	2579	18.6	0.37	3506	18.1	0.31
2005	2375	18.9	0.36	3279	18.4	0.30
Quercus ilex and ***Q. rotundifolia***						
1990	3074	13.8	0.25			
1991	3064	16.0	0.22			
1992	3080	17.4	0.24			
1993	3055	16.0	0.17			
1994	3027	19.6	0.29			
1995	3052	24.0	0.28			
1996	3034	22.6	0.27			
1997	3034	19.4	0.25	3677	20.4	0.24
1998	3026	18.5	0.23	3612	19.3	0.21
1999	3820	21.1	0.23	4456	21.2	0.21
2000	3852	20.9	0.19	4512	21.1	0.18
2001	3853	20.2	0.19	4528	20.7	0.18
2002	3857	21.2	0.18	4514	21.7	0.18
2003	3859	22.3	0.22	4446	22.8	0.21
2004	3855	20.3	0.17	4516	21.0	0.18
2005	3832	23.8	0.18	4448	24.3	0.18

Annex I-10
Level II plots for which data are available



Annex II-1
Forests and surveys in European countries (2005)

Participating countries	Total area (1000 ha)	Forest area (1000 ha)	Coniferous forest (1000 ha)	Broadleav. forest (1000 ha)	Area surveyed (1000 ha)	Grid size (km x km)	No. of sample plots	No. of sample trees
Albania	2875	1036	172	607	no survey in 2005			
Andorra	47	17	15	2	no survey in 2005			
Austria	8385	3878	2683	798	3481	16 x 16	136	3528
Belarus	20760	7812	4685	3127	7812	16 x 16	406	9490
Belgium	3035	691	281	324	691	4^2 / 8^2	132	3126
Bulgaria	11100	4064	1289	2775	4064	$4^2/8^2/16^2$	139	4817
Croatia	5654	2061	321	1740	2061	16 x 16	86	2046
Cyprus	925	298	172	0	138	16x16	15	360
Czech Republic	7886	2630	2057	573	2630	$8^2/16^2$	138	6128
Denmark	4300	468	294	174	468	$7^2/16^2$	22	528
Estonia	4510	2285	1142	1143	2285	16 x 16	92	2167
Finland	30460	20302	18058	1962	20020	16^2 / 24x32	609	11535
France	54926	14591	9228	4058	1305	16 x 16	509	10129
Germany	35562	11076	6084	4236	10890	16^2 / 4^2	451	13630
Greece	12890	2512	954	1080	2512	16 x 16	72	1697
Hungary	9300	1851	239	1612	1851	4 x 4	1218	28506
Ireland	7028	680	399	37	436	16 x 16	22	382
Italy	30128	8675	1735	6940	8675	16 x 16	238	6573
Latvia	6459	2944	1563	1230	2944	8 x 8	349	8208
Liechtenstein	16	8	6	2	no survey in 2005			
Lithuania	6520	2091	1155	833	1988	8x8/16x16	262	6315
Luxembourg	259	89	30	54	no survey in 2005			
Rep. of Moldova	3376	318	6	312	318	2x2/2x4	528	14575
The Netherlands	3482	334	158	52	210	16 x 16	11	229
Norway	32376	12000	6800	5200	12000	$3^2/9^2$	1595	8497
Poland	31268	8756	6868	1970	6868	16 x 16	1298	25960
Portugal	8893	3234	1081	2153	3234	16 x 16	119	3570
Romania	23750	6244	1929	4315	6244	4 x 4	6132	100718
Russian Fed.	11100	8125			no survey in 2005			
Serbia and Montenegro	8836	2360	179	2181	1868	16x16/4x4	129	2995
Slovak Republic	4901	1961	815	1069	1961	16 x 16	108	4111
Slovenia	2027	1099	410	688	1099	16 x 16	44	1056
Spain	50471	11588	5910	4056	11588	16 x 16	620	14880
Sweden	41000	23400	19600	900	20600	varying	3954	17610
Switzerland	4129	1186	818	368	1186	16 x 16	48	1031
Turkey	77945	20199	9426	10773	no survey in 2005			
Ukraine	60350	9400	3969	5347	4921	16 x 16	1329	26720
United Kingdom	24291	2825	1647	1178	2825	random	345	8280
TOTAL	651220	203088	112178	73869	149969	varying	21156	349397

Russian Federation: North-western and Central European parts only.
Serbia and Montenegro: Serbia only.

Annex II-2

Defoliation of all species by classes and class aggregates (2005)

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 2005				
Andorra			no survey in 2005				
Austria	3481	3528	50.5	34.7	11.7	3.1	14.8
Belarus	7812	9490	37.7	53.3	7.1	1.9	9.0
Belgium	691	3126	38.4	41.7	16.4	3.5	19.9
Bulgaria	4064	4817	22.4	42.6	27.1	7.9	35.0
Croatia		2046	36.3	36.6	23.8	3.3	27.1
Cyprus	138	360	20.0	69.2	10.8	0.0	10.8
Czech Republic	2630	6128	11.6	31.3	56.1	1.0	57.1
Denmark	468	528	68.8	21.8	8.1	1.3	9.4
Estonia	2285	2167	54.2	40.4	4.4	1.0	5.4
Finland	20020	11535	57.6	33.6	8.0	0.8	8.8
France	13100	10129	30.5	35.3	31.3	2.9	34.2
Germany	10890	13630	29.1	42.4	26.7	1.8	28.5
Greece	2512	1697	44.2	39.5	13.3	3.0	16.3
Hungary	1851	28506	38.8	40.2	15.2	5.8	21.0
Ireland	399	382	51.1	32.7	12.3	3.9	16.2
Italy	436	6573	25.6	41.5	28.3	4.6	32.9
Latvia	2944	8208	19.7	67.2	11.2	1.9	13.1
Liechtenstein			no survey in 2005				
Lithuania	1988	6315	14.1	74.9	9.0	2.0	11.0
Luxembourg			no survey in 2005				
Rep. of Moldova		14575	41.0	32.5	21.8	4.7	26.5
The Netherlands	210	229	55.2	14.6	28.4	1.8	30.2
Norway	12000	8497	44.2	34.2	17.6	4.0	21.6
Poland	6868	25960	12.2	57.1	28.2	2.5	30.7
Portugal	3234	3570	28.2	47.5	19.8	4.5	24.3
Romania	6244	100718	73.1	18.8	7.2	0.9	8.1
Russian Fed.			no survey in 2005				
Serbia and Montenegro	1868	2995	50.7	32.9	15.6	0.8	16.4
Slovak Republic	1961	4111	14.2	62.9	21.8	1.1	22.9
Slovenia	1099	1056	29.3	40.1	25.1	5.5	30.6
Spain	11588	14880	17.0	61.7	18.0	3.3	21.3
Sweden	20600	17610	46.1	35.5	14.8	3.6	18.4
Switzerland	1186	1031	28.8	43.1	19.4	8.7	28.1
Turkey			no survey in 2005				
Ukraine	4921	26720	62.6	28.7	7.6	1.1	8.7
United Kingdom	2825	8280	29.1	46.1	23.0	1.8	24.8

Serbia and Montenegro: Serbia only.

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
Defoliation of conifers by classes and class aggregates (2005)

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	171		no survey in 2005				
Andorra	15		no survey in 2005				
Austria	2683	3140	50.7	34.2	11.9	3.2	15.1
Belarus	4685	6940	37.2	54.4	6.8	1.6	8.4
Belgium	281	1062	40.5	42.7	14.2	2.6	16.8
Bulgaria	1289	2585	9.0	45.6	35.7	9.7	45.4
Croatia	321	268	4.5	16.0	66.4	13.1	79.5
Cyprus	172	360	20.0	69.2	10.8	0.0	10.8
Czech Republic	2057	5023	9.7	27.6	61.7	1.0	62.7
Denmark	294	291	80.4	14.1	4.8	0.7	5.5
Estonia	1142	2051	52.7	41.7	4.6	1.0	5.6
Finland	18058	9539	56.7	34.1	8.4	0.8	9.2
France	9228	3503	51.7	27.5	18.8	2.0	20.8
Germany	6084	9392	31.0	44.1	23.6	1.3	24.9
Greece	954	938	48.5	36.5	12.3	2.7	15.0
Hungary	239	3950	36.4	41.6	15.9	6.1	22.0
Ireland	399	382	51.1	32.7	12.3	3.9	16.2
Italy	1735	1719	41.0	36.2	19.9	2.9	22.8
Latvia	1563	6021	16.1	70.7	11.3	1.9	13.2
Liechtenstein	6		no survey in 2005				
Lithuania	1155	4454	14.9	75.8	7.9	1.4	9.3
Luxembourg	30		no survey in 2005				
Rep. of Moldova	6	71	43.7	18.3	35.2	2.8	38.0
The Netherlands	158	151	78.8	3.3	17.2	0.7	17.9
Norway	6800	6426	47.2	33.1	16.3	3.4	19.7
Poland	6786	19860	12.3	58.1	27.2	2.4	29.6
Portugal	1081	965	47.5	35.4	16.5	0.6	17.1
Romania	1929	25627	79.6	15.7	3.9	0.8	4.7
Russian Fed.	5800		no survey in 2005				
Serbia and Montenegro	179	338	46.2	32.5	20.1	1.2	21.3
Slovak Republic	815	1781	5.6	59.1	33.4	1.9	35.3
Slovenia	410	410	28.1	38.1	27.3	6.5	33.8
Spain	5910	7511	20.4	60.2	16.2	3.2	19.4
Sweden	19600	16095	45.1	35.3	15.5	4.1	19.6
Switzerland	818	718	23.7	48.1	20.9	7.3	28.2
Turkey	9426		no survey in 2005				
Ukraine	3969	10635	63.0	28.9	7.0	1.1	8.1
United Kingdom	1647	4656	30.8	47.0	20.8	1.4	22.2

Russian Federation: North-western and Central European parts only.
Serbia and Montenegro: Serbia only.

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

Defoliation of broadleaves by classes and class aggregates (2005)

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	599		no survey in 2005				
Andorra			no survey in 2005				
Austria	798	388	48.7	38.4	10.6	2.3	12.9
Belarus	3108	2550	39.1	50.3	8.0	2.6	10.6
Belgium	324	2064	37.3	41.3	17.8	3.6	21.4
Bulgaria	2775	2232	37.8	39.1	17.1	6.0	23.1
Croatia	1740	1778	41.1	39.7	17.4	1.8	19.2
Cyprus			only conifers assessed				
Czech Republic	573	1105	19.8	48.2	30.7	1.3	32.0
Denmark	174	237	54.4	31.2	12.3	2.1	14.4
Estonia	1143	116	78.5	18.1	1.7	1.7	3.4
Finland	1962	1996	61.7	31.1	6.1	1.1	7.2
France	4058	6626	19.3	39.4	37.9	3.4	38.7
Germany	4236	4238	25.2	39.0	32.8	3.0	35.8
Greece	1080	759	38.7	43.4	14.6	3.3	17.9
Hungary	1612	24556	39.1	40.0	15.0	5.9	20.9
Ireland	37		only conifers assessed				
Italy	6940	4854	20.1	43.4	31.2	5.3	36.5
Latvia	1230	2187	29.6	57.5	11.0	1.9	12.9
Liechtenstein	2		no survey in 2005				
Lithuania	833	1861	12.1	72.5	11.6	3.8	15.4
Luxembourg	54		no survey in 2005				
Rep. of Moldova		14504	41.1	32.5	21.7	4.7	26.4
The Netherlands	52	81	11.1	35.8	49.4	3.7	53.1
Norway	5200	2071	34.8	37.6	21.8	5.8	27.6
Poland	1970	6100	12.0	53.9	31.4	2.7	34.1
Portugal	2153	2605	21.0	52.0	21.0	6.0	27.0
Romania	4315	75091	70.9	19.8	8.4	0.9	9.3
Russian Fed.	510		no survey in 2005				
Serbia and Montenegro	2181	2657	51.3	33.0	15.0	0.7	15.7
Slovak Republic	1069	2330	20.7	65.7	13.0	0.6	13.6
Slovenia	688	646	30.2	41.3	23.7	4.8	28.5
Spain	4056	7369	13.5	63.2	19.9	3.4	23.3
Sweden	900	1515	55.9	34.9	7.9	1.3	9.2
Switzerland	368	313	39.0	33.1	16.3	11.6	27.9
Turkey	10773		no survey in 2005				
Ukraine	5347	16085	62.2	28.6	8.0	1.2	9.2
United Kingdom	1178	3624	26.8	45.0	25.8	2.4	28.2

Norway: Special study on birch. *Russian Federation:* North-western and Central European parts only.
Serbia and Montenegro: Serbia only.

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
Defoliation of all species (1994-2005)

Participating countries	All species Defoliation classes 2-4												change % points
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2004/ 2005
Albania					9.8	9.9	10.1	10.2	13.1		12.2		
Andorra											36.1		
Austria	7.8	6.6	7.9	7.1	6.7	6.8	8.9	9.7	10.2	11.1	13.1	14.8	1.7
Belarus	37.4	38.3	39.7	36.3	30.5	26.0	24.0	20.7	9.5	11.3	10.0	9.0	-1.0
Belgium	16.9	24.5	21.2	17.4	17.0	17.7	19.0	17.9	17.8	17.3	19.4	19.9	0.5
Bulgaria	28.9	38.0	39.2	49.6	60.2	44.2	46.3	33.8	37.1	33.7	39.7	35.0	-4.7
Croatia	28.8	39.8	30.1	33.1	25.6	23.1	23.4	25.0	20.6	22.0	25.2	27.1	1.9
Cyprus								8.9	2.8	18.4	12.2	10.8	-1.4
Czech Rep.	57.7	58.5	71.9	68.6	48.8	50.4	51.7	52.1	53.4	54.4	57.3	57.1	-0.2
Denmark	36.5	36.6	28.0	20.7	22.0	13.2	11.0	7.4	8.7	10.2	11.8	9.4	-2.4
Estonia	15.7	13.6	14.2	11.2	8.7	8.7	7.4	8.5	7.6	7.6	5.3	5.4	0.1
Finland	13.0	13.3	13.2	12.2	11.8	11.4	11.6	11.0	11.5	10.7	9.8	8.8	-1.0
France	8.4	12.5	17.8	25.2	23.3	19.7	18.3	20.3	21.9	28.4	31.7	34.2	2.5
Germany	24.4	22.1	20.3	19.8	21.0	21.7	23.0	21.9	21.4	22.5	31.4	28.5	-2.9
Greece	23.2	25.1	23.9	23.7	21.7	16.6	18.2	21.7	20.9			16.3	
Hungary	21.7	20.0	19.2	19.4	19.0	18.2	20.8	21.2	21.2	22.5	21.5	21.0	-0.5
Ireland	19.7	26.3	13.0	13.6	16.1	13.0	14.6	17.4	20.7	13.9	17.4	16.2	-1.2
Italy	19.5	18.9	29.9	35.8	35.9	35.3	34.4	38.4	37.3	37.6	35.9	32.9	-3.0
Latvia	30.0	20.0	21.2	19.2	16.6	18.9	20.7	15.6	13.8	12.5	12.5	13.1	0.6
Liechtenstein													
Lithuania	25.4	24.9	12.6	14.5	15.7	11.6	13.9	11.7	12.8	14.7	13.9	11.0	-2.9
Luxembourg	34.8	38.3	37.5	29.9	25.3	19.2	23.4						
Rep. of Moldova		40.4	41.2				29.1	36.9	42.5	42.4	34.0	26.5	-7.5
The Netherlands	19.4	32.0	34.1	34.6	31.0	12.9	21.8	19.9	21.7	18.0	27.5	30.2	2.7
Norway	27.5	28.8	29.4	30.7	30.6	28.6	24.3	27.2	25.5	22.9	20.7	21.6	0.9
Poland	54.9	52.6	39.7	36.6	34.6	30.6	32.0	30.6	32.7	34.7	34.6	30.7	-3.9
Portugal	5.7	9.1	7.3	8.3	10.2	11.1	10.3	10.1	9.6	13.0	16.6	24.3	7.7
Romania	21.2	21.2	16.9	15.6	12.3	12.7	14.3	13.3	13.5	12.6	11.7	8.1	-3.6
Russian Fed.	10.7	12.5						9.8	10.9				
Serbia and Monten.			3.6	7.7	8.4	11.2	8.4	14.0	3.9	22.8	14.3	16.4	2.1
Slovak Rep.	41.8	42.6	34.0	31.0	32.5	27.8	23.5	31.7	24.8	31.4	26.7	22.9	-3.8
Slovenia	16.0	24.7	19.0	25.7	27.6	29.1	24.8	28.9	28.1	27.5	29.3	30.6	1.3
Spain	19.4	23.5	19.4	13.7	13.6	12.9	13.8	13.0	16.4	16.6	15.0	21.3	6.3
Sweden		14.2	17.4	14.9	14.2	13.2	13.7	17.5	16.8	19.2	16.5	18.4	1.9
Switzerland	18.2	24.6	20.8	16.9	19.1	19.0	29.4	18.2	18.6	14.9	29.1	28.1	-1.0
Turkey													
Ukraine	32.4	29.6	46.0	31.4	51.5	56.2	60.7	39.6	27.7	27.0	29.9	8.7	-21.2
United Kingdom	13.9	13.6	14.3	19.0	21.1	21.4	21.6	21.1	27.3	24.7	26.5	24.8	-1.7

Austria: From 2003 on, results are based on the 16x16 km transnational gridnet and must not be compared with previous years. *Czech Republic*: Only trees older than 60 years assessed until 1997. *France*: Due to methodological changes, only the time series 1993-94 and 1997-2005 are consistent, but not comparable to each other. *Italy*: Due to methodological changes, only the time series 1993-96 and 1997-2005 are consistent, but not comparable to each other. *Russian Federation:* North-western and Central European parts only. *United Kingdom*: The difference between 1992 and subsequent years is mainly due to a change of assessment method in line with that used in other States. *Ukraine*: Due to a denser gridnet since 2005, results must not be compared with previous years.

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

Defoliation of conifers (1994-2005)

Paticipating countries	Conifers Defoliation classes 2-4												change% points
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2004/ 2005
Albania					12.0	12.1	12.3	12.4	15.5		14.0		
Andorra											36.1		
Austria	7.9	6.6	7.3	6.3	6.3	6.4	9.1	9.6	10.1	11.2	13.1	15.1	2.0
Belarus	44.0	43.9	43.1	41.2	33.9	28.9	26.1	23.4	9.7	9.5	8.9	8.4	-0.5
Belgium	21.2	21.0	25.8	19.2	13.5	15.5	19.5	17.5	19.7	18.6	15.6	16.8	1.2
Bulgaria	25.0	41.4	46.5	53.5	69.8	48.9	46.4	39.1	44.0	38.4	47.1	45.4	-1.7
Croatia	39.3	57.5	57.0	68.7	45.8	53.2	53.3	65.1	63.5	77.4	70.6	79.5	8.9
Cyprus								8.9	2.8	18.4	12.2	10.8	-1.4
Czech Rep.	59.0	60.7	74.9	71.9	54.6	57.4	58.3	58.1	60.1	60.7	62.6	62.7	0.1
Denmark	38.7	34.8	23.2	15.9	17.0	9.9	8.8	6.7	4.5	6.1	5.8	5.5	-0.3
Estonia	16.0	14.2	14.6	11.4	9.0	9.1	7.5	8.8	7.9	7.7	5.3	5.6	0.3
Finland	13.1	13.7	13.7	12.8	12.2	11.9	12.0	11.4	11.9	11.1	10.1	9.2	-0.9
France	8.2	9.2	13.5	16.2	16.8	14.1	12.0	14.0	15.2	18.9	18.6	20.8	2.2
Germany	21.6	18.3	16.7	15.4	19.0	19.2	19.6	20.0	19.8	20.1	26.3	24.9	-1.4
Greece	13.2	13.6	14.4	13.8	12.9	13.5	16.5	17.2	16.1			15.0	
Hungary	21.2	18.7	17.8	17.4	18.7	17.6	21.5	19.5	22.8	27.6	24.2	22.0	-2.2
Ireland	19.7	26.3	13.0	13.6	16.1	13.0	14.6	17.4	20.7	13.9	17.4	16.2	-1.2
Italy	15.0	19.4	25.1	28.1	25.5	23.1	19.2	19.1	20.5	20.4	21.7	22.8	1.1
Latvia	34.0	23.0	24.8	21.9	18.9	20.6	20.1	15.8	14.3	12.2	11.9	13.2	1.3
Liechtenstein													
Lithuania	26.3	26.6	12.9	13.9	13.6	11.5	12.0	9.8	9.3	10.7	10.2	9.3	-0.9
Luxembourg	12.8	12.9	12.7	8.0	10.5	8.7	7.0						
Rep. of Moldova		33.3	48.4							55.4	35.5	38.0	2.5
The Netherlands	27.7	45.4	43.5	45.3	43.2	14.5	23.5	20.7	17.5	9.4	17.2	17.9	0.7
Norway	22.4	24.0	25.1	28.5	27.5	24.3	21.8	25.1	24.1	21.2	16.7	19.7	3.0
Poland	55.6	54.5	40.5	36.8	34.6	30.6	32.1	30.3	32.5	33.2	33.4	29.6	-3.8
Portugal	5.4	6.6	5.6	7.8	6.6	6.0	4.3	4.3	3.6	5.3	10.8	17.1	6.3
Romania	15.5	15.2	10.4	10.3	9.0	9.1	9.8	9.6	9.9	9.8	7.6	4.7	-2.9
Russian Fed.	9.4	10.1	9.4	0.0				9.8	10.0				
Serbia and Monten.			4.4	7.9	6.0	9.2	10.0	21.3	7.3	39.6	19.8	21.3	1.5
Slovak Rep.	50.3	52.0	41.0	42.2	40.3	40.2	37.9	38.7	40.4	39.7	36.2	35.3	-0.9
Slovenia	19.0	33.6	26.0	32.5	36.7	38.0	34.5	32.2	31.4	35.3	37.4	33.8	-3.6
Spain	19.1	18.1	18.1	11.5	12.9	9.8	12.0	11.6	15.6	14.1	14.0	19.4	5.4
Sweden	16.2	14.5	16.9	15.9	15.0	13.6	13.5	18.4	17.7	20.4	16.0	19.6	3.6
Switzerland	19.6	23.2	21.4	19.9	19.7	18.3	33.0	19.1	19.9	13.3	27.4	28.2	0.8
Turkey													
Ukraine	34.8	25.7	45.8	32.7	64.9	50.0	47.3	16.8	14.6	15.4	11.4	8.1	-3.3
United Kingdom	15.0	13.0	13.9	17.0	19.8	20.1	20.2	20.6	25.1	25.8	23.2	22.2	-1.0

Austria: From 2003 on, results are based on the 16x16 km transnational gridnet and must not be compared with previous years. Czech Republic: Only trees older than 60 years assessed until 1997. *France:* Due to methodological changes, only the time series 1993-94 and 1997-2005 are consistent, but not comparable to each other. *Italy:* Due to methodological changes, only the time series 1993-96 and 1997-2005 are consistent, but not comparable to each other. *Russian Federation:* North-western and Central European parts only. *United Kingdom:* The difference between 1992 and subsequent years is mainly due to a change of assessment method in line with that used in other States. *Ukraine:* Due to a denser gridnet since 2005, results must not be compared with previous years. *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

Defoliation of broadleaves (1994-2005)

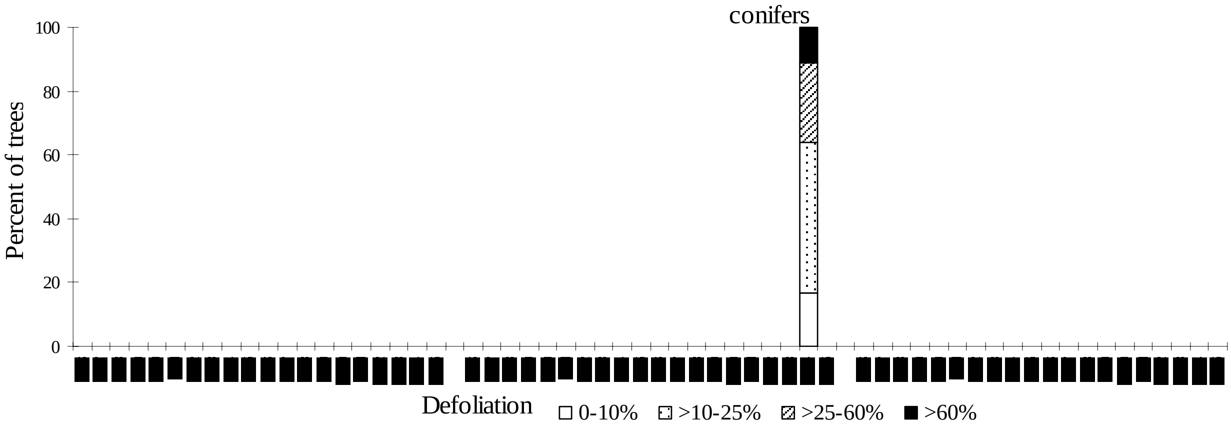
Paticipating countries	Broadleaves Defoliation classes 2-4												change % points
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2004/ 2005
Albania					8.0	8.1	8.4	8.4	10.7		10.3		
Andorra									only conifers assessed				
Austria	7.4	6.5	11.6	12.2	9.6	9.4	7.6	10.4	11.3	10.2	13.6	12.9	-0.7
Belarus	18.6	22.9	29.2	23.0	19.3	17.0	16.9	13.3	9.0	15.8	12.9	10.6	-2.3
Belgium	12.8	26.6	18.5	16.1	19.2	19.1	18.8	18.3	17.0	16.6	21.3	21.4	0.1
Bulgaria	34.4	32.7	33.0	43.9	48.4	35.9	45.8	26.0	29.0	27.2	30.1	23.1	-7.0
Croatia	26.4	35.2	26.0	27.8	21.9	16.8	18.3	18.7	14.4	14.3	17.2	19.2	2.0
Cyprus									only conifers assessed				
Czech Rep.	48.0	30.6	34.0	26.5	13.5	17.1	21.4	21.7	19.9	24.4	31.8	32.0	0.2
Denmark	32.4	39.7	36.1	28.4	30.1	18.8	13.9	8.5	15.4	16.6	19.1	14.4	-4.7
Estonia	2.0	1.1	5.3	7.4	1.0	1.1	9.5	2.1	2.7	6.7	5.3	3.4	-1.9
Finland	12.0	11.0	10.3	8.4	9.4	8.6	9.9	8.8	8.8	8.3	8.4	7.2	-1.2
France	8.4	14.3	20.1	29.9	26.9	22.9	21.6	23.6	25.5	33.5	38.7	41.3	2.6
Germany	30.1	29.9	30.8	28.6	25.2	26.9	29.9	25.4	24.7	27.3	41.5	35.8	-5.7
Greece	35.0	38.2	34.6	34.9	31.7	20.2	20.2	26.6	26.5			17.9	
Hungary	21.8	20.2	19.5	19.7	19.0	18.2	20.8	21.5	20.8	22.0	21.0	20.9	-0.1
Ireland									only conifers assessed				
Italy	20.7	18.5	31.2	38.0	38.9	39.3	40.5	46.3	44.6	45.0	42.0	36.5	-5.5
Latvia	15.0	10.0	11.4	11.3	13.6	14.2	22.2	14.8	12.8	13.5	14.3	12.9	-1.4
Liechtenstein													
Lithuania	23.3	20.8	12.2	15.9	19.7	11.8	17.7	16.3	19.0	24.6	21.8	15.4	-6.4
Luxembourg	46.8	51.4	49.8	41.8	33.3	25.8	33.5						
Rep. of Moldova	21.9	40.5	41.1	30.0		41.4	29.2	36.9	42.5	42.3	33.9	26.4	-7.5
The Netherlands	5.1	10.8	19.2	17.8	14.0	10.0	18.8	18.5	29.6	33.7	46.9	53.1	6.2
Norway	47.6	47.4	45.0	38.9	42.2	44.8	34.0	33.7	30.4	29.0	33.2	27.6	-5.6
Poland	51.5	46.7	37.4	35.8	34.8	31.1	32.0	31.4	33.1	39.6	38.7	34.1	-4.6
Portugal	5.8	10.4	8.3	8.6	12.0	13.7	13.2	12.8	12.6	16.2	19.0	27.0	8.0
Romania	22.9	23.1	18.7	16.9	13.3	14.0	15.8	14.7	14.8	13.3	13.0	9.3	-3.7
Russian Fed.	39.4	34.4							16.0				
Serbia and Monten.			3.5	7.4	10.1	13.0	6.7	6.7	0.6	21.5	13.5	15.7	2.2
Slovak Rep.	35.6	35.8	28.0	23.3	27.0	19.3	13.9	26.9	14.5	25.6	19.9	13.6	-6.3
Slovenia	13.0	19.3	15.0	21.4	21.7	23.2	18.4	26.7	25.9	22.6	24.2	28.5	4.3
Spain	19.6	28.7	20.7	15.8	14.4	16.1	15.7	14.4	17.3	19.1	16.1	23.3	7.2
Sweden		7.9	20.7	6.1	7.4	8.7	7.5	14.1	9.6	11.1	8.3	9.2	0.9
Switzerland	16.2	27.0	19.8	12.5	18.1	20.4	22.1	16.3	16.0	18.1	32.8	27.9	-4.9
Turkey													
Ukraine	29.9	33.0	46.2	30.7	43.2	59.7	69.6	53.3	36.7	35.3	43.2	9.2	-34.0
United Kingd.	12.4	14.5	15.0	22.0	22.9	23.2	23.8	21.9	30.3	23.2	30.6	28.2	-2.4

Austria: From 2003 on, results are based on the 16x16 km transnational gridnet and must not be compared with previous years. Czech Republic: Only trees older than 60 years assessed until 1997. *France:* Due to methodological changes, only the time series 1993-94 and 1997-2005 are consistent, but not comparable to each other. *Italy:* Due to methodological changes, only the time series 1993-96 and 1997-2005 are consistent, but not comparable to each other. *Russian Federation:* North-western and Central European parts only. *United Kingdom:* The difference between 1992 and subsequent years is mainly due to a change of assessment method in line with that used in other States. *Ukraine:* Due to a denser gridnet since 2005, results must not be compared with previous years. *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.*

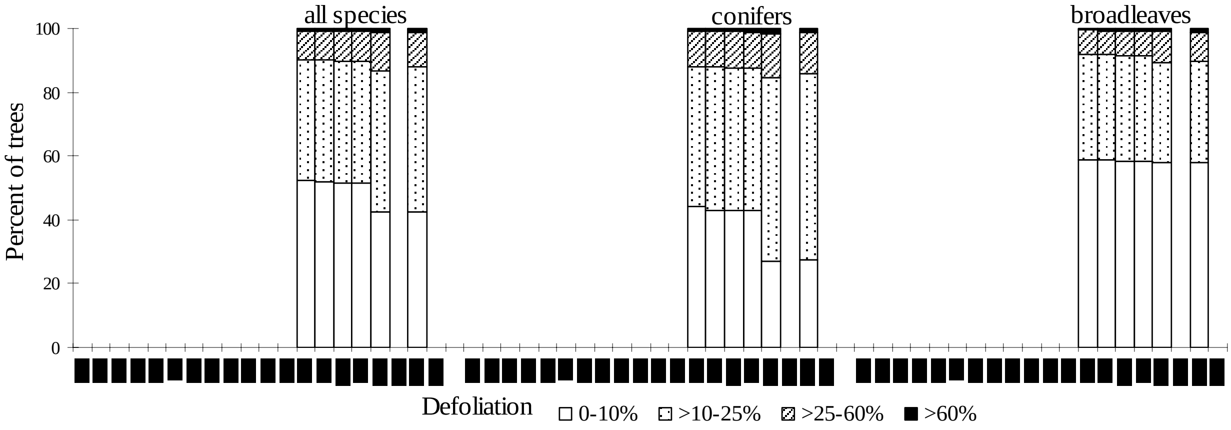
Annex II-8

Changes in defoliation (1986-2005)

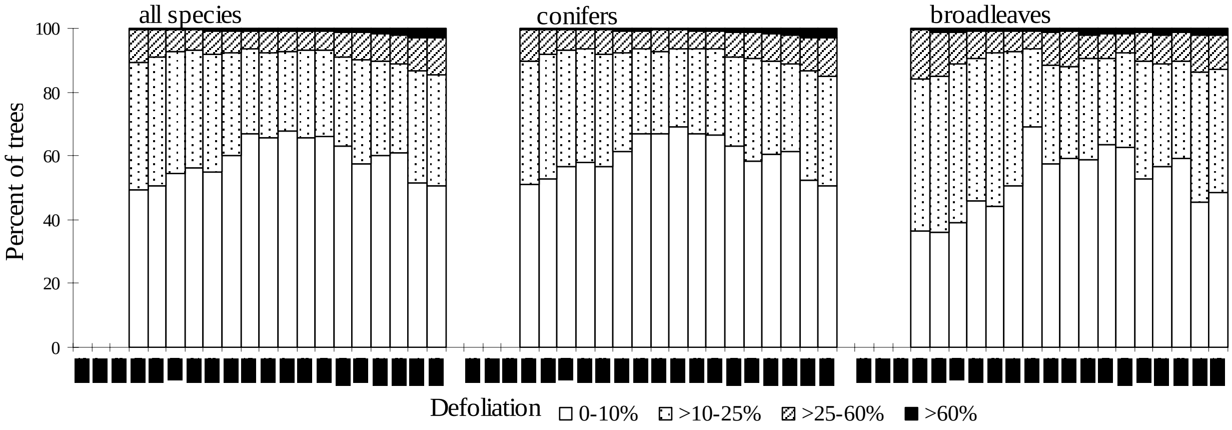
Andorra



Albania

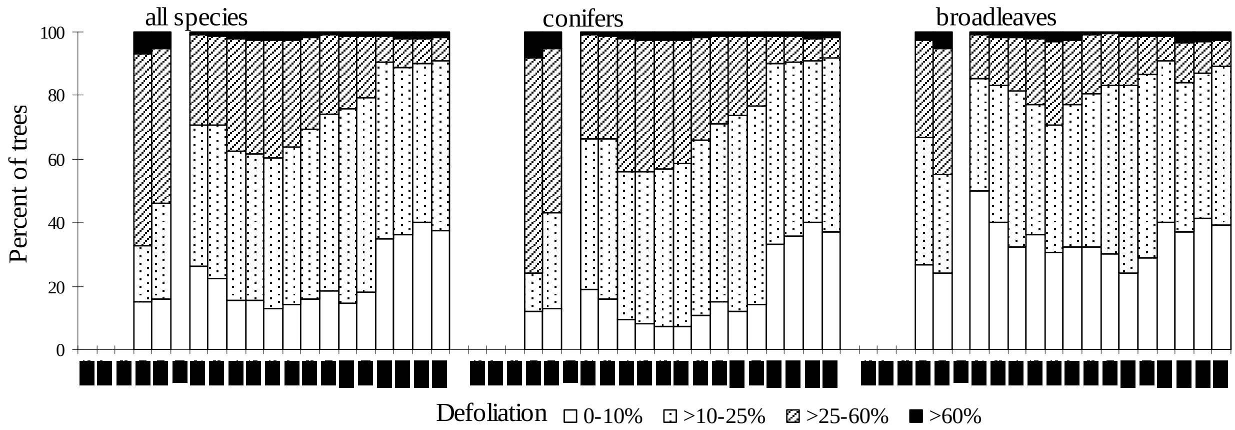


Austria *

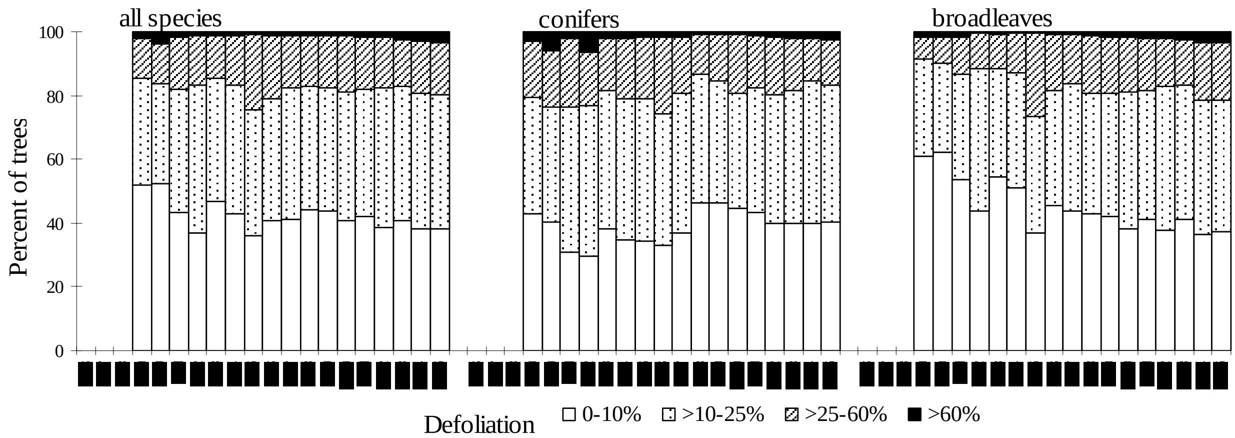


* from 2003 on, results are based on the 16x16 km transnational gridnet and must not be compared with previous years.

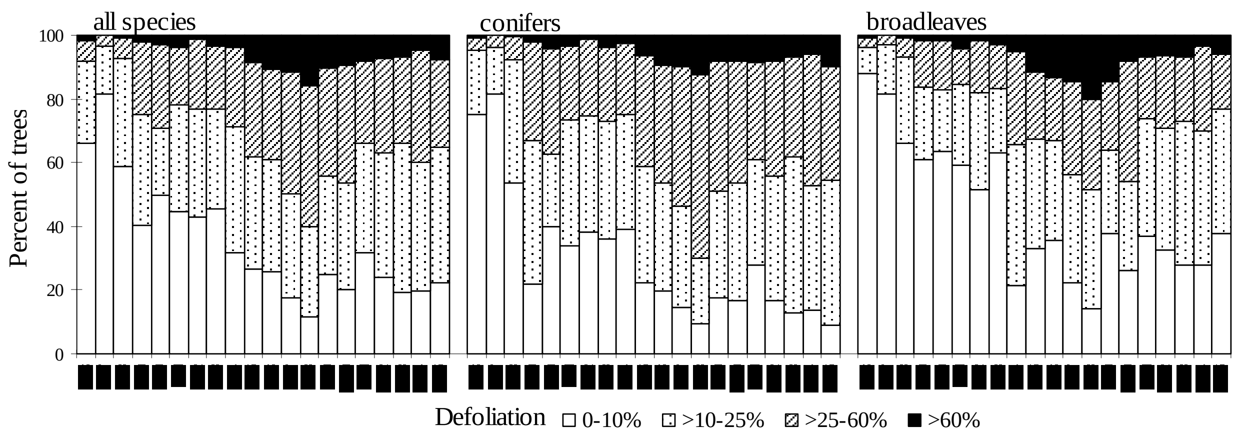
Belarus

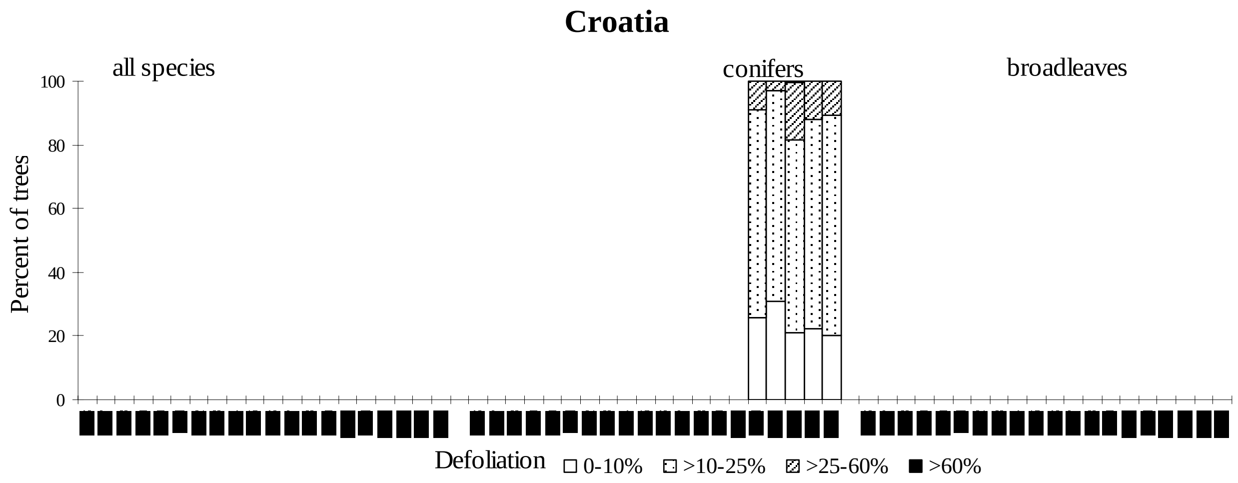


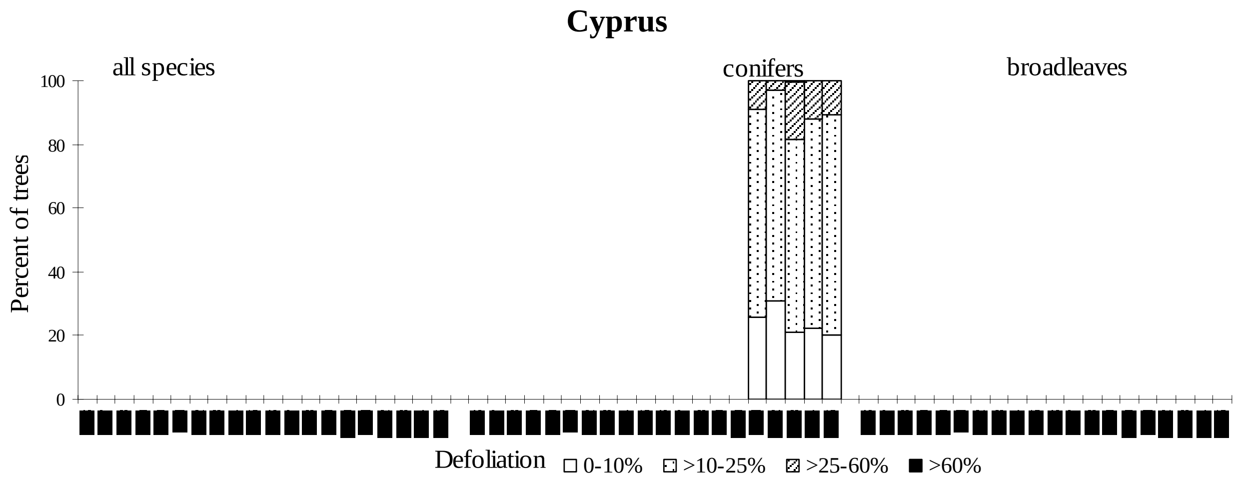
Belgium

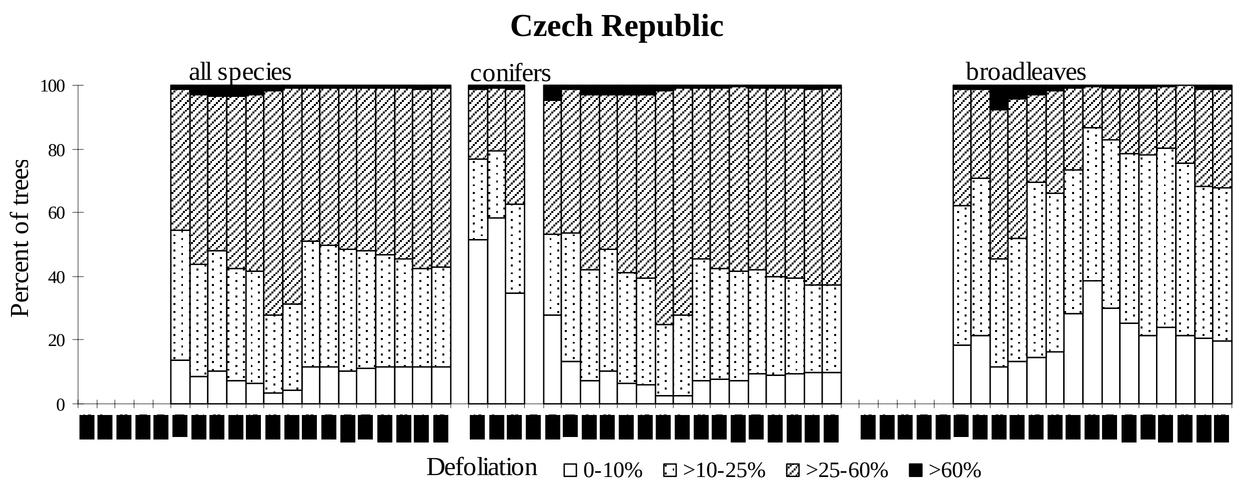


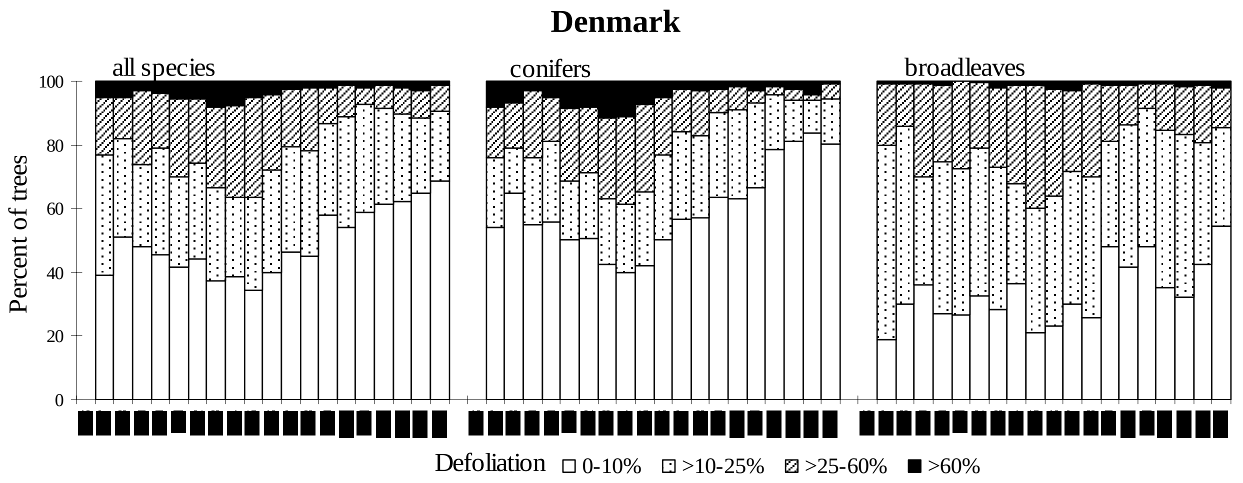
Bulgaria

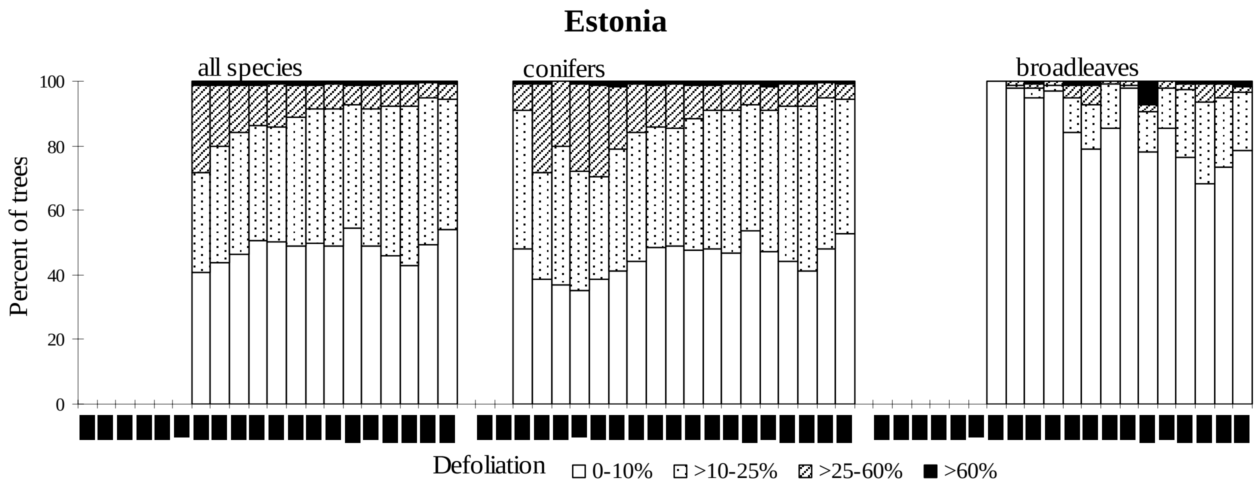


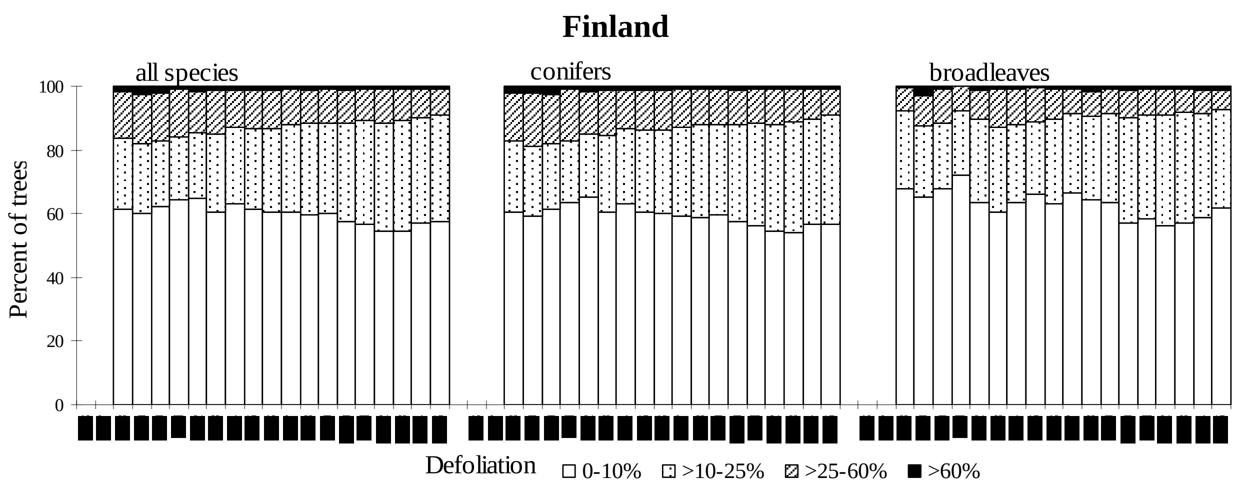

Croatia
all species
conifers
broadleaves
Percent of trees
100
80
60
40
20
0
Defoliation
0-10%
>10-25%
>25-60%
>60%


Cyprus
all species
conifers
broadleaves
Percent of trees
100
80
60
40
20
0
Defoliation
0-10%
>10-25%
>25-60%
>60%

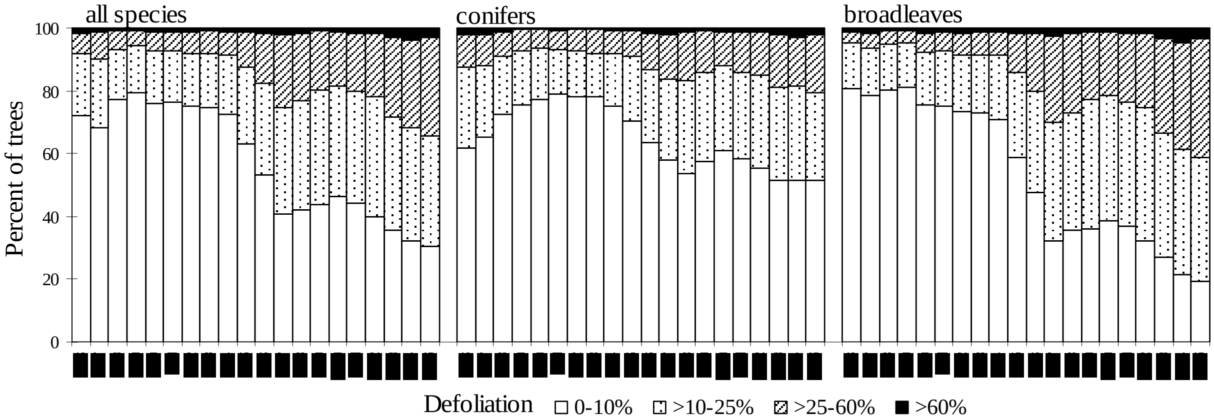

Czech Republic
all species
conifers
broadleaves
Percent of trees
100
80
60
40
20
0
Defoliation
0-10%
>10-25%
>25-60%
>60%


Denmark
all species
conifers
broadleaves
Percent of trees
100
80
60
40
20
0
Defoliation
0-10%
>10-25%
>25-60%
>60%


Estonia
all species
conifers
broadleaves
Percent of trees
100
80
60
40
20
0
Defoliation
0-10%
>10-25%
>25-60%
>60%

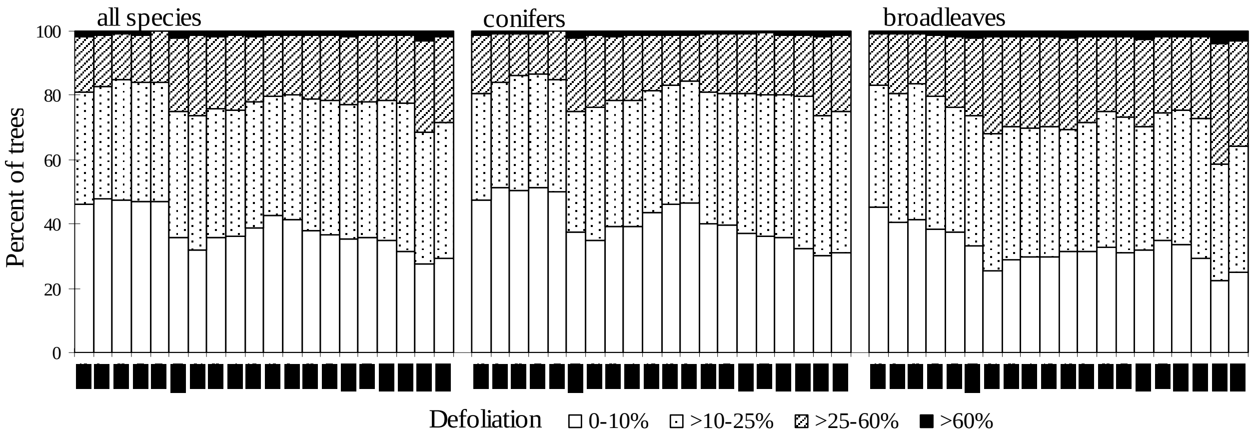

Finland
all species
conifers
broadleaves
Percent of trees
100
80
60
40
20
0
Defoliation
0-10%
>10-25%
>25-60%
>60%

France *



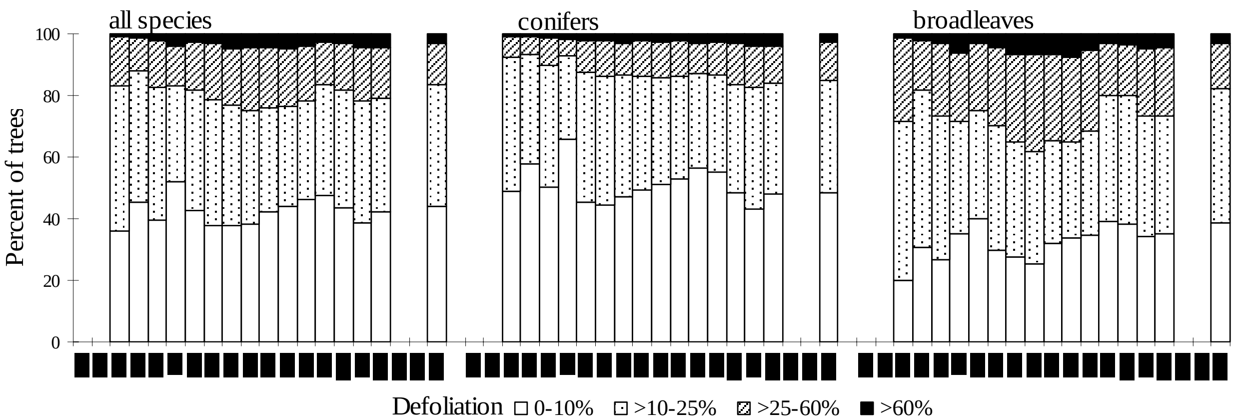
* due to methodological changes, only the time series 1988-94 and 1997-99 are consistent, but not comparable to each other.

Germany

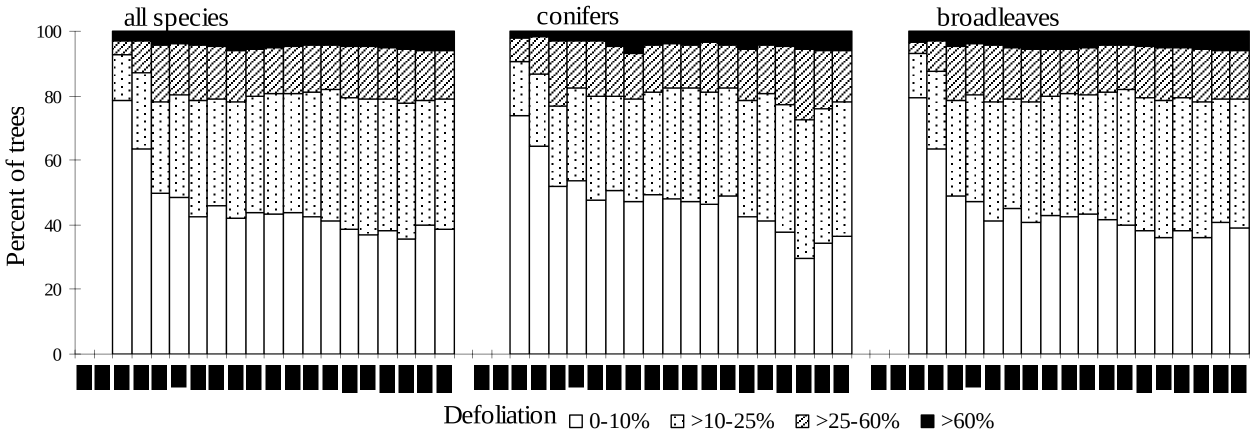


* since 1991 with former GDR

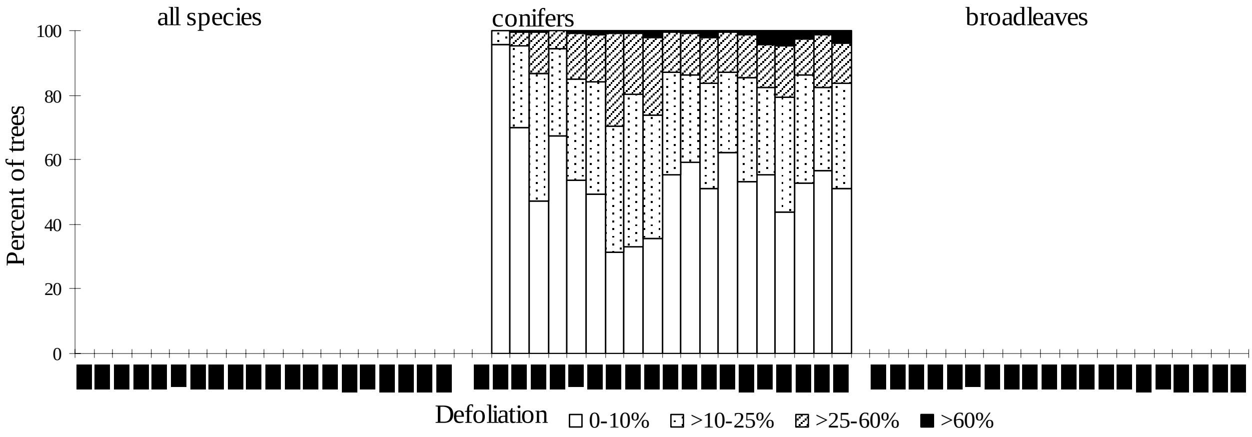
Greece



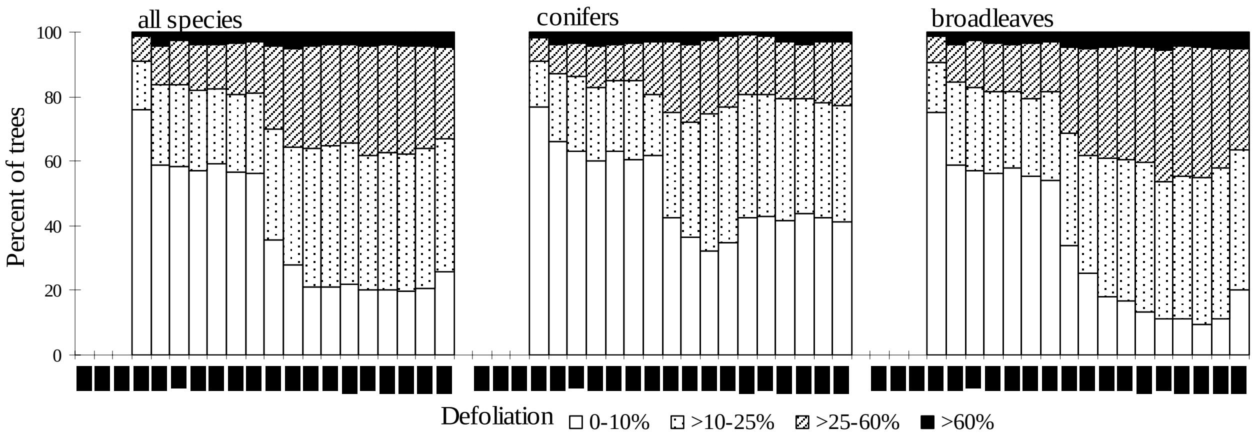
Hungary



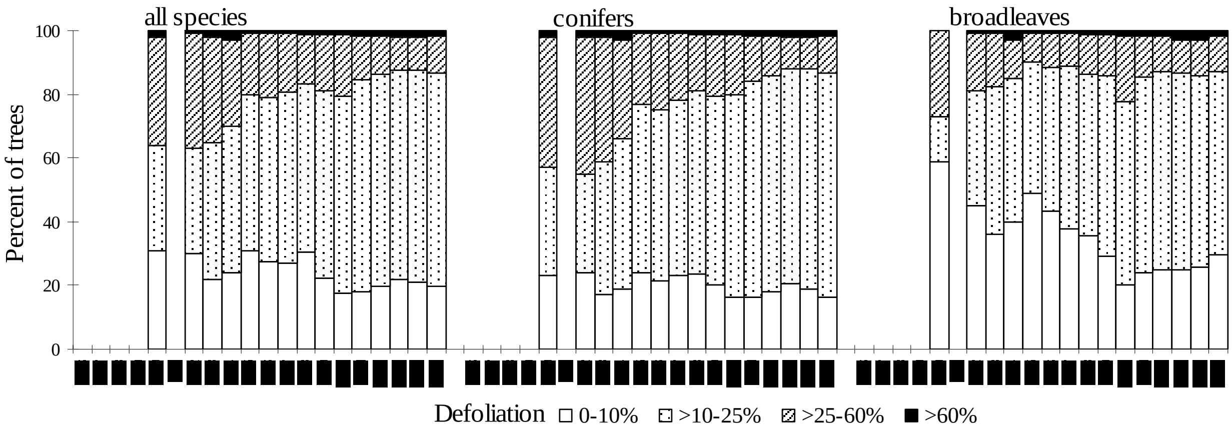
Ireland



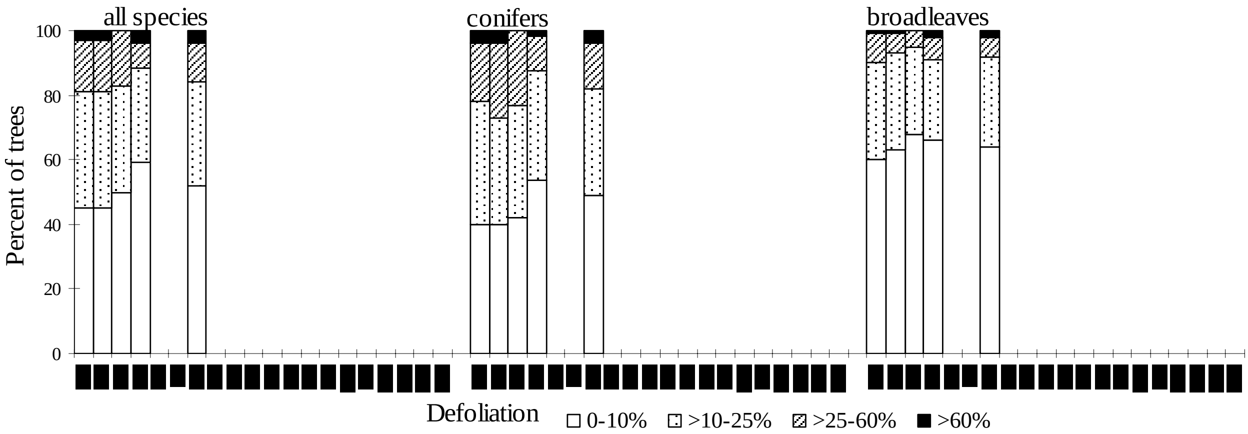
Italy



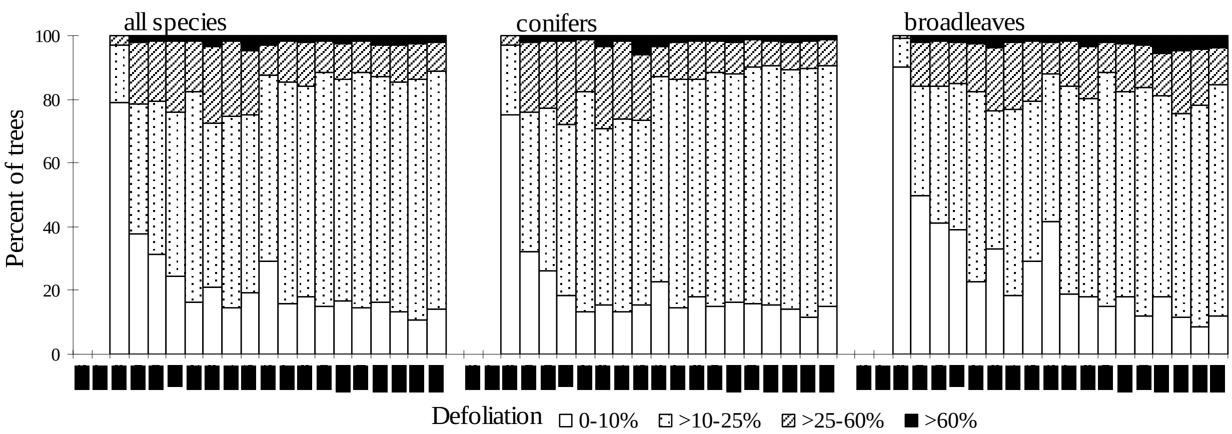
Latvia

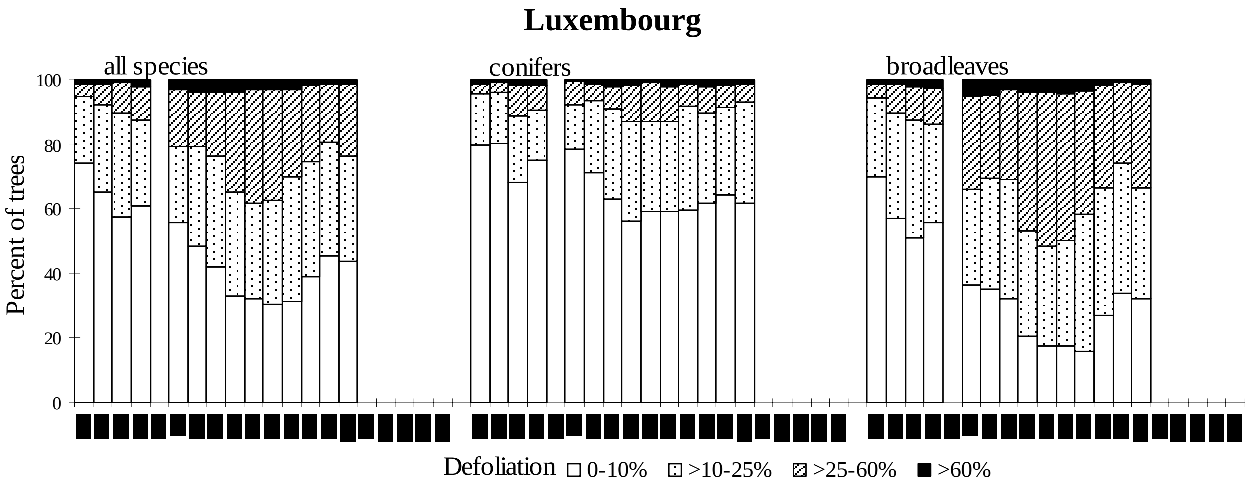


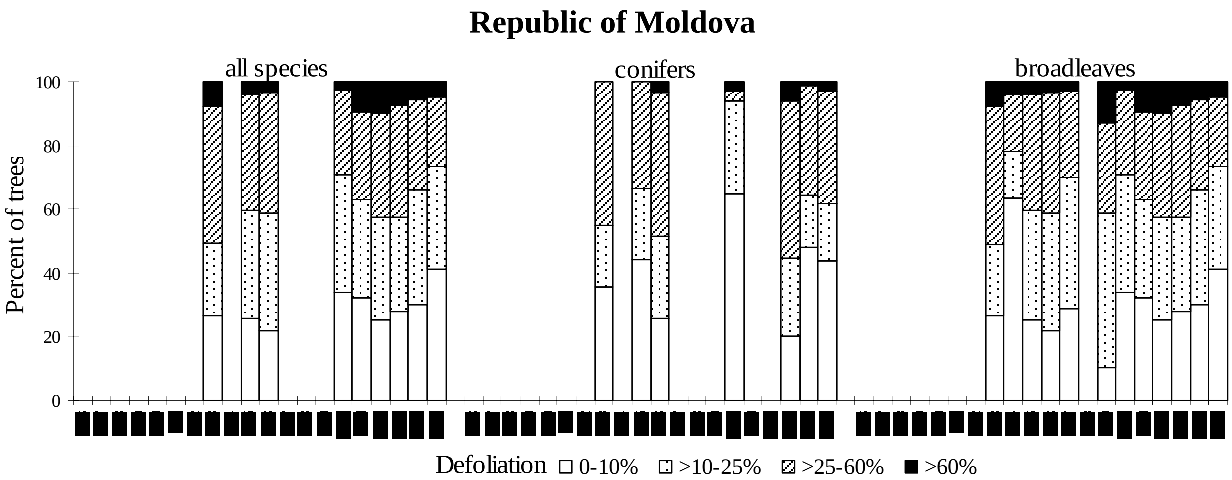
Liechtenstein

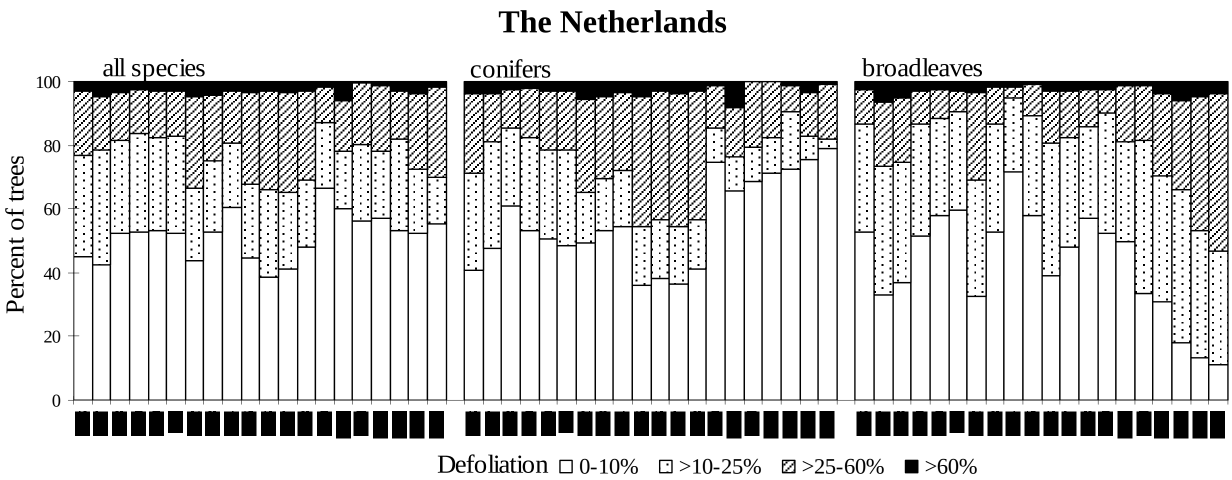


Lithuania



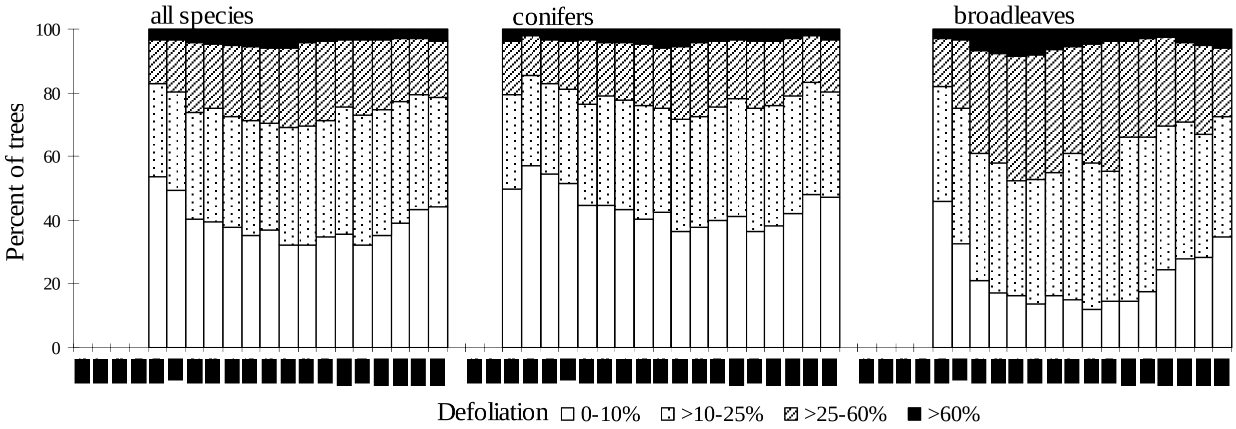




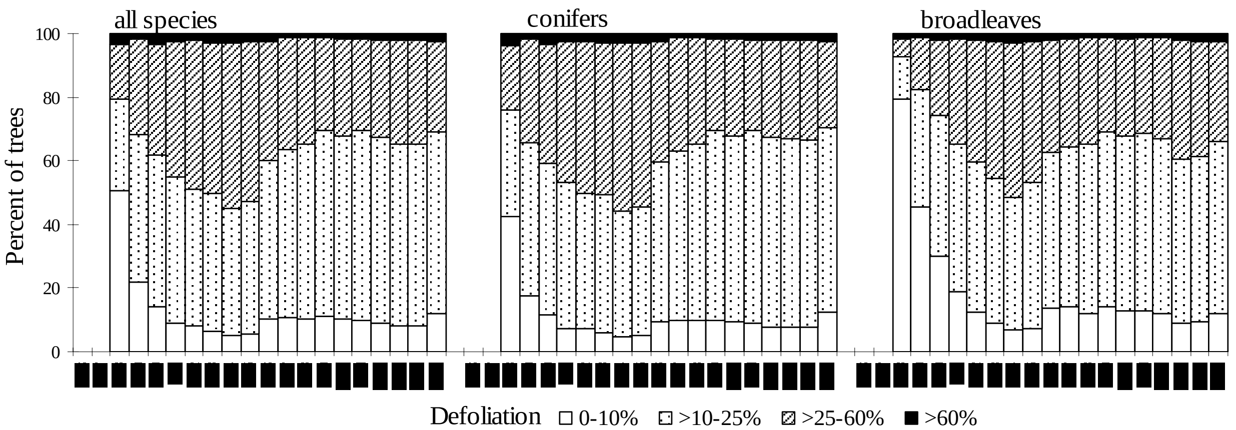


1989-1994: 1500 plots, 1995-1998: 200 plots, since 1999: 11 plots

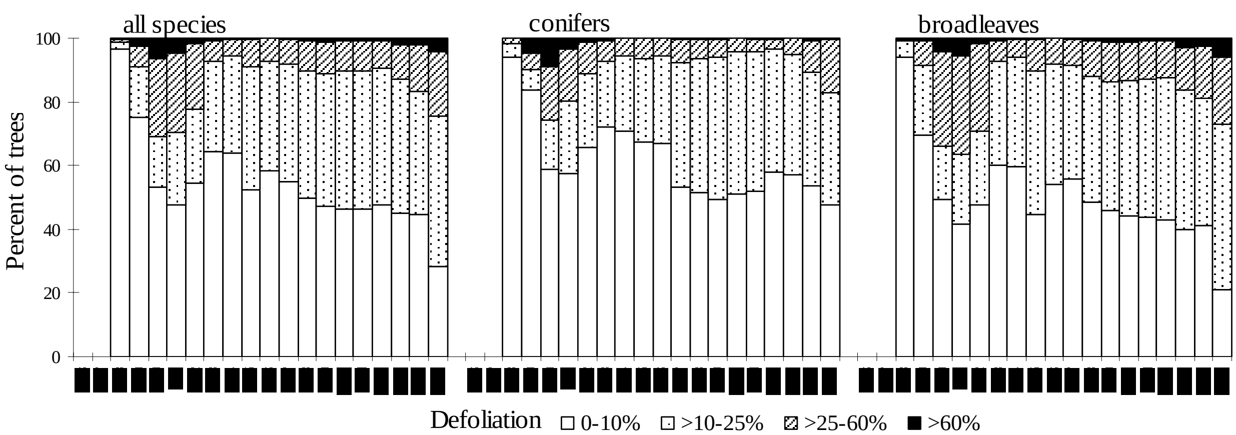
Norway



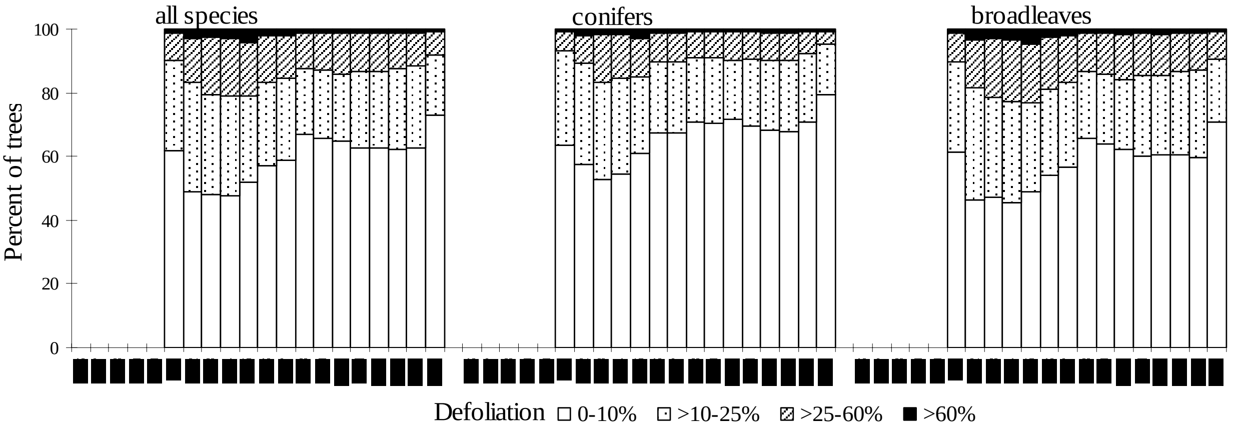
Poland



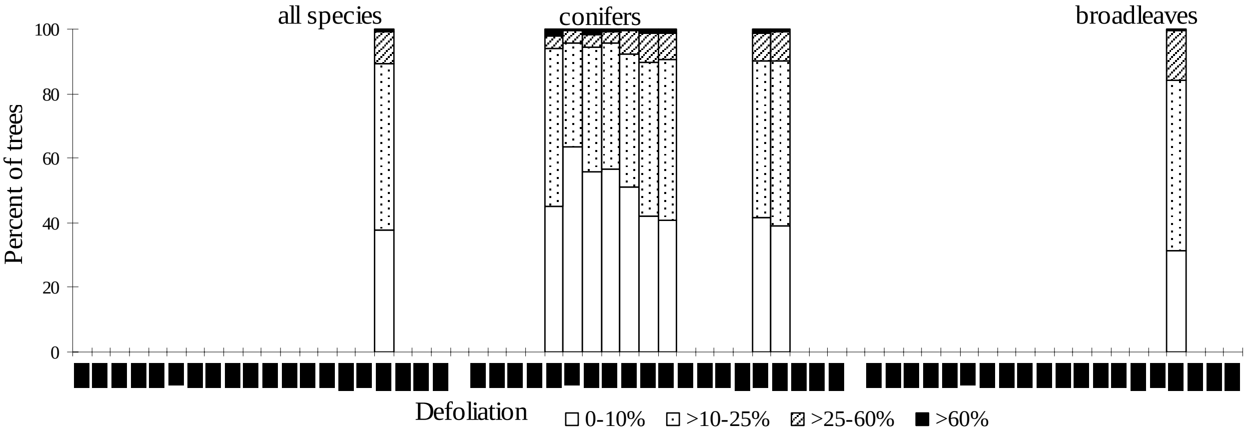
Portugal



Romania

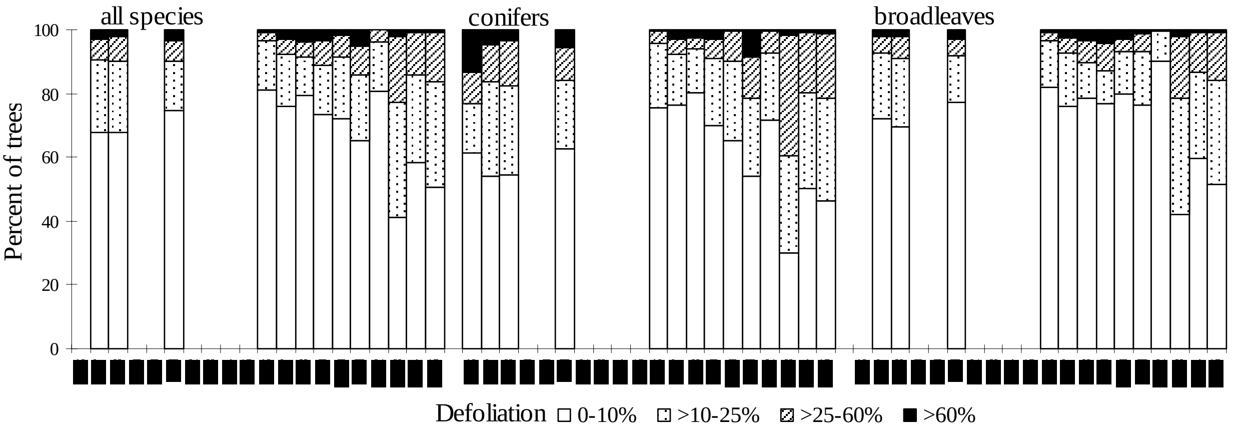


Russian Federation *

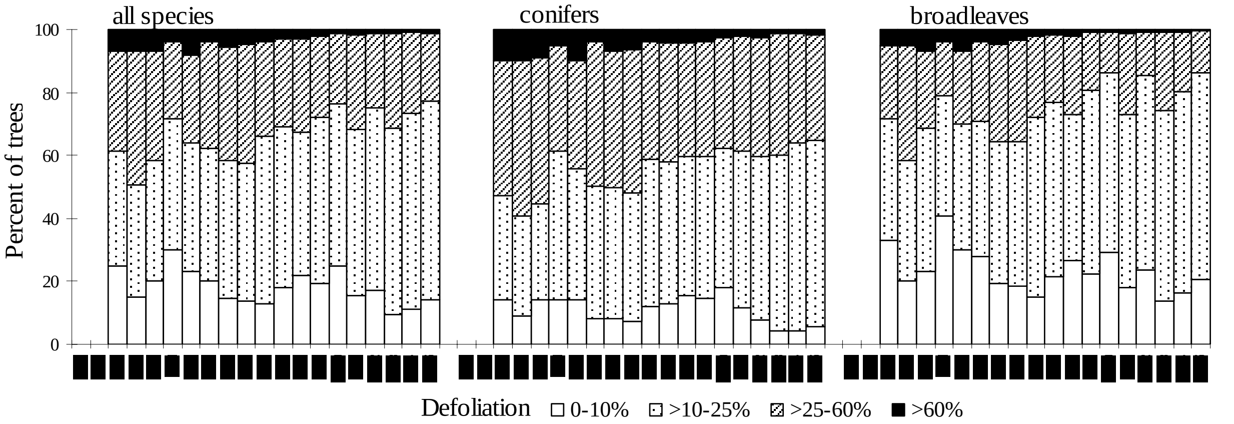


* Only regional surveys in north-western and Central European parts of Russia.

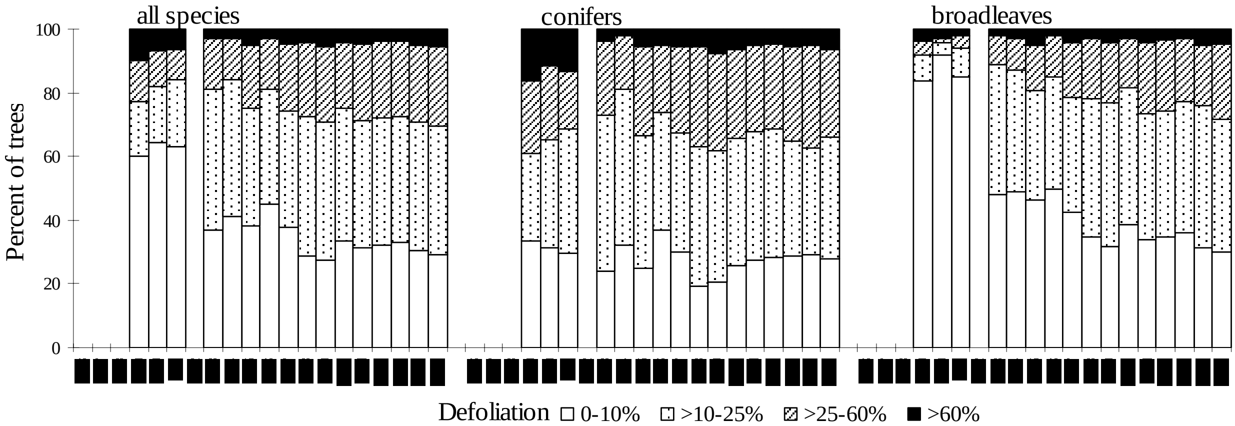
Serbia and Montenegro



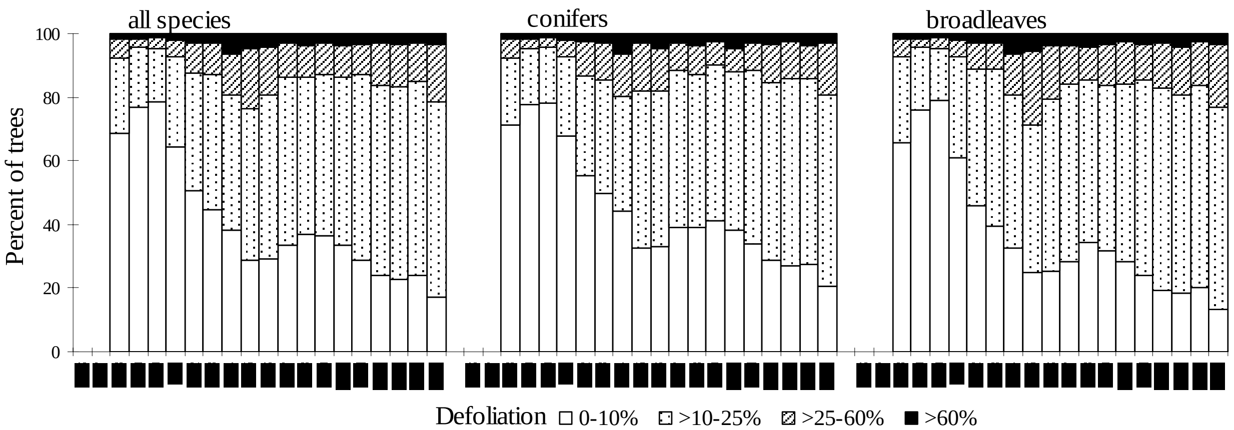
Slovak Republic



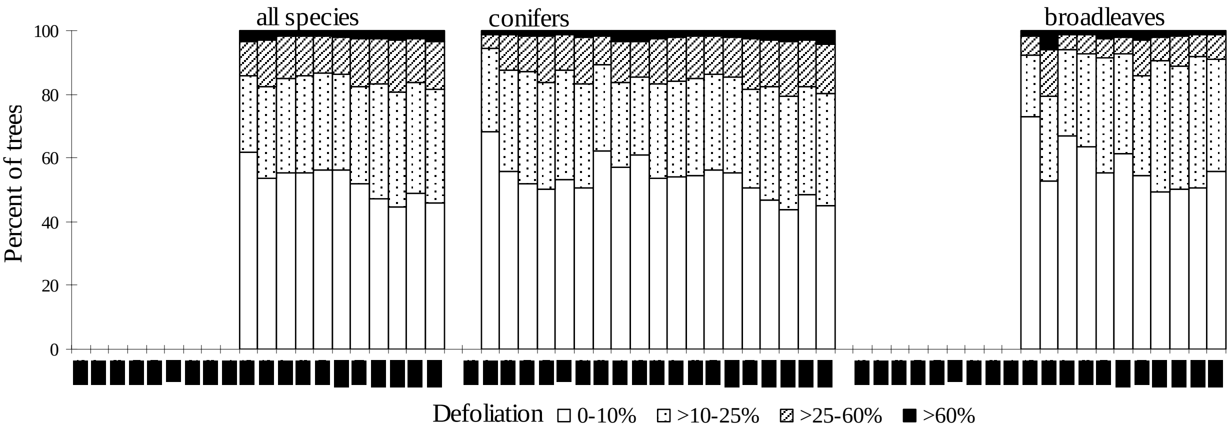
Slovenia



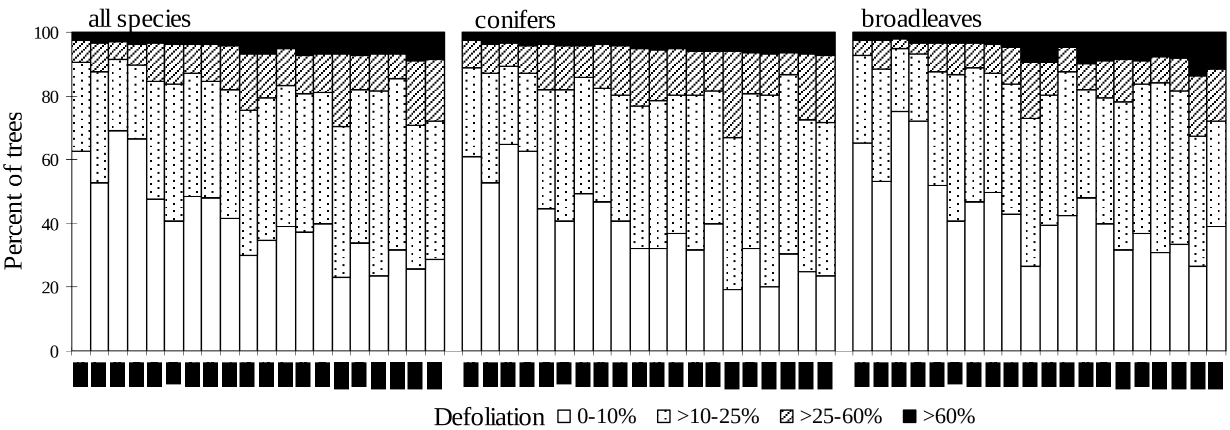
Spain



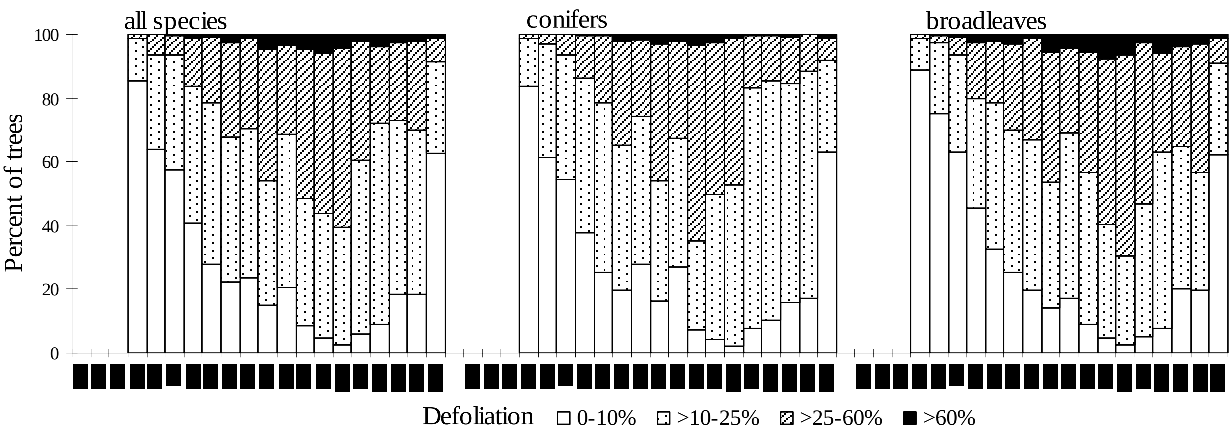
Sweden



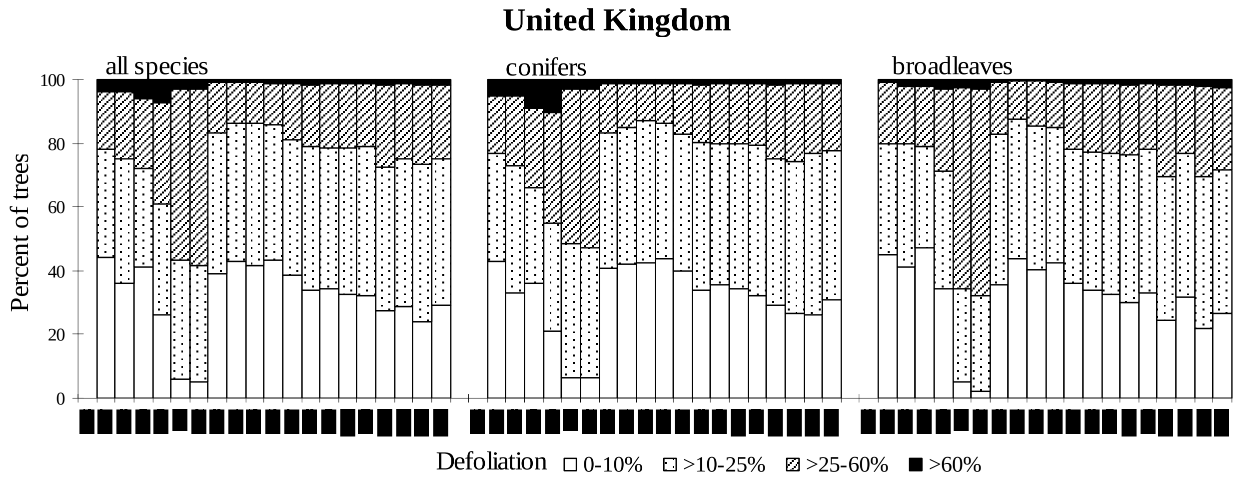
Switzerland



Ukraine



since 2005 change of assessment grid



after 1992 change of assessment method in line with that used in other countries

Annex III
Main species referred to in the text

Botanical name	Danish	Dutch	English	Finnish	French	German
Fagus sylvatica	Bøg	Beuk	Common beech	Pyökki	Hêtre	Rotbuche
Quercus petraea	Vintereg	Wintereik	Sessile oak	Talvitammi	Chêne rouvre	Traubeneiche
Quercus robur	Stilkeg	Zomereik	European oak	Metsätammi	Chêne pédonculé	Stieleiche
Quercus ilex	Steneg	Steeneik	Holm oak	Rautatammi	Chêne vert	Steineiche
Quercus suber	Korkeg	Kurkeik	Cork oak	Korkkitammi	Chêne liège	Korkeiche
Pinus sylvestris	Skovfyr	Grove den	Scots pine	Metsämänty	Pin sylvestre	Gemeine Kiefer
Pinus nigra	Østrigsk fyr	Oostenrijkse Corsicaanse zwarte den	Corsican/ Austrian black pine	Euroopanmustamänty	Pin noir	Schwarzkiefer
Pinus pinaster	Strandfyr	Zeeden	Maritime pine	Rannikkomänty	Pin maritime	Seestrandkiefer
Pinus halepensis	Aleppofyr	Aleppoden	Aleppo pine	Aleponmänty	Pin d'Alep	Aleppokiefer
Picea abies	Rødgran	Fijnspar	Norway spruce	Metsäkuusi	Epicéa commun	Rotfichte
Picea sitchensis	Sitkagran	Sitkaspar	Sitka spruce	Sitkankuusi	Epicéa de Sitka	Sitkafichte
Abies alba	Ædelgran	Zilverden	Silver fir	Saksanpihta	Sapin pectiné	Weißtanne
Larix decidua	Lærk	Europese lariks	European larch	Euroopanlehtikuusi	Mélèze d'Europe	Europäische Lärche

Botanical name	Greek	Italian	Portuguese	Russian	Spanish	Swedish
Fagus sylvatica	Οξυά δασική	Faggio	Faia	бук лесной	Haya	Bok
Quercus petraea	Δρυς απόδισκος	Rovere	Carvalho branco Americano	дуб скальный	Roble albar	Bergek
Quercus robur	Δρυς ποδισκοφόρος	Farnia	Carvalho roble	дуб черещатый	Roble común	Ek
Quercus ilex	Αριά	Leccio	Azinheira	дуб каменный	Encina	Stenek
Quercus suber	Φελλοδρύς	Sughera	Sobreiro	дуб пробковый	Alcornoque	Korkek
Pinus sylvestris	Δασική πεύκη	Pino silvestre	Pinheiro silvestre	сосна обыкновенная	Pino silvestre	Tall
Pinus nigra	Μαύρη πεύκη	Pino nero	Pinheiro Austríaco	сосна чёрная	Pino laricio	Svarttall
Pinus pinaster	Θαλασσία πεύκη	Pino marittimo	Pinheiro bravo	сосна приморская	Pino negral	Terpentintall
Pinus halepensis	Χαλέπιος πεύκη	Pino d'Aleppo	Pinheiro de alepo	сосна алеппская	Pino carrasco	Aleppotall
Picea abies	Ερυθρελάτη υψηλή	Abete rosso	Picea	ель европейская	Abeto rojo	Gran
Picea sitchensis	Ερυθρελάτη	Picea di Sitka	Picea de Sitka	ель ситхинская	Picea de Sitka	Sitkagran
Abies alba	Λευκή ελάτη	Abete bianco	Abeto branco	пихта белая	Abeto común	Sivergran
Larix decidua	Λάριξ ευρωπαϊκή	Larice	Larício Europeu	литвенница европейская	Alerce	Europeisklärk

Annex IV

Testing statistical significance of the differences in mean plot defoliation between two years of assessment.

Differences between mean plot defoliation were statistically examined for Common Sample Plots (CSPs) using the following test statistic:

$$t = \frac{\left|\bar{x}_{2005} - \bar{x}_{2004}\right|}{\sqrt{\frac{s^2}{n_{2005}} + \frac{s^2}{n_{2004}}}}$$

where $\bar{x}_{2005} - \bar{x}_{2004}$ is the difference in mean plot defoliation between the assessments in 2004 and 2005,

s - the standard deviation of these differences,

n_{2005}, n_{2004} - number of sample trees on plots being tested.

The standard deviation s is calculated as follows

$$s = \sqrt{\frac{(n_{2005} - 1)s_{2005}^2 + (n_{2004} - 1)s_{2004}^2}{n_{2005} + n_{2004} - 2}}$$

with standard deviations s_{2005}, s_{2004} derived from the defoliation scores for the years 2005 and 2004 on the plots investigated.

The minimal difference for qualifying a plot as having changed its mean defoliation was 5% and more. This applies to the map in Annex I-7. This additional criterion to the formal statistical test was chosen since 5% is the highest accuracy in the assessment of defoliation in the field.

Annex V
Addresses

1. UN/ECE, ICP Forests and the European Commission

UN/ECE	United Nations Economic Commission for Europe Environment and Human Settlements Division Air Pollution Unit Palais des Nations 1211 GENEVA 10 SWITZERLAND Phone: +41 22 91 71 234/-91 72 358 Fax: +41 22 90 70 107 e-mail: keith.bull@unece.org; Matti.Johansson@unece.org Mr Keith Bull Mr Matti Johansson
ICP Forests	International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests Bundesforschungsanstalt für Forst- und Holzwirtschaft Leuschnerstr. 91 21031 HAMBURG GERMANY Phone: +49 40 739 62 100/Fax: +49 40 739 62 299 e-mail: m.koehl@holz.uni-hamburg.de Mr Michael Köhl, Chairman of ICP Forests
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. 533 Postfach 14 02 70 53107 BONN GERMANY Phone: +49 228 529-4130/Fax: +49 228 529-4318 e-mail: sigrid.strich@bmelv.bund.de Ms Sigrid Strich
PCC of ICP Forests	Programme Coordinating Centre of ICP Forests Bundesforschungsanstalt für Forst- und Holzwirtschaft Leuschnerstr. 91 21031 HAMBURG GERMANY Phone: +49 40 739 62 140/Fax: +49 40 739 62 480 e-mail: lorenz@holz.uni-hamburg.de Internet: http://www.icp-forests.org Mr Martin Lorenz
EC	European Commission DG ENV B.3 Avenue Beaulieu 9 1160 BRUSSELS BELGIUM Phone: +32 2 2957979/ Fax: +32 2 2968824 e-mail: robert.flies@cec.eu.int Internet: http://www.europa.eu.int/comm/environment Mr Robert Flies

European Commission - DG Joint Research Centre	Institute for Environment and Sustainability, LMU - INFOREST (TP 261) Via E. Fermi 1 21020 ISPRA (VA) ITALY http://inforest.jrc.it/ Phone: +39 0332 786138, Fax: +39 0332 785500 e-mail: jesus.san-miguel@jrc.it, Mr Jesus San Miguel Phone: +39 0332 786362 | Fax: +39 0332 789803 e-mail: annemarie.bastrup-birk@jrc.it Ms Annemarie Bastrup-Birk

2. Expert Panels, WG and other Coordinating Institutions

Expert Panel on Soil and Soil Solution	Laboratorium Bodemkunde Universiteit Gent Geologisch Instituut Krijgslaan 281 9000 GENT BELGIUM Phone: +32 9 264 46 37/Fax: +32 9 264 49 97 e-mail: eric.vanranst@ugent.be Mr Eric van Ranst, Chairman
	Research Institute for Forest and Nature Gaverstraat 4 9500 GERAARDSBERGEN BELGIUM Phone: +32 54 43 7111/Fax: +32 54 43 6160 e-mail: bruno.devos@inbo.be Mr Bruno De Vos, Co-Chairman
Working Group on Soil Solution	Finnish Forest Research Institute (METLA) Rovaniemi Research Station Eteläranta 55 96300 ROVANIEMI FINLAND Phone: +358 10 211 4552 / Fax: +358 10 211 4552 e-mail: john.derome@metla.fi Mr John Derome
Expert Panel on Foliar Analysis and Litterfall	Finnish Forest Research Institute Kaironiementie 54 39700 PARKANO FINLAND Phone: +358 10 2111/Fax: +358 10 211 4001 e-mail: pasi.rautio@metla.fi Mr Pasi Rautio, Chairman

Expert Panel on Forest Growth	Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft WSL Zürcherstr. 111 8903 BIRMENSDORF SWITZERLAND Phone: +41 44 739 25 94/Fax: +41 44 739 22 15 e-mail: dobbertin@wsl.ch Mr Matthias Dobbertin, Chairman
	Bundesforschungs- und Ausbildungszentrum für Wald, Naturgefahren und Landschaft (BFW) Seckendorff-Gudentweg 8 1131 WIEN AUSTRIA Phone: +43 1 878 38 1327/Fax: +43 1 878 38 1250 e-mail: markus.neumann@bfw.gv.at Mr Markus Neumann, Co-Chairman
	Forest Research Station Alice Holt Lodge Wrecclesham, Farnham Surrey GU10 4LH United Kingdom e-mail: Sam.Evans@forestry.gsi.gov.uk Mr Sam Evans, Co-Chairman
Expert Panel on Deposition Measurements	Norwegian Forest and Landscape Institute Raveien 9 1432 AS NORWAY Phone: +47 64 94 8892/Fax: +47 64 94 2980 e-mail: Nicholas.Clarke@skogoglandskap.no Mr Nicholas Clarke, Chairman
Working Group on Ambient Air Quality	CEAM c/Charles Darvin, 14 46980 PATERNA SPAIN e-mail: MJose@ceam.es Ms M. Sanz, Chairwoman
	Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft (WSL) Zürcherstr. 111 8903 BIRMENSDORF SWITZERLAND Phone: +41 44 7392 564/Fax: +41 44 7392 215 e-mail: marcus.schaub@wsl.ch Mr Marcus Schaub, Vice-Chairman

Expert Panel on Crown Condition Assessment	Nordwestdeutsche Forstliche Versuchsanstalt Grätzelstr. 2 37079 Göttingen GERMANY Phone: +49 551 69401 222/Fax: +49 551 -69401-160 e-mail: johannes.eichhorn@nw-fva.de Mr Johannes Eichhorn, Chairman Mr Marco Ferretti, Vice-chairman e-mail: marcoferretti_004@fastwebnet.it Mr Andras Szepesi, Vice-chairman e-mail: szepesi.andras@aesz.hu
ad hoc Group on Quality Assurance within Crown Condition Assessments	Forest Research Station Alice Holt Lodge, Wrecclesham FARNHAM SURREY GU10 4LH UNITED KINGDOM Phone: +44 1 420 526202/Fax: +44 1 420 23653 e-mail: d.durrant@forestry.gov.uk Mr. Dave Durrant
Expert Panel on Biodiversity and Ground Vegetation Assessment	Coillte Teoranta Research and Development Newtownmountkennedy CO. WICKLOW IRELAND Phone: +353 120 11 162/Fax: +3531 20 111 99 e-mail: Pat.Neville@coillte.ie Mr Pat Neville, Chairman Ministry for Agriculture and Forestry Policy VI Div. - National Forest Service CONECOFOR Office via Carducci 5 00187 ROMA ITALY Phone: +39 06 46656084/184/284/Fax: +39 06 42815632 e-mail: conecofor@corpoforestale.it Mr Bruno Petriccione, Co-Chairman
ad hoc Group on Assessment of Biotic Damage Causes	Institute for Forestry and Game Management Gaverstraat 4 9500 GERAARDSBERGEN BELGIUM Tel. +32 54 43 71 15/Fax: +32 54 43 61 60 e-mail: peter.roskams@inbo.be Mr Peter Roskams, Chairman
WG on Quality Assurance and Quality Control in Laboratories	C.N.R. Institute Ecosystem Study Largo Tonolli 50 28922 Pallanza (VB) ITALIA Phone: +0323 518300/Fax: +0323 556513 e-mail: r.mosello@ise.cnr.it Mr Rosario Mosello, Chairman

Expert Panel on Meteorology and Phenology	Bavarian State Institute of Forestry Am Hochanger 13 85354 FREISING GERMANY Phone: +49 (8161) 71 – 4921Fax: e-mail: ras@lwf.uni-muenchen.de Mr Stephan Raspe, Chairman
	Finnish Forest Research Institute Punkaharju Research Station Finlandtie 18 58450 PUNKAHARJU FINLAND Phone: +358 211 4010/Fax: +358 211 4001 e-mail: egbert.beuker@metla.fi Mr Egbert Beuker, Co-chairman Phenology
FFCC	Bundesamt und Forschungszentrum für Wald Seckendorff-Gudent-Weg 8 1131 WIEN AUSTRIA Phone: +43-1-87838-1114/ Fax:+43-1-87838-1250 e-mail: alfred.fuerst@bfw.gv.at Mr Alfred Fürst
FSCC	Research Institute for Forest and Nature - INBO Gaverstraat 4 9500 GERAARDSBERGEN BELGIUM Phone: + 32 (0) 54 43 61 75/Fax: + 32 (0) 54 436160 e-mail: FSCC@inbo.be Ms Nathalie Cools

3. Ministries (Min) and National Focal Centres (NFC)

Albania (Min)	Ministry of the Environment Dep. of Biodiversity and Natural Resources Management Rruga e Durresit Nr. 27 TIRANA ALBANIA Phone: +355 4 270 630 7 624 Fax: +355 4 270 627 e-mail: cep@cep.tirana.al
(NFC)	Institute of Forestry and Pasture Research Kongresi i Lushnjes 33/1/5 P.O.Box 74 TIRANA ALBANIA Phone/Fax: +355 42 31595

Andorra (Min) (NFC)	Ministry of Agriculture and Environment Environmental Department C/Prat de la Creu núm. 62-64 ANDORRA LA VELLA Phone : +376-875707 e-mail: area_epr_ambiental@govern.ad Ms Anna Moles/Ms Silvia Ferrer
Austria (NFC)	Bundesforschungs- und Ausbildungszentrum für Wald, Naturgefahren und Landschaft (BFW) Seckendorff-Gudent-Weg 8 1131 WIEN AUSTRIA Phone: +43 1 878 38 1327/Fax: +43 1 878 38 1250 e-mail: ferdinand.kristoefel@bfw.gv.at Mr. Ferdinand Kristöfel markus.neumann@bfw.gv.at Mr Markus Neumann
(Min)	Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft Marxergasse 2 1030 WIEN AUSTRIA Phone: +43 1 71100 7218/Fax: +43 1 71100 7399 e-mail: rudolf.themessl@bmlf.gv.at Mr R. Themessl
Belarus (NFC)	Forest Inventory republican unitary company "Belgosles" 27, Zheleznodorozhnaja St. 220089 MINSK BELARUS Phone: +375 17 2263105/Fax: +375 17 226 3092 e-mail: belgosles@open.minsk.by Mr V. Kastsiukevich
(Min)	Committee of Forestry Chkalov-Street 6 220039 MINSK BELARUS Phone: +375 172 24 03/Fax: +375 172 24 41 83 e-mail: belgosles@open.minsk.by Mr N. Kruk
Belgium *Wallonia* (Min) (NFC)	Ministère de la Région Wallonne Div. de la Nature et des Forêts Dir. des Ressources Forestières Avenue Prince de Liège, 15 5000 NAMUR BELGIUM Phone: +32 81 33 58 42/Fax: +32 81 33 58 33 e-mail: c.laurent@mrw.wallonie.be Mr C. Laurent Mr E. Gérard

Flanders (Min)	AMINAL – Forest and Green Areas Division Graf de Ferraris-gebouw Koning Albert II laan 20 – bus 8 1000 BRUSSELS BELGIUM Phone: +322 553 81 02/Fax: +322 553 81 05 e-mail: carl.deschepper@lin.vlaanderen.be Mr Carl De Schepper
Flanders (NFC)	Research Institute for Forest and Nature Gaverstraat 4 9500 GERAARDSBERGEN BELGIUM Tel. +32 54 43 71 15/Fax: +32 54 43 61 60 e-mail: peter.roskams@inbo.be Mr Peter Roskams
Bulgaria (Min) (NFC)	Ministry of Environment and Waters National Centre of Environment and Sustainable Development 136, Tzar Boris III blvd. 1618 SOFIA BULGARIA Phone: +359 2 955 98 11/Fax:+359 2 955 90 15 e-mail: forest@nfp-bg.eionet.eu.int Ms. Penka Stoichkova / Mr. Dimitar Kantardjiev (Level I) e-mail: forest@nfp-bg.eionet.eu.int Ms Genoveva Popova (Level II)
Canada (Min) (NFC)	Natural Resources Canada 580 Booth Street OTTAWA, ONT K1A 0E4 CANADA Phone: +1 613 947 9060/Fax: +1 613 947 9035 e-mail: bmcafee@NRCan.gc.ca Ms Brenda McAfee
Quebec (Min) (NFC)	Ministère des Ressources naturelles Direction de la recherche forestière Forêt Quebec Complexe scientifique 2700, Einstein STE. FOY - QUEBEC G1P 3W8 CANADA Phone: + 418 643-7994 Ext. 384/Fax: + 418 643-2165 e-mail: rock.ouimet@mrn.gouv.qc.ca Mr Rock Ouimet
Croatia (NFC)	Sumarski Institut Cvjetno Naselje 41 10450 JASTREBARSKO CROATIA Phone: +385 1 6273 000/Fax: + 385 1 6273 035 e-mail: josog@sumins.hr Mr Joso Gracan

Cyprus (Min) (NFC)	Ministry of Agriculture, Natural Resources and Environment Cyprus Forestry Department P.O.Box 4157 1414-NIKOSIA CYPRUS Phone: +357 22 819490/Fax: +357 22 303935 e-mail: achristou@fd.moa.gov.cy, publicity@fd.moa.gov.cy Mr Andreas K. Christou
Czech Republic (NFC)	Forestry and Game Management Research Institute (VULHM) Zbraslav Strnady 136 15604 PRAHA 516 CZECH REPUBLIC Phone: +420 2 57892222/Fax: +420 2 57921444 e-mail: lomsky@vulhm.cz Mr Bohumir Lomsky
(Min)	Ministerstvo zemedelstvi CR, Odbor lesniho hospodarstvi Tesnov 17 11705 PRAHA 1 CZECH REPUBLIC Phone: +42 02 2181 2677/Fax: +420 2 2181 2988 Mr Tomas Krejzar
Denmark (NFC)	Danish Forest and Landscape Research Institute Hörsholm Kongevej 11 2970 HÖRSHOLM DENMARK Phone: +45 3528 1672 /Fax: +45 3528 1517 e-mail: lv@kvl.dk Mr Lars Vesterdal
(Min)	Minstry of Environment and Energy Danish Forest and Nature Agency Haraldsgade 53 2100 COPENHAGEN DENMARK Phone: +45 3947 2000/Fax: +45 3927 9899 e-mail:k06@sns.dk Ms Agnete Thomsen
Estonia (NFC)	Estonian Centre for Forest Protection and Silviculture Rôômu tee 2 51013 TARTU ESTONIA Phone:+3727 339 713/Fax: +3727 339 464 e-mail: mmk@uninet.ee / kalle.karoles@metsad.ee Mr Kalle Karoles, Director

(Min)	Ministry of Environment Forest Department Bureau of Ecosystems Toompuiestee 24 15172 TALLINN ESTONIA Phone: +27 2 6262902/Fax:+2726 262 801 e-mail: olav.etverk@ekm.envir.ee Mr Olav Etverk
Finland (NFC)	Finnish Forest Research Institute (METLA) Rovaniemi Research Station Eteläranta 55 96300 ROVANIEMI FINLAND Phone: +358 10 211 4552 / Fax: +358 10 211 4001 e-mail: john.derome@metla.fi Mr John Derome
(Min)	Ministry of Agriculture and Forestry, Department of Forestry Hallituskatu 3 A - Helsinki P.O.Box 30, 00023 GOVERNMENT FINLAND Phone: +358 9 160 52407 / Fax +358 9 160 52430 e-mail: anne.vehvilainen@mmm.fi Ms Anne Vehvilainen
France (Min) (NFC)	Ministère de l'agriculture et de la pêche Direction de générale de la forêt et des affaires rurales Sous-Direction de la forêt et du bois Département de la santé des forêts 19, avenue du Maine 75732 PARIS Cedex 15 FRANCE Phone: +33 1 49 55 51 95/Fax: +33 1 49 55 57 67 e-mail : jean-luc.flot@agriculture.gouv.fr Mr Jean Luc Flot
Germany (Min) (NFC)	Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz – Ref. 533 Postfach 14 02 70 53107 BONN GERMANY Phone: +49 228 529-4130/Fax: +49 228 529-4318 e-mail: sigrid.strich@bmelv.bund.de
Greece (NFC)	Institute of Mediterranean Forest Ecosystems Terma Alkmanos P.O. Box 14180 11528 ATHENS-ILISSIA GREECE Phone: +30210-7784240/Fax: +30210-7784602 e-mail: mpag@fria.gr, oika@fria.gr Mr George Baloutsos, Mr. Anastasios Economou
(Min)	Ministry of Rural Development and Foods

	Gen. Secretariat for Forests and the Natural Environment Dir. of Forest Resources Development 31, Chalkokondili street 101 64 ATHENS GREECE Phone: +30 210 52 42 3497Fax: +30 210 52 44 135 e-mail: pbalatso@yahoo.com, skollarou@yahoo.gr Mr Panagiotis Balatsos, Mrs Sofia Kollarou
Hungary (NFC)	State Forest Service Széchenyi u. 14 1054 BUDAPEST 5 HUNGARY Phone: +36 1 37 43 216/Fax: +36-1-3743206 e-mail: szepesi.andras@aesz.hu Mr Andras Szepesi
(Min)	Ministry of Agriculture and Regional Development Department of Forestry Kossuth Lajos tér 11 1055 BUDAPEST HUNGARY Phone: +36 1 301 4025/Fax: +36 1 301 4678 e-mail: tamas.szedlak@fvm.hu Mr Tamas Szedlak
Ireland (NFC)	Coillte Teoranta Research and Development Newtownmountkennedy CO. WICKLOW IRELAND Phone: +353 120 11 162/Fax: +3531 20 111 99 e-mail: Pat.Neville@coillte.ie Mr Pat Neville
(Min)	Forest Service Department of Agriculture and Food Davitt House CASTLEBAR, CO. MAYO IRELAND Phone: +353 (0)94 9042925/Fax: +353 (0)94 9023633 e-mail: Orla.Fahy@agriculture.gov.ie Ms Orla Fahy
Italy (Min) (NFC)	Ministry for Agriculture and Forestry Policy VI Div. - National Forest Service CONECOFOR Office via Carducci 5 00187 ROMA ITALY Phone: +39 06 46656084/184/284/Fax: +39 06 42815632 e-mail: conecofor@corpoforestale.it Mr Bruno Petriccione

Latvia (Min)	Ministry of Agriculture Department of Forest Resources and Forest Economy Republikas laukums 2 1981 RIGA LATVIA Phone: +371 7027285/ Fax:+371 7027094 e-mail: lasma.abolina@zm.gov.lv Ms Lasma Abolina
(NFC)	State Forest Service of Latvia Division of Environment Protection 13. Janvara iela 15 1932 RIGA LATVIA Phone: +371 7222820/Fax: +371 7211176 e-mail: ieva.zadeika@vmd.gov.lv Ms Ieva Zadeika
Liechtenstein (Min) (NFC)	Amt für Wald, Natur und Landschaft Dr. Grass-Strasse 10 9490 VADUZ FÜRSTENTUM LIECHTENSTEIN Phone: +423 236 64 01/Fax: +423 236 64 11 e-mail: felix.naescher@awnl.llv.li Mr Felix Näscher
Lithuania (NFC)	State Forest Survey Service Pramones ave. 11a 3031 KAUNAS LITHUANIA Phone: +370 37 490210/Fax: +370 37 490251 e-mail: vmt@lvmi.lt Mr Andrius Kuliesis
(Min)	Ministry of Environment Dep. of Forests and Protected Areas A. Juozapaviciaus g. 9 2600 VILNIUS LITHUANIA Phone: +370 2 723648/Fax: +370 2 72 20 29 e-mail: v.vaiciunas@am.lt Mr Valdas Vaiciunas
Luxembourg (Min) (NFC)	Administration des Eaux et Forêts Service de l'Aménagement des Bois et de l'Economie Forestière 16, rue Eugène Ruppert 2453 LUXEMBOURG-Ville (Cloche d’Or) LUXEMBOURG Phone: +352 402 201 206/Fax: +352 402201 250 e-mail: claude.parini@ef.etat.lu Mr Claude Parini

Moldova (Min) (NFC)	State Forest Agency 124 bd. Stefan Cel Mare 2001 CHISINAU REPUBLIC OF MOLDOVA Phone : +37322 27 23 06/Fax : +37322 2773 45 e-mail: icaspiu@starnet.md Mr Anatolie Popusoi
The Netherlands (NFC) (Min)	Ministry of Agriculture, Nature and Food Quality Expertisecentrum LNV P.O.Box 482 6710 BL EDE THE NETHERLANDS Phone: +31 318 822860/Fax: +31 318 822550 e-mail: g.t.m.grimberg@minlnv.nl Mr Gerard Grimberg
Norway (NFC)	Norsk institutt for skog og landskap Norwegian Forest and Landscape Institute Høgskoleveien 8 1432 ÅS NORWAY Phone: +47 64 94 89 92/Fax: +47 64 94 29 80 e-mail: dan.aamlid@skogforsk.no Mr Dan Aamlid
(Min)	Norwegian Pollution Control Authority (SFT) Dep. for Environmental Strategy Section for Environmental Monitoring P. O. Box 8100 Dep Strömsveien 96 0032 OSLO 1 NORWAY Phone: +472 257 3400/Fax: +472 257 67 06 e-mail: tor.johannessen@sft.no Mr Tor Johannessen
Poland (NFC)	Forest Research Institute Bitwy Warszawskiej 1920 nr. 3 00973 WARSZAWA POLAND Phone: +48 22 822 32 01/Fax: +48 22 822 49 35 e-mail: j.wawrzoniak@ibles.waw.pl Mr Jerzy Wawrzoniak
(Min)	Ministerstwo Srodowiska Ministry of Environment Wawelska 52/54 00 922Warszawa POLAND Phone: +48 22 579 2580/Fax: +48 22 579 2290 e-mail: elenart@mos.gov.pl Mr Edward Lenart

Portugal (Min)	Ministério da Agricultura, do Desenvolvimento Rural e das Pescas Direcção-Geral dos Recursos Florestais Av. João Crisostomo 26-28 1069-040 LISBOA PORTUGAL Phone: +351 21 312 48 00/Fax: +351 21 312 49 88 e-mail: info@dgrf.min-agricultura.pt
(NFC)	Direcção Geral dos Recursos Florestais Divisão de Protecção e Conservação Florestal Av. João Crisóstomo 26-28 1069-040 LISBOA PORTUGAL Phone: +351 21 312 48 96/Fax: +351 21 312 49 87 e-mail: mbarros@dgrf.min-agricultura.pt Ms Maria Barros e-mail: jrodrigues@dgrf.min-agricultura.pt Mr José Rodrigues
Romania (Min) (NFC)	Forest Research and Management Institute Sos. Stefanesti nr. 128 sector 2 72904 BUKAREST ROMANIA Phone: +40 21 2406095/Fax (and phone): +40 21 3503245 e-mail: biometrie@icas.ro Mr Romica Tomescu/ Mr. Ovidiu Badea
Russian Fed. (Min)	Ministry of Natural Resources (MINPRIRODA) Dept. of International Cooperation Div. of Environmental Protection and Use of Nature B. Grusinskaya str. 4/6 123995 MOSKVA D-242, GSP-5, RUSSIA Phone: +7 495 252 0300/Fax: +7 495 254 8283 e-mail: korolev@mnr.gov.ru Mr Igor A. Korolev
(NFC)	Russian Academy of Sciences Centre for Forest Ecology and Productivity (CEPF RAS) Profsouznaya st. 84/32 117997 MOSKVA RUSSIA Phone: +7 495 332 23 209/Fax: +7 495 332 26 17 e-mail: lukina@cepl.rssi.ru Ms Natalia Lukina
Serbia and Montenegro (Min)	Ministry for Protection of Natural Resources and Environment Directorate for Forest Republic of Serbia Dr. Ivana Ribara street 91 11000 BEOGRAD SERBIA Phone: +381 11 361 63 68/Fax: 381 11 158 793 e-mail: ekabin@ekoserb.sr.yu / minpsum@ptt.yu Mr Aleksandar Vasiljevic
(NFC)	Institute for Forestry

	Kneza Viseslava street 3 11000 BEOGRAD SERBIA Phone: +381 11 553 454/Fax: +381 11 545 969 e-mail: inszasum@Eunet.yu / nevenic@Eunet.yu Mr Radovan Nevenic
Slovak Republic (NFC)	National Forest Centre Národné Lesnícke Centrum Lesnicky vyskumny ustav T.G. Masaryka 22 96092 ZVOLEN SLOVAK REPUBLIC Phone: +421 45 5314 149/Fax: +421 45 5321 883 e-mail: pavlenda@nlcsk.org Mr Pavel Pavlenda
(Min)	Ministerstvo podohospodarstva Dobrovicova 12 81266 BRATISLAVA SLOVAK REPUBLIC Phone: +4217 59266530 Fax: +4217 59266517 e-mail: carny@mpsr.sanet.sk Mr Juraj Balkovic
Slovenia (NFC)	Gozdarski institut Slovenija Slovenian Forestry Institute Vecna pot 2 1000 LJUBLJANA SLOVENIA Phone +3861 200 78 00/Fax:+3861 257 35 89 e-mail: nike.pogacnik@gozdis.si Ms Nike Krajnc
Spain (NFC)	Dirección General para la Biodiversidad (DGB) Servicio de Protección de los Montes Contra Agentes Nocivos (SPCAN) Gran Vía de San Francisco, 4 28005 MADRID SPAIN Phone: +3491 596 4812/Fax: +3491 596 48 72 e-mail: gsanchez@mma.es Mr Gerardo Sanchez
(Min)	Ministerio de Medio Ambiente Dirección General para la Biodiversidad - DGB Gran Vía de San Francisco, 4 28005 MADRID SPAIN Phone: +34 91 596 48 20/Fax: +34 91 596 48 71 e-mail: jherranz@mma.es Mr José Luis Herranz

Sweden (Min) (NFC)	Swedish Forest Agency Vallgatan 6 551 83 JÖNKÖPING SWEDEN Phone: +46 36 15 57 15/Fax: +46 36 16 61 70 e-mail: sture.wijk@svo.se Mr Sture Wijk
Switzerland (NFC)	Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft (WSL) Zürcherstr. 111 8903 BIRMENSDORF SWITZERLAND Phone: +41 44 739 25 95/Fax: +41 44 739 22 15 e-mail: kraeuchi@wsl.ch Mr Norbert Kräuchi
(Min)	Bundesamt für Umwelt, Wald und Landschaft Eidgenössische Forstdirektion Papiermühlestr. 172 3003 BERN SWITZERLAND Phone: +41 31 324 77 86/Fax: +41 31 324 77 89 e-mail: richard.volz@buwal.admin.ch Mr Richard Volz
Turkey (NFC)	Ormancilik Arastirma Enstitüsü Müdürlügü P.K. 24 Bahcelievler -06561 GAZI-ANKARA TURKEY Phone: +90 312 21 31 734/Fax: +90 312 21 22 944 Mr Yasar Simsek
(Min)	General Directorate of Forestry Orman Genel Mudurlugu Gazi Tesisleri APK 1 Nolu Bina 06561 GAZI-ANKARA TURKEY Phone: +90 312 212 80 42/Fax: +90 312 222 73 36 e-mail: apk@ogm.gov.tr Mr Atatürk Ormanciftligi
Ukraine (NFC)	Ukrainian Research Institute of Forestry and Forest Melioration Laboratory of Forest Monitoring and Certification Pushkinskaja 86 61024 KHARKIV UKRAINE Phone: +38057 7078049/ Fax: +38057 7078057 e-mail: buksha@uriffm.org.ua Mr. Igor F. Buksha

(Min)	State Committee of Forestry of the Ukrainian Republic 5, Chreshchatic 252001 KIEV UKRAINE Phone: +380 44 22 8 78 58/Fax: +380 44 228 77 94 e-mail: yyy@mlg.kiev.ua Mr Victor Kornienko
United Kingdom (NFC)	Forest Research Station Alice Holt Lodge, Wrecclesham FARNHAM SURREY GU10 4LH UNITED KINGDOM Phone: +44 1 420 526202/Fax: +44 1 420 23653 e-mail: andy.moffat@forestry.gsi.gov.uk Mr Andrew J Moffat
(Min)	Air and Environment Quality Division DETR Ashdown House, zone 4/F15 123 Victoria Street LONDON SW1E 6DE UNITED KINGDOM Phone: +44 (0)20 7082 8373/Fax: +44 (0)20 7082 8385 e-mail: alison.vipond@defra.gsi.gov.uk Ms Alison Vipond
United States **of America** (NFC)	USDA Forest Service Pacific Southwest Research Station 4955 Canyon Crest Drive RIVERSIDE, CA 92507 UNITED STATES OF AMERICA Phone: +1 951 680 1562/Fax: +1 951 680 1501 e-mail: abytnerowicz@fs.fed.us Mr Andrzej Bytnerowicz
(Min)	National Program Leader for Atmospheric Sciences USDA Forest Service Wildlife, Fisheries, Watershed & Air Research (WFWAR) RPC-4th P.O. Box 96090 WASHINGTON, DC 20090 UNITED STATES OF AMERICA Phone: +1 703 605 5280/Fax: +703 605 0279 e-mail: ariebau@fs.fed.us Mr Allen Robert Riebau, Ph.D.

For further information please contact:

Federal Research Centre for Forestry and Forest Products
PCC of ICP Forests
Dr. M. Lorenz
Leuschnerstr. 91
D-21031 HAMBURG
Internet: http://www.icp-forests.org
email: m.lorenz@holz.uni-hamburg.de