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ON ASSESSMENT AND MONITORING
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Forest Condition in Europe

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PREFACE

Forest condition in Europe has been monitored by the International Co-operative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) under the Convention on Long-range Transboundary Air Pollution (CLRTAP) of the United Nations Economic Commission for Europe (UNECE) since 1986. In close cooperation with the European Union (EU) and with 39 countries including Canada and the United States of America participating, the programme has over the years grown up into one of the largest biomonitoring networks of the world.

Aimed to assess effects of air pollution on forests, the programme has provided important information for the implementation of clean air policies under CLRTAP of UNECE and will continue to do so in the future. However, its well established infrastructure, its multidisciplinary monitoring approach and its comprehensive data base permit significant contributions to other processes of international environmental politics. It pursues the objectives of Resolutions S1, H1 and L2 and provides information on three out of 27 indicators for sustainable forest management of the Ministerial Conference for the Protection of Forests in Europe (MCPFE). In addition, the soil data of the programme are expected to contribute to the assessment of carbon sinks as a contribution of the European Union to the Kyoto Protocol under the Framework Convention on Climatic Change (FCCC). Besides this, the programme receives increasing attention by research institutions and political bodies outside Europe. An example is its recently launched cooperation with the Acid Deposition Monitoring Network in East Asia (EANET).

The programme 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. On the transnational grid soil condition and foliage chemistry have also been assessed. 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.

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 2003 and presents results of individual studies of the intensive monitoring data made available by the year 2002.

SUMMARY

Eighteen years ago the monitoring of forest condition in Europe started under the International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) of the United Nations Economic Commission for Europe (UNECE) and under the Scheme on the Protection of Forests against Atmospheric Pollution of the European Union (EU). With 39 participating countries, a large-scale monitoring net of more than 6 000 plots and an intensive monitoring net of more than 860 plots the programme is today running one of the largest biomonitoring networks of the world.

In 2003 crown condition was assessed on 311 726 sample trees on 15 551 sample plots of different national grids in 30 of the participating 39 countries. Results on the European scale were derived from a subsample of 131 503 trees on 5 915 plots being part of the 16 x 16 km transnational grid covering 33 countries.The transnational survey of 2003 revealed a mean defoliation of 19.8%. Of the main species, *Quercus robur* and *Q. petraea* had by far the highest mean defoliation (25.9%), followed by *Fagus sylvatica* (20.3%), *Picea abies* (19.6%) and *Pinus sylvestris* (18.7%).

The long-term and medium-term development of defoliation was derived from tracing the annual results of two series of successive years, each of them representing a fixed number of countries in order to avoid distortions due to the inclusion of newly participating countries in the course of time. During the period 1990-2003 the largest increase in mean defoliation occurred on *Quercus ilex* and *Quercus rotundifolia* (from 13.8% to 22.3%). Also mean defoliation of *Fagus sylvatica* has increased since 1990. In contrast *Pinus sylvestris* showed a recovery since the mid 1990s particularly in Belarus, Poland and parts of the Baltic States. This yielded a better crown condition of *Pinus sylvestris* in 2003 than at the beginning of the time series. Also *Picea abies* has recovered since the mid 1990s, but to a lesser extent. It has now approximately the same mean defoliation as in 1990. Of these main species the broadleaves reveal a sharp increase in defoliation from 2002 to 2003, which reflects presumably the summer heat and drought of 2003. The main causes for changes in defoliation reported by the countries are biotic stressors and weather extremes. Defoliation was rarely attributed to depositions of air pollutants by the countries, because the relationship between both stands out against the effects of other factors only in cases of severe local air pollution.

Based on more than 400 intensive monitoring plots, concentrations of nitrate, ammonium and sulphate in bulk deposition were assessed. The results indicate regional differences in concentrations and a decrease in sulphur concentrations in recent years. For the first time the relationship between defoliation and forest growth was evaluated for 237 intensive monitoring plots in 15 countries comprising about 15 000 trees of *Pinus sylvestris, Picea abies* and *Fagus sylvatica*. The results confirm those of earlier studies revealing a tight correlation between the two parameters. However, the recent increases in defoliation have not reduced forest growth as compared to previous times. Tree ring and stem analysis on 46 Level II plots reveal that tree growth has increased over the past decades. The presumed reasons are increased nitrogen deposition, increased temperature, increased availability of carbon dioxide as well as changes in silviculture. First results of a test phase on the monitoring of biodiversity on intensive monitoring plots support the idea that lichens are suitable bioindicators also for large-scale biomonitoring.

1. INTRODUCTION

The present report describes the results of the large-scale transnational survey of the year 2003 and of individual evaluations of the intensive monitoring data. The report is outlined as follows:

Chapter 2 refers to the large-scale crown condition survey. The basic methods of the sampling, assessment and evaluation are described. Moreover results of recent data quality control exercises are provided. The last subchapter presents the results of the crown condition assessment of the year 2003. Emphasis is laid upon the current status and the development of crown condition with respect to species and regions.

Chapter 3 presents thre studies conducted on intensive monitoring plots. The first study analyses trends in bulk deposition. The second study describes forest growth in relationship with atmospheric deposition and crown condition. Third, first results of assessments of the diversity of epiphytic lichens are presented.

Chapter 4 consists of national reports by the participating countries, focussing on crown condition in 2003 as well as on 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 2003

2.1.1 Background

The following sections describe the selection of sample plots, the assessment of stand and site characteristics and the assessment of crown condition. Moreover, measures and results of data quality assurance as well as the evaluation and presentation of the survey results are described. The complete methods of the transnational survey 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) and in Commission Regulation (EEC) No. 1996/87 and its amendments.

2.1.2 Selection of sample plots

2.1.2.1 The transnational survey

The transnational survey aims to assess the spatial development of forest condition at the European level. This 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 the homogeneity of these forests.

In the transnational survey of the year 2003, 5 915 plots were assessed in 30 countries. The number of plots in each participating country is presented in Table 2.1.2.1-1 for the last 13 years. The figures in Table 2.1.2.1-1 are not necessarily identical to those published in previous reports. Consistency checks and subsequent data corrections as well as new data submitted by countries may have caused rearward changes in the data base. For example, in 2000 Belarus submitted new data which dated back to 1997. Italy and Spain completed their plot sample by establishing additional plots. The Czech Republic reduced from 1998 onwards the number of its plots in order to avoid an overrepresentation of its results in the transnational data base.

The spatial distribution of the plots assessed in 2003 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 1991 to 2003 according to the current database.

Country	Number of sample plots												
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Austria	79	77	76	76	76	130	130	130	130	130	130	133	131
Belgium	29	29	29	29	29	29	29	29	30	29	29	29	29
Denmark	25	25	25	25	24	23	22	23	23	21	21	20	20
Finland	359	413	405	382	455	455	460	459	457	453	454	457	453
France	513	505	506	534	543	540	540	537	544	516	519	518	515
Germany	411	414	412	417	417	420	421	421	433	444	446	447	447
Greece	101	98	96	96	95	95	94	93	93	93	92	91	-
Ireland	22	22	22	21	21	21	21	21	20	20	20	20	19
Italy	206	202	212	209	207	207	181	177	239	255	265	258	247
Luxembourg	4	4	4	4	4	4	4	4	4	4	-	4	4
The Netherlands	14	14	13	13	13	12	11	11	11	11	11	11	11
Portugal	151	149	143	147	141	142	144	143	143	143	144	145	136
Spain *	436	462	460	444	454	447	449	452	598	607	607	607	607
Sweden	45	67	59	340	726	766	758	764	764	769	770	769	776
United Kingdom	74	72	69	66	63	79	82	88	85	89	86	86	86
EU	2469	2553	2531	2803	3268	3370	3346	3352	3574	3584	3594	3595	3481
Belarus							416	416	408	408	408	407	406
Bulgaria				109	120	120	120	135	115	108	109	99	106
Croatia			84	88	82	83	86	89	84	83	81	80	78
Cyprus											15	15	15
Czech Republic	362	156	178	205	199	196	196	116	139	139	139	140	140
Estonia			86	90	90	91	91	91	91	90	89	92	93
Hungary	66	65	65	62	63	60	58	59	62	63	63	62	62
Latvia	101	100	101	94	94	99	96	97	98	94	97	97	95
Lithuania		73	74	73	73	67	67	67	67	67	66	66	64
Moldova			12	12	11	10	10	10	10	10	10	-	-
Norway		387	390	384	386	387	386	386	381	382	408	414	411
Poland	476	476	476	441	432	431	431	431	431	431	431	433	433
Romania		215	167	199	241	224	237	235	238	235	232	231	231
Russian Fed.				7	134								
Serbia and Monten.													103
Slovak Republic	111	111	111	111	111	110	110	109	110	111	110	110	108
Slovenia			34	34	42	42	42	41	41	41	41	39	41
Switzerland	45	45	45	45	47	49	49	49	49	49	49	49	48
Total Europe	3630	4181	4354	4757	5393	5339	5741	5683	5898	5895	5942	5929	5915

(*) excluding Canary Islands

Table 2.1.2.1-2: Distribution of the 2003 sample plots over the climatic regions.

Climatic region	Number of plots	Percentage of plots
Boreal	999	16.9
Boreal (Temperate)	940	15.9
Atlantic (North)	338	5.7
Atlantic (South)	285	4.8
Sub-atlantic	1119	18.9
Continental	325	5.5
Mountainous (North)	271	4.6
Mountainous (South)	730	12.3
Mediterranean (Higher)	336	5.7
Mediterranean (Lower)	572	9.7
All regions	5915	100.0

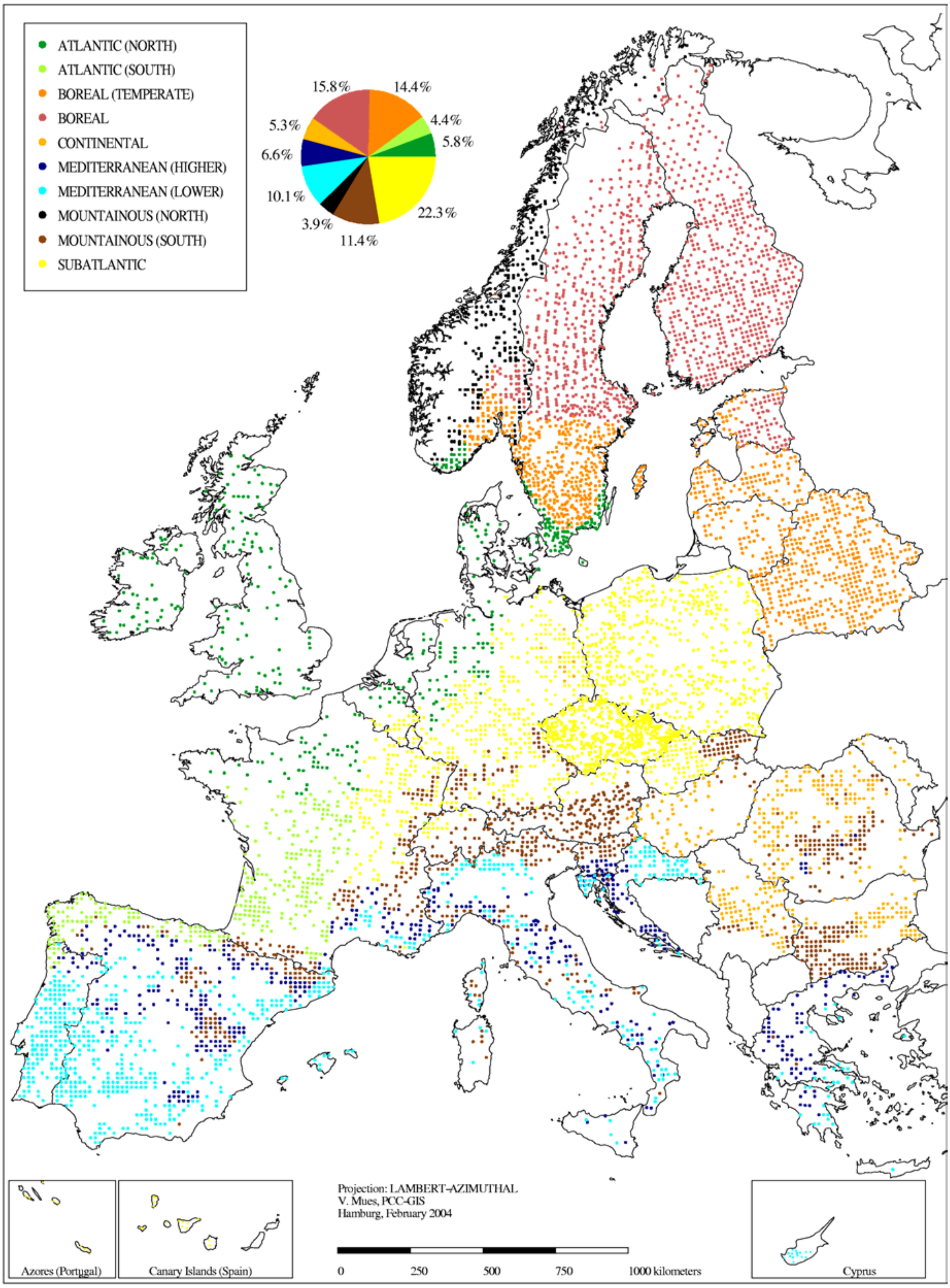

Figure 2.1.2.1-1: Plots according to climatic regions (2003).

2.1.2.2 National surveys

Besides the transnational survey, national surveys are conducted in many countries. These aim at the documentation of forest condition and its development in the respective country. Therefore, the national surveys are conducted on national grids. 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. The national reports of Chapter 4 are based on these data. Any 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

On the plots of the transnational survey, the following plot and tree parameters are reported 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).

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)
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 the EU-Member States. One EU-Member State did not report soil type.

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	131	131	131	131	131	131	126
Belgium	29	29	29	29	29	29	28
Denmark	20	20	20	20	20	20	20
Finland	453	453	453	453	453	453	453
France	515	515	515	515	514	515	515
Germany	447	447	447	447	447	447	411
Ireland	19	19	19	19	19	19	19
Greece	-	-	-	-	-	-	-
Italy	247	247	247	247	247	247	0
Luxembourg	4	4	4	4	4	4	4
The Netherlands	11	11	11	11	11	11	11
Portugal	136	136	136	136	136	136	129
Spain *	607	607	607	607	607	607	431
Sweden	776	776	763	776	776	776	576
United Kingdom	86	86	86	86	86	86	86
EU	3481	3481	3461	3481	3480	3481	2809
Percent of EU plot sample		100.0	99.4	100.0	99.9	100.0	80.7
Belarus	406	405	81	376	406	406	81
Bulgaria	106	106	106	106	106	106	105
Croatia	78	78	78	78	78	78	64
Cyprus	15	15	15	15	15	15	0
Czech Republic	140	140	59	140	140	140	59
Estonia	93	93	93	93	93	93	93
Hungary	62	62	41	62	62	62	62
Latvia	95	95	95	95	95	95	95
Lithuania	64	64	1	64	64	64	64
Rep. of Moldova	-	-	-	-	-	-	-
Norway	411	0	374	411	411	411	368
Poland	433	433	431	433	433	433	38
Romania	231	231	231	231	231	231	221
Serbia	103	103	34	103	102	100	18
Slovak Republic	108	0	108	108	108	108	108
Slovenia	41	41	41	41	41	41	41
Switzerland	48	45	45	48	48	48	45
Total Europe	5915	5392	5294	5885	5913	5912	4271
Percent of total plot sample		91.2	89.5	99.5	99.9	99.9	72.2

(*) excluding Canary Islands

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 (Anonymous, 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.

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 2.1.5). Discolouration is reported both in the transnational and in the national surveys using the traditional classification.

The total numbers of trees assessed from 1991 to 2003 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 2003 tree sample 106 species were reported. 63.5% of the plots were dominated by conifers, 36.5% 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 27.0%, followed by *Picea abies* with 20.1%, *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 1991 to 2003 according to the current database.

Country	Number of sample trees												
	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Austria	2244	2167	2121	2107	2101	3670	3604	3577	3535	3506	3451	3503	3470
Belgium	686	673	685	684	678	684	683	692	696	686	682	684	684
Denmark	600	600	600	600	576	552	528	552	552	504	504	480	480
Finland	3899	4545	4427	4261	8754	8732	8788	8758	8662	8576	8579	8593	8482
France	10255	10093	10118	10672	10851	10800	10800	10740	10883	10317	10373	10355	10298
Germany	10662	10767	10729	10866	10907	10980	10990	13178	13466	13722	13478	13534	13572
Greece	2392	2320	2272	2272	2248	2248	2224	2204	2192	2192	2168	2144	-
Ireland	458	460	462	441	441	441	441	441	417	420	420	424	403
Italy	5741	5643	5884	5791	5703	5836	4873	4939	6710	7128	7350	7165	6866
Luxembourg	96	95	95	93	96	96	96	96	96	96		96	96
The Netherlands	280	280	260	260	257	237	220	220	225	218	231	232	231
Portugal	4585	4508	4308	4414	4230	4260	4319	4290	4290	4290	4320	4350	4080
Spain *	10462	11088	11040	10656	10896	10728	10776	10848	14352	14568	14568	14568	14568
Sweden	265	300	311	3989	10310	10925	10910	11044	11135	11361	11283	11278	11321
United Kingdom	1770	1728	1656	1584	1512	1896	1968	2112	2039	2136	2064	2064	2064
EU	54395	55267	54968	58690	69560	72085	71220	73691	79250	79720	79471	79470	76615
Belarus							9974	9896	9745	9763	9761	9723	9716
Bulgaria				4370	4812	4789	4788	5389	4379	4197	4209	3753	3870
Croatia			2016	2150	1970	1974	2030	2066	2015	1991	1941	1910	1869
Cyprus											360	360	360
Czech Rep	8971	3882	4423	5087	4933	4853	4844	2899	3475	3475	3475	3500	3500
Estonia			2064	2159	2160	2184	2184	2184	2184	2160	2136	2169	2228
Hungary	1371	1348	1361	1322	1342	1298	1257	1383	1470	1488	1469	1446	1446
Latvia	2424	2396	2420	2257	2262	2368	2297	2326	2348	2256	2325	2340	2293
Lithuania		1768	1843	1760	1776	1643	1634	1616	1613	1609	1597	1583	1560
Moldova			288	288	263	236	253	234	259	234	234	-	
Norway		4001	4016	3942	3905	3948	4028	4069	4052	4051	4304	4444	4547
Poland	9520	9520	9520	8820	8640	8620	8620	8620	8620	8620	8620	8660	8660
Romania		5155	4004	4776	5688	5375	5687	5637	5712	5640	5568	5544	5544
Russian Fed.				183	3180								
Serbia and Mont.													2390
Slovak Rep.	5296	5251	5144	5115	5091	5018	5033	5094	5063	5157	5054	5076	5116
Slovenia			816	816	1008	1008	1008	984	984	984	984	936	983
Switzerland	487	488	500	509	824	854	880	868	857	855	834	827	806
Total Europe	82464	89076	93383	102244	117414	116253	125737	126956	132026	132200	132342	131741	131503

(*) excluding Canary Islands

2.1.4 International Cross-calibration Courses

Quality assurance (QA) procedures applied within the transnational crown condition assessments have been described extensively in previous reports (e.g. UNECE and EC, 2001). A recently elaborated concept for future International Cross-calibration Courses (ICCs) aims to derive country specific differences from the scores of the participating national team leaders. At these courses, participants are being asked to use their national methods and not to communicate their estimates in the course of the assessments. The assessment results are subject to statistical evaluations. The aims of the ICCs are to

- document the relative position of individual National Reference Teams (NRTs) within the international context,
- monitor the consistency of NRTs' position through time,
- improve the traceability of the data by establishing a direct connection with the data collected at national level. This will help also explaining anomalous year-by-year fluctuations, and
- explore the relationships between the performance of the various NRTs and the major site and stand characteristics.

In the year 2003 two courses took place. The ICC for Central Europe on *Picea abies* and *Fagus sylvatica* in Germany from 10-13 August 2003 was attended by 18 experts from nine countries. The ICC for Northern Europe on *Pinus sylvestris* and *Betula pendula* in Estonia from 19-22 August 2003 was attended by 14 experts from eight countries.

Every year the host countries are focusing on special issues. In the year 2003 during the ICC in Germany a relatively high number of stands with varying stand density and tree age were prepared to enable an evaluation on aspects related with these variables. In Estonia the participants were asked to make two estimates based on the upper third of the crown and on the entire crown, respectively, or at least to note which part of the crown was assessed. This aimed on possible differences between assessments due to differences in the assessable crown. The main outcomes of the courses are:

- The rank correlations show clearly that the methodologies pursued by the participants lead to a consistent ranking of the trees. This is the most important result and a precondition for any evaluation and presentation of the European monitoring data on forest condition.
- The comparison of the location of the assessment distributions shows for many pairs of teams significant differences. In most cases, however, these differences are low.
- For most pairs of participants a huge part of the tree specific differences are within a range of +/-5%, or at the most +/-10%. Relatively high frequencies of differences of more than +/-20% are exceptions which can be explained by environmental or stand conditions of the test range plots, under which the respective participants are not used to work. Also differences in the definition of the assessable crown are a reason for differences of the assessed values.
- Effects of low experience with special conditions or certain tree species which are less frequent in the home country of a participant are not expected to be important concerning the outcomes of the ICP Forests monitoring system.

The implementation of long term test ranges leads to relatively high efforts for the host countries on the first run. Both host countries of the ICCs 2003 as well as those of the years before did well in managing all the organizational tasks. The re- assessment of the same trees and plots will save time in the future and will thus be an important advantage of the new ICC concept. With respect to the variation of stand and site conditions it can be stated that a reduction of the distance between the test range plots permits a very time effective field work. The evaluation of the photo exercises 2002 and 2003 (LORENZ et al., 2003) showed that there is a significant correlation between field and photo assessments even if both assessments are not always on the same level. In 2004 an international photo exercise will be conducted which will help to utilize this methodology for a wide range of participants in order to improve the documentation of temporal consistency of the ICP Forests defoliation assessments. Especially the combination of ICCs, national Comparison Courses, and photo exercises will be an important task for the future QA/QC work.

2.1.5 Evaluation and presentation of the survey results
2.1.5.1 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).

Table 2.1.5.2-1: 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

2.1.5.2 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 2.1.5.2-1) 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.

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 those 15 countries being EU-Member States.

2.1.5.3 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 mean defoliation was calculated as the mean of defoliation values of the trees 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 3% means an increase by 3% defoliation per year on average. These slopes are called "significant" if there was less than 5% probability that they are different from zero by random variation only.

Besides the temporal development, also the change in the results from 2002 to 2003 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 2002 to 2003 see Annex IV.

2.2 Results of the transnational survey in 2003

2.2.1 Crown condition in 2003

In the transnational survey of the year 2003, defoliation of 131 503 sample trees was assessed on 5 915 sample plots. 21.3% of these trees had a defoliation of more than 25%, i.e. were classified as "damaged" (Table 2.2.1-1). The share of damaged broadleaves exceeded with 22.0% the share of damaged conifers with 19.3%. The percentages of damaged trees are mapped for each plot in Annex I-4.

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

	Species type	Percentage of trees in defoliation class: 0-10%	>10-25%	0-25%	>25-60%	>60%	dead	>25%	Defoliation: Mean	Median	No. of trees
EU	Broad-leaves	27.4	46.2	73.6	22.9	2.6	0.9	26.4	22.4	20	30837
	Conifers	42.6	40.4	83.0	14.9	1.6	0.5	17.0	17.5	15	45778
	All species	36.5	42.7	79.2	18.2	2.0	0.6	20.8	19.5	15	76615
Total Europe	*Fagus sylv.*	31.4	45.7	77.1	20.9	1.6	0.4	22.9	20.3	20	11753
	Quercus robur + Q. petraea	15.7	47.1	62.8	34.0	2.7	0.5	37.2	25.9	25	8262
	Broad-leaves	28.6	45.5	74.1	22.8	2.3	0.8	25.9	22.0	20	53837
	Picea abies	38.5	36.2	74.7	22.8	2.0	0.5	25.3	19.6	15	26469
	Pinus sylv.	33.5	50.3	83.8	14.6	1.1	0.5	16.2	18.7	15	35559
	Conifers	34.9	44.6	79.5	18.3	1.6	0.6	20.5	19.3	15	77666
	All species	32.3	45.0	77.3	20.1	1.9	0.7	22.7	20.4	15	131503

The classical defoliation classes are of uneven width. Therefore, the frequency distributions for the 5% classes in which defoliation data are submitted were calculated. The frequency distributions for the broadleaved trees, the coniferous trees and the total of all trees are shown in Figures 2.2.1-1a and 2.2.1-1b for each climatic region as well as for the total of all regions. The number of trees, the mean defoliation and the median are also given. The maps in Figures 2.2.1-2 to 2.2.1-5 show mean plot defoliation for *Pinus sylvestris*, *Picea abies*, *Fagus sylvatica*, and *Quercus robur* and *Q. petraea*. Plots qualified for inclusion into a map whenever the number of trees of the given species on them was at least three.

For the two main coniferous species, *Pinus sylvestris* and *Picea abies,* the maps show large and partly well defined regions of both high and low defoliation. In contrast, the main broadleaved species, *Fagus sylvatica* as well as *Quercus robur* and *Quercus petraea,* show highly defoliated plots throughout their habitat. Of these species, the defoliation is highest for *Quercus*. Mean defoliation for the total of all regions is 20.4%. A map of mean plot defoliation of all species is given in Annex I-5.

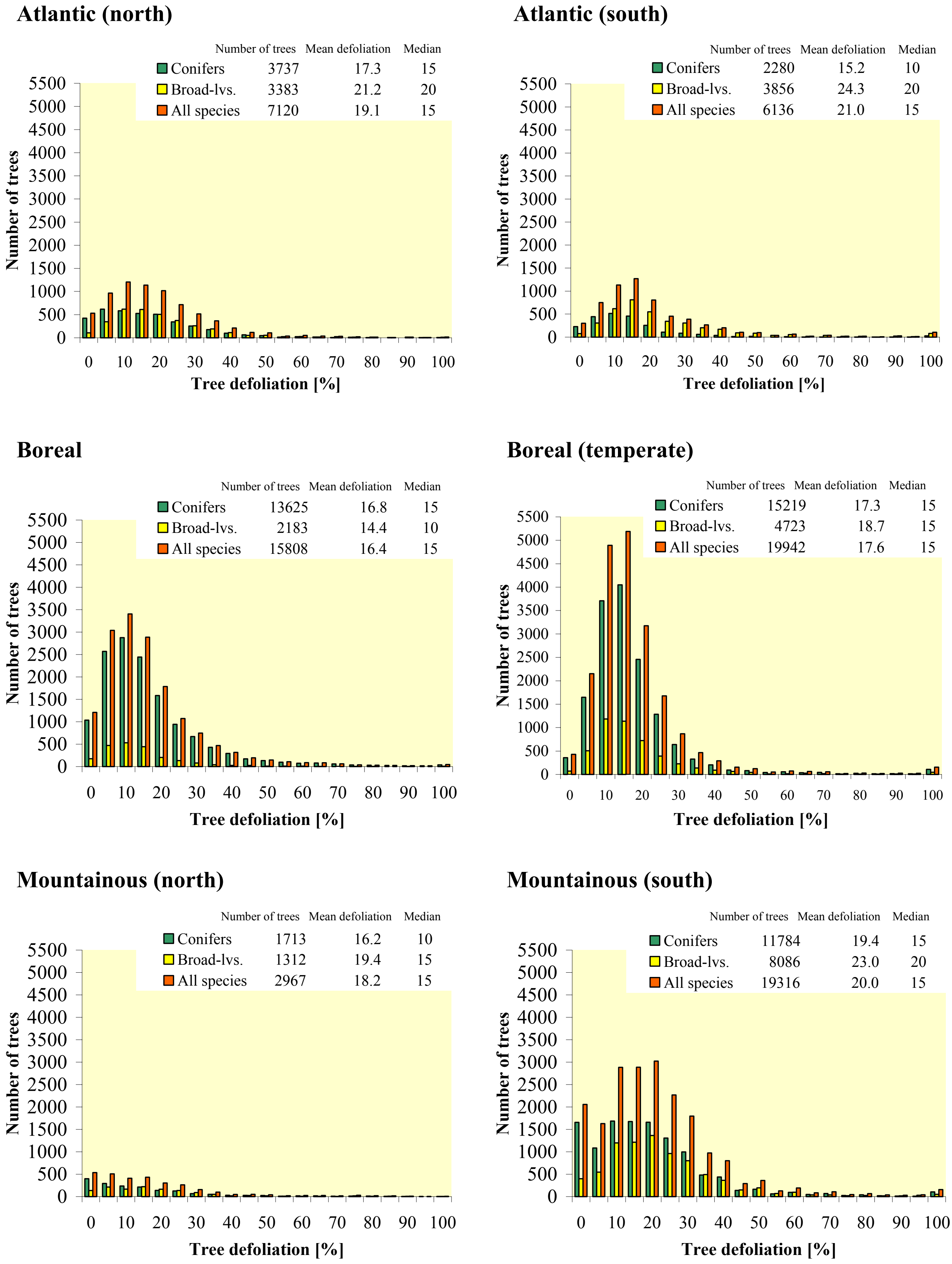

Figure 2.2.1-1a: Frequency distribution of trees in 5%-defoliation steps

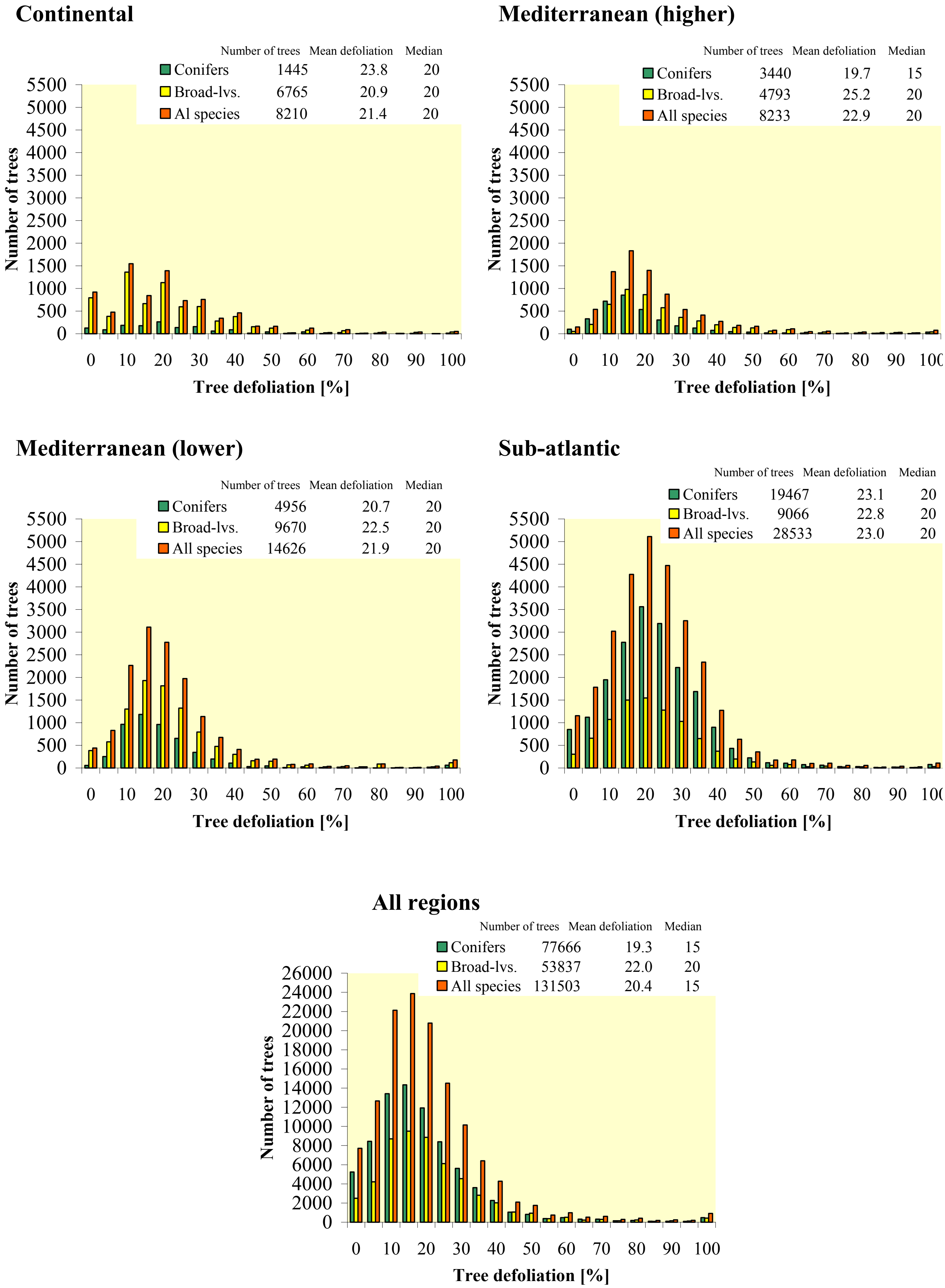

Figure 2.2.1-1b: Frequency distribution of trees in 5%-defoliation steps

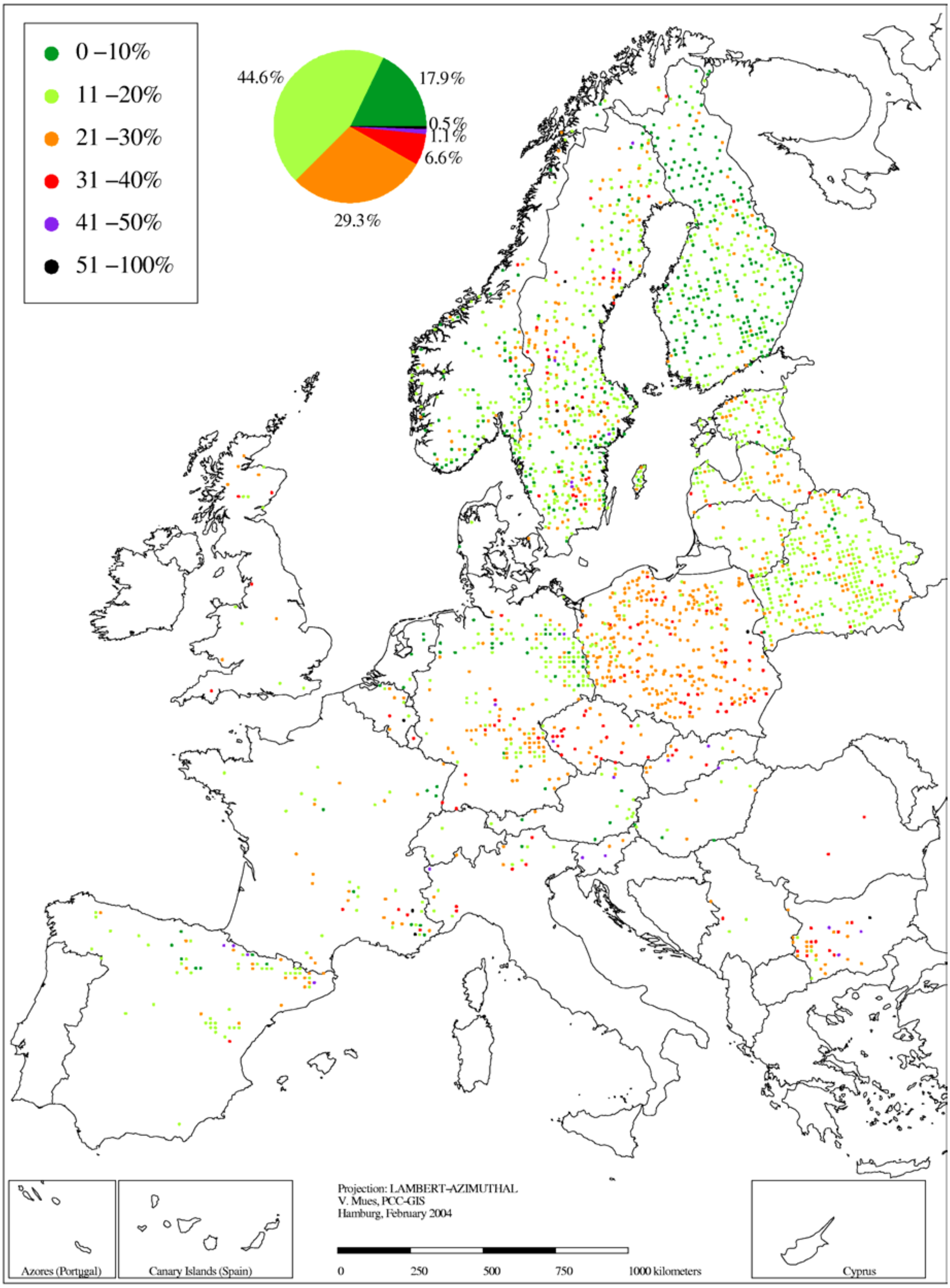

Figure 2.2.1-2: Mean plot defoliation of *Pinus sylvestris*

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

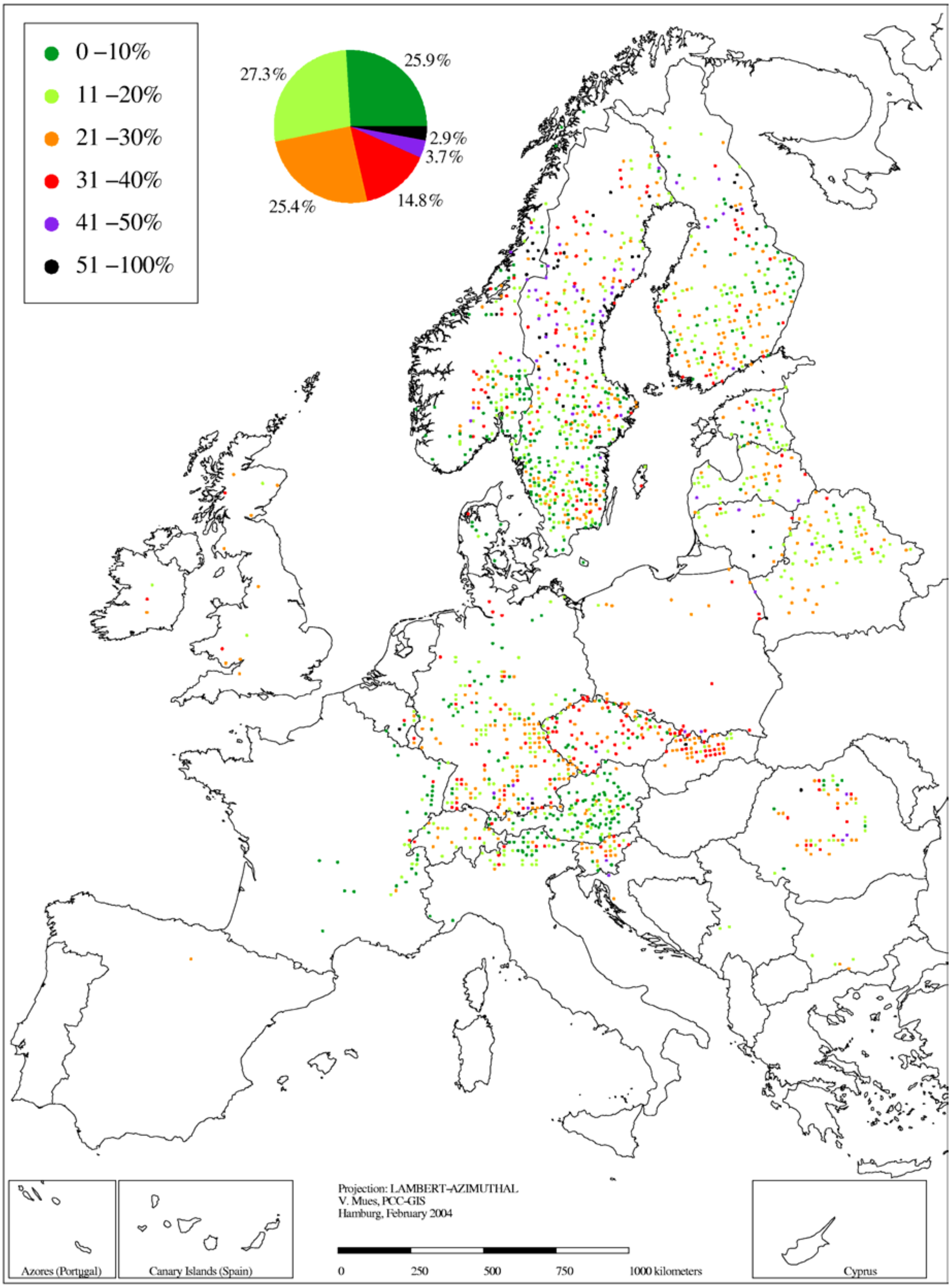

Figure 2.2.1-3: Mean plot defoliation of *Picea abies*

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

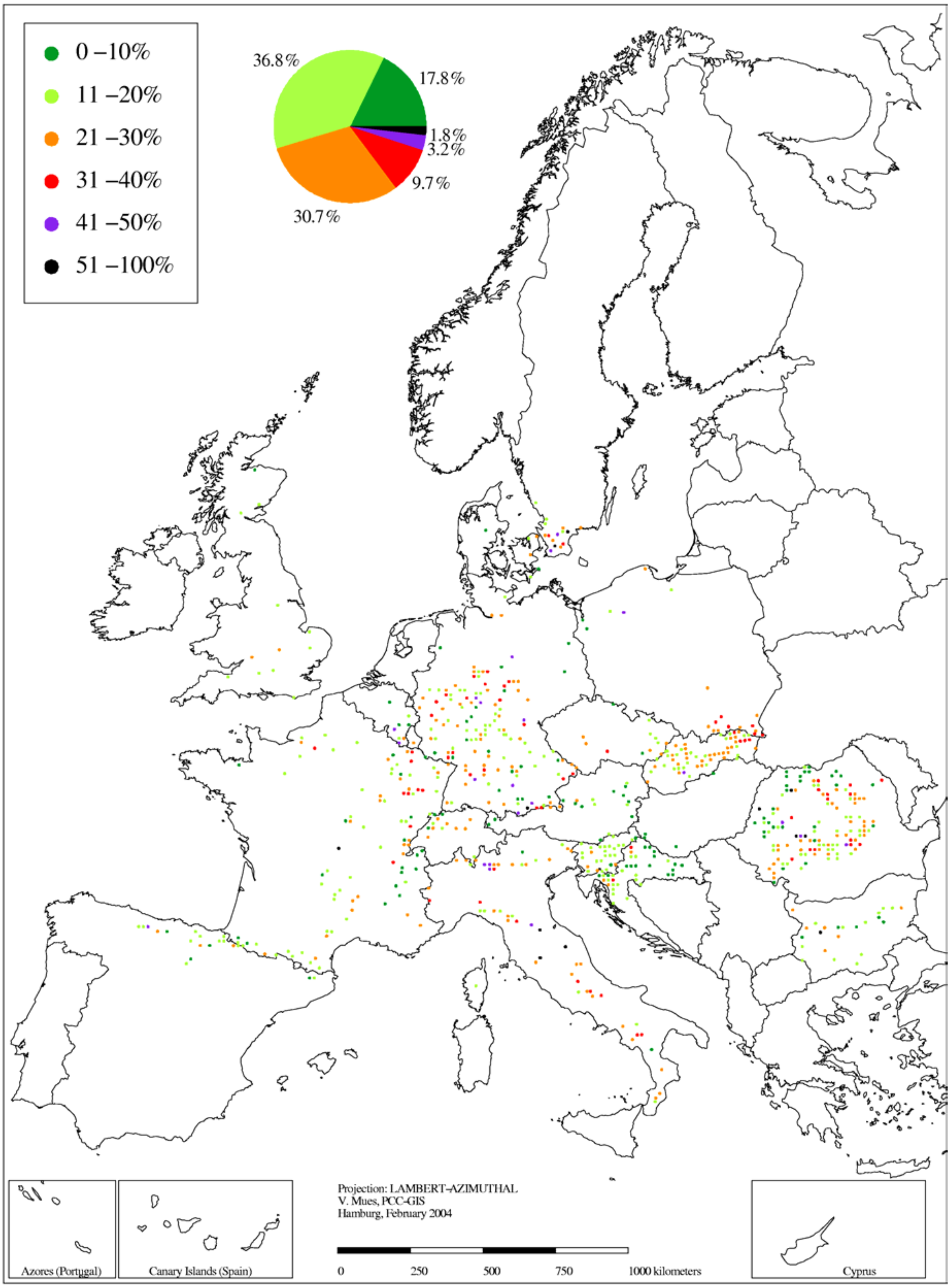

Figure 2.2.1-4: Mean plot defoliation of *Fagus sylvatica*

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

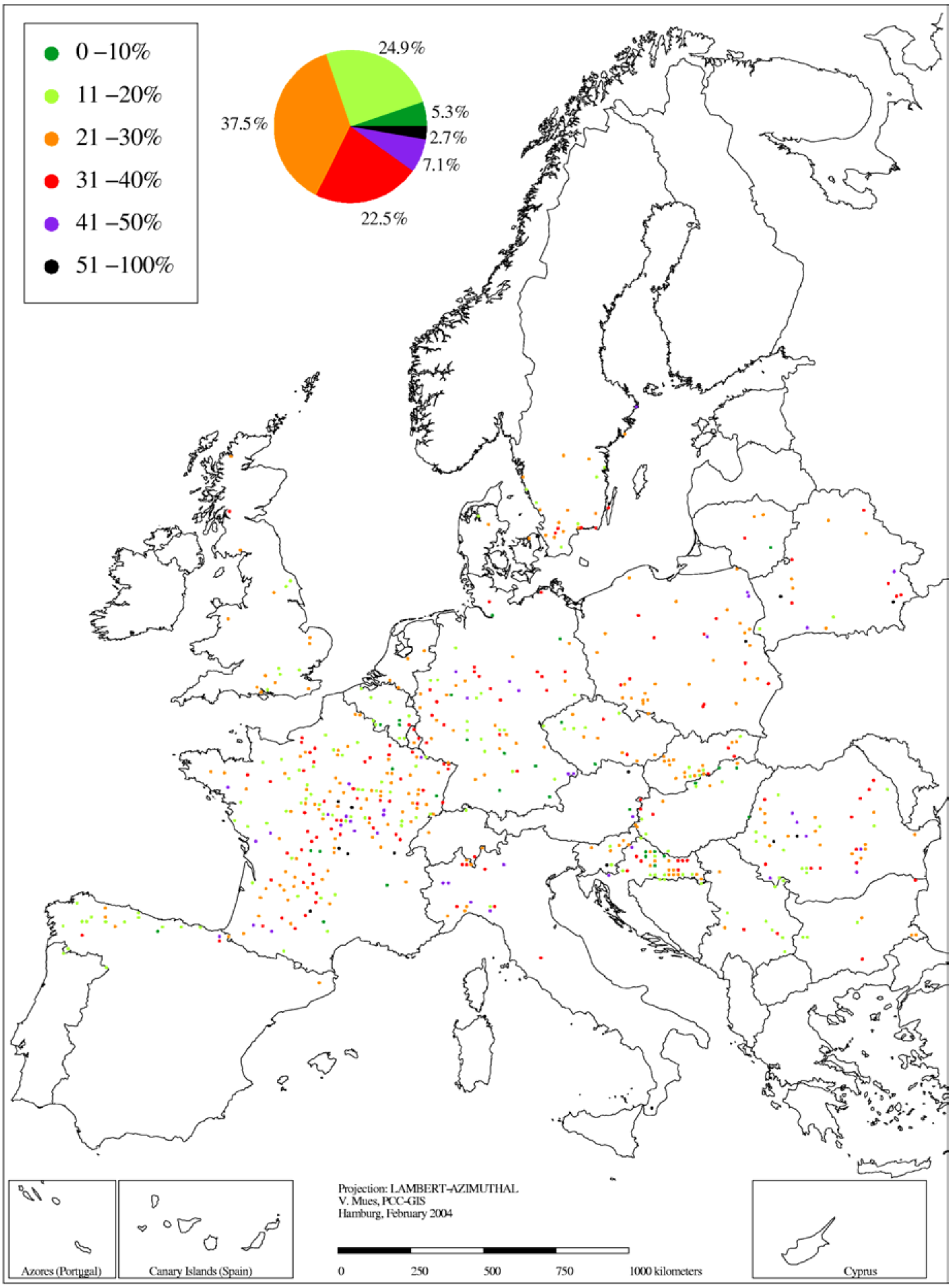

Figure 2.2.1-5: Mean plot defoliation of *Quercus robur* and *Quercus petraea*

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

The share of the discoloured trees (i.e. trees of discolouration greater than 10%) of all species in total Europe was 8.5% (Table 2.2.1-2). Plot discolouration is mapped in Annex I-6.

Table 2.2.1-2: Percentages of trees in discolouration classes 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	89.6	6.4	2.1	1.0	0.9	10.4	30837
	Conifers	94.0	4.0	1.2	0.4	0.4	6.0	45778
	All species	92.2	5.0	1.6	0.6	0.6	7.8	76615
Total Europe	Broad-leaves	88.8	7.6	2.1	0.8	0.7	11.2	53837
	Conifers	93.2	4.6	1.5	0.3	0.4	6.8	77666
	All species	91.5	5.8	1.7	0.5	0.5	8.5	131503

2.2.2 Development of defoliation

2.2.2.1 Background

The development of defoliation was in previous reports traced by means of special samples of those trees having been monitored continuously over a certain period. This tree sample was common to all survey years of the selected period (“common sample trees”). It had the advantage that its defoliation was unaffected by the large numbers of new trees added to the transnational survey in the course of the expansion of the transnational grid due to the increasing number of participating countries. The expansion of the grid has slowed down in recent years and the main drawback of the common sample tree approach becomes of increasing influence: The number of common sample trees becomes smaller and smaller as more and more trees are being felled or die off.

A new approach avoids the mentioned main drawback of the previous one. The basic assumption of the new approach is that the tree sample of each survey year represents forest condition, no matter to which degree it includes sample trees also assessed in other years. 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 is not thought to 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 new approach can be applied only to a defined set 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 1990-2003:
  Belgium, Denmark, Germany (west), Hungary, Ireland, Latvia, Poland, Portugal, Slovak Republic, Spain, Switzerland, and The Netherlands.

- Period 1997-2003:

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.

It must be noted that a six-year time series (1997-2003) is too short to allow a pronouncement on long-term deterioration or improvement. 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 assessements 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 during the two above mentioned periods also the change in mean plot defoliation from 2002 to 2003 was mapped. The result of this biannual comparison is presented in annex I-7. It shows a significant increase in defoliation on 16.3% of the plots, against only 7.1% of the plots showing a decrease. The deteriorating plots are scattered across Europe. The high proportion of them in Sweden is partly attributed to a previous outbreak of *Gremmeniella abietina*. Trends in mean plot defoliation for the period 1997-2003 are mapped in Figure 2.2.2.1-1. The share of plots with distinctly increasing defoliation (15.3%) surmounts the share of plots with decreasing defoliation (10.7%). The latter improving plots are largely concentrated in Belarus. Figure 2.2.2.1-2 shows the development of mean defoliation of the trees of the six most frequent species from 1990 to 2003. The recovery of *Pinus sylvestris* particularly in Belarus, Poland and parts of the Baltic states since the mid 1990s renders this species in 2003 in a better condition than at the beginning of the time series in1990. Also *Picea abies* has recovered in the mid 1990s, but to a lesser extent, and has now approximately the same defoliation as in 1990. Defoliation of *Pinus pinaster* has been undulating around 15% with only a slight increase between 1990 and 2003. *Quercus robur* and *Quercus petraea* have recovered from their peak defoliation in 1996, but defoliation in 2003 was still higher than in 1990. Defoliation of *Fagus sylvatica* has increased since 1990. The largest increase in defoliation occurred on *Quercus ilex* and *Quercus rotundifolia*. All of these species, except *Pinus sylvestris* and *Picea abies*, show a marked increase in defoliation from 2002 to 2003. The trends of defoliation for the time series 1997-2003 are presented in Figure 2.2.2.1-3. The numerical basis behind the latter two graphs can be found in Annex I-9.

Trends in defoliation of the six most frequent species are described in greater detail in Chapters 2.2.2.2 to 2.2.2.7. In each chapter 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 two more species, namely *Abies alba* and *Picea sitchensis* because of their ecological and economical importance in some regions.

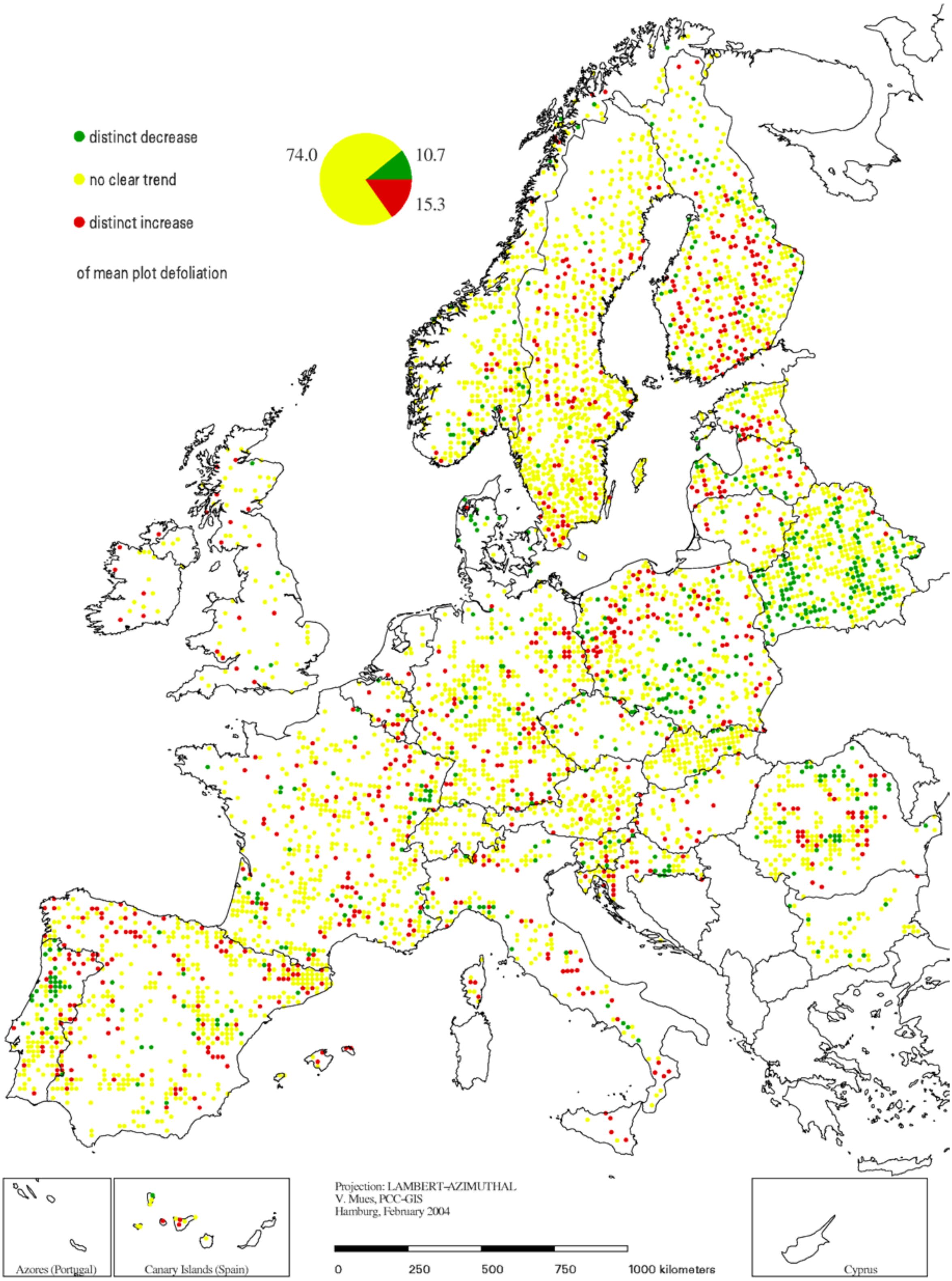

Figure 2.2.2.1-1: Trends of mean plot defoliation of all main species over the years 1997 to 2003.

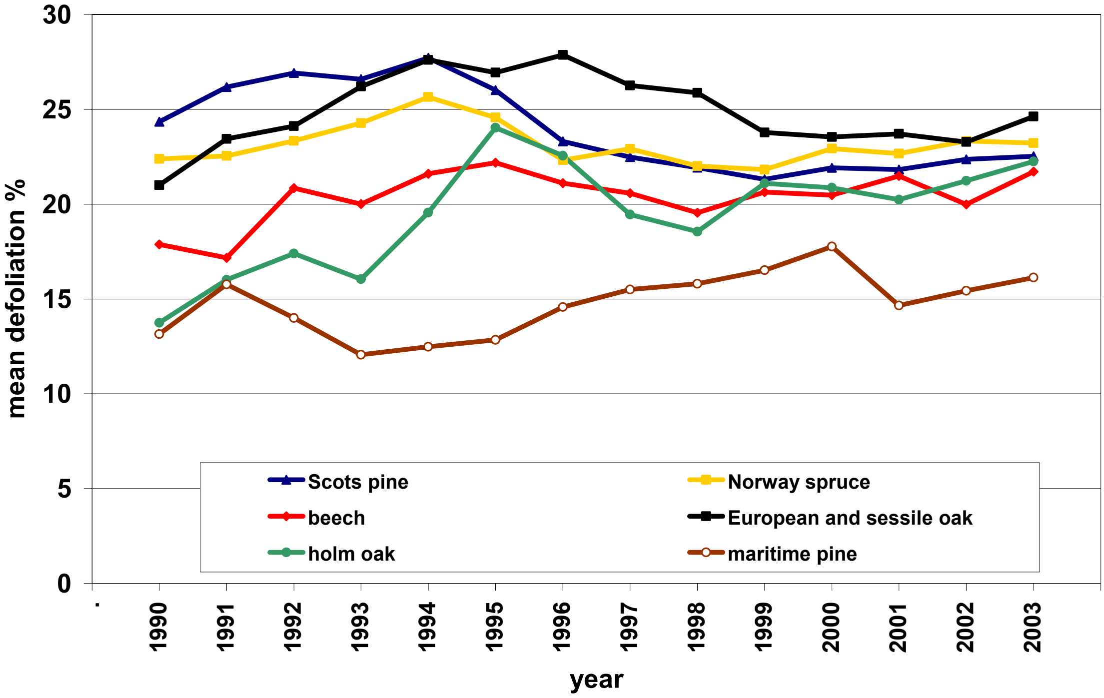

Figure 2.2.2.1-2: Mean defoliation of main species 1990 – 2003.

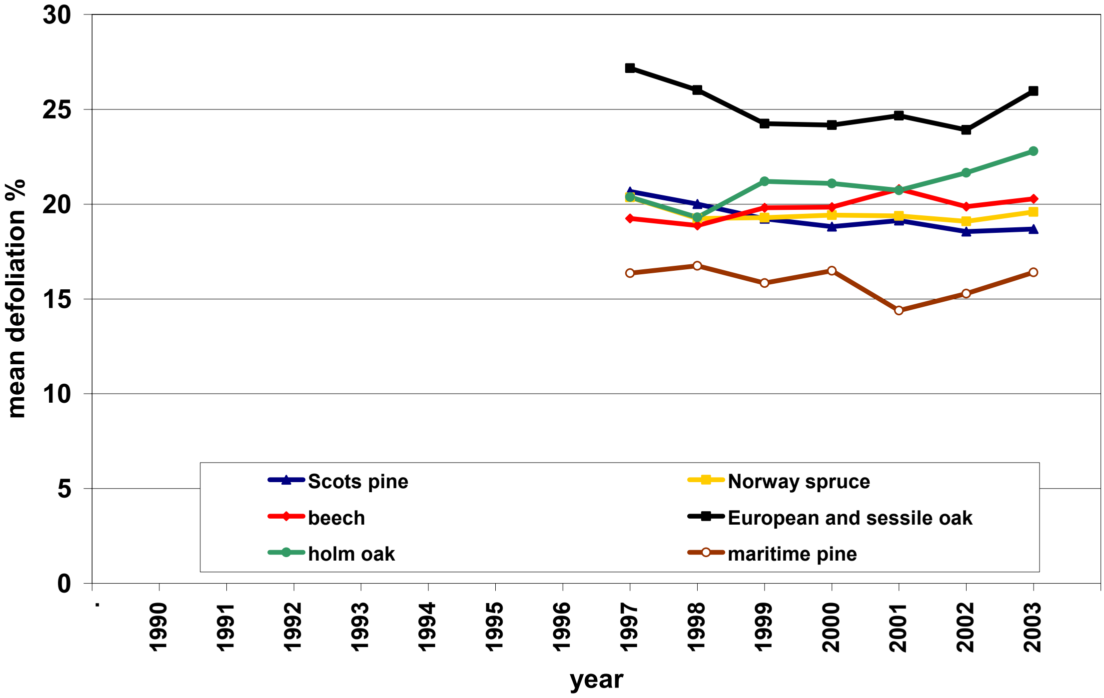

Figure 2.2.2.1-3: Mean defoliation of main species 1997 – 2003.

2.2.2.2 Pinus sylvestris

Pinus sylvestris represents the largest share of sample trees in both periods of investigation, 1990-2003 and 1997-2003. It is the only species present in all climatic regions. Between 1990 and 2003 the share of damaged trees in the total of all regions shows a peak with 46.2% in 1994, followed by a remarkable recuperation to 23.2% in 2003. This recuperation reflects mainly the decreasing defoliation in the Sub-Atlantic region, which represents by far the largest share of trees. The extreme decrease of the share of damaged trees from 70.6% in 1992 to 9.4% in 2003 in the Boreal (temperate) region is based solely on trees in Latvia. The recuperation of *Pinus sylvestris* is absent or less pronounced in other climatic regions, for instance in the Mountainous (south) region (Figure 2.2.2.2-1).

In the period 1997-2003 the recuperation was most pronounced in Belarus, but many recuperating plots are also seen in Poland, Finland, the Baltic states and Germany (Figure 2.2.2.2-2). Especially Poland and Lithuania have attributed the recuperation largely to reduced air pollution.

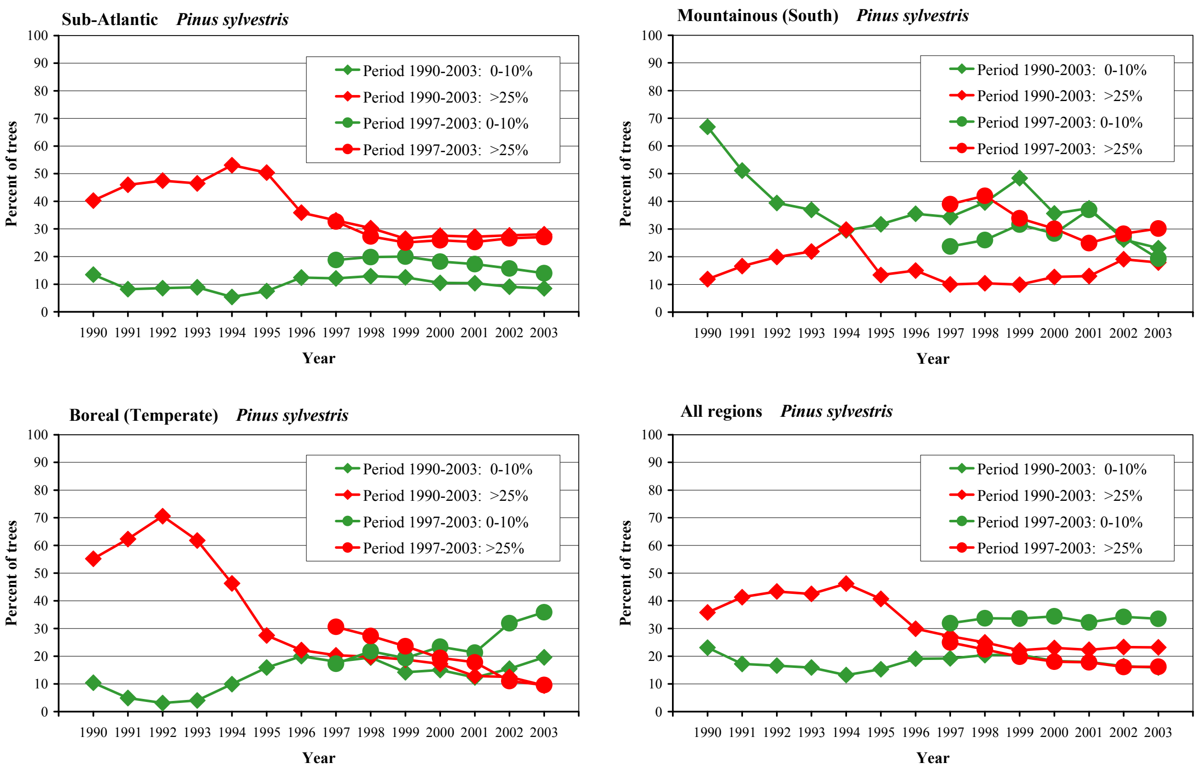

Figure 2.2.2.2-1: Shares of trees of defoliation 0-10% and >25% in two periods (1990-2003 and 1997-2003).

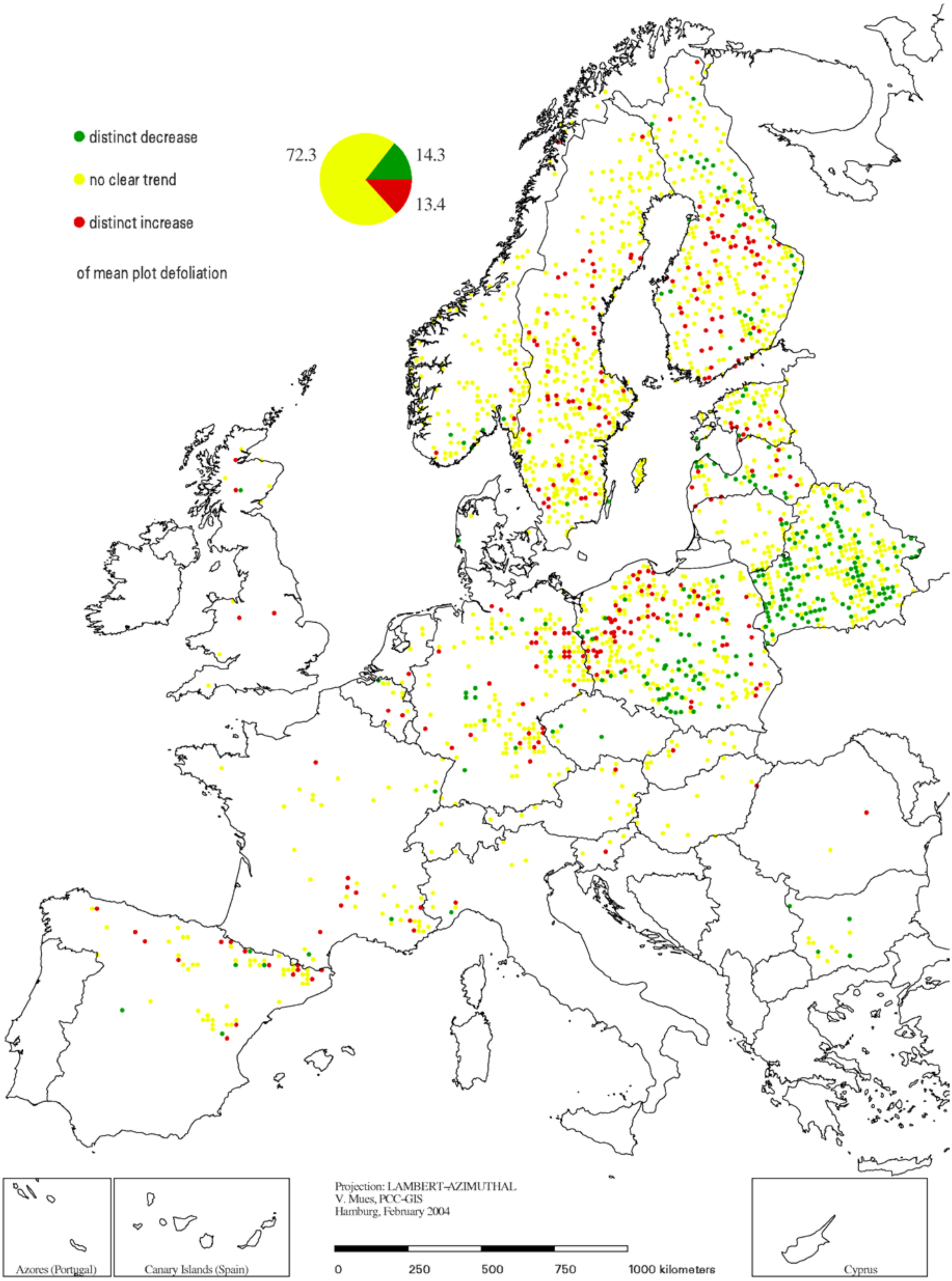

Figure 2.2.2.2-2: Trend of mean plot defoliation (slope of linear regression) of *Pinus sylvestris* over the years 1997 to 2003.

2.2.2.3 Picea abies

In both periods of observation, 1990-2003 and 1997-2003, *Picea abies* represents the second largest share of trees behind *Pinus sylvestris*. In the period 1990-2003 the share of damaged trees in the total of all regions culminated to 38.2% in 1994 and decreased to 30.6%. This reflects largely the development in the Sub-Atlantic and Mountainous (south) regions, which constitute the largest and second largest shares of all trees, respectively. In both regions the development between 1990 and 2003 was similar (Figure 2.2.2.3-1).

The development in the period 1997 to 2003 is also strongly influenced by the high number of sample trees in the Boreal region. In the Boreal, Sub-Atlantic and Mountainous (south) regions defoliation changed only very little. The high share of not defoliated trees in the Mountainous (south) region is largely growing in Austria. In some regions the recuperation of crown condition of *Picea abies* reminds of that observed for *Pinus sylvestris* (Chapter 2.2.2.2), but is less pronounced. In contrast to *Pinus sylvestris*, the share of plots showing increasing defoliation surmounted with 13.9% that showing decreasing defoliation with 8.5% (pie diagram in Figure 2.2.2.3-2).

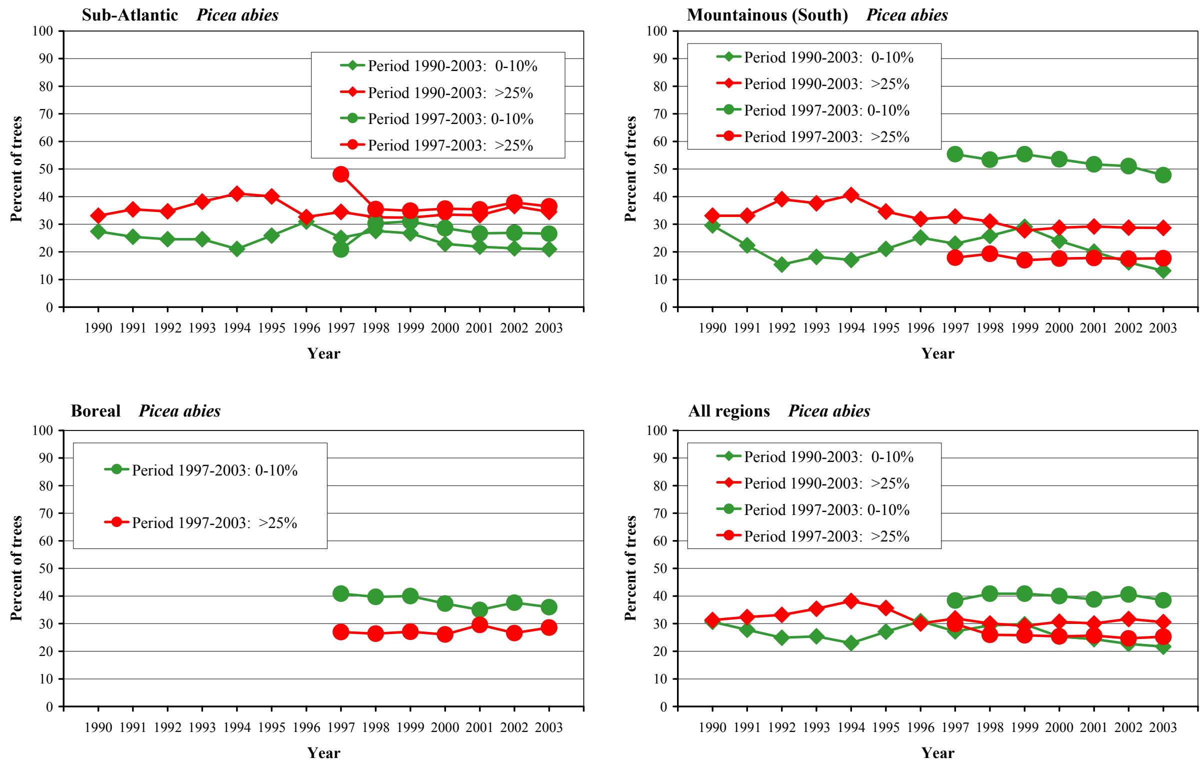

Figure 2.2.2.3-1: Shares of trees of defoliation 0-10% and >25% in two periods (1990-2003 and 1997-2003).

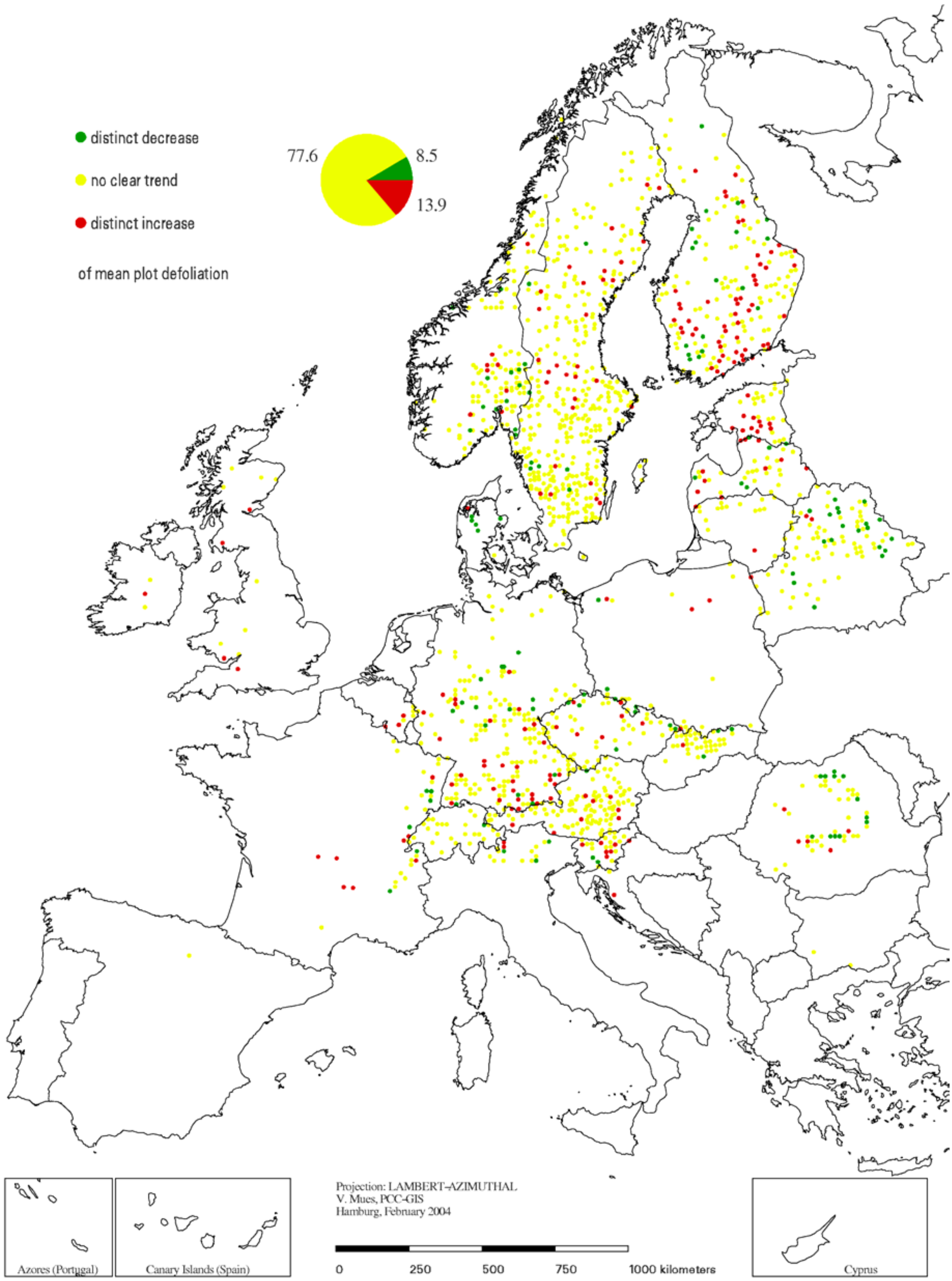

Figure 2.2.2.3-2: Trend of mean plot defoliation (slope of linear regression) of *Picea abies* over the years 1997 to 2003.

2.2.2.4 Fagus sylvatica

Fagus sylvatica constitutes the most frequent broadleaved tree species in both periods of investigation, 1990-2003 and 1997-2003. In the period 1990-1997 its share of damaged trees shows a slight recuperation from its peak in 1995 (30.1%) to a minimum in 2002 (20.2%). In 2003 the share of "damaged" trees (displaying more than 25% defoliation, see Chapter 2.1.5.1) increased clearly to 26.1%. This development is dominated by that in the Sub-Atlantic region which comprises more than half of the sample trees. However, the increase in defoliation from 2002 to 2003 reflects the recent development in the Mountainous (south) region, which comprises about one quarter of all trees. In the Mountainous (south) region the share of damaged trees increased from 11.8% in 2002 to 32.5% in 2003 (Figure 2.2.2.4-1).

In the period 1997-2003 defoliation developed mostly similarly to the one in the period 1990-2003. However, there is a striking difference in the shares of the not defoliated and the damaged trees in the Continental region. This reflects the high share of not defoliated plots in the lowlands and the high share of clearly defoliated plots in the mountains of Romania (Figure 2.2.1-4). Across Europe the share of deteriorating plots (16.5%) surmounted the share of recuperating plots (10.3%) (Figure 2.2.2.4-2).

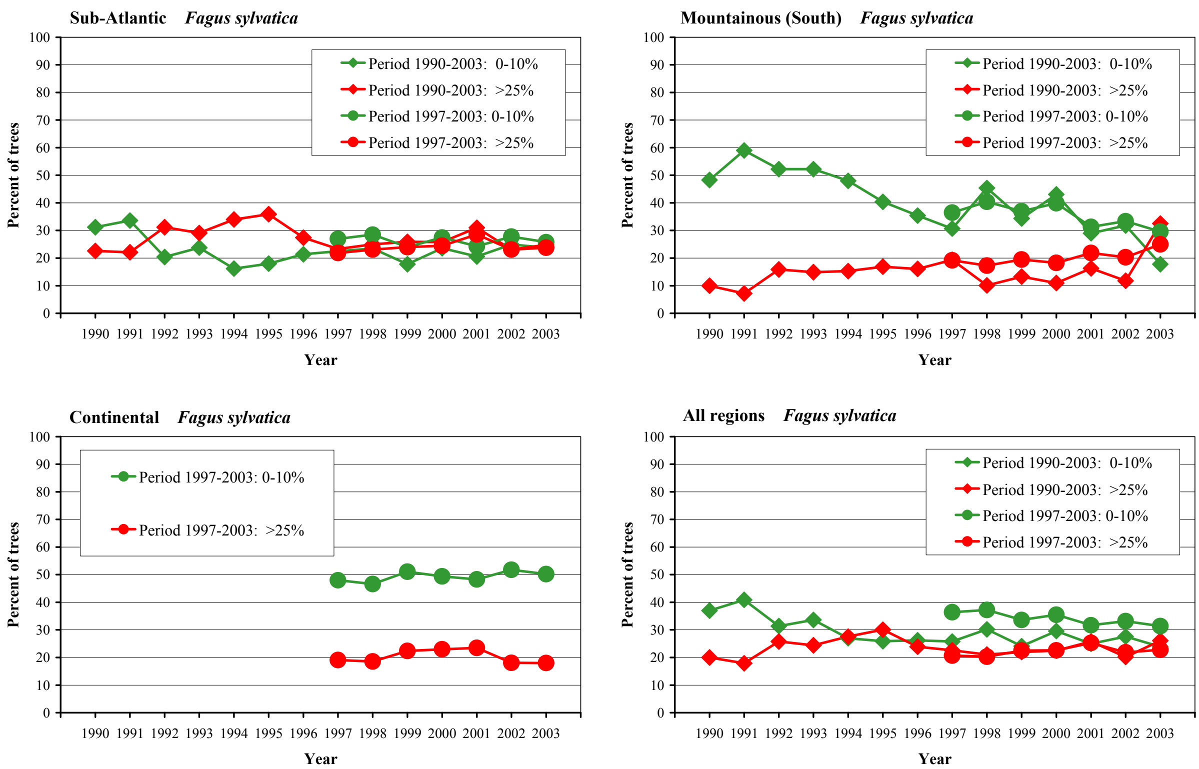

Figure 2.2.2.4-1: Shares of trees of defoliation 0-10% and >25% in two periods (1990-2003 and 1997-2003).

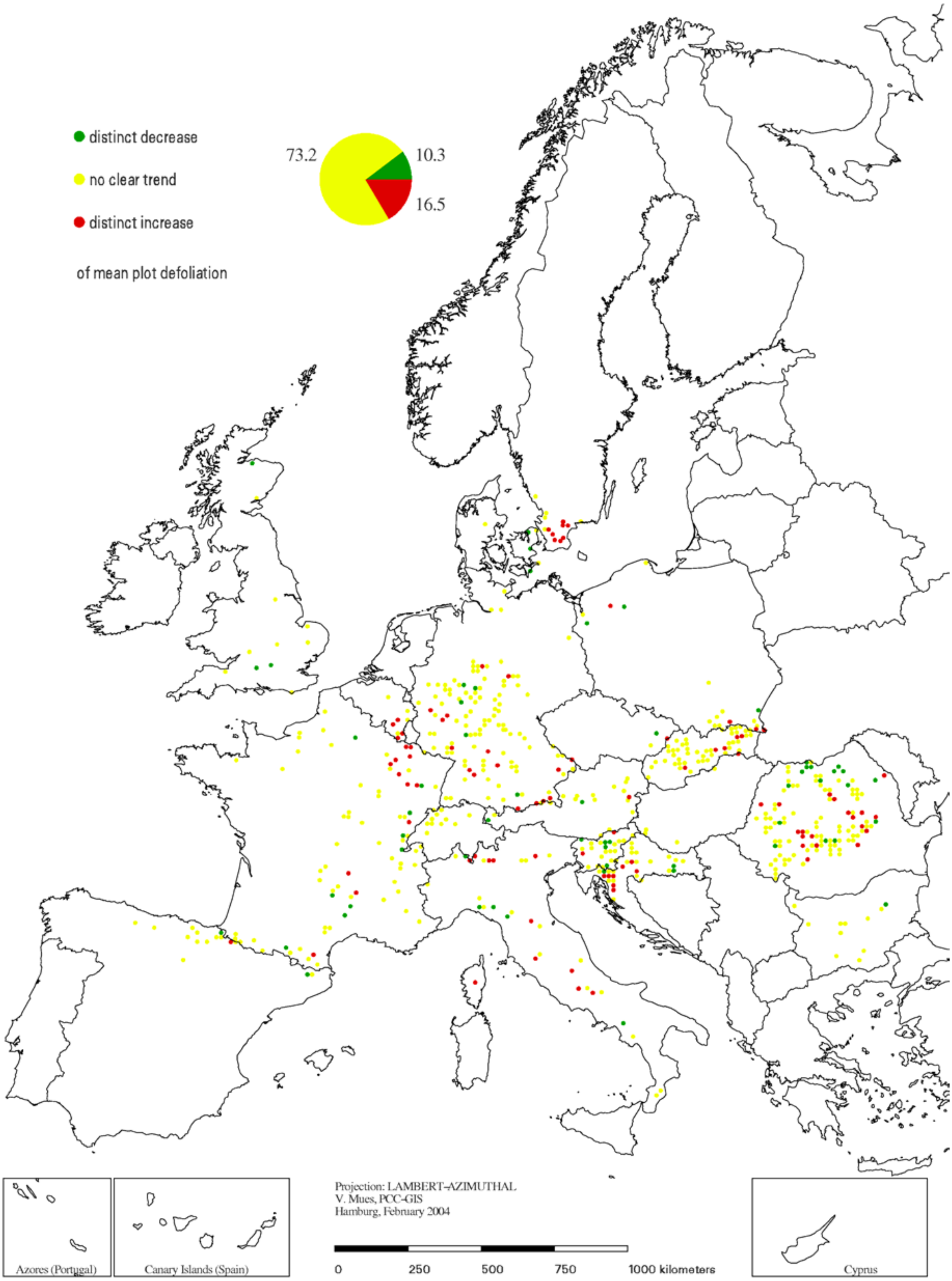

Figure 2.2.2.4-2: Trend of mean plot defoliation (slope of linear regression) of *Fagus sylvatica* over the years 1997 to 2003.

2.2.2.5 Quercus robur and Q. petraea

The species group *Quercus robur* and *Quercus petraea* shares the regional recovery since the mid 1990s which is also observed for other main species (Chapters 2.2.2.2-2.2.2.4). Within the period 1990-2003 the share of damaged trees of the total of all regions fell clearly from its high of 46.5% in 1994 to a low of 30.5% in 2000. This reflects mainly the development of defoliation in the Sub-Atlantic region which comprises by far the largest proportion of the sample trees. In the Sub-Atlantic region defoliation increased suddenly, after some years of nearly steady state, from 2002 to 2003. This deterioration is seen in the samples of both periods of investigation, 1990-2003 and 1997-2003. The latter period shows the same sudden deterioration in the Atlantic (south) region, which comprises the second largest share of the *Quercus robur* and *Quercus petraea* trees. However, the development of defoliation in the Atlantic (south) region differed otherwise greatly from that in the Sub-Atlantic region. During the period from 1990 to 2003 the share of not defoliated trees decreased from 66.5% to 22.1%. In the Continental region defoliation developed heterogeneously and without any clear trends (Figure 2.2.2.5-1). Figure 2.2.2.5-2 shows that the deteriorating plots are largely situated in France. The share of deteriorating plots (13.0%) exceeds those plots showing an improvement (10.8%).

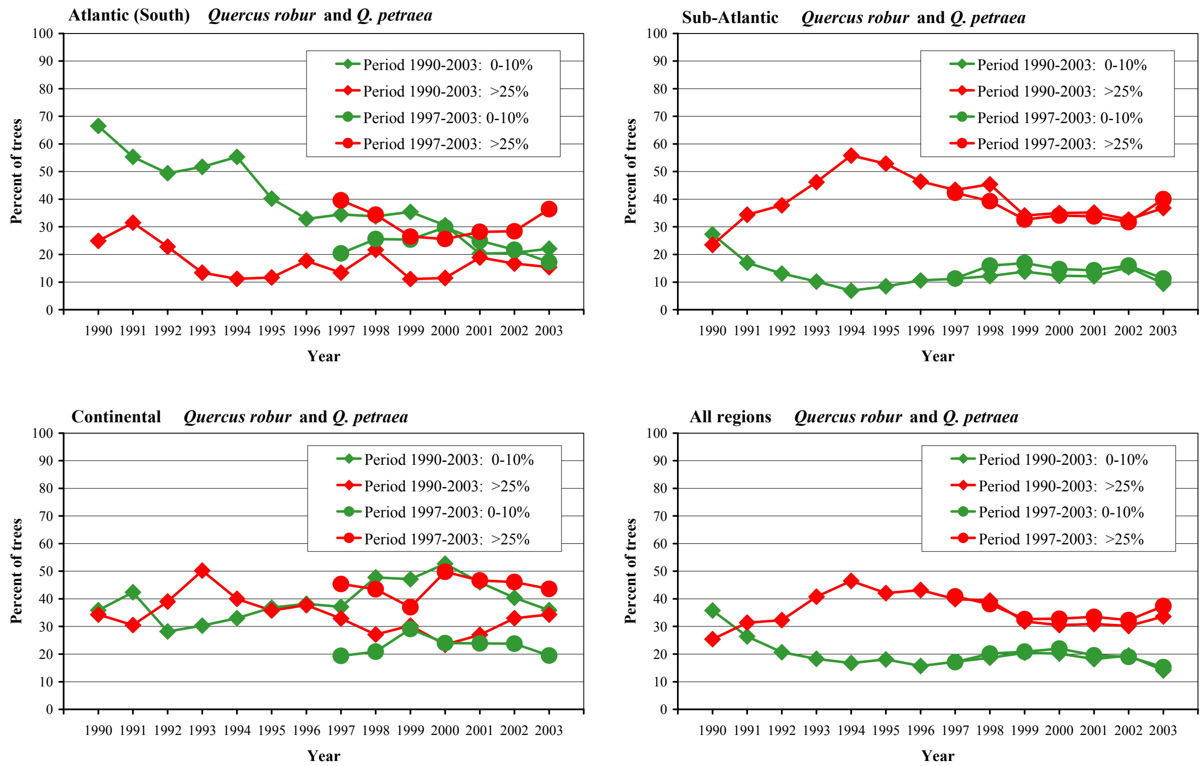

Figure 2.2.2.5-1: Shares of trees of defoliation 0-10% and >25% in two periods (1990-2003 and 1997-2003).

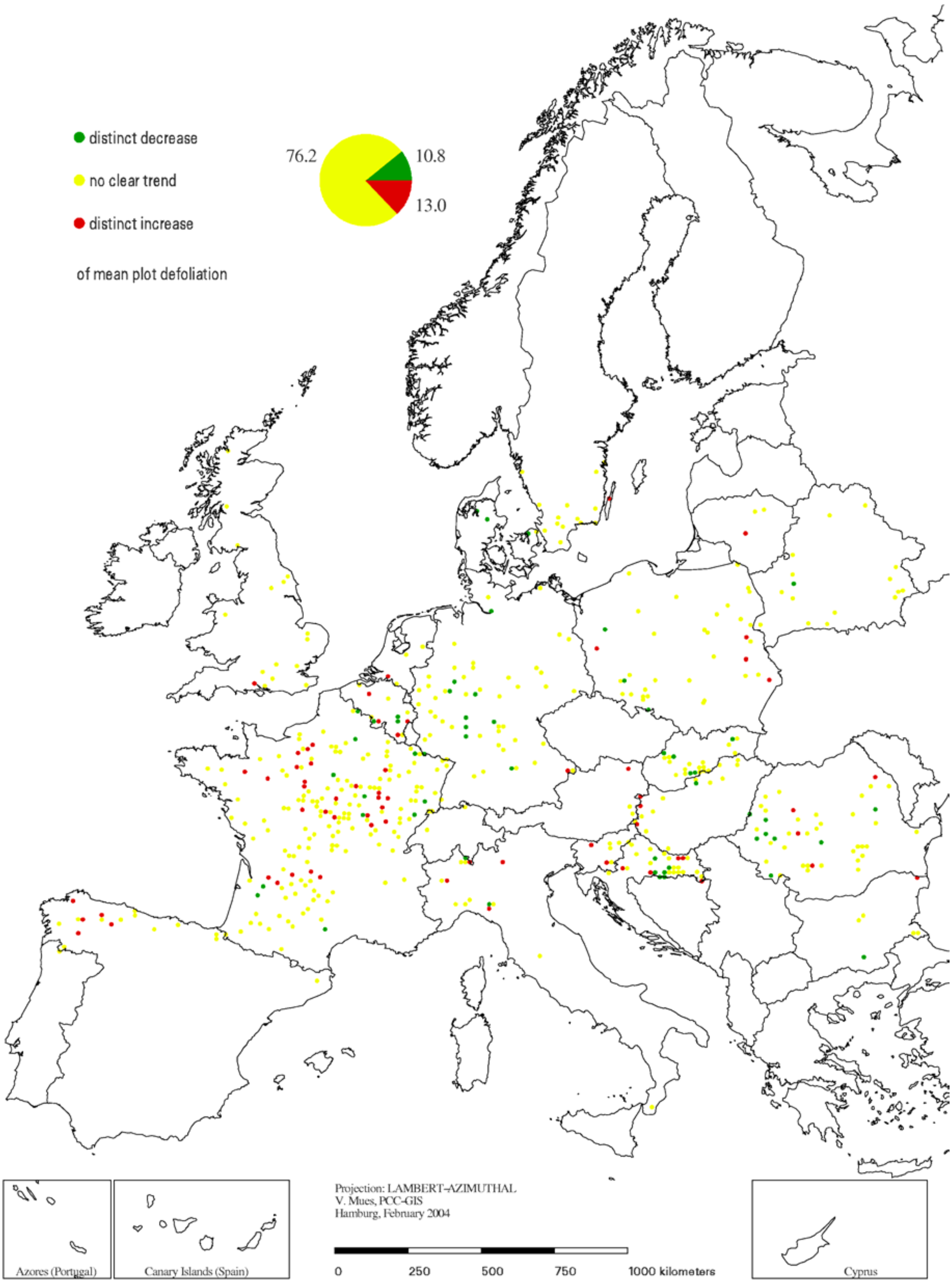

Figure 2.2.2.5-2: Trend of mean plot defoliation (slope of linear regression) of *Quercus robur* and *Quercus petraea* over the years 1997 to 2003.

2.2.2.6 Quercus ilex and Q. rotundifolia

The species group of *Quercus ilex* and *Quercus rotundifolia* is mainly distributed over the Mediterranean (lower) region, which comprises about three quarters of the sample trees of both periods of observation, 1990-2003 and 1997-2003. The share of damaged trees in the total of all regions increased from 11.3% in 1990 to a peak of 28.1% in 1995. This deterioration was followed by a clear recuperation until 1998, when the share of damaged trees had been reduced to 13.4%. Since then each of the samples of both periods of observation reveals and increase in its share of damaged trees by about seven percent points. The development of defoliation in the Mediterranean (higher) region is similar (Fig. 2.2.2.6-1). A comparison of the map in Figure 2.2.2.6-2 with that in Figure 2.1.2.1-1 suggests that defoliation is highest at higher altitudes. This is supported by the figures presented in Annex I-9. The highest share of damaged trees is found in the Mountainous (south) region. For all regions 21.0% of the plots showed increasing defoliation against only 6.1% of the plots with a decrease.

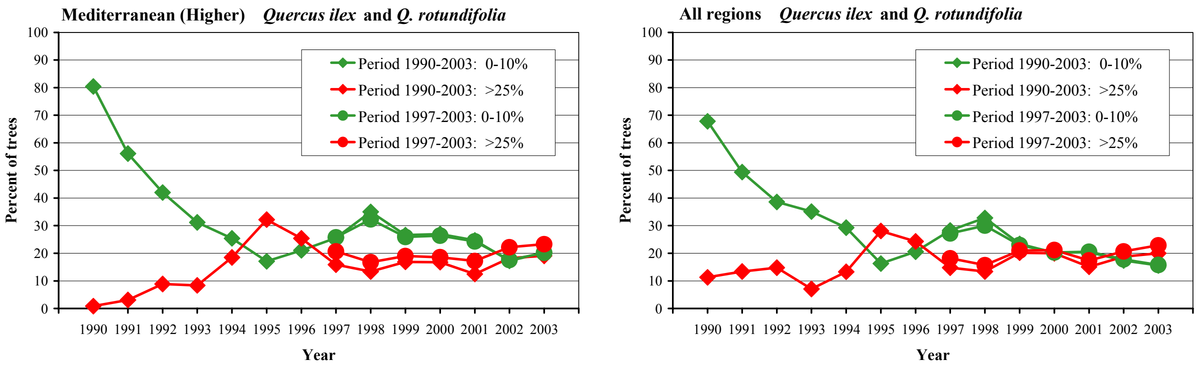

Figure 2.2.2.6-1: Shares of trees of defoliation 0-10% and >25% in two periods (1990-2003 and 1997-2003).

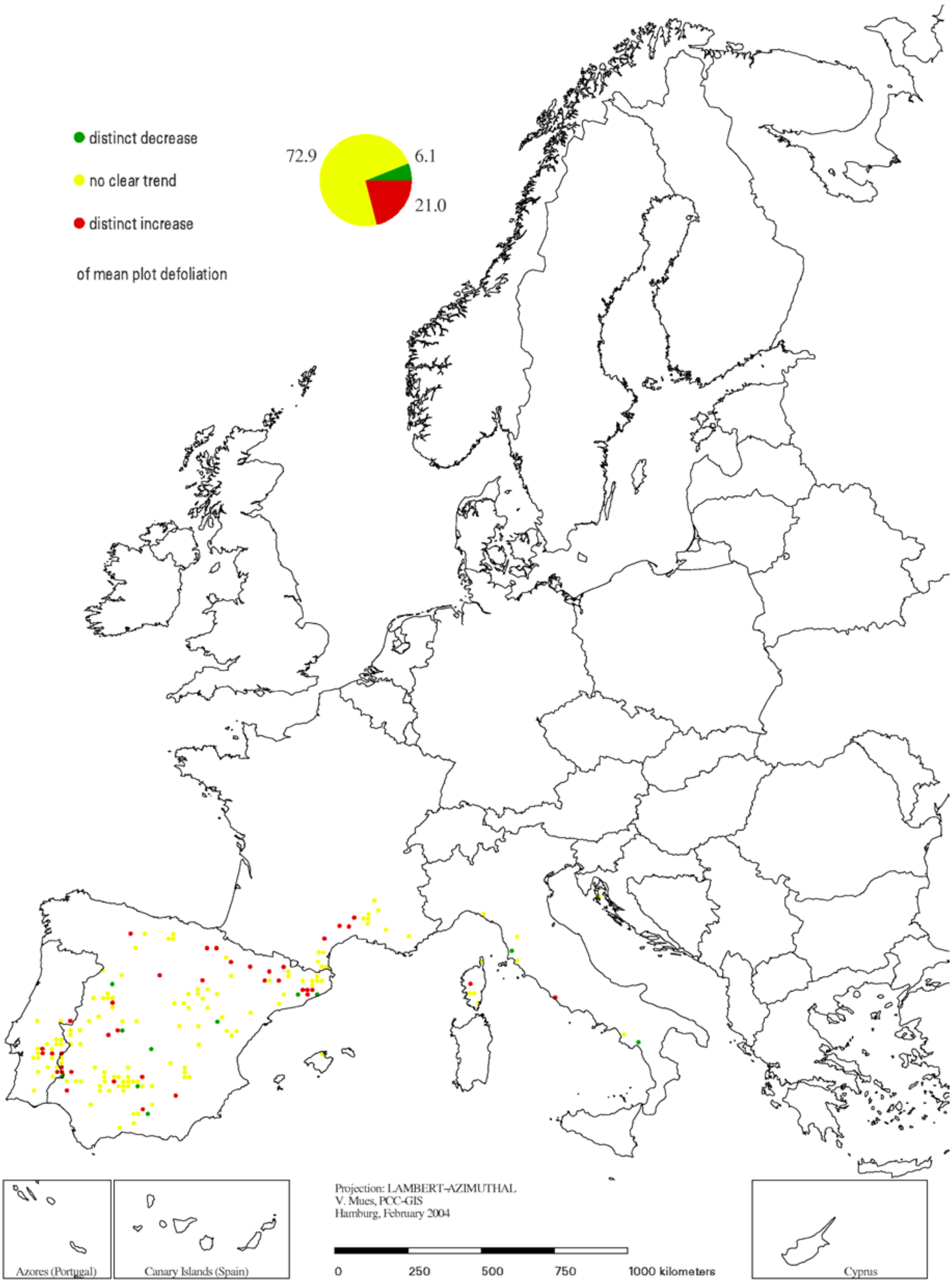

Figure 2.2.2.6-2: Trend of mean plot defoliation (slope of linear regression) of *Quercus ilex* and *Quercus rotundifolia* over the years 1997 to 2003.

2.2.2.7 Pinus pinaster

Pinus pinaster is most widely distributed in the Mediterranean (lower) region with most plots located in Portugal. A second centre of distribution lies in the Atlantic (south) region in the southwest of France. The share of not defoliated trees in the total of all regions decreased during the period 1990-2003 from 68.1% to 45.2%. During the same time the share of damaged trees undulated around 10% without any clear trend. A similar development of defoliation was observed in the Mediterranean (higher) region, but there the decrease in not defoliated trees was even more pronounced. The development of defoliation of the tree sample of the shorter period (1997-2003) was similar to that of the longer period (Figure 2.2.2.7-1). The map in Figure 2.2.2.7-2 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 19.6% nearly as large as the share of improving plots with 18.9%.

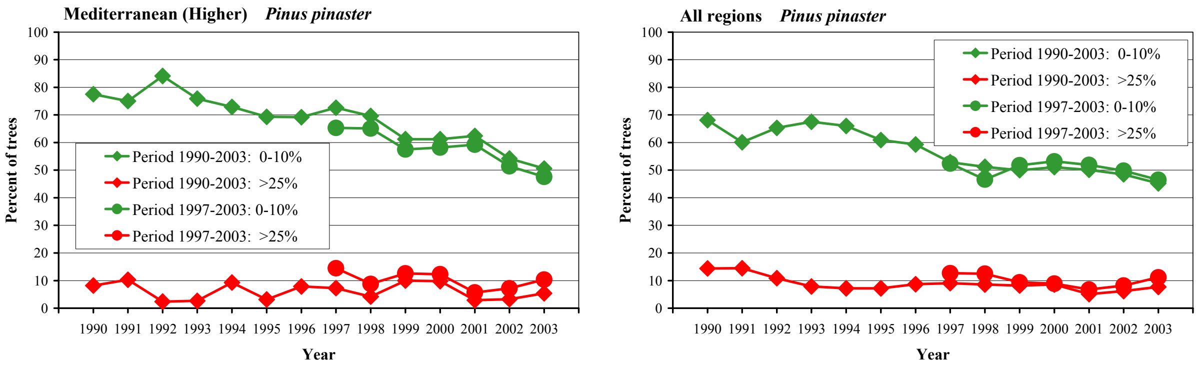

Figure 2.2.2.7-1: Shares of trees of defoliation 0-10% and >25% in two periods (1990-2003 and 1997-2003).

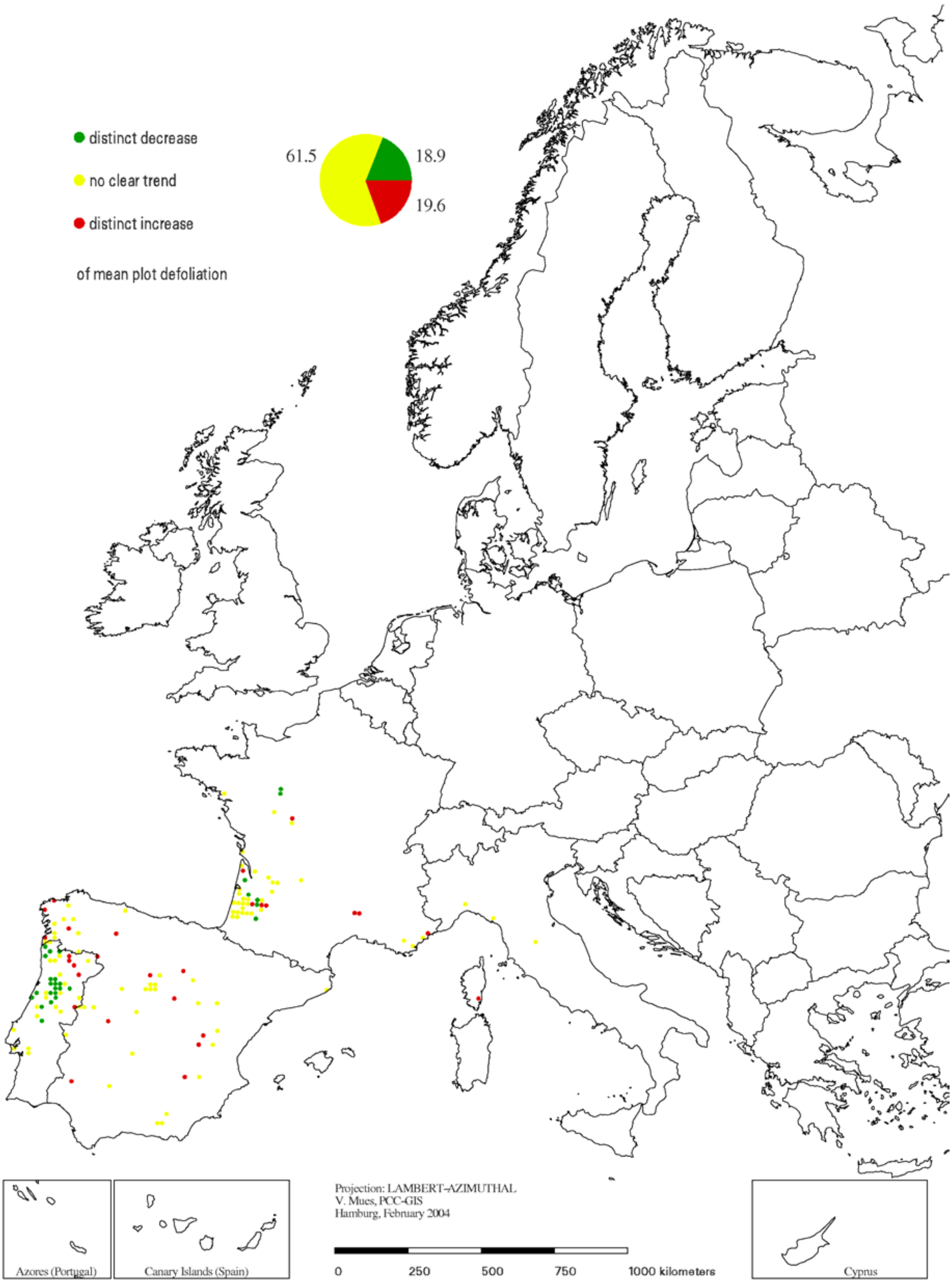

Figure 2.2.2.7-2: Trend of mean plot defoliation (slope of linear regression) of *Pinus pinaster* over the years 1997 to 2003.

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. 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). In Chapter 3.2 results of bulk deposition measurements based on the Level II data made available by the countries by 2001 are presented. Chapter 3.3 contains results of three different multinational studies of forest growth involving Level II plots. Chapter 3.4 presents first results of a national assessment of epiphytic lichen diversity assessments on Level II plots in Switzerland.

3.2 Concentrations of nitrogen and sulphur in bulk deposition samples

3.2.1 Introduction

Deposition of nitrogen, sulphur and base cations belongs to the most important parameters monitored at Level II. The present chapter presents the methods and results of a study of the temporal development and the spatial variability of nitrate ($N\text{-}NO_3$), ammonium ($N\text{-}NH_4$) and sulphate ($S\text{-}SO_4$), based on the bulk-deposition data measured in the open field close to Level II plots. Open field 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 generally larger than in the open field as wet deposition is additionally polluted by dry deposition washed off the foliage. It is influenced by canopy exchange, i.e. the uptake and leaching of elements from the foliage. Pollutants having reached the forest soil via wet deposition are partly taken up by the trees via the roots and can thus be accumulated in the forest ecosystem. Element input, element leaching and element budgets for forest soils on Level II plots were described in previous reports (DE VRIES et al., 2001). The present study aims to assess differences over space and time in the concentrations of nitrogen and sulphur of the precipitation in the open field.

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). The variables subjected to the statistical analyses are bulk deposition data expressed in terms of annual mean concentration. The calculation of annual mean concentration of nitrate ($N\text{-}NO_3$), ammonium ($N\text{-}NH_4$) and sulphate ($S\text{-}SO_4$) was performed as volume weighted average in mg/l (Farmer et al., 1987). For trend analyses a trade-off had to be made between the length of the time span on the one hand and the amount of data (number of countries having contributed to the data pool) on the other hand. Taking into account these two aspects the time period 1996-2001 was considered as most suitable for performing a first step towards trend analyses. In fact, real trend analysis begins to make sense only for periods of at least 10 years. Deposition measurements on the different plots are carried out in different time intervals ranging mostly from monthly to fortnightly and weekly. This results in a larger number of measurements per plot and year (e.g. 13, 26 or 52). Among the approximately 500 sites on which deposition is measured within ICP Forests, only those sites were selected which fulfil the following criteria: (i) the sites have been operational for the whole period 1996-2001, with a maximum of 1 month of missing data per year and (ii) for the eventually missing period of max. 1 month per year and per site, the mean weighted concentration as calculated from the data of the remaining year was used per ion for the missing period. For mapping and quantifying temporal changes linear regression as only thinkable method could be used. With the years of assessment as predictor and annual mean ion concentration 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:

- negative slope, error probability 5% and less (green)
- negative slope, error probability more than 5% (light green)
- positive slope, error probability 5% and less (red)
- positive slope, error probability 5% and more (orange)

It must be stressed that conclusions about temporal changes in ion concentration based on such short time series can only be made with great reservations and do not have final character or validity. Nevertheless, there is no doubt about temporal changes in annual concentration of nitrate, ammonium and sulphate in bulk precipitation. BORMANN and LIKENS (1977) showed their evidence for watershed ecosystems in New England. ULRICH and LANIER (1999) developed a national indicator based on national volume-weighted mean concentrations, which was used by ULRICH (2003) for the French intensive monitoring network “RENECOFOR” and found linear trends in nitrogen, sulphur, calcium and magnesium concentration between 1992 and 2002. Besides plot-wise ion concentrations for each year between 1999 and 2001, the overall plot means over all years were calculated, using the same selection criteria as mentioned above. For mapping volume weighted mean plot concentrations over all years of assessment, classes with equidistant length were chosen comprising the whole range of values found.

3.2.3 Results

3.2.3.1 Nitrate ($N\text{-}NO_3$)

Figure 3.2.3.1-1 shows volume weighted concentrations of $N\text{-}NO_3$ over Europe. A little more than half of the 409 plots for which the calculation was carried out shows nitrate loads between 0.1 and 0.5 mg/l. Plots exhibiting these $N\text{-}NO_3$ concentrations are more or less evenly distributed over Europe. In central Europe, however, there is an obvious cluster of plots with $N\text{-}NO_3$ concentrations ranging from >0.5 to 0.65 mg/l. In Poland and northern Germany, about one third of the plots has $N\text{-}NO_3$ concentrations ranging from >0.65 to 2.6 mg/l.

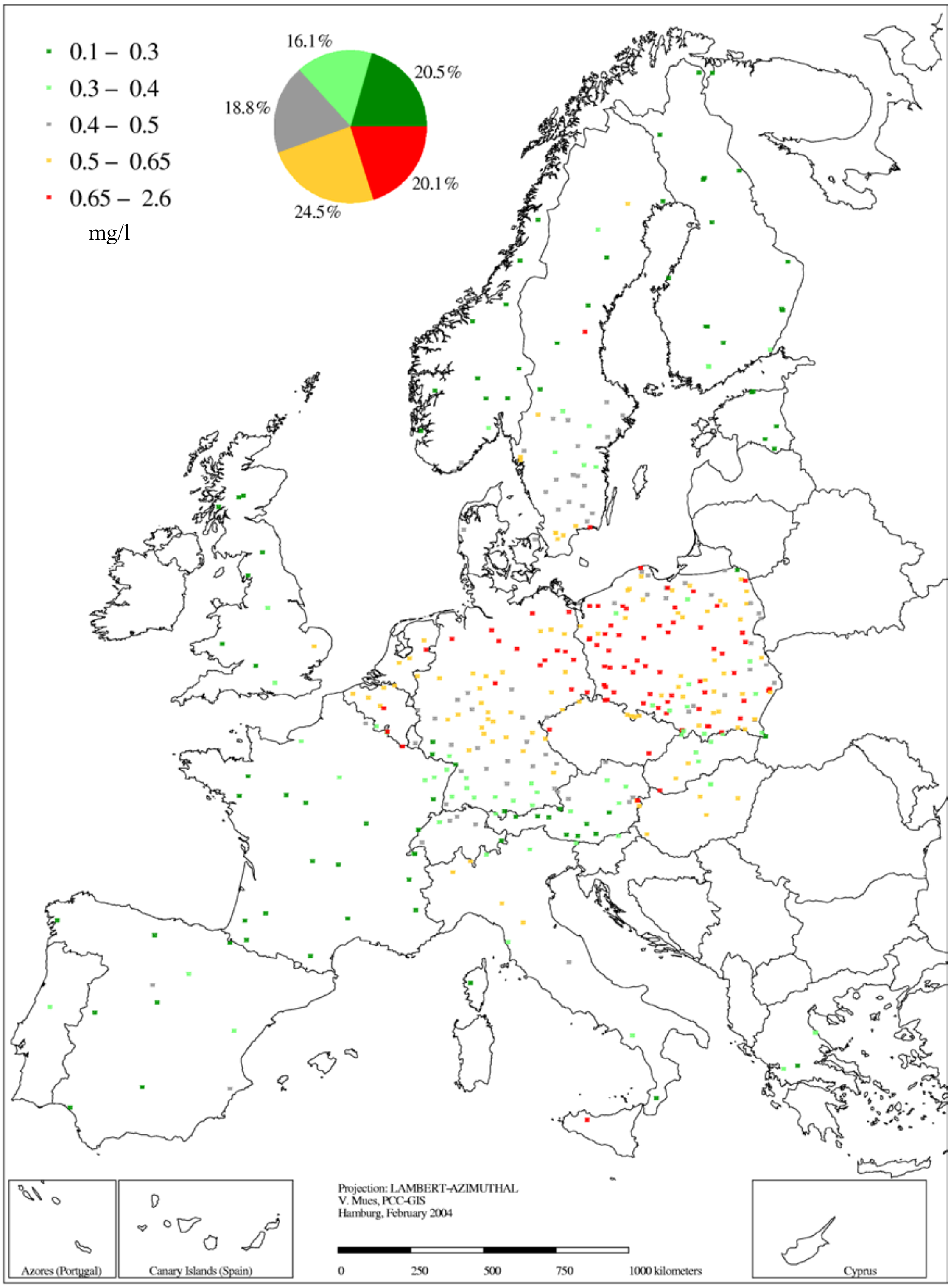

Figure 3.2.3.1-1: Geographic variation of the volume weighted mean N-NO_3 concentration in mg/l between 1999 and 2001 at 409 Level II plots.

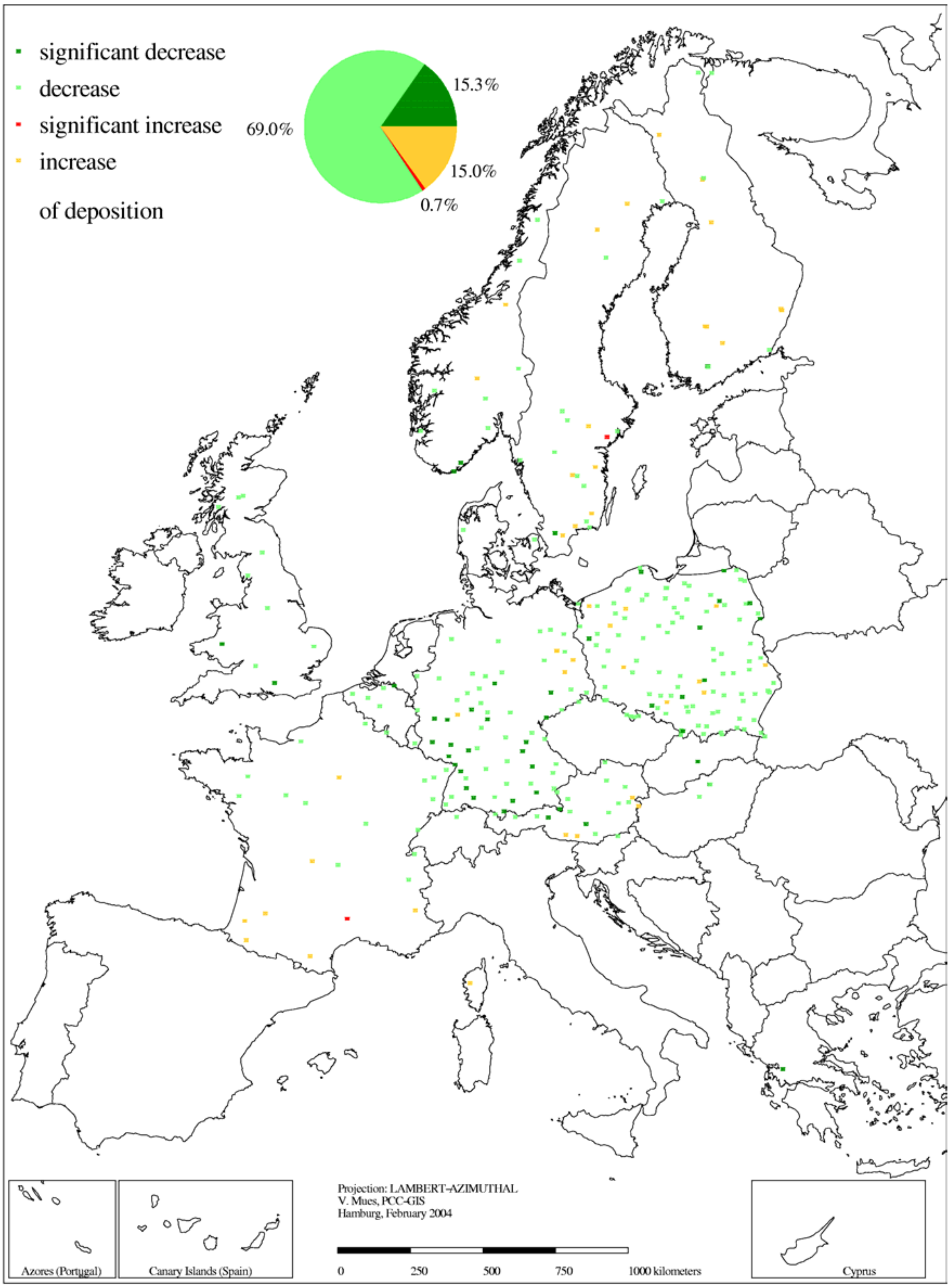

Figure 3.2.3.1-2: Linear trends of the volume weighted mean N-NO_3 concentration in mg/l between 1996 and 2001 at 294 Level II plots.

The temporal development in N-NO_3 concentrations (Figure 3.2.3.1-2) reflects the uncertainties in calculation and statistical inference when analysing short time series. This is absolutely the case here since only measurements for six consecutive years namely 1996 to 2001 were available. Consequently, most plots do not show changes in N-NO_3 concentrations between 1996 and 2001. Nevertheless, considering the pie diagram in Figure 3.1-2, a cautious interpretation towards diminution of the N-NO_3 concentration may be allowed since the percentages of plots with significant and no significant decrease in N-NO_3 concentration is 84.3%. Moreover, there are only few plots (0.7%) with significantly increase in $N\text{-}NO_3$ inputs whereas the proportion of plots with statistically proven decrease lies about twenty times higher (15.3%).

3.2.3.2. Ammonium ($N\text{-}NH_4$)

The ammonium nitrogen expressed in terms of volume weighted mean concentration is slightly higher than that of nitrate (Figure 3.2.3.2-1), which shows that its sources (mainly agricultural emissions) have gained ever more importance over the last years. The spatial distribution of $N\text{-}NH_4$ concentrations as assign to five classes resembles that of $N\text{-}NO_3$. In contrast to $N\text{-}NO_3$, only 38.8% of the plots show low $N\text{-}NH_4$ concentration of up to 0.5 mg/l. Higher concentrations (1.4 to 11.6 mg/l) were recorded in Poland. Ammonium is known for its deposition not far from emission sources. The high density of plots with high concentrations in Poland may simply reflect the agricultural production pattern in this country.

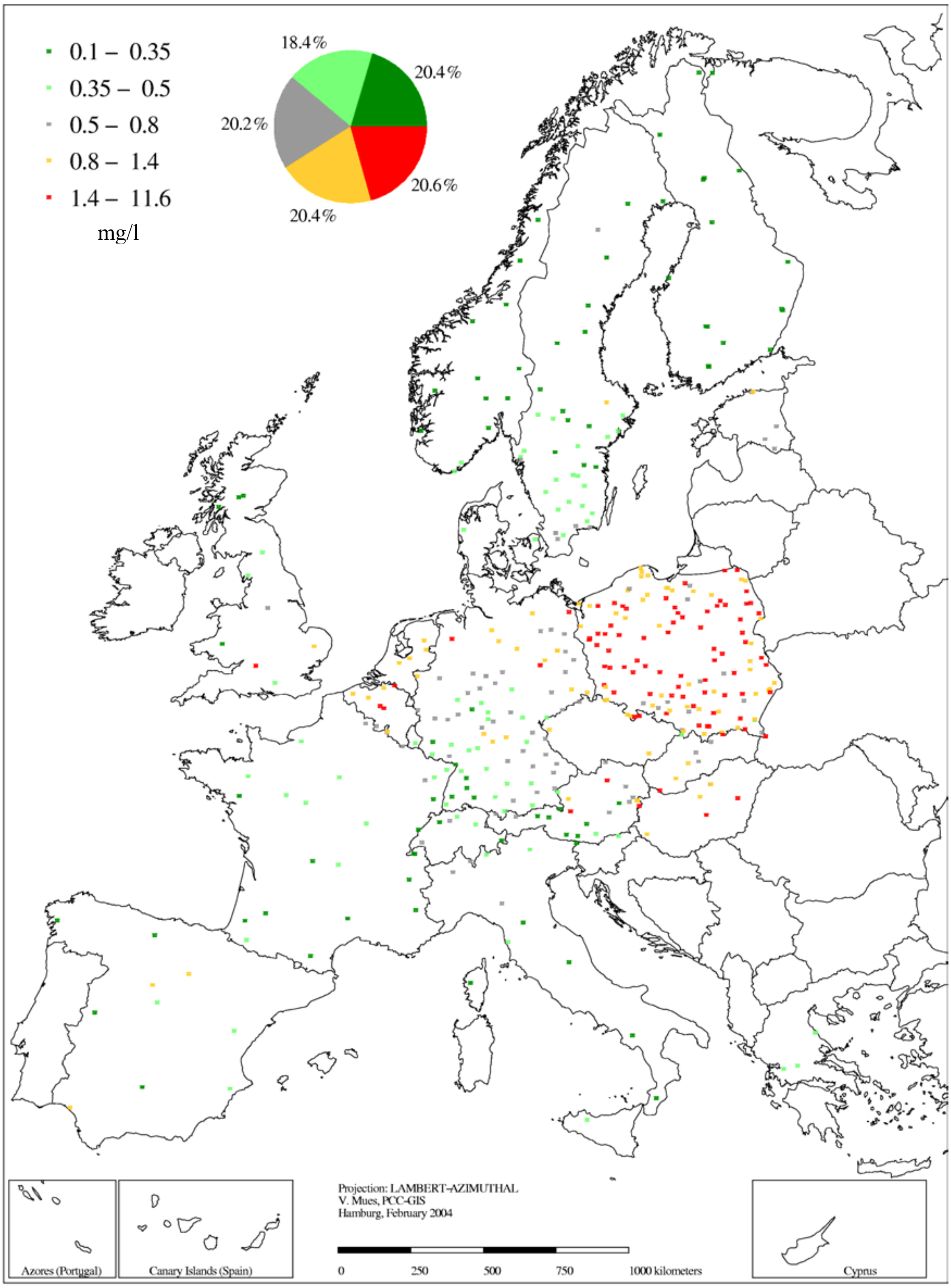

Figure 3.2.3.2-1: Geographic variation of the volume weighted mean N-NH_4 concentration in mg/l between 1999 and 2001 at 407 Level II plots.

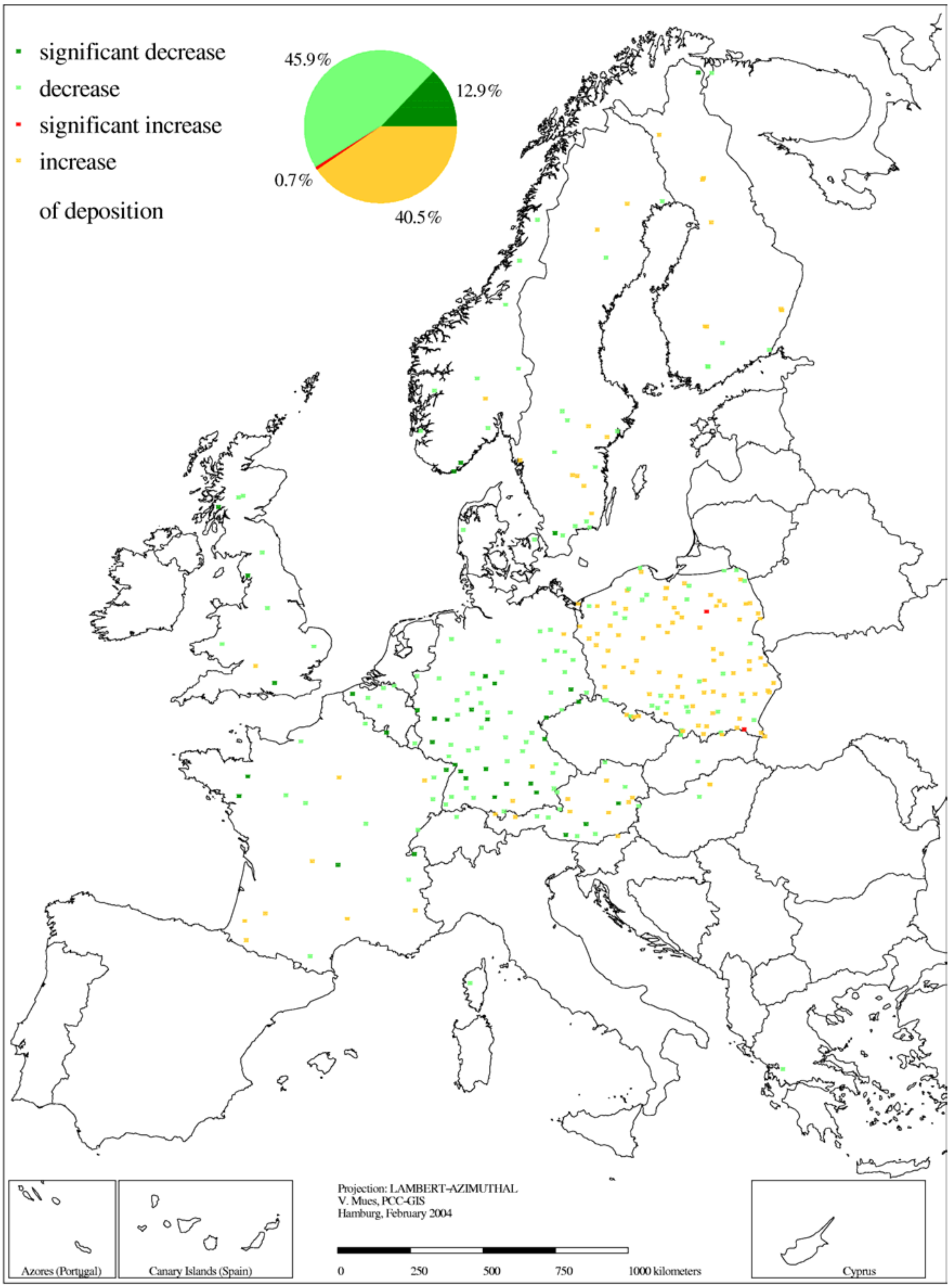

Figure 3.2.3.2-2: Linear trends of the volume weighted mean N-NH_4 concentration in mg/l between 1996 and 2001 at 294 Level II plots.

As regards temporal development modelled as slopes of linear trends from 1996 to 2001, the concentration of ammonium appears to have increased in Poland and southern Sweden (Figure 3.2.3.2-2). However, this trend recorded for about 40% of all plots is statistically uncertain as the error probability for slopes being different from zero is greater than 5%. Most plots with decreasing trends in N-NH_4 concentration are located in Germany. The plot-wise reduction of N-NH_4 turned out to be statistically significant only on 12.9% of the plots for which the volume weighted concentration could be calculated.

3.2.3.3 Sulphate (S-SO_4)

The S-SO_4 concentrations calculated as volume weighted average ranges from 0.2 to 10.3 mg/l. The frequency distribution of plots with different concentrations comes close to that of N-NO_3. Plots with S-SO_4 concentrations ranging from 1.5 to 10.3 mg/l are clustered in Poland (Figure 3.2.3.3-1).

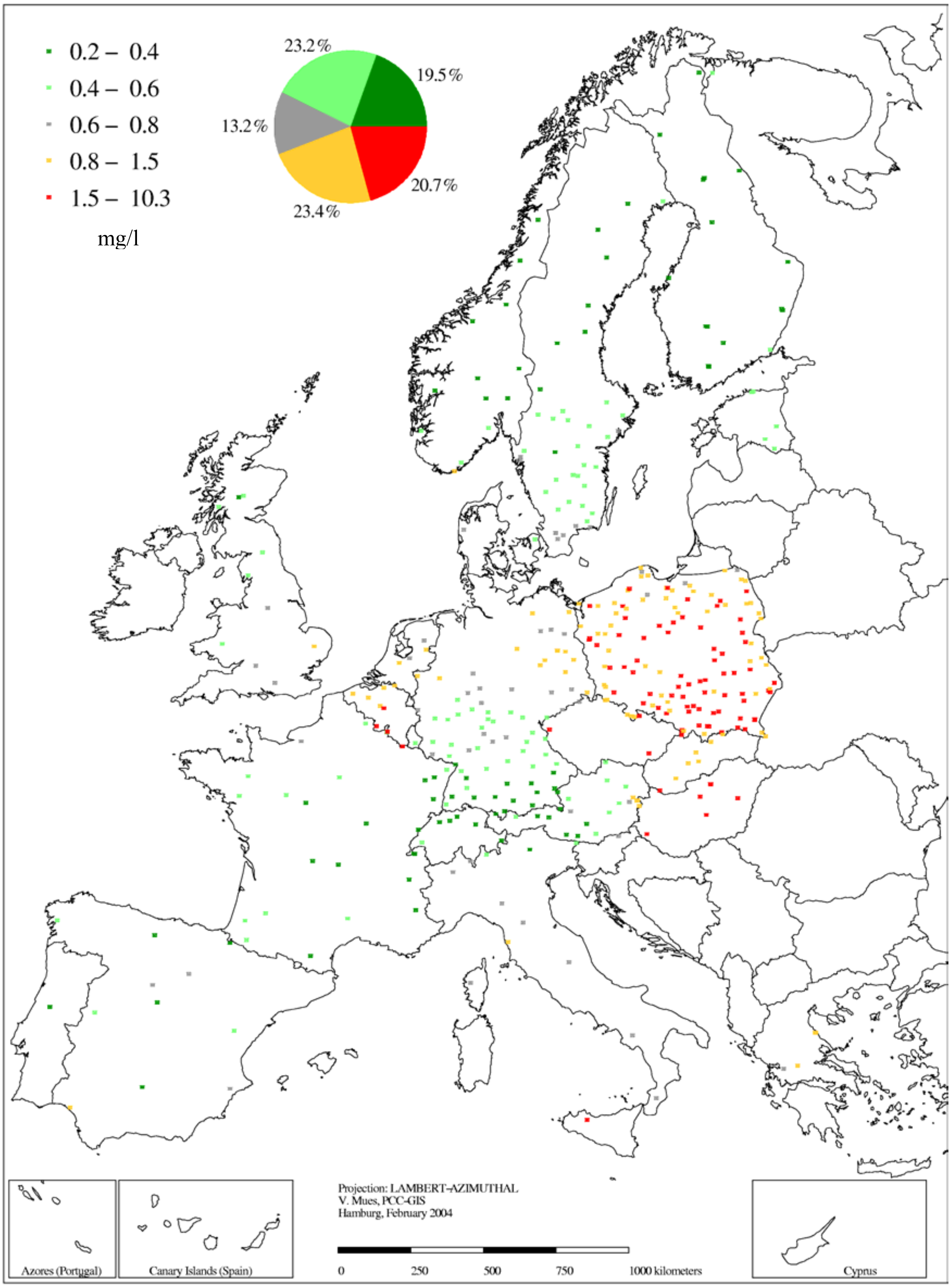

Figure 3.2.3.3-1: Geographic variation of the volume weighted mean S-SO_4 concentration in mg/l between 1999 and 2001 at 401 Level II plots.

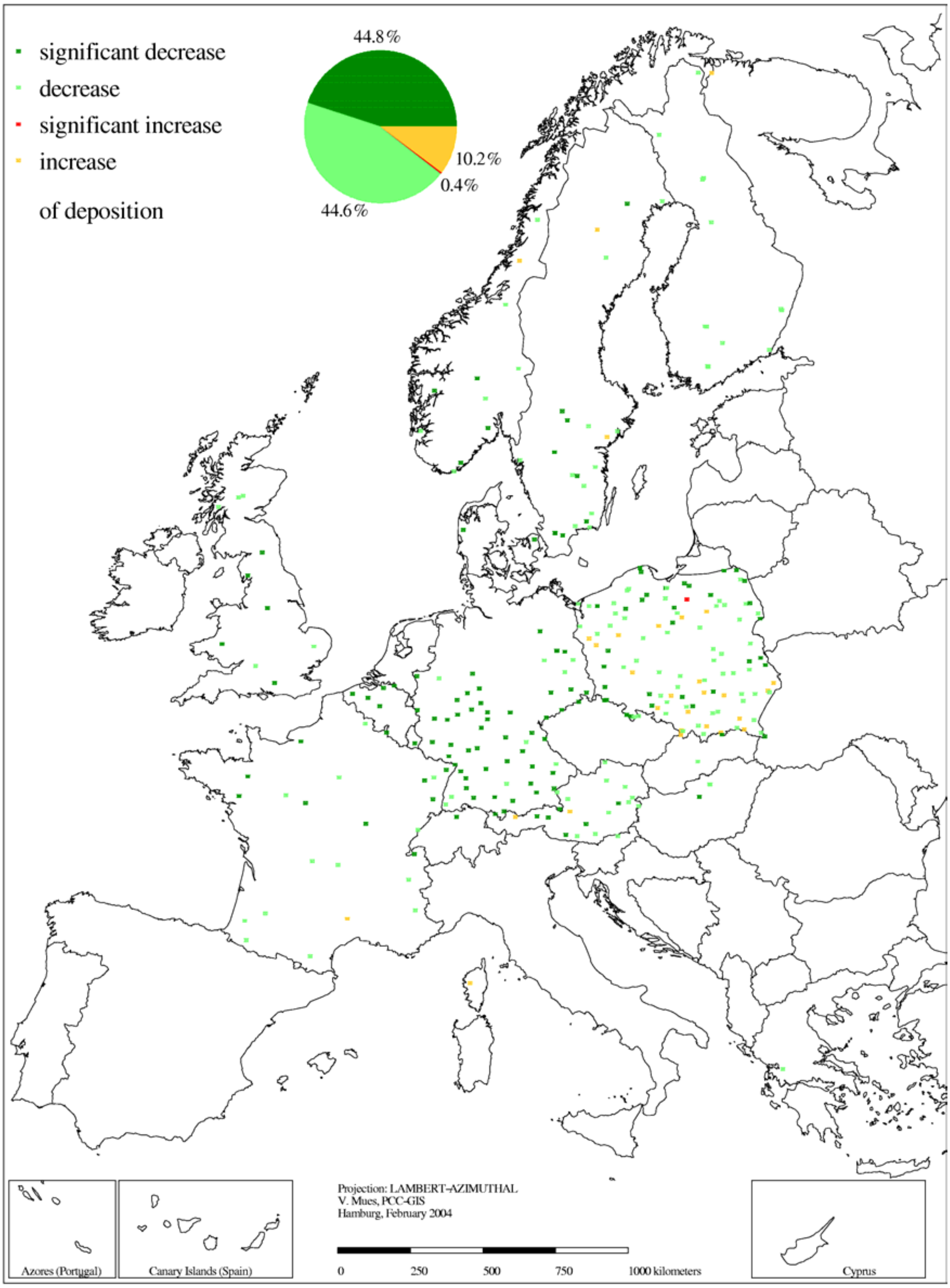

Figure 3.2.3.3-2: Linear trends of the volume weighted mean S-SO_4 concentration in mg/l between 1996 and 2001 at 285 Level II plots.

Compared with nitrate (N-NO_3) and ammonium (N-NH_4) the concentration of sulphate ions (S-SO_4) shows a much more pronounced decrease between 1996 and 2001. Reductions were found on 89% of the plots (Figure 3.2.3.3-2). On almost half of these plots the decline of sulphate concentration proved to be statistically significant. This reflects the successful reduction of sulphur emissions under CLRTAP. Similar to the nitrogen input, an increase in S-SO_4 concentrations can be observed in Poland and sporadically in Sweden, Slovakia and Czech Republic.

3.2.3.4 Trends

In Sub-chapters 3.2.3.1 – 3.2.3.3 the trends in the concentrations of ions in wet deposition were presented for each plot. The present sub-chapter provides the trends as calculated for the total of theses plots. For this purpose, volume weighted mean concentrations were calculated for each year of the period 1996-2001 (Figure 3.2.3.4-1). As already stressed above, however, the short length of the time period is detrimental to the reliability of the calculated trends. This drawback is particularly obvious for the trend of the concentrations of N-NH_4. Since 1996 the concentration has been increasing. Having started the evaluation only in 1997 would have shown a decrease. Therefore, for the nitrogen fixed as ammonium the decrease in volume weighted concentration can hardly be modelled linearly for the time period 1996 and 2001. In contrast to N-NH_4 the linear regressions for the temporal development of S-SO_4 and N-NO_3 yield stable statistical parameters giving evidence of a clear decrease in sulphate and nitrate loads for Europe between 1996 and 2001. As mentioned above, however, at least four more years would have to be included in order to pursue reliable trend analyses.

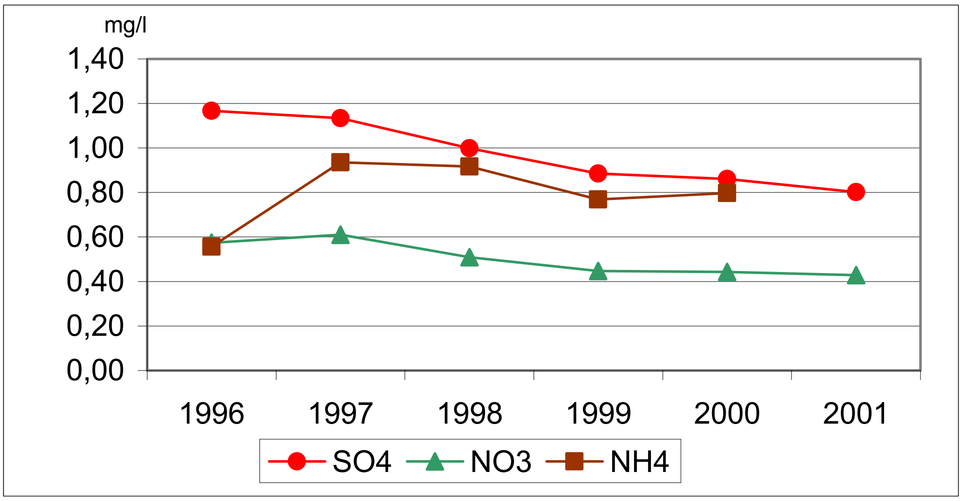

Figure 3.2.3.4-1: Development of volume-weighted concentrations

3.2.4. Conclusions

This exercise allowed verifying the possibility to use the plots on which open field bulk deposition measurements are made within ICP-Forests for the development of simple plot-wise and European-wide indicators of precipitation quality. Given the strict selection criteria, it seems that about 80% of the plots can be used for such an estimation. The fact that pollutant concentrations were mapped for several hundred plots must not be misinterpreted as a sign for large-scale representativity. This is not within the scope of the Level II approach. However, the concentrations of all three substances investigated show distinct spatial patterns across more than 400 plots. These patterns often cross national borders and coincide partly with the emission situations in different regions. But ongoing data quality assurance must be used in future to exclude any possible systematic methodological influence on these spatial patterns.

Evolutions analysed so far show beginning decreases for nitrate, a stability to slight decrease for ammonium and a very strong and significant decrease for sulphate. All these three trends seem to be in accordance with the current emission situation and its sources: (i) nitrate for traffic, (ii) ammonium for agriculture and (iii) sulphate for industry. However, longer time series will be needed to verify the trends indicated in the present study, especially with regard to the nitrogen compounds.

3.3 Forest growth studies on Level II plots

One key indicator of forest condition is the growth of the trees. Forest measurements are relatively inexpensive and in the case of stem diameter measurements they are precise if measurement height is marked. Forest growth and the knowledge of forest structure are also prerequisites for the analysis of many other parameters assessed on Level II plots. Forest growth is influenced by internal factors (stand age, stand density and inter-tree competition, biotic damage) and external factors (weather conditions, nutrients and water supply, deposition, biotic/abiotic damage). The impact of internal factors needs to be eliminated or reduced if growth is used as a response parameter to environmental stress factors. This can be done by standardizing growth data within a plot, by choosing height growth of dominant trees being less affected by internal factors or by applying a growth model that incorporates the internal factors.

Forest growth measurements have been carried out on Level II plots in five year intervals since 1994/1995. Recently, several studies have been conducted on tree growth in Level II plots. In the following paragraph, results of three independent studies will be presented. The aims and methods used were different in the three studies. Two studies were co-financed within the EU regulation 3528/86 (DEFOGRO and PROGNEU), while the third study was conducted on ICP Forests Level II plots as a part of the EU-Project RECOGNITION.

DEFOGRO and PROGNEU used the actual 5-year growth of stem diameter or basal area periodically measured on Level II plots while for RECOGNITION five dominant trees were felled in the buffer zone of selected Level II sites and a comparable adjacent stand of different age. Stem disks of felled trees were taken and tree height increment was either assessed directly by measuring the length of the internodes or determined from the stem disks.

3.3.1 DEFOGRO

3.3.1.1 Aims

In DEFOGRO the relationship between tree defoliation and tree growth was evaluated using the stem diameter measurements and the annual defoliation assessments. The project was the first evaluation of Level II data with regard to defoliation and tree growth. It was tested if differences between countries or three main species (Norway spruce, Common beech and Scots pine) existed for the relationship between defoliation and growth.

3.3.1.2 Methods

The DEFOGRO analysis was carried out for the three most widely distributed tree species Scots pine, Norway spruce and Common beech. Only Level II plots with one of the three species being the main species were used. For inclusion in the study the trees had to have two diameter measurements (period 1994/95 and 1999/2000) and at least one crown defoliation assessment. Predominant, dominant, and co-dominant trees were used only, i.e. suppressed trees, and trees that died during the period, were excluded. After eliminating the plots and trees not fulfilling the data requirements a data base with both the tree and plot information was set up. Altogether the study comprised about 15’000 trees on 237 plots from 15 countries (Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Luxembourg, Norway, Slovakia, Spain, Sweden, Switzerland, The Netherlands, United Kingdom) (see Table 3.3.1.2-1).

Table 3.3.1.2-1: Statistics of the data set used.

	Number of			Trees per plot		
	countries	plots	trees	avg	min	max
Spruce	9	103	7845	64	8	219
Pine	12	87	5234	56	11	297
Beech	9	47	2546	50	11	180
Overall	15	237	15625	52	8	297

For each tree the annual defoliation scores during the growing period, i.e. starting in the summer after the first diameter measurement up to the summer before the second measurement, were averaged. These mean defoliation scores were grouped into 10% classes, i.e. assigned to the values 5% (0-9.9%), 15% (10-19.9%), and so on. For tree growth the stem basal area growth in percent of the basal area at the beginning of measurement interval was used. The median growth of trees within the lowest defoliation class (‘undefoliated’ trees) was used as the growth reference for each plot (‘optimal’ growth of the ‘healthy’ trees). In the other defoliation classes growth was computed in percent of the ‘optimal’ growth of these ‘undefoliated’ trees. Statistical analysis was performed to test for differences between species, defoliation classes and countries.

3.3.1.3 Results

Although tree growth was highly variable, basal area growth and defoliation correlated negatively for all three species (Fig. 3.3.1.3-1). In other words within a stand trees with fewer needles or leaves had less basal area growth than undefoliated trees. This relation had previously been found in some studies for spruce and pine, but for beech no such clear results had been established. For spruce in lower defoliation classes an increase in defoliation corresponded to a more than proportional growth reduction. The relative growth reduction was higher for spruce than for pine and beech. For beech this relationship was not as clear as for the other two species – at least for trees in low defoliation classes.

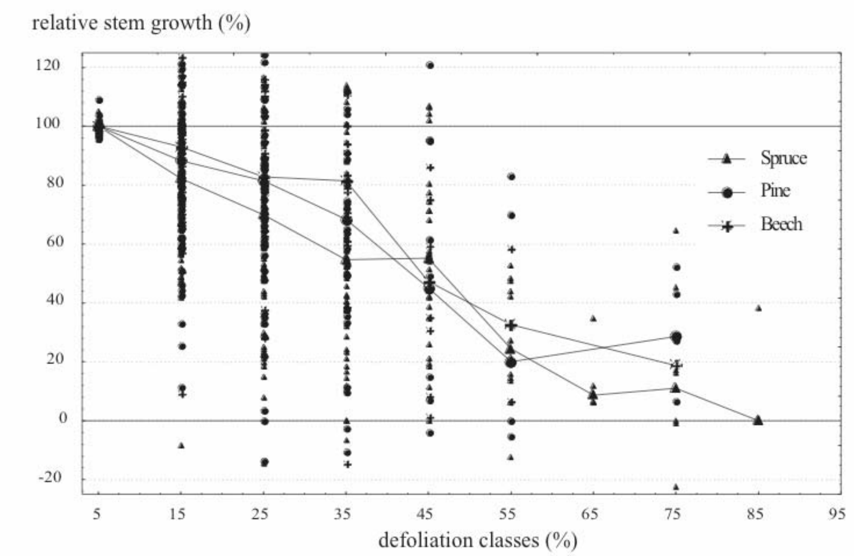

Figure 3.3.1.3-1: Basal area growth of the five year period in percent of the initial basal area and undefoliated trees set to 100% plotted against mean defoliation of the period grouped into 10-% classes.

Tree growth is influenced by various internal and external factors. According to the nature of these factors the relation with increment is different. For example, chronic pollutant deposition will increase defoliation and reduce tree growth at the same time, while acute events such as attack by leaf defoliator can only manifest itself in future growth reduction. Other factors, such as drought or heat, may even negatively affect the tree physiology and growth without immediate defoliation symptoms.

Having no exact information on these causal factors such clear relation between unspecific defoliation and growth could only be achieved with a large data set such as in this study.
When analysed in a multivariate way, significant differences were found between countries. The differences between countries can be due to differences in site or stand condition but also due to differences in crown defoliation assessment methods. The method can be used to detect differences between plots and to test if environmental stress factors influence this relationship.

3.3.2 PROGNEU

3.3.2.1 Aims

The aims of PROGNEU were to develop a tree-individual basal area growth model and to relate the difference in modelled and observed growth to various environmental and tree factors, such as defoliation. The tree growth model was used to account for the differences between the internal factors affecting tree growth such as size, inter-tree competition and inter-plot differences of various site factors.

3.3.2.2 Methods

Only plots with at least 25% spruce or beech trees were selected from neighbouring central European countries Austria, Switzerland, Luxembourg, France, Germany (Bavaria), Czech Rep. and Hungary. Information used for the model were individual tree measures (dbh in

1994/1995 and 1999/2000, crown ratio: ratio of crown length to tree height) and site variables (slope, azimuth, elevation, annual temperature and precipitation, base saturation, field capacity, vegetation type). A log-linear regression model, with basal area increment as dependent variable was fit separately for the two species.
The ratios between observed growth and modelled growth were then compared against tree defoliation and deposition rates.

3.3.2.3 Results

For Norway spruce the full model explained 53 % of the total variation and for beech 70%. The modelled growth was compared with the actually observed growth of trees. (Fig. 3.3.2.3-1). For higher defoliation classes the actual growth was lower than the modelled growth, while trees in the lowest defoliation class had higher growth than modelled. Essentially the same relation was found for beech. Beech in the lowest defoliation class also grew better than modelled, while trees with higher defoliation grew less than modelled. The decrease of growth with increasing defoliation was less for beech than for spruce at least for trees with less than 50% defoliation.

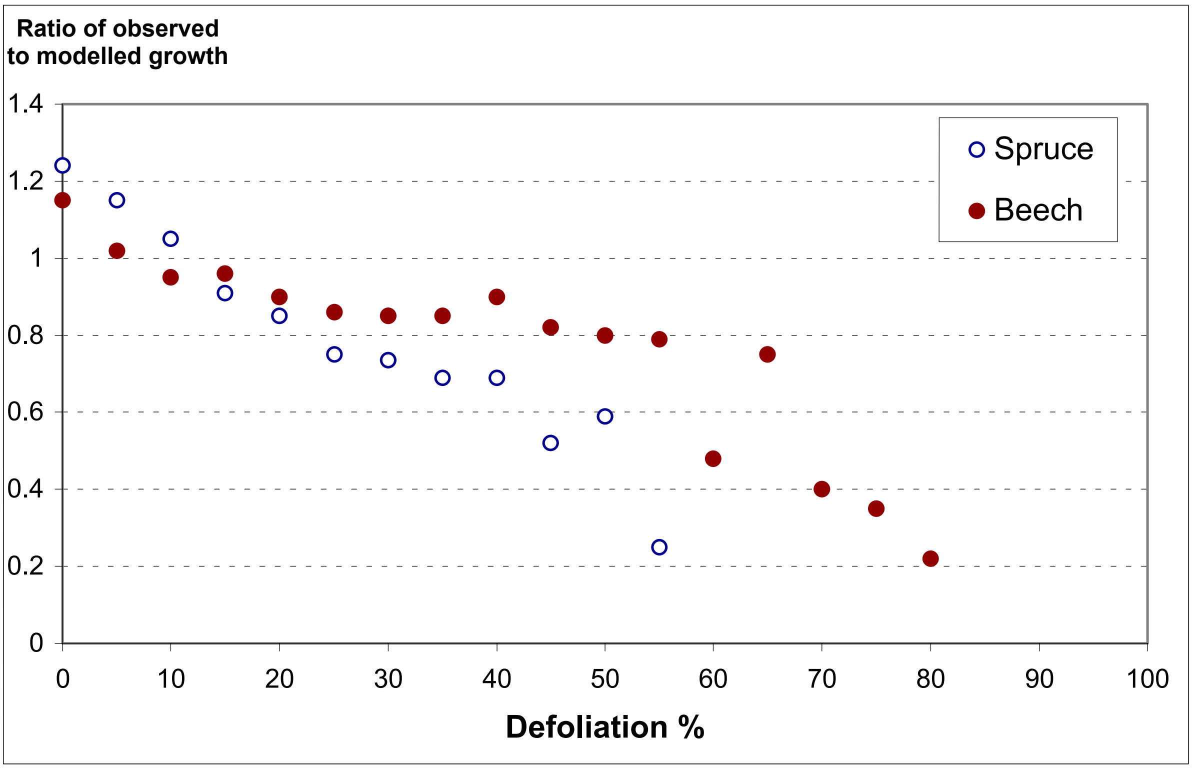

Figure3.3.2.3-1: Ratio of actual to modelled growth decreases with increasing defoliation for beech and Norway spruce.

The relationships between defoliation and growth ratios differed significantly between countries. It is thus concluded that growth is a more reliable indicator for forest condition than defoliation assessment, because it is more objective and repeatable and if related to an appropriate growth model more generally comparable.

Actual growth on beech plots with high N or S deposition was less than estimated by the model (Fig.3.3.2.3-2). For spruce no clear correlation was found between growth residuals and deposition loads. Future detailed studies may include more detailed investigations or could be focussed on plots with specific growth behaviour to determine possible causes for the deviation. The study also shows the importance of measuring N deposition and meteorological data on the plot.

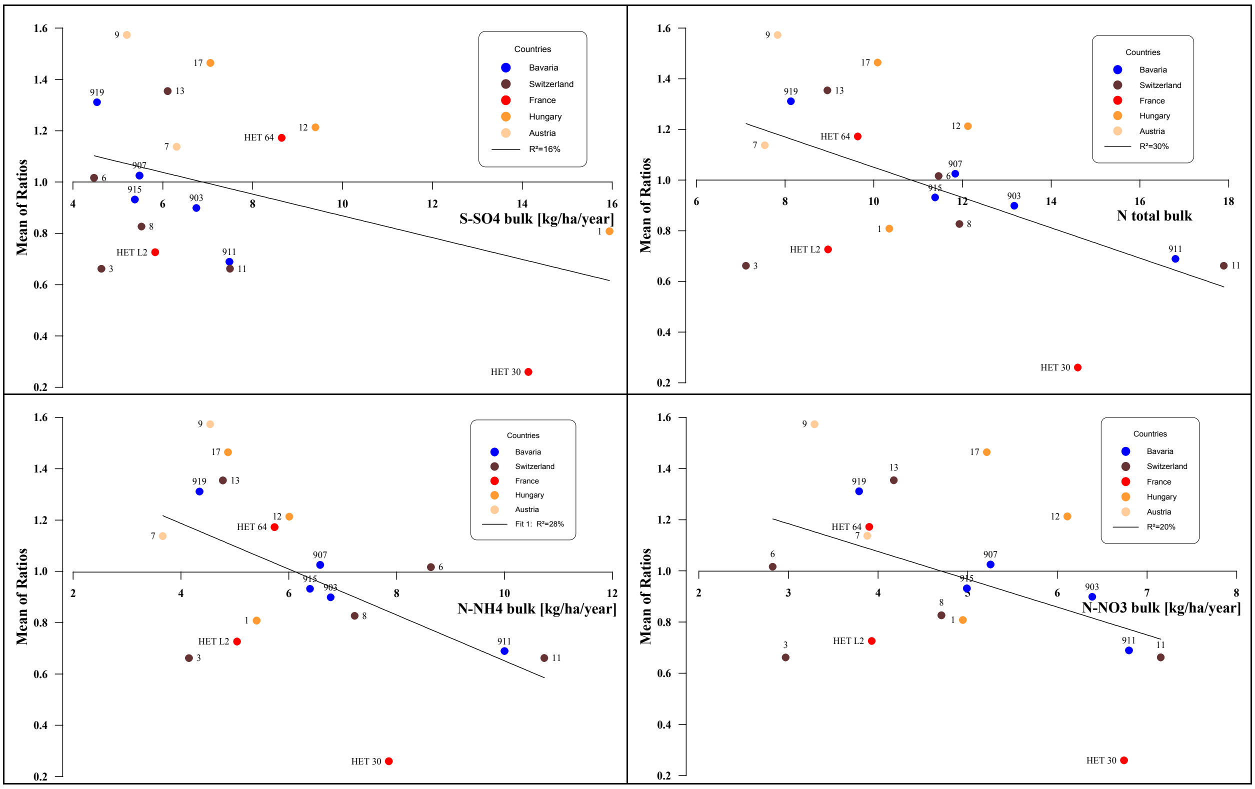

Figure 3.3.2.3-2a: Ratios between observed and modelled basal area increment (means by plot) of beech over deposition loads.

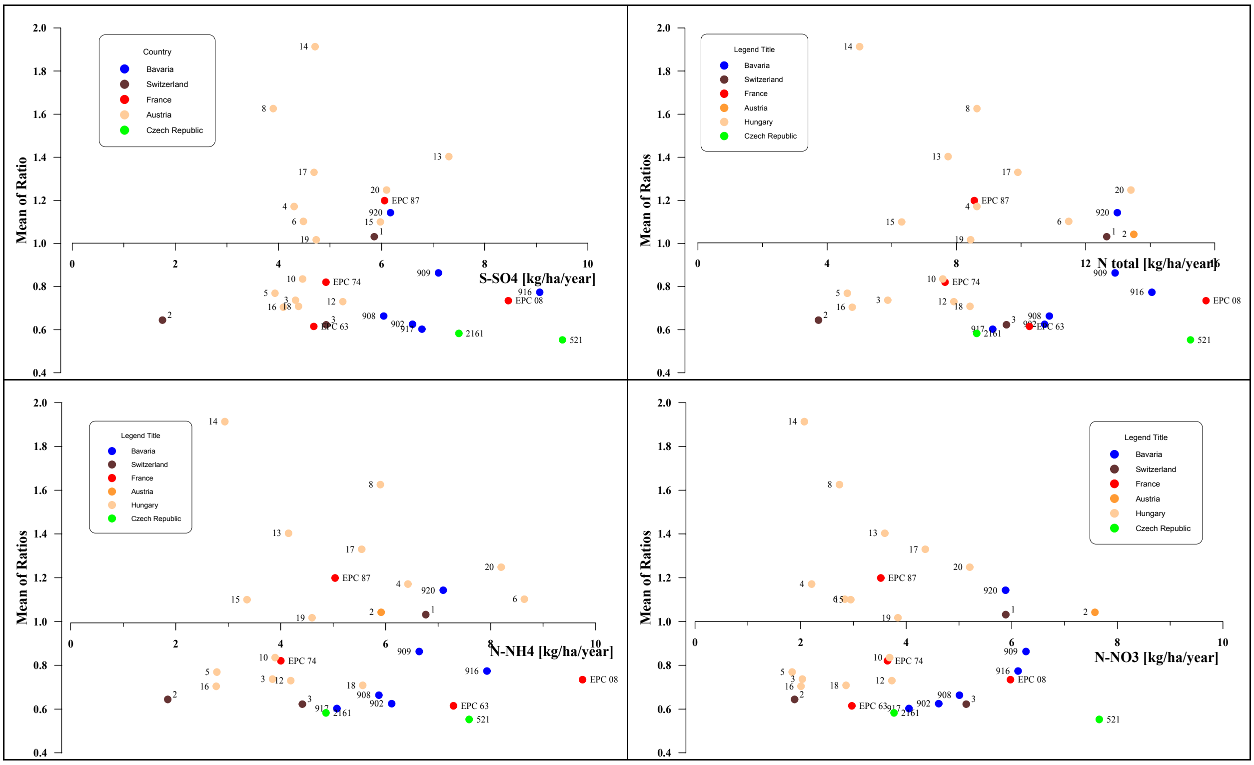

Figure 3.3.2.3-2b: Ratios between observed and modelled basal area increment (means by plot) of spruce over deposition loads.

3.3.3 RECOGNITION
3.3.3.1 Aims

The EU-Project RECOGNITION investigated trends in site productivity of European forests with the aim to identify factors which were responsible for it.
Several approaches were used in RECOGNITION. The present state analysis as one of the "correlative approaches" used data from Level II plots of EU / ICP Forests. For the analysis height growth of dominant trees was used, as it is less affected by tree competition and stand density. Spatial patterns and temporal trends of changes in height growth of Norway spruce, Scots pine and European beech were analysed in relation to changes in air temperature and precipitation, and in relation to levels of foliar nitrogen and nitrogen deposition across sites in Europe. Changes in age-related height growth between trees with different germination dates are considered as indicative for changes in forest site productivity.

3.3.3.2 Methods

The selection of the research sites was designed in such a way that each sample site represented a certain combination of different levels of three a priori determined causal factors of change in forest growth: (i) mean stand foliar nitrogen concentration [N] (average foliar [N] of the assessments conducted on the Level II plots 1993-1998), (ii) change in seasonal air temperature, and (iii) change in seasonal precipitation between the periods 1961-2000 and 1901-1930.
Sites were selected adjacent to the plots of the EC-UNECE Forest Intensive Monitoring Programme in Europe (Fig. 3.3.3.2-1). At each indicated site sample trees from an old and a young forest stand were selected and felled for stem analysis. The number of sites was for Norway spruce *n*=17, for Scots pine *n*=20, and for European beech *n*=9.

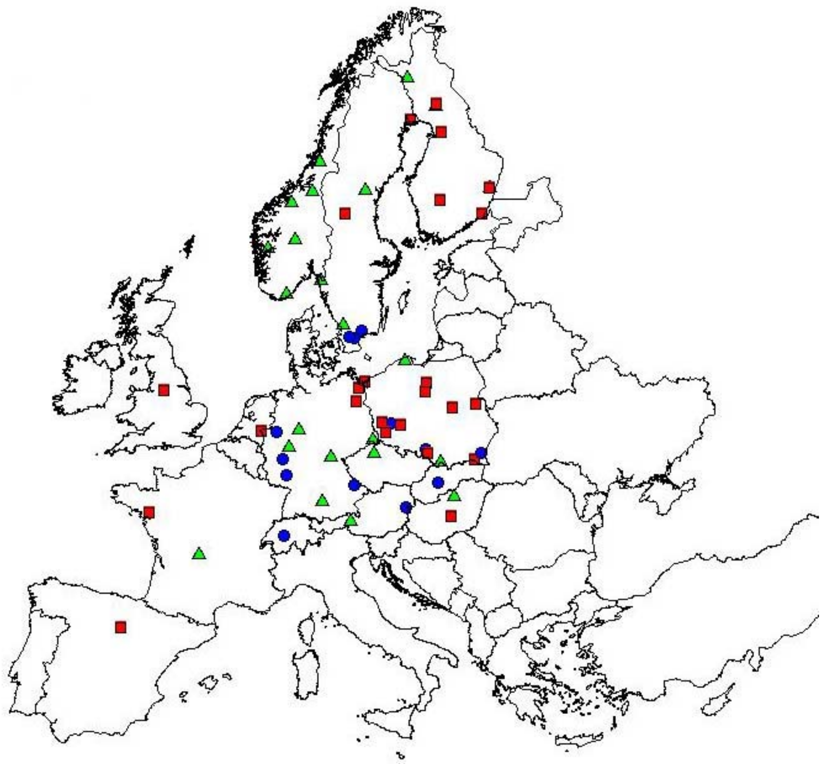

Figure 3.3.3.2-1: Level II sites selected for the growth assessment for the RECOGNITION "Present State Analysis" (blue: *Fagus sylvatica*, green: *Picea abies*, red: *Pinus sylvestris)*.

3.3.3.3 Results

During the period 1960 to 2000 height increment of the younger Norway spruce, Scots pine and Common beech sample trees is significantly and consistently larger than that of the older sample trees at the same site when they had the same age. Over the 41-years period the median deviation in relative annual height increment of the Norway spruce sample trees is 22.8%, for Scots pine 24.8%, and for European beech 25.1% (Fig. 3.3.3.3-1).

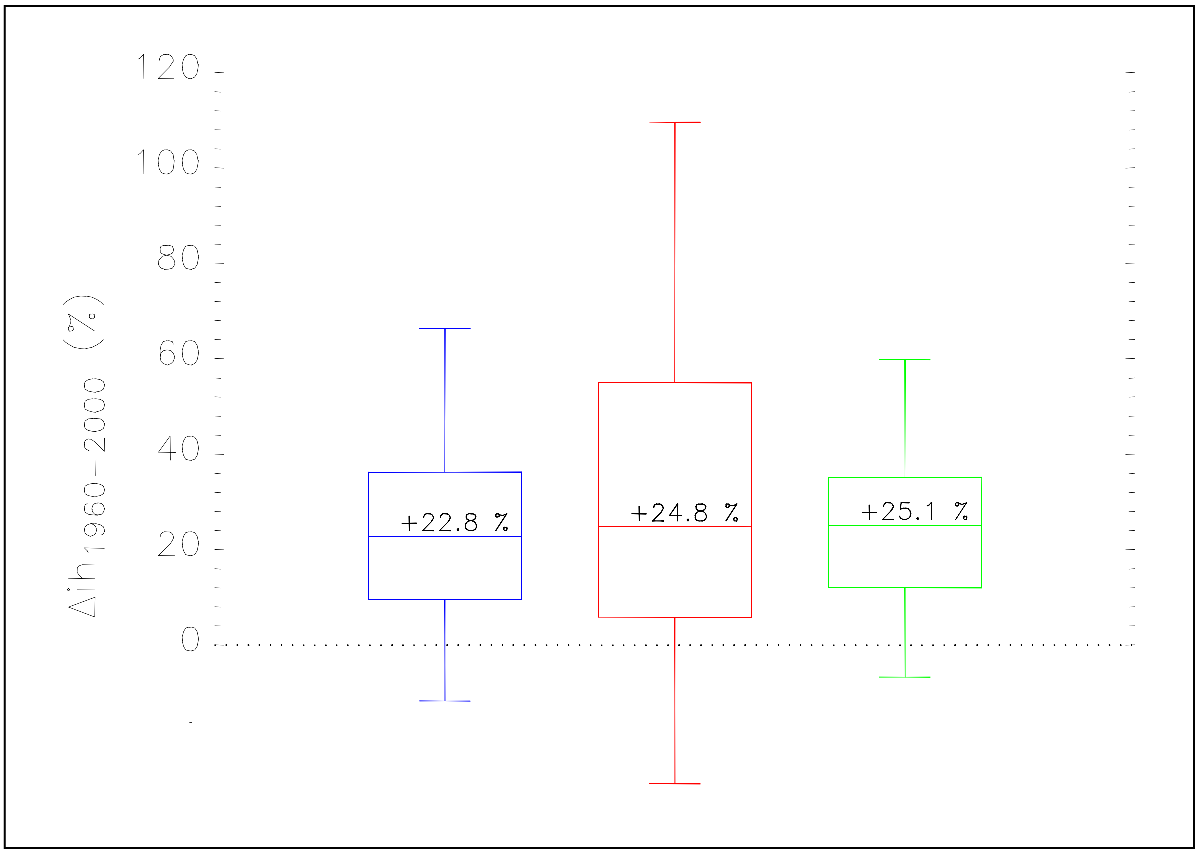

Figure 3.3.3.3-1: Plot wise deviation of median relative annual height increment during 1960-2000 of Norway spruce (left), Scots pine (middle), and European beech (right).

The ranges of median height growth increase differ between species: the difference between maximum and minimum values is largest for Scots pine, reflecting considerable heterogeneity in this sample.

Norway spruce trees with a lower level of foliar [N] in recent years show a larger mean increase in height growth acceleration over the last 30-40 years (Fig. 3.3.3.3-2). For the Scots pine and European beech sample the opposite is true: trees with higher foliar [N] show a larger median height growth acceleration rate. The temporal trend of height growth acceleration during 1960 to 2000 is for all three species negatively related to the level of foliar [N]. However, confounding between foliar [N] and change in seasonal temperature obscures identification of independent factor specific effects on changes in height growth. Height growth acceleration of Scots pine and European beech growing on sites with low initial site productivity was significantly larger than on more fertile sites (similar tendency for Norway spruce but not significant).

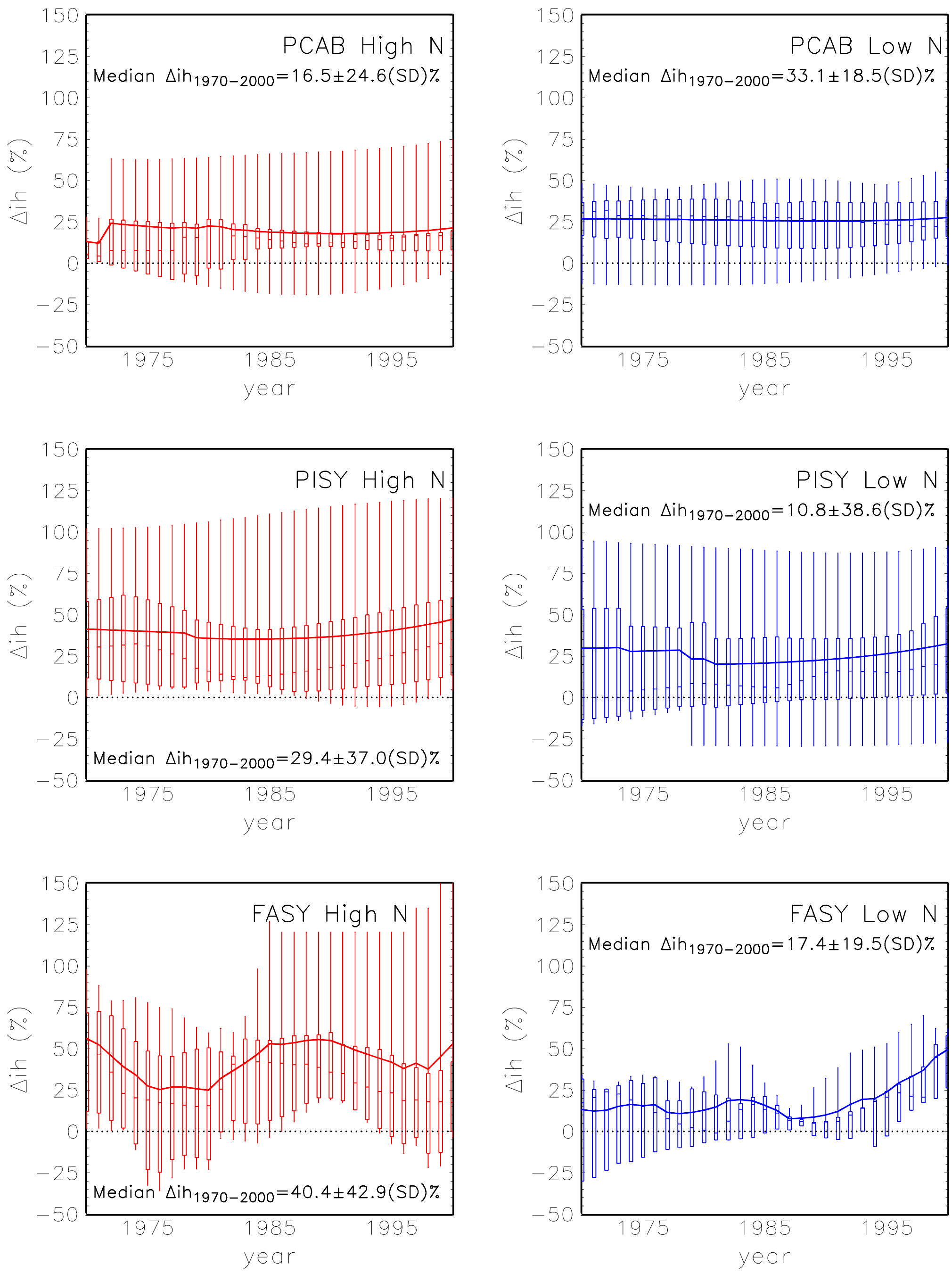

Figure 3.3.3.3-2: Deviation in relative annual height increment (D_{ih} in %) stratified by species specific classes of foliar N concentration ([N]), high N: high foliar [N], low N: low foliar [N]. For all species differences in overall means between strata are significant ($p < 0.05$). PCAB: *Picea abies*, PISY: *Pinus sylvestris*, Fasy: F*agus sylvatica.*

3.3.4 Summary of the findings of all three studies

Although highly variable, basal area growth and defoliation correlated negatively for all species examined in the two studies DEFOGRO (Norway spruce, Common beech and Scots pine) and PROGNEU (Norway spruce and Common beech). In other words trees with fewer needles or leaves had reduced basal area growth. This relation had previously been found in some studies for spruce and pine, but for beech no such clear results had been established. For Norway spruce one percent defoliation corresponded to more than one percent growth differences. Beech showed less growth reduction for low defoliation classes than spruce.

Growth and defoliation are both integrative, but unspecific indicators of tree vitality. The correlation between both variables confirms their usefulness as vitality indicators. For a given tree defoliation a wide variability of tree growth was observed, indicating other additional factors, such as tree competition and tree size as well as differences in site conditions, as being important to describe tree growth. The observed differences between countries may originate in various tree provenances, site specific environmental factors as well as in some specific differences in defoliation assessments. Tree growth measurements, on the other hand, are more objective and can therefore, if related to an appropriate growth model, be used as vitality indicators.

The RECOGNITION study found for the period 1960-2000, that median annual height growth of younger trees for all three species (Norway spruce, Common beech and Scots pine) was more than 20% above the height growth of older trees when they were of the same age. Trees grow faster now than in the past due to changes in site productivity as several studies have shown already. This increase in tree growth is not contradictory to the confirmed general relationship between defoliation and increment. While increased site productivity enhances the potential growth level of a stand, defoliation of a specific tree limits its growth within a stand. This has been demonstrated by the studies DEFOGRO and PrognEU.

According to RECOGNITION, Norway spruce with low N needle content showed higher mean growth increases. For beech and Scots pine the opposite was found. However, the trend of height growth acceleration is for all three species negatively related to the level of foliar N, suggesting that in case of high foliar N-levels height growth acceleration has slowed down during 1960 to 2000. No clear indication of influences of temperature increase on growth changes was detected. On the other hand, it was found in the PrognEU study that beech plots with high N deposition rates had lower than modelled basal area growth. Despite of these findings it could not exactly be determined whether and how deposition loads and nutrient availability affected tree growth. Further studies are therefore needed.

3.4 First Results of Epiphytic Lichen Diversity Assessment on EU/ICP Forests Level II plots in Switzerland

3.4.1 Introduction

In 2003 the EU/ICP Forests test phase for further development of forest biodiversity assessment methods was launched (Fischer et al. 2002). In addition to various aspects related to biological diversity already available in the database, e.g. tree species and size, stand age and ground vegetation, the EU/ICP Working Group on Biodiversity evaluated and discussed additional surveys that can contribute to the assessment of forest biodiversity in Europe.

At the 4th meeting of the Working Group in Sabaudia (Italy), it was agreed upon a method for the assessment of epiphytic lichen diversity on Level II plots for the test phase. The method ensures a link to other existing European Networks, e.g. BioAssess (Scheidegger et al. 2002) and Lacope (http://www.lacope.net).

In January 2004 ForestBIOTA (Forest Biodiversity Test-phase Assessments), a project proposal under Regulation (EC) No. 2152/2003 (Forest Focus) for the development of forest biodiversity monitoring, was submitted. ForestBIOTA aims at the further development of monitoring methods for some aspects of forest biodiversity as well as towards correlative studies between some compositional, structural and functional indices of forest biodiversity (http://www.forestbiota.org).

First results of a preliminary assessment on 15 EU/ICP Forests Level II plots in Switzerland during summer 2003 can already be presented.

3.4.2 Methods

Study area and sampling design

Lichen data were sampled on 15 Level II plots (Fig. 3.4.2-1) belonging to the five main biogeographical regions of Switzerland (Jura = 2, Central Plateau = 4, Pre-Alps = 3, Alps = 5, Southern Alps = 1). On each plot a subplot of 1 ha within the boundary of the plot was selected (Alptal 0.6 ha). For the selection of the sampling trees, a pre-stratification based on four tree classes was carried out for each subplot by means of the existing data base. The considered tree classes are described in Table 3.4.2-1. Within each subplot 12 sampling trees were selected randomly according to the abundance of the tree classes on the subplot. If a tree class was represented by less than three trees, additional trees of this class were randomly selected until it contained three trees.

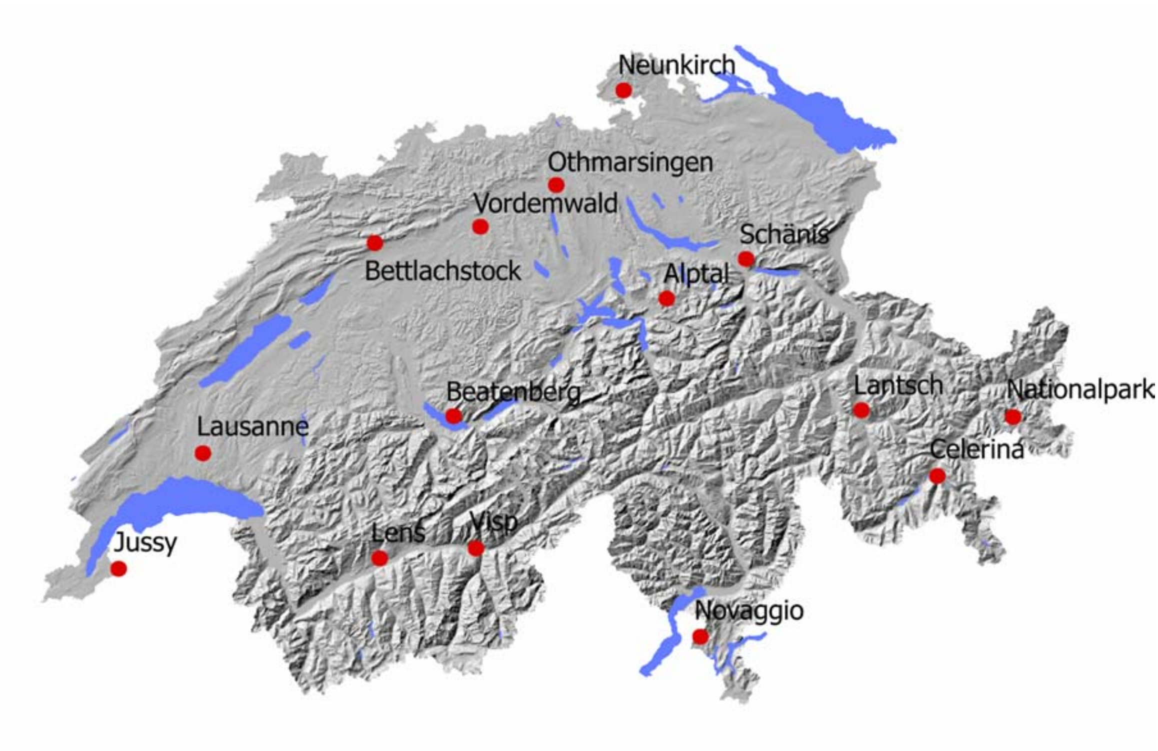

Figure 3.4.2-1: Location and names of the 15 Level II plots in Switzerland.

Table 3.4.2-1: The four tree classes considered. Only trees with a minimum circumference at breast height (dbh) of 16 cm are taken into account.

Tree class	Description
Class 1	Neutral bark, dbh > 36 cm
Class 2	Neutral bark, dbh ≤ 36 cm
Class 3	Acidic bark, dbh > 36 cm
Class 4	Acidic bark, dbh ≤ 36 cm

On each of the selected trees, the four directions of the compass (N, W, S, E) were marked at 150 cm above ground level and four frequency ladders (each 10 x 50 cm and composed of 5 grid cells of 10 x 10 cm) are set up (Fig. 3.4.2-2). All lichens occurring within the frequency ladders were noted and for each species the number of occupied grid cells was counted. Since delimitation of individuals is often difficult or even not possible for lichens, we used the number of occupied grid cells as abundance measure. For simplicity we use the term individual for the number of occupied grid cells from now on. Specimens which could not be identified in the field were collected and checked in the lab, if necessary applying thin layer chromatography analyses of the secondary chemical compounds (Culberson & Ammann 1979; Culberson & Johnson 1982; Culberson & Culberson 1994; Huneck & Yoshimura 1996). Specimens are kept at the Swiss Federal Research Institute WSL.

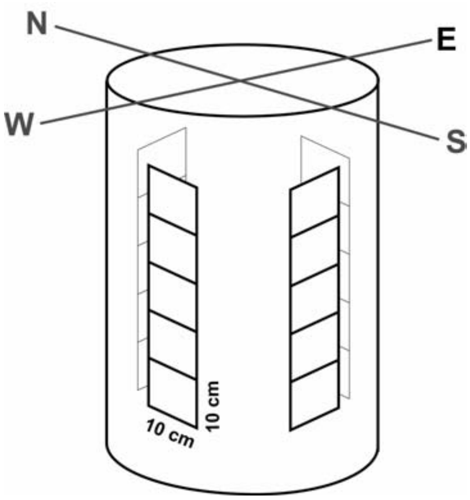

Figure 3.4.2-2: The four frequency ladders per tree.
The upper margin of each ladder is fixed at 150 cm above ground.

Further details concerning the pre-stratification and standardization of the applied lichen assessment method are described in Stofer et al. (2003).

Data

The lichen data were stored in a relational data base (Access) at the Federal Research Institute WSL at Birmensdorf in Switzerland.

A Spearman correlation was used to evaluate the relationship between macrolichen and crustose lichen species richness and a Wilcoxon signed rank test to compare the effect of additional trees on plot species richness. Direct ordination (CCA) was used to study effects of the explanatory variables (see Tab.3.4.3-1) on lichen species composition.

The Spearman correlation was carried out with the GENSTAT 5.0 program, release 3.2 (Payne et al. 1993) and a Wilcoxon signed rank test performed by R 1.8.1 (R Development Core Team 2003). For the canonical correspondence analyses (CCA) rare species were downweighted. Otherwise default settings for ordinations in CANOCO 4.5. were used (ter Braak & Smilauer 1997-2002). To reduce the number of explanatory variables (see Tab. 2 for all explanatory variables) in the multivariate analyses we used the CANOCO procedure of 'forward selection of environmental variables'. Statistical significance of explanatory variables was tested by subsequent Monte Carlo permutation tests (999 unrestricted permutations).

3.4.3 Results and discussion

Species richness

In total 132 different epiphytic lichen species were found and more than 4000 individuals were counted. The mean species richness per plot was 22, and the mean number of individuals was 268. There was no significant relationship ($r = 0.31$, $p > 0.05$, $n = 15$) between species richness and number of individuals (Fig. 3.4.3-1).

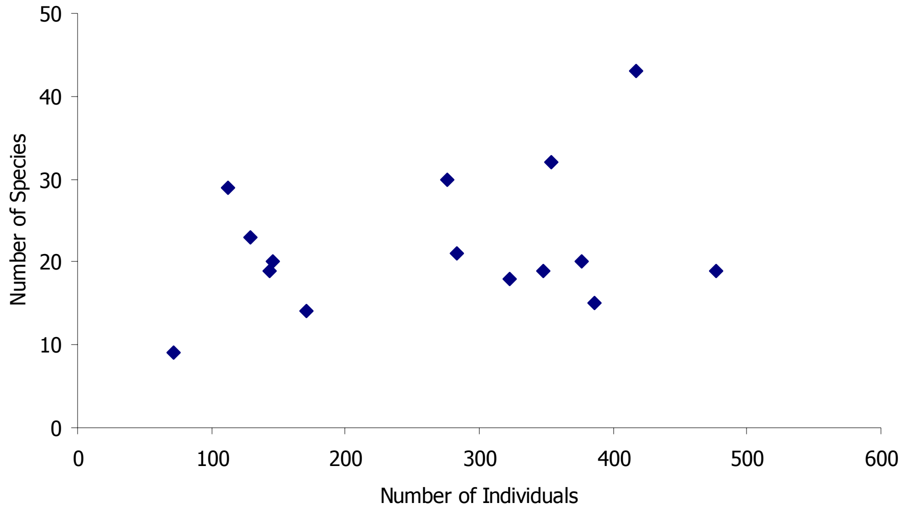

Figure 3.4.3-1: Relationship between the number of species and the number of individuals ($p > 0.05$, $n = 15$).

The number of lichen species on the 15 plots differed considerably (Fig. 3.4.3-2). The highest number of species (43 species) was reported from the Alptal (mixed coniferous forest in the Pre-Alps), whereas the lowest species richness (9 species) was observed in the Swiss National Park (*Pinus mugo*-forest in the alpine region). The oceanic aspect of the climate in the Alptal and the stand characters (mainly the different tree species composition and the varying tree age) favour the lichen species richness on this plot. In contrast, the rather dry climate and the uniform stand (tree age, tree species) in the Swiss National Park support a rather low lichen species richness.

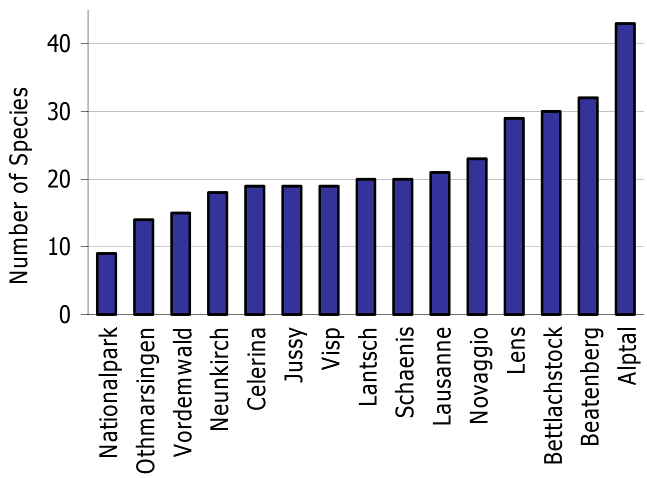

Figure 3.4.3-2: Number of lichen species per plot.

Species composition

The impact of environmental and forest stand variables on epiphytic lichen species composition was investigated by a direct ordination analysis. Table 3.4.3-1 shows all the explanatory variables considered for the model together with their importance in explaining the species data. Monte Carlo permutation tests revealed for several variables significant effects on species composition (Tab. 3.4.3-1). However, after including altitude, which is the variable with the highest 'extra fit' (i.e. the variable which explained the highest variance fraction) into the model, significance of most of these variables vanished due to high correlation with altitude. Only relative number of conifers had still a significant effect ($p = 0.045$) on species composition. A canonical correspondence analysis with the two selected variables explained 27.5 % of the total variation in the species data (Fig. 3.4.3-2). The small sample of this preliminary study keeps the possibilities to analyse the data within a limit. The entire ForestBIOTA data will allow more detailed analyses.

Table 3.4.3-1: 'Extra fit' of environmental variables as revealed by forward selection of environmental variables in the CCA. Extra fit is equal to the eigenvalue of a CCA if the corresponding variable were the only variable included in the CCA (ter Braak & Smilauer 1998). (*): $p < 0.1$, **: $p < 0.01$, ***: $p < 0.001$.

Variable	**'Extra fit'**
Altitude	0.80 ***
Yearly mean temperature	0.78 ***
Mean temperature of July	0.78 ***
Mean temperature of January	0.76 **
Relative number of conifers	0.75 ***
Yearly mean snow cover	0.72 ***
Standard deviation of dbh	0.60 **
Coefficient of variation of dbh	0.52 (*)
Mean precipitation of January	0.48
Mean precipitation of July	0.48
Number of different tree species	0.46
Yearly mean precipitation	0.45
Mean dbh	0.42
Slope	0.35
Number of trees per ha	0.30

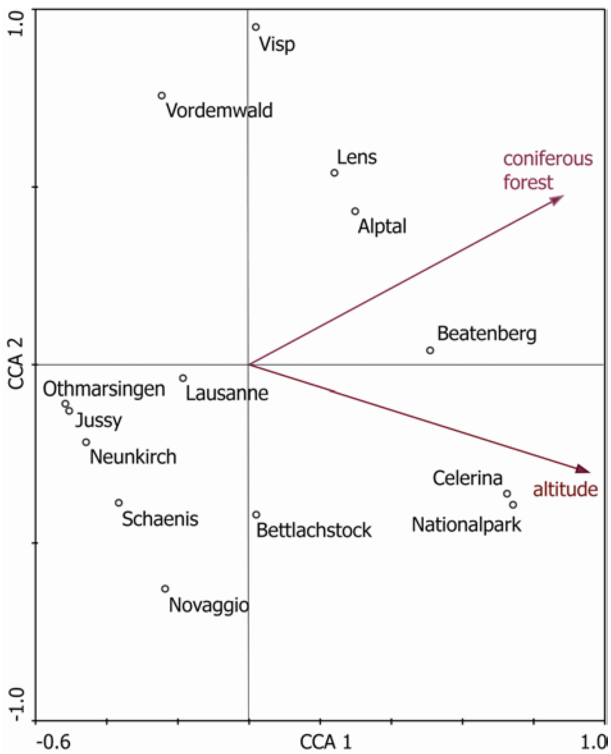

Figure 3.4.3-2: CCA ordination diagram of 14 plots (Lantsch is omitted due to lack of data) in relation to axis 1 and 2.

The next two analyses are tackling the question of possibilities to simplify the method and in doing so saving money.

Could we consider only macrolichens?

In total, 36 macrolichens and 96 crustose lichens were found. Crustose lichens represent an important part of the epiphytic lichen diversity. High species richness of crustose lichens in surveys is a common pattern and Dietrich & Scheidegger (1996) point out that the biodiversity of lichens can not be determined without considering sorediate crustose lichens or crustose lichens in general. Nevertheless recording only macrolichens would reduce the amount of work in the field as well as in the laboratory considerably. However, we found no relationship (Spearman's r = 0.027, $p > 0.05$, n = 15) between macrolichen and crustose lichen species richness (Fig. 3.4.3-3). Thus, macrolichen richness as indicator for total lichen richness can not be recommended for forest ecosystems. But, attention should be paid to the small sample size of this preliminary study. Analyses based on lichen data of a project over a large geographical scale, which aimed at developing biodiversity indicators across land-use gradients in Europe ("BioAssess"), have shown a highly significant relationship between the species richness of macrolichens and crustose lichens on different scales and substrate types (Bergamini et al. in prep.). However, they don't recommend macrolichens uncritically as indicators of total lichen species richness because the amount of explained variation was rather low and, thus, predictions were very imprecise. Analyses with the entire ForestBIOTA data will provide a more substantiated base to answer this question.

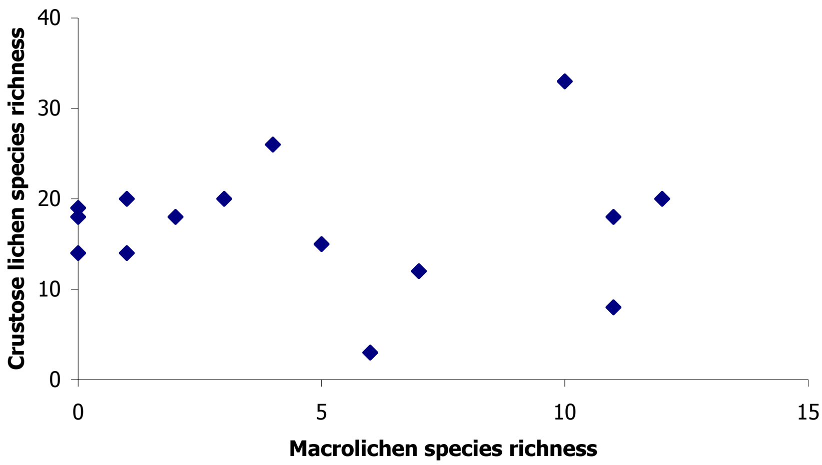

Figure 3.4.3-3: Relationship between macrolichen species richness and crustose lichen species richness ($p > 0.05$, n = 15).

What is the effect of the additional trees on the lichen diversity of the plots?

For six plots the minimal number of trees per tree class was reached after the pre-stratification according to the abundance of the tree class and there was no need to look for additional trees. For nine plots additional trees had to be selected to get the demanded three trees per class. These additional trees were selected to get a better estimation of the species richness of the plot. We found a highly significant effect of additional trees on the plot species richness ($p = 0.007$, n = 9, Fig. 3.4.3-4). Moreover, the number of additional lichen species found did not seem to depend on the number of species already observed on the plot. In the mean 2.6 additional trees were studied. This confirms that with little additional effort a much better estimation of the effective plot species richness can be achieved.

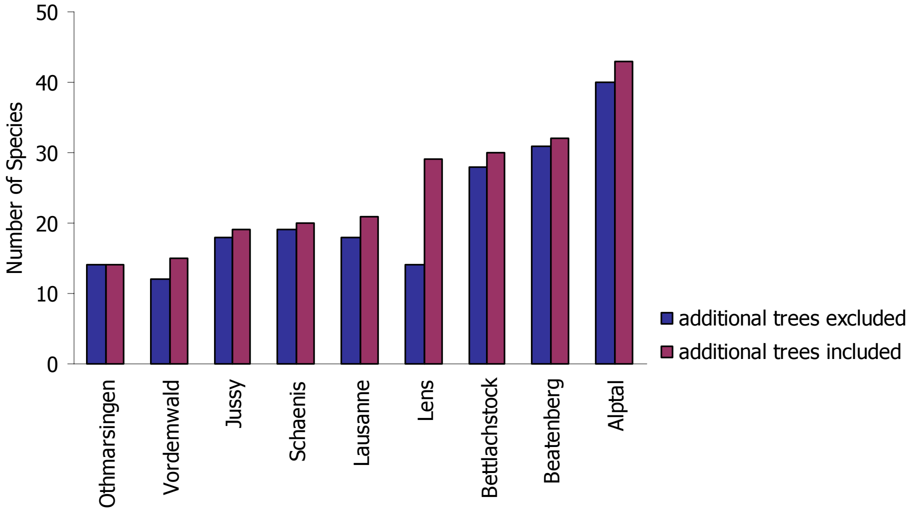

Figure 3.4.3-4: Lichen species richness with and without additional trees per plot.

4. NATIONAL SURVEY REPORTS IN 2003

In 2003, 32 countries contributed summaries of their national Level I crown condition survey results. These reports are presented in the following.

Numerical data presenting the crown condition in the participating countries were made available by 30 countries. These tabulated results are presented 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 broad-leaved trees, respectively. The annual changes of crown condition are presented for all species in Annex II-5, for the conifers in Annex II-6, and for broad-leaved 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 2003, 2228 trees were assessed on 93 permanent Level I sample plots in the period from August to October.

Altogether 9 tree species were assessed:

Since years the most defoliated tree species has been *Pinus sylvestris*. The percentage of not defoliated *Pinus sylvestris* was 51.1% in 2000. In 2003 this share was 16 percent points lower than, and it was on a similar level as in the years 1994 and 1995. Diseases, especially the outbreak of shoot blight caused by *Ascocalyx abietina* recorded on 610 *Pinus sylvestris* trees and needle cast caused by *Lophodermium seditiosum* had an important influence on defoliation.

The permanent increase in defoliation of *Picea abies* which occurred in 1995-2001, stopped in 2002 and 2003. In 2003 the share of healthy *Picea abies* trees was 4 percent points lower than in 2002, but 19 percent points lower than in 1995. The percentage of healthy *Picea abies* on level I sample plots was 63% in 1988, 58% in 1991, 75% in 1995 and 56% in 2003. Only 10% of *Picea abies* were in defoliation classes 2–4 in 2002.

Mechanical and wind damage, moose peeling injures of stem, root rot and colonisation of trees by bark beetles were the most important reasons for damage and death of *Picea abies*.

In total the healthy state of deciduous species was markedly better than that of the conifers.

There were considerable regional differences in defoliation rate in Estonia. The regions with higher defoliation rates remain the same as in previous years. Some sample plots with high level of defoliation of *Picea abies* were close to local sources of air pollution in North-West of Estonia. The most severe defoliation of *Pinus sylvestris* occurred also in north-western and western Estonia.

4.1.2 Finland

The 2003 forest condition survey was conducted on 453 sample plots arranged in 24 x 32 and 16 x 16 km grids. No changes were observed in the average defoliation level of any tree species between the years 2002 and 2003. Of the 8 482 trees examined in 2003, the average tree-specific degree of defoliation was 9.4% (9.3% in 2002) in *Pinus sylvestris*, 18.5% (18.8% in 2002) in *Picea abies* and 11.6% (11.7% in 2002) in broadleaves (mainly *Betula* spp.). A total of 9 trees (0.1%) died during 2002-2003 (0.4% in 2001/2002).

The proportion of discoloration (extent of discoloured needle/leaf mass more than 10%) on *Pinus sylvestris* remained at the same level (under 1%) as in 2002, and that of *Picea abies* decreased from 4.5% to 3.8%. Leaf discoloration on broadleaves decreased from 1.4% to 0.5%. The most frequent discolouration symptoms were needle tip yellowing and needle yellowing, and the symptoms were mainly concentrated on needles older than two years. However, the proportion of slightly discoloured (extent of discoloured needle mass 1-10%) conifers was higher than that in the previous year.

In 2003 there were several storms affecting most parts of Finland, which caused scattered damage. The damage was more widespread, but totalled less than that in 2002. Storms were still the main cause of forest damage. There was increasing snow damage especially in southern and central Finland. Forests were stressed by the drought that started in 2002 and continued far into the summer. Pine stands growing on exposed bedrock areas and well–drained soils suffered the most, and local stand mortality occurred on many sites along the southern coast.

Fungal diseases decreased in general. However, *Chrysomyxa* needle rust occurred as a belt across Central Finland. No extensive insect outbreaks were detected, but the defoliators especially seemed to be favoured by the dry periods. Bark beetles were also on the increase (e.g. *Tomicus* sp.), but the unfavourable weather conditions in spring and early summer hindered the spruce bark beetle (*Ips typographus*) from swarming and reproducing

No correlation was found between the defoliation pattern of conifers or broadleaves and the modelled sulphur or nitrogen deposition (1993) at the national level in 2003.

4.1.3 Latvia

The forest condition survey in Latvia was carried out on 361 permanent sample plots on the national 8 x 8 km grid net. Of all tree species 21.8% of the assessed trees were not defoliated, 65.7% - slightly defoliated and 12.5% - moderately defoliated to dead (defoliation classes 2-4). The main species assessed were *Pinus sylvestris, Picea abies and Betula* spp. Mean defoliation of *Pinus sylvestris* was 19.4%, i.e. by 1.1 percent points lower than in 2002 (20.5%). The proportion of undamaged trees increased by 3.6 percent points as compared to 2002. A decrease in defoliation of *Pinus sylvestris* has been observed since 1993. No significant changes were observed for the mean defoliation of *Picea abies* during the last years, in 2003 showing 20.6%. Since 2001 after some years of deterioration the defoliation level of *Picea abies* has stabilized slightly above 20%. Mean defoliation of *Betula* spp. was 19.8% (19.4% in 2002). No obvious changes in defoliation have been observed for this species during the recent years.

Discoloration was observed on 0.6% of the assessed trees.

Damage symptoms were identified on 8.8% of all trees. For individual tree species damage was as follows: *Pinus sylvestris* – 5.2%, *Picea abies* – 9.2% and *Betula* spp. – 13.8%. The most frequent damage type was insect damage which was observed on 32.7% of all damaged trees (fungi: 18.3%; human activities: 18.1 and adverse abiotic factors 13.8%). Most of the damage symptoms are of local character.

4.1.4 Lithuania

The 2003 forest condition survey was carried out on 280 sample plots on the Level I transnational (16 x 16 km) and national (8 x 8 km) grids. In total of 6 758 sample trees representing 17 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.*

13.3% of all sample trees were not defoliated and 14.7% were assessed as damaged (defoliation classes 2 – 4). The mean defoliation of all species was 21.2% (20.4% in 2002). The mean defoliation of broadleaves (24.4%) was higher than that of conifers (19.8%). The mean defoliation of *Fraxinus excelsior* decreased to 32.9% (45.9% in 2002) and the share of damaged trees decreased to 38.3% (60.8% in 2002). The condition of some species of broadleaves noticeably deteriorated during the last year. In 2003, the mean defoliation of *Quercus robur* was 29.7% (24.5% in 2002) and that of *Betula* spp. was 23.0% (18.0% in 2002). *Betula* spp. was specifically defoliated in the top crowns. *Pinus sylvestris* and *Alnus glutinosa* were the most healthy tree species. The mean defoliation of *Pinus sylvestris* was 19.1% (19.5% in 2002) and *Alnus glutinosa* - 19.2% (24.2% in 2002).

Mean discolouration (classes 1 – 4) of all sample trees was less then 1%.

9.4% of all sample trees had some kind of identifiable damage symptoms. The most frequent damage was caused by insects (2.5%), direct action of man (1.6%), abiotic agents (1.4%), fungi (1.1%), game and grazing (0.5%) and other (2.3%).

4.1.5 Norway

The national survey design in Norway was changed in 2001 and 2002. The survey in 2003 was conducted on selected plots of a 9 x 9 km grid net for *Picea abies, Pinus sylvestris* and *Betula* spp. Included are also sample trees of *Picea abies* and *Pinus sylvestris* of the national forest inventory on a 3 x 3 km grid net, re-measured every five years.

With respect to all assessed tree species, 38.8% of all trees were not defoliated and 89.7% were not discoloured. The mortality rate was 0.2%. Average crown density was 82.1%, showing an increase by 1.1 percent points as compared to 2002. In general, these results represent an improvement in crown condition compared to last year.

For *Picea abies*, average crown density increased from 81.1% in 2002 to 82.8%, and for *Pinus sylvestris* from 82.4% to 83.6% in 2003. The crown density for *Betula* spp. was recorded to 78.8%, representing a very slight decrease by 0.1 percent points compared to the result in 2002.

Of the coniferous trees, 42.1% were rated not defoliated, representing an increase by 4.1 percent points in comparison to the results in 2002. An increase for *Betula* spp. by 3.7 percent points was observed in the class “not defoliated”, and was assessed to 28.0% in 2003.

16.9% of *Picea abies* showed signs of discolouration, after 16.1% in 2002. For *Pinus sylvestris*, 4.0% were assessed as discoloured, reflecting a decrease by 3.1 percent points as compared to 2002. In *Betula* spp., a decrease in discoloured trees was observed from 10.1% in 2002 to 5.6% in 2003.

No serious attacks of pests or pathogens were recorded this year. In general, the observed crown condition results from an interaction between climate, pests, pathogens and general stress. The results of the 2003 assessments confirm the forest vitality status recorded over the last few years.

4.1.6 Sweden

The results from the national forest condition survey concern only forests of thinning age or older. On a national level deterioration in tree health of the main conifer species *Picea abies* and *Pinus sylvestris* is observed. The proportion of trees with more than 25% defoliation is 25.1% for *Picea abies* (21.7% in 2002) and 13.6% for *Pinus sylvestris* (11.9% in 2002). The increased defoliation is mainly observed in the northern part of the country. In *Picea abies* the defoliation level is about the same as in the years prior to 2002. A slight improvement of *Pinus sylvestris* is noticed in southern Sweden, but the damage level is still clearly higher than before the extensive outbreak of *Gremmeniella abietina* in 2001. In *Betula* spp. a slightly increased defoliation is noticed and the proportion of trees with more than 25% is 9.7% (8.1% in 2002). The share of discoloured *Picea abies* trees slightly increased to 11% in 2003. In *Pinus sylvestris* discolouration is still rare, less than 3%.

The excessive outbreak of *Gremmeniella abietina,* which arose in 2001, still strongly influenced the tree health of *Pinus sylvestris*. New infections are now however at a low level. Other fungi damage (root rot excluded) and insect damage were observed on less than 2% of the main conifer species. Attacks of *Tomicus* spp., at 0.3% of the pine trees, are more rarely noticed than what could have been expected after the extensive outbreak of *Gremmeniella abietina*. A smaller outbreak of *Chrysomyxa abietis* is observed in southern Sweden. An increased defoliation seen in *Quercus robur* can be related to a regional attack in south-eastern Sweden of *Tortrix viridana*.

The forest damage level as well as the year-to-year variation is interpreted as an effect of natural stress factors. Air pollution inflicts and interacts with these factors.

4.2. Central Europe

4.2.1 Austria

In 2003, for the first time in Austria the crown condition assessment was restricted to the transnational grid of 16x16 km only. The 131 plots of the transnational grid comprehend only half of the number of plots of the national grid. Therefore, this year's results are prone to be altered by random effects and must not be compared with the results of the previous years based on denser sampling. Consequently no conclusions on development of defoliation are possible. The year 2003 was generally warmer than average with amounts of precipitation below average in wide parts of Austria. About 3400 sample trees have been assessed in this year's survey. 11.2% of the conifers and 10.2% of the broadleaved species were classified as damaged. Of the conifers, *Pinus sylvestris* showed the highest amount of trees classified as damaged. This is due to the fact of early shedding of the needles caused by heat and drought. Because of the small sample size, species-specific information for broadleaved trees is not longer inferable.

Damage by spruce bark beetles exceeded the amount of 2 Mio m³ of timber and caused the highest losses since more than 50 years. Reasons for the severe situation were more than 5,6 Mio m³ of wind thrown and wind broken timber in November 2002 and the warm and dry weather of the year 2003. This caused *Ips typographus* over three generations in the lowlands and two generations at higher altitudes in the Alps. In some areas in the eastern parts of Austria *Pytogenes chalcographus* was even more important than *Ips typographus*. During the last years, problems with bark beetles on pine, fir and larch have been increasing.

4.2.2 Croatia

78 sample plots on the 16 x 16 km grid network were included in the forest condition survey this year. For broadleaves the share of trees in classes 2-4 remained the same (14.4%). For conifers, the percentage of damaged trees (classes 2-4) shows an increase by 13.9 percent points from 63.5% to 77.4%. Although this percentage is high, it does not have a stronger impact on the overall percentage of trees of all species for the same damage class, due to the low representation of conifer trees in the sample (226 conifer trees vs 1643 broadleaves).

Abies alba is the most damaged species. 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%) this year it is 83.3%. The minimum damage for *Quercus robur* was recorded in 1988 (8.1%), the maximum in 1994 (42.5%), while it has been fairly costant in the past few years at around 25-30%. In 2003 it decreased to 15.4%. For *Fagus sylvatica*, the share of trees in classes 2-4 remained low (around 5%) in the past ten years. In the year 2001 it more than doubled to 12.5%, and this year it is back to 5.1%.

Unlike the last year, which was exceptionally wet, even during the summer period, the year 2003 was a dry year. These conditions seemed to influence mainly the conifers which exhibited a significantly higher proportion of moderately to severely damaged trees.

Overall, despite a relatively high degree of damage, forest condition in Croatia has remained stable in the course of the last few years.

4.2.3 Czech Republic

No major changes were observed for both age categories of *Picea abies* (stands < 60 years and ≥ 60 years) when compared with last year's results. Defoliation of younger and older *Pinus sylvestris* stands slightly increased. The most distinct changes appeared in older *Larix* spp. stands where the share of trees in defoliation class 1 markedly dropped from 67.8 to 51.7% and simultaneously increased in class 2 from 28.9 to 46.3%. *Abies alba* showed a comparable worsening in both age categories. The relatively most important increase in defoliation in older coniferous stands appeared on plots of southern and eastern Bohemia. A less distinct shift of trees from lower to higher defoliation classes was observed for all deciduous species. This slight overall worsening of defoliation might be due to the warm and dry weather conditions during the vegetation period.

Between June and August, forests mainly in western Bohemia and northern Moravia were mechanically damaged by wind, which in some cases had the character of tornados. During the vegetation period, some serious cases of bark beetle attacks occurred in northern Moravia.

In 2003, the decrease of air pollutions (solid particulates, SO_2, CO, VOC) was less distinct when compared with the previous years. Emission of nitrogen oxides (NO_x) slightly increased in recent years. In 2002, the exposure index for ozone AOT40 was exceeded within 67% of the territory qualified for vegetation preservation (Act no. 86/2002). The territory concerned was mostly located at higher altitudes.

4.2.4 Germany

Since 1984, crown condition of forest trees in Germany has been recorded annually on a representative gridnet. The 2003 results are based on 13 572 sample trees and show a slight overall deterioration.

The proportion of all trees without visible crown defoliation declined by a total of 4 percent points to 31%. The proportion of trees with slight defoliation increased by 2 percent points and now amounts to 46%. The proportion of damaged and dead trees (defoliation classes 2-4) also increased by 2 percent points and now totals 23%. Mean defoliation developed differently for single tree species. While it remained rather unchanged for *Picea abies* (27%) and *Pinus sylvestris* (13%), it slightly dropped to 30% for *Fagus sylvatica* (previous year: 32%). In contrast, crown condition of *Quercus robur* and *Q. petraea* has significantly deteriorated. The proportion of damaged and dead trees increased by 10 percent points to 39%. Heat and drought stress affected these tree species more severely than others.

The year 2003 was characterized by extreme climate. A period of sustained drought started in February 2003 and lasted well into late summer. It was accompanied by extremely high temperatures. This caused damage to farming and forestry, especially in eastern and southern Germany. Combined with the existing air pollution, intensive sun radiation also contributed to high ozone levels. The results of the 2003 crown condition assessment do not reflect the full impact of this heat and drought stress due to the fact that forest condition also depends on the previous year when bud formation takes place. The year 2002 was, in terms of weather conditions, a favourable year for the condition of most German forests. Due to the wet late summer and autumn of 2002, water supply in the most forest soils was good until early summer 2003. In addition, drought stress and ozone levels only peaked towards mid-August, when crown condition assessments were almost completed. Overall, these stress factors of 2003 did not leave the forests untouched, but the full extent of the damage is expected to become visible only in the years to come.

Drought and ozone exposure are not the only severe stress factors for forest ecosystems. Deposition inputs of many decades have accumulated in forest soils, resulting in nutrient loss and increasing acidification of soils. This is aggravated by daily new inputs, in spite of all efforts towards emission reduction. Taking the resilience of ecosystems into account, air pollution emissions are still too high, especially those of acidifying and eutrophying air pollutants (nitrogen oxides and ammonia, above all). Hence, Germany still regards a firm clean-air policy as absolutely imperative.

4.2.5 Poland

The forest condition survey 2003 was carried out on 1 257 permanent observation plots of the national network, including 433 plots of the transnational network arranged in a 16x16 km grid. Each plot consists of 20 marked dominant trees.

Forest condition was a little worse than in the previous year. 8.2% of all sample trees were without any symptoms of defoliation, indicating a decrease only by 0.6 percent points as compared to 2002. The proportion of damaged trees (defoliation classes 2-4) increased by 2.1 percent points to a present level of 34.8% of all trees.

For 33.3% of the conifers a defoliation of more than 25% (classes 2-4) was observed. Defoliation of *Abies alba* increased by 4.2 percent points. *Abies alba* thus remained the species with the highest defoliation (62.6% trees in classes 2-4).

For broadleaved species the proportion of trees with more than 25% defoliation (classes 2-4) amounted to 39.6% which is an increase by 6.5 percent points. As in the previous survey, the highest defoliation amongst broadleaved trees was observed in *Quercus* spp. stands. In 2003, a share of 50.5% of all *Quercus* spp. was in damage classes 2-4. This is an increase by 7.9 percent points compared to the previous year.

In 2003, discolouration (classes 1-4) was observed on 0.8% of the conifers and 0.8% of the broadleaves.

Unfavourable weather condition especially low precipitation in the vegetation period was the main reason for the slight worsening of crown condition.

The total number of forest fires in 2003 was 17 743, more than 40% above 1992 when the number of forest fires was the highest till the year 2003. The main reasons for forest fires were meteorological conditions, mainly low precipitation level and high air temperature. The forest fires occurred with the highest frequency in April (27%) and July (23%). In 2003, 28 653 ha of forest were burnt, five times more than in 2002. The average area of forest fires was 1.62 ha.

4.2.6 Slovak Republic

The 2003 national crown condition survey was carried out on 108 Level I plots on the 16x16km grid net. The assessments covered 5 116 trees, 4 253 of which being assessed as dominant or co-dominant trees according to Kraft. 39.7% of the conifers and 25.6% of the broadleaves were rated as damaged (defoliation classes 2-4). For all tree species, this share increased by 6.6 percent points.

Overall mean defoliation was 24.2%, with 26.5% for conifers and 22.6% for broadleaves. Results show that crown condition in Slovak Republic is below the European average. This is mainly due to the condition of the conifers.

Compared to the 2002 survey, a pronounced deterioration of mean defoliation was observed for *Carpinus betulus* and *Fagus sylvatica* – mainly because of strong fructification. Significant improvement was not observed for any species.

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

Within time series analyses, statistical significant improvement has been observed for broadleaves and for conifers.

As a part of the crown condition survey, identifiable damage types were assessed. 24.9% of all sampling trees had some kind of damage symptoms. The most frequent damage was caused by fungi (11.9%) as a consequence of tree stem damage. The next more important cause of damage were logging activities (8.0%), insects (6.9%) and abiotic agents (3.1%).

The most important influence on defoliation was calculated for epiphytes. 62% of trees with epiphytes had defoliation above 25%.

4.2.7 Slovenia

The 2003 national forest condition survey encompassed 41 sample plots and 984 trees. The increase in number of plots and trees (2 and 48 respectively) is to be ascribed to the assessments on the plots that could not be inventoried in the past years. The sampling scheme and the assessment method remain unchanged.

The mean defoliation of all tree species was estimated to 22.1% while the share of trees with more than 25% unexplained defoliation attained 27.6%. Despite the fact that the values of both indicators decreased (the 2002 values were 23.2% and 30.2% respectively), only the change of unexplained defoliation could be proven statistically significant.

The differences in defoliation between conifers and broadleaves are big. 28.9% of the sampled conifers were defoliated less than 10%, 35.8% of them between 11% and 25%, 29.9% between 26% and 60%, and 5.4% of them were severely defoliated or dead. On the other side, 36.0% of all broadleaves were unaffected at all, 41.4% of them were defoliated slightly, 19.6% moderately and 3.0% of trees were defoliated higher than 60%. In comparison to the values of the last year, the shifts could not be proven statistically significant.

The analysis of individual tree species shows that mean defoliation of *Picea abies* is 24.2%, while the share of more than 25% defoliated trees is 37.2%. The values of the both indicators are lower than in 2002 (26.3% and 40.7% respectively), however, the changes are not statistically significant. In the case of *Fagus sylvatica*, the values of the both indicators are also lower than compared to 2002 (mean defoliation 14.7% and 15.6 respectively; the share of more than 25% defoliated trees 13.3% and 15.6% respectively). The changes again are not statistically significant.

As far as weather conditions are concerned it should be noted that 2003 was extremely unfavourable for the trees of all regions. The year was the hottest and the driest one in the last 100 years and most of the effects will most likely be detected in the forthcoming years.

4.2.8 Switzerland

In 2003, the Swiss national forest health inventory was carried out on 49 plots of the 16 x 16 km grid using the same sampling and assessment methods as in the previous years. Despite the drought conditions that began in March and the extreme heat during the summer (almost continuously from end of May to end of August), the defoliation of unknown causes and the total defoliation decreased. In 2003, 14.9% (-3.7 percent points in comparison to 2002) of the trees had more than 25% unexplained defoliation (i.e. subtracting the known causes such as insect damage, or frost damage), and 24.4% (-5.7%) of the trees had more than 25% total defoliation. These low proportions have not been reached since 1993. Annual tree mortality was 0.4% (4 trees out of around 1000 living trees died), which is average. However, on one of the 49 plots all 16 *Picea abies* trees had been cut because of bark beetles.

The above reported results must be interpreted carefully. The favourable weather conditions in 2001 and 2002 may have resulted in increased foliage, in particular for *Fagus sylvatica*. On the other hand, first effects of the drought in 2003 became only visible by the time most of the survey had been completed. Except *Betula* spp., most tree species showed little drought effects before the end of July. Some *Fagus sylvatica* trees developed early foliar discolouration during the first week of August. A survey on five Level II *Fagus sylvatica* plots in mid September revealed that early leaf discolouration and leaf fall varied with location (the proportion ranged between 0% and 20% of the trees per plot). Litter fall collectors showed for *Abies alba* an increased needle fall for 2003 with a peak in July and August. Annual stem growth measurements from girth bands showed that growth in 2003 decreased at altitudes below 1200 m a.s.l. (-10% to -70%), where water availability was limiting, and increased above 1200 m a.s.l. (10% to 20%) where water is not limiting but temperature. On the Swiss Plateau, where the *Picea abies* bark beetle outbreak had almost diminished in 2002, new infestations started in late summer with additional bark beetles joining *Ips typographus.* In some mountain areas the *Ips typographus* outbreak continued and has reached a record high in 2003.

4.3 Southern Europe

4.3.1 Albania

In 2003 a total of 458 wildfires was recorded. Most of them occured by the end of spring and in the summer period. Fires were observed in the following districts: Puke, Kukes, Tropoje, Vlore, Mirdite, Gramsh, Mat, Gjirokaster, Sarande, Delvine, Tepelene, Berat. 709 ha of completely burned area were recorded.

4.3.2 Cyprus

The annual assessment of crown condition was conducted on 15 Level I plots, between September and October 2003. A comparison of the results of the conducted survey with those of the previous year shows deterioration for all observed species (*Pinus brutia, Pinus nigra* and *Cedrus brevifolia*). From the total number of 360 trees assessed, 18.3% were moderately or severely defoliated. This is an increase by 15.6 percent points compared to 2002.

In *Pinus brutia*, 21.7% were moderately and 0.3% were severely defoliated. This is an increase by 18.4 and 0.3 percent points respectively. In *Pinus nigra*, 41.7% of the sample trees showed no defoliation while the rest 58.3% of them were slightly defoliated. In *Cedrus brevifolia*, 33.3% of the sample trees showed no defoliation and 66.7% of them were slightly defoliated.

From the total number of sample trees, 40.3% showed signs of insect attack and 6.4% showed signs of attack by "*other agents*" (lichens).

20% of the trees were attacked by *Thaumetopoea wilkinsoni*, 4.4% by *Tomicus* spp., 0.6% by *Leucaspis* spp. and 8.9% by unspecified defoliating insects. Additionally, 0.3% of the trees were attacked by both *Tomicus* spp and unspecified defoliating insects, 6.1% were attacked by both *Tomicus* spp insect and *Thaumetopoea wilkinsoni*.

The above preliminary analysis shows that *Thaumetopoea wilkinsoni* is the major biotic factor causing defoliation during the year 2003. No damage was attributed to any of the known pollutants. However, the poor edaphic conditions and the adverse climatic condition 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 low precipitation and high temperatures prevailing on the island. During 2003, 14 forest fires damaged 3.7 ha of state forests. 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 2003.

4.3.3 Greece

The 2003 fire season, was not an exceptionally difficult one for Greece. The winter and spring seasons had been quite rainy. This resulted in heavy grass growth and fears of a bad fire season. However, except for a dry May and June, there were some rains (mainly thunderstorms with rain) in July and August, which helped keep fire danger to manageable levels. The rains occurred mainly in western, central and northern Greece, where the vegetation did not reach maximum flammability. On the contrary, the south and southeast part of the country did not get any rain and also experienced many days with strong NE ("etesians" or "meltemi" winds), bringing the level of fire danger there to level 4 (very high), of the 1-5 scale used in the country. Fortunately, relative humidity did not dip to extremely low levels during those days.

According to the statistics collected by the Forest Service, there had been 1.425 forest fires, which burned a total forest area of 2.605 ha of which only 960 ha were high forest. This level of damage, which was almost the same as in the previous year 2002, is very low in comparison to the annual mean of burned area of the last decade (45.237 ha). In other words 2003 was a very good year as regards the forest fires in Greece. The Greek Fire Corps (GFC) reported 4.942 more outdoor fires in this time, including agricultural and all non-urban fires that burned an additional 3.210 ha.

4.3.4 Italy

The 2003 crown condition assessment was carried out on 6 866 sample trees on 247 Level I plots of the 16 x 16 km transnational grid. Compared to 2002, the number of assessed plots was reduced by 11 plots because data transmission was delayed or trees were cut. Considering the total tree sample, the share of damaged trees (defoliation classes 2-4) was 37.6%. With 23.2% trees in defoliation classes 2-4, conifers showed less defoliation than broadleaves with a share of 49.3% trees in these classes. When comparing the surveys results 2002 and 2003, crown condition remained nearly unchanged with 37.3% trees in defoliation classes 2-4 in 2002 and 37.6% trees in 2003.

With regard to age classes and tree species, 35.6% of *Pinus sylvestris* trees younger than 60 years were in defoliation classes 2-4, whereas *Picea abies* trees presented a good health status with only 6.9% in defoliation classes 2-4. 16.4% of *Pinus nigra*, 22.3% of *Larix decidua* and 10.0% of *Pinus halepensis* younger than 60 years were in defoliation classes 2-4. Among the conifers older than 60 years, *Pinus sylvestris* showed the worst crown condition with a share of 49.0% of trees in defoliation classes 2-4, *Pinus cembra* had 39.0% and *Larix decidua* 37.4% trees in the respective classes, whereas *Picea abies* and *Abies alba* showed less defoliation with 9.4% and 13.6% trees in defoliation classes 2-4.

For broadleaves in the age class <60 years, 66.3% of the assessed *Quercus pubescens* and 61.3% *Castanea sativa* were in defoliation classes 2-4; other broadleaves showed lower defoliation: for *Quercus cerris* 31.0%, *Fagus sylvatica* 32.7% and *Ostrya carpinifolia* 38.9%. In the age class <60 years *Castanea sativa* showed 75.6% trees in defoliation classes 2-4 and *Fagus sylvatica* 42.8%. *Quercus ilex* was clearly less defoliated with only 17.5% trees in defoliation classes 2-4.

Analyzing the presence of biotic and abiotic factors as possible causes for defoliation and discolouration, 59.1% of all sample trees revealed one or more damage types. The most frequently observed damage types were insects, fungi and climatic stress.

4.3.5 Portugal

In 2003, on 136 forest plots a number of 4 080 trees was assessed, of which 70% were less than 60 years old. The assessment results since 1990 show that forest condition in general has improved.

Considering the results from 1990 to 2003, the share of both damaged broadleaves and damaged conifers shows a decrease. However, in 2003 a slight increase was observed. For all species, the share of damaged trees reached its maximum with 30.8% in 1990, decreased rapidly to 5.7% in 1994 and was 9.1% in 1995. From 1995 until 2000, a slight variation was observed, reaching in 2001 10.1% damaged trees. In 2003 a slight increase to 13.0% was observed.

With respect to the development of the most important tree species in Portugal since 1988, *Quercus suber* shows the severest decline, reaching the peak of its share of damaged trees (52.7%) in 1991. In the same year, *Quercus ilex* showed its maximum of damaged trees (46.2%). The share of damaged trees was generally far lower in *Pinus pinaster* with a maximum of 26.3% in 1990, and in *Eucalyptus globulus* with 7.3% in 1991. The bad crown condition of several tree species in the years 1990 and 1991 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 (1989-1991). The obvious recuperation after that time was interrupted in 1995 mainly due to a new drought period in connection with forest fires. The improvement of crown condition observed in 1996 can be interpreted as an effect of more favorable weather conditions. In the same way but in an opposite direction, the recent slightly worsening observed in 2003, affecting mainly the broadleaves, can be interpreted as an effect of not so favourable weather conditions and to the effects of forest fires.

In fact, 2003 was the worst year on which concerns forest fires, since systematic data registration exists. 423 276 ha were burned, 283 063 of which (67%) were forest stands (8% of the total Portuguese forest). In terms of forest species, *Pinus pinaster* was the most affected one (109 567 ha – 39%), followed by *Eucalyptus* spp. (58 343 ha – 21%) and *Quercus suber* (43 613 ha – 15%). The peak of forest fires occurred between the 27th July and the 4th August due to the influence of both an atmospheric depression over the Iberian Peninsula and the Azores Anticyclone carried a very hot and dry air mass, causing an unusual temperature rise and an excessive decrease in the air moisture content, together with very strong, dry and hot eastern winds. In this short period, 250 161 ha were burned (59% of the total burned area), 1/3 of which on one single day – August the 1st. In this same period, 49 forest fires were, each one, responsible for a burned area bigger than 500 ha.

4.3.6 Spain

Overall results of the 2003 defoliation assessments were stable compared to 2002. Also, the percentage of dead trees does not show remarkable variations, if compared to the previous year. Conifers tend to a slight improvement. Broadleaves suffer a slight worsening.
A decline process had stared 1991, which, in the beginning seemed to affect more conifers, but from 1993 on, the worsening tendency has become higher in broadleaves. 1995 represented the maximum of the worsening process, with higher impact on broadleaves. During 1996 and 1997 surveys, an improvement in the health condition of forest trees was detected. Since 1997, conifers have shown an irregular behaviour. Broadleaves kept on declining during 2002 and 2003, whereas conifers show a slight recovery in 2003.

Among the biotic damage causes, defoliating insects were of importance, such as *Lymantria* spp. and *Thaumetooea pyitiocampa*, as well as wood boring insects in pine forests. There are also frequent observations of *Gonipterus scutellatus* in *Eucalyptus* plantations, *Altica quercetorum* and some other defoliators in broadleaves, together with the year by year increasing presence of *Viscum album.* Damage caused by *Coroebus florentinus* in *Quercus* spp. remains the same, whereas the presence of *Micosphaera alphitoides* in humid areas seems to be lower. At a general level, the decline process of *Quercus* spp. stands along the Mediterranean coast (the so called “Seca” syndrome), which was serious for *Quercus ilex* and *Quercus suber* between 1993 and 1996, seems to cause an important problem again. Among the fungi, there were some relevant conifer defoliators noted, especially *Scirrhia pini*. Also, damage related to the presence of *Sirococcus conigenum* was registered in *Pinus halepensis* forests. A general decline of forests in some areas of the central and south-eastern part of the Iberian peninsula, was related to water supply shortage. High populations of wood borers affected *Pinus* spp. stands in Murcia.

The importance of atmospheric pollution in the evolution of forest condition is a factor which can not be quantified directly, as it is frequently disguised by other kind of processes which are more apparent. However, its role (in combination with other agents), contributing to the degradation processes of the forests falling under their influence, can’t be denied. As regards the forest fires situation in Spain, it was clearly influenced by weather conditions. The first five months of the year were in general very rainy. Therefore, the risk of forest fires kept low or moderate. Only at the end of February, under a situation of dry winds (tramontana in Catalonia and poniente in Valencia region), there were two important forest fires, in the Eastern part of Spain.

June started with very hot weather and numerous days of high risk in the South half and in the East of Iberian Peninsula. Activity of the means of extinction was stronger than usual for this time of the year. However, figures on number of fires and affected areas showed (in the first 6 months) very much lower values, if compared to the same figures of previous year and the mean values of the ten-year period 1993 – 2002.

July continued with the same weather conditions: high temperatures and lack of precipitations. However, the absence of strong winds allowed keeping the risk just high in all regions, with very few days of extreme risk situation. Weather conditions were more unfavourable in August, when there were many big (larger than 500 hectares) forest fires, affecting to the greater part of Iberian Peninsula. Logistical support was offered to Portugal, whenever it was possible. Also French airplanes supported in the extinction of a fire in Catalonia.

In September temperatures lowed down and the first rains started to fall in the North and afterwards in the East. During that month, the bigger fires affected the central western part of Iberian Peninsula. Also Spanish amphibian airplanes supported in France and Portugal.

October, November and December have been rainy in the whole country so the risk has kept low. The area affected by fires since the beginning of the year showed at the end of the year values higher than the ones of 2002 and slightly lower than the mean of the ten - year period.

4.4 Western Europe

4.4.1 Belgium

Flanders

The 2003 survey was performed on 72 plots with 1 728 sample trees on a 4x4 km grid. The share of trees in defoliation classes 2-4 was 20% while discolouration was noticed on 8.7% of the trees. 0.5% of the sample trees died in 2002-2003.

There was a slight improvement of the crown condition, both for broadleaves and conifers. 18.9% of the broadleaves showed moderate to severe defoliation, while in conifers 22.3% of the trees were classified as being damaged (defoliation classes 2-4). In comparison to 2002 the overall share of damaged trees decreased. Discolouration increased, related to the higher share of discolouration in *Fagus sylvatica* and especially in *Pinus sylvestris*.

Compared to last year's survey, there were no remarkable changes in the condition of *Quercus robur* and *Pinus nigra subsp. laricio*. With 21% of the trees damaged, *Quercus robur* still shows an improvement compared to the period 1993-2000. The share of damaged *Pinus nigra* trees remained very high (47.5%). With a proportion of 15.4% trees in defoliation classes 2-4, *Pinus sylvestris* revealed a good condition. Compared to last year, fewer trees were rated damaged but the average defoliation level remained the same.

The condition of *Fagus sylvatica* and *Quercus rubra* improved. Although the mean tree age is the highest of all species, *Fagus sylvatica* remained the species with the lowest level of defoliation and only 7.1% trees in defoliation classes 2-4. In contrast to 2002 there was a lower share of *Quercus rubra* trees with moderate to severe defoliation (13.8%) in comparison to *Q. robur*.

The survey revealed a higher defoliation level for *Populus* spp., with 48.5% of the trees being damaged. In many poplar stands in Flanders trees with dead branches and dying trees have been observed. After the heavy rust infections (*Melampsora* sp.) of the last years, the trees became sensitive to infections of weakness parasites like *Discosporium populeum* and *Cytospora chrysosperma*. Also a late spring frost may have contributed to the observed damage.

Probably due to the dry weather conditions, fungal infections occurred less frequently in most of the tree species. Also severe insect damage was observed less frequently. In one of the main forest areas of the Campine region, *Pinus nigra* was damaged by a hailstorm. A few sample trees had to be replaced because of wind damage, caused by a storm in October 2002.

Wallonia

The 2003 survey concerned 1359 trees (531 conifers and 838 broadleaves) on 60 plots, on a regional 8x8 km systematic grid.

As in the 2002 survey, defoliation rate shows minor changes, for broadleaves and conifers as well, but discolouration has increased both species groups.

For conifers, the increase in *Pinus sylvestris* discolouration (more than 50% of trees with more than 25% discolouration) explains this evolution. Spruce shows minor changes since 2000, with 14% to 17% from year to year.

For broadleaved species, young stands are not discoloured.

For stands older than 60 years, the high level of discolouration is explained by beech and pedunculate oak, with respectively 32.2% and 14.8% of trees moderately or severely defoliated.

These general conditions for beech are likely explained by consequences of beetle damage during the last years and by the dry weather conditions from June to October, high level of insolation and high temperatures.

4.4.2 Denmark

The Danish Level I forest condition survey in 2003 showed a satisfying condition for all tree species, based on both EU/ICP Forests plots (20) and national plots (30), in total 1 200 trees. The crown condition survey showed increased defoliation for *Quercus* spp. compared to 2002. The defoliation of *Picea abies* was at the same level as in 2001, and *Fagus sylvatica* showed less defoliation. Generally, other tree species were also in good health, although *Fraxinus excelsior* had problems in some areas.

The results of the crown condition survey in 2003 showed that 79% of all coniferous trees and 56% of all deciduous trees were undamaged. 16% of all conifers and 35% of all deciduous trees showed warning signs of damage, and 5% of all conifers and 9% of all deciduous trees were damaged. 2003 is thus one of the best years of forest health since the beginning of the survey.

The mean defoliation of *Picea abies* remained at 13% in 2002, and the share of damaged trees was still only 5%. As in 2002, more than 80% of the monitored spruces were in the lowest defoliation class. Only one Danish stand of *Picea abies* had serious damage, and this could be explained by exposure to desiccation from wind.

The health condition for *Fagus sylvatica* improved from 2002 to 2003 in spite of summer droughts in both years. The share of damaged trees fell from 8% to 6%. Since 2000 none of the monitored beech trees have been in the two highest damage classes.

In 2003 the mean defoliation of oak *Quercus robur* and *Q. petraea* increased from 14% in 2002 to 20%, and the share of damaged trees rose to 14% in 2003 (from 8% in 2002). The health of oak was comparable to 2001, which was a good year compared to the mid 1990's. Some of the damage in 2003 was due to defoliators, but the main reason was probably the late summer drought in 2002.

4.4.3 France

The forest condition survey in France included 10298 trees from 515 permanent plots. This growing season was marked by an exceptionally hot summer, associated to a particularly severe heat wave that peaks in the first weeks of August. Globally, most species have shown an increase in defoliation as compared to 2002. Broad-leaved trees still showed a higher defoliation level as compared to conifers. Even though a slight increase in discoloration was observed in 2003, this factor remained at a relatively low level, affecting less than 15% of the trees. Mortality, except a slight increase observed for conifers, remained stable at a very low level over the last ten years (0.2%). In 2003, species that worsened the most as compared to 2002 were wild cherry trees, chestnuts and black pines. However, at the national scale, all species, except beeches, larches and poplars significantly worsened in term of defoliation. Nevertheless, these tendencies mask a certain amount of variability at the regional scale.

Over the last 7 years, biotic and abiotic factors were assessed in association to crown condition. To these assessments, an intensity rating is also reported since 2000. For the last season, the main stressing agent that affected the forest condition was certainly the heat wave, which represented more than 25% of overall stress factors reported. Some other factors, such as *Coroebus bisfasciatus* and *Microsphaera alphitoides* on oak, as well as several other entomological damages were also mentioned to contribute to crown condition deterioration in 2003.

In 2003, mainly in summer, about 73 000 ha of forests and shrubs burned in France, about 6 000 forest fires were registered. The main area affected by fires was the Mediterranean region where 62 000 ha burned by about 3 500 forest fires. The Var department and Corsica suffered the most by the fires. Since 1973, this was the heaviest damage by fires in south-eastern France, connected to a very early and intensive summer drought. This fact is aggravated by the death of 10 persons, 5 of them fire-fighters, by a few tens of injured people and destroyed habitations and camping sites.

4.4.4 Ireland

Overall mean percent defoliation and discolouration in Ireland was 15.4% and 6.1% respectively. This represents an improvement in crown condition of Irish forests between the 2002 and 2003 survey of 2.5% percent points for defoliation and of 1.2% percent points for discolouration. Defoliation levels recorded in 2003 were less than the 12-year average of 16.2% and discolouration in 2003 was also below the 12 year average of 7.5%. In terms of species, defoliation decreased in the order of *Picea abies* (23.3%) > *Pinus contorta* (17.0%) > *Picea sitchensis* (13.1%). These results do not vary significantly from those recorded in 2002.

The trends in crown density among species are similar to last year's survey. In 2003, *Picea abies* had the highest defoliation levels as was observed in 2002 and 2001 also. This was the result of a combination of defoliation levels decreasing in *Pinus contorta* and increasing somewhat in both spruce species since 1999. *Pinus contorta* had the highest discolouration levels of the three species in 2003, which was also the observation in last year's 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 2003 by 2% percent points to 14% of trees in the survey. An additional 32% of trees had such low levels of defoliation and discolouration that the causes of damage were indiscernible. This represents a considerable increase, some 8% percent points, in the number of trees recorded in this category in 2002. Of the remaining trees where causes of damage could be identified, approximately 14% of trees had greater 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 approximately 30% of sample trees showing some damage attributable to the abiotic environment. The instances of observed aphid damage however were significantly decreased since 2002, in particular for *Picea sitchensis*, with only 9% of tress affected in 2003. 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 2003; recorded on the young spruce trees at Ballinglen. No instances of damage directly attributable to atmospheric deposition were recorded in the 2003 survey.

4.4.5 United Kingdom

In 2003, the growing season was both drier and warmer than average in most parts of the United Kingdom. However, May was unseasonably wet and the driest conditions of the year were not encountered until August. As a result, few acute symptoms of water deficit were noted on trees during the course of the survey. Overall, the condition of the surveyed trees was better this year than in 2002 due to a marked improvement in crown density of the broadleaved species. However, the gradual trend of deterioration which has been evident in conifers since 1995 continued in 2003.

A marked improvement in the condition of *Fagus sylvatica* was largely attributable to much reduced mast formation compared to last year, with fruiting being absent or scarce on 92% of the assessed trees. Levels of biotic and abiotic damage to this species were broadly comparable with those recorded in 2002. An increase in the mean crown density of *Quercus robur* occurred in 2003 in spite of a higher incidence of insect damage in the sample population. However, such insect damage was usually light and attacks which affected the crown density of trees were confined to a limited number of plots in which dense populations of Winter moth (*Operophthera brumata* and *Erranis defoliaria*) larvae were present.

As in 2002, *Picea sitchensis* was defoliated by the green spruce aphid *Elatobium abietinum* with current attacks reported from 52% of plots. *Picea abies*, although not so severely affected, also suffered some damage from *E. abietinum* in 2003 and deteriorated slightly in condition. Of the conifers, only *Pinus sylvestris* displayed an improvement in crown density in 2003 with damage from *Tomicus piniperda* being common but minor in extent.

4.5 South-eastern Europe

4.5.1 Bulgaria

In 2003, the crown condition assessment was carried out on 139 plots on a grid net of 16x16 km, 8x8 km and 4x4 km. A total of 5 115 sample trees were assessed: 2 959 conifers and 2 156 broadleaves.

The share of damaged trees (defoliation classes 2-4) decreased slightly by 3.4 percent points. As a general trend an increase in trees in the warning stage (defoliation class 1) was observed.

For all assessed conifers younger than 60 years, significant changes were observed in defoliation class 1. The share of the trees in the warning stage increased by 11 percent points, compared to 2002. Moderately defoliated trees decreased by 5.1 percent points. No significant changes were observed in the condition of the conifers older than 60 years. *Picea abies* was in a better condition in comparison to the other assessed conifer species in both age groups.

For broadleaves, *Fagus sylvatica* was in a better condition than *Quercus* spp. in both age groups. The share of damaged *Betula* spp. (defoliation classes 2-4) up to 59 years old decreased substantially by 29.3 percent points.

In 2003, a number of natural and anthropogenic stress factors influenced the forest condition in Bulgaria. They had specific importance depending on the region, tree species, age, and site characteristics. Attacks by *Cecidomya fagi, Rhinchaenus fagi, Hermes abietis, Gnomonia quercina* and *Aphididae* were observed. *Picea abies, Pinus silvestris, Pinus nigra, Fagus sylvatica* and *Quercus* spp. were mostly affected.

The climatic conditions in 2003 were characterized by a relatively mild winter, higher temperatures and precipitation than the normal climatic values. In spring, temperatures and precipitation were higher than the norms. A drought period occurred in June-August with air temperatures higher than the norms. Autumn was characterized by temperatures under the norms and precipitation 1-2 times higher than the long term mean values.

4.5.2 Hungary

In 2003, unfavourable weather conditions continued, drought and high temperature in the growing season were again typical like in the previous year. The increase in overall defoliation was however moderate, (22.5% in damage classes 2-4 compared to 21.1% in 2002). *Fagus sylvatica* and conifers had considerably higher defoliation than in 2002, while the condition of *Populus* spp. and *Quercus petraea* improved. Defoliation of *Pinus sylvestris*, *Pinus nigra*, *Picea abies* has been the highest ever since the first survey in 1988.

Unidentified browning of leaves on individual *Fagus sylvatica* trees was observed in September-October in the south-western part of the country, that may indicate local diebacks. The reasons are not known yet, further assessment is necessary in spring to verify the phenomena.

Activity of bark beetles (mainly *Ips typhographus*) increased in coniferous forests, brown or short needles of the last year were frequently observed on pines due to drought or other biotic damage like *Sphaeropsis sapinea.* On very dry and shallow sites deterioration of *Pinus* stands may result the disappearance of closed forest and patchy-bushy vegetation may start to develop.

Local damage causes by some leaf-eaters like *Lymantria dispar* and *Thaometapoea processionea* were observed, outstanding gipsy moth gradation is expected in 2004 north from the lake Balaton. Damage caused by leaf miners (*Parectopa robiniella* and *Phillonoricter robiniella)* in *Robinia pseudoaccacia* stands are widespread over the country and may influence the health condition of this important tree species in Hungary.

4.5.3 Romania

In 2003, 101 243 trees were assessed on the national monitoring network (4 x 4 km) comprising 3 840 plots. Of the total number of assessed trees, 12.6% are in defoliation classes 2-4 (9.8% of the conifers and 13.3% of the broadleaves). In general, in 2003 the forest health status in Romania slightly improved as compared to the previous year, the shares of damaged trees (defoliation classes 2-4) being lower by 0.9 percent points.

Among the main tree species, the lowest shares of damaged trees (defoliation classes 2-4) were recorded for *Picea abies* (8.1%), *Fagus sylvatica* (8.5%) and *Abies alba* (13.1%). The highest shares were registered for *Quercus pubescens* and *Q. pedunculiflora* (37.9%), *Quercus frainetto* (35.7%), *Robinia pseudoaccacia* (31.0%), *Quercus cerris* (22.7%) and *Quercus robur* (21.4%). As compared to 2002, *Fagus sylvatica* showed an improvement by 1.7 percent points, *Quercus* spp. by 2.2 percent points and *Quercus freinetto* by 5.8 percent points. *Quercus pedunculiflora* and *Q. pubescens* showed a decrease by 4.6 percent points and *Robinia pseudoaccacia* by 1.1 percent points.

This situation can be explained by the occurrence of weather conditions similar to the previous year. Particularly at the beginning of the vegetation season (May/June), when the water need is higher, it could be covered by the stock from the autumn of the previous year and by actual rainfalls only slightly lower as compared to 2002. In the rest of the growing season of 2003, the rainfall amount was sufficient to slightly improve the forest health status as compared to the previous year.

Nevertheless, the broadleaved species occurring in the southern and south-eastern parts of the country are still characterized by a weaker forest health status than in the rest of the territory.

4.5.4 Serbia

In the Republic of Serbia, the established 16 x 16 km grid consists of altogether 103 sampling plots (not including AP Kosovo and Metohija). 2003 was the first year of monitoring after a pause of several years. In the restored grid, some of the previously selected plots have been retained and some sampling plots are new plots.

On each sampling plot, 24 trees were selected and marked, all the plots were photographed, and the degrees of defoliation and discoloration of the trees were assessed.

The total number of trees assessed on all sampling plots was 2 390 trees, 2 216 broadleaves and 174 conifers.

From the conifers 39.6% showed moderate or severe defoliation. The respective share for broadleaves was 21.0%. From the broadleaves *Fagus moesiaca* had the lowest share of trees in defoliation classes 2 - 4, namely 11.0%. The share was highest for *Quercus petraea* with 16.6%.

4.6 Eastern Europe

4.6.1 Belarus

In 2003 a total of 9 691 trees were assessed, with 11.3% being in defoliation classes 2-4. This is an increase in damaged trees by 1.8 percent points compared to 2002.

9.1% of the assessed *Pinus sylvestris* and 11.4% of the *Picea abies* were in defoliation classes 2-4. For the other tree species the respective values were 38.5% (*Quercus robur*), 29.3% (*Fraxinus excelsior*), 21.0% (*Populus tremula*), 13.4% (*Betula pendula*), and 3.6% (*Alnus glutinosa*).

As concerns the damage causes, 4.0% of the *Picea abies* trees older than 60 years died due to insect damage (mainly by *Ips typographus*), and 6.0% of the assessed stems were attacked by insects. 48.4% of the *Quercus robur* and 24.6% of the *Betula pendula* trees were damaged by insects and fungi.

The past two years had rather extreme climatic conditions. For the vegetation period of 2002 the average amount of precipitation in Belarus was 40-60%, and temperatures were clearly above the long term average. In the winter of 2002-2003 forest soils froze extremely deep (0.5-0.7m). In 2003, precipitation and temperature were however less extreme than in other European regions.

4.6.2 Republic of Moldova

In 2003, 14 631 trees on 490 permanent plots were assessed. From the total number of assessed trees 42.4% were classified into defoliation classes 2-4.

High percentages of damage were registered for *Quercus robur* (54.2%), *Quercus freinetto* (53.5%), *Quercus petraea* (44.5%), *Populus* spp (45.8%), *Accacia* spp. (43.9%), *Ulmus* spp. (43.1%), and *Fraxinus* spp. (41.2%).

The percentage of trees in defoliation classes 2-4 also varies for different altitude categories. Thus, at the altitude of 0-250 m it constitutes 41.8% and at 251-500 m – 45.6%.

In stands with the age of 61-80 years defoliation reaches 44.4%. In young stands, up to 60 years, defoliation varies between 36.3% and 44.1%.

The weakening of the health condition of forests is assumed to be a result of the climatic events taken place in the country during the previous years. At the same time the share of forests damaged by defoliators (51.2%) and by abiotic agents (63.0%) has increased.

In 2003, 4 cases of fires were registered on the territory of the Forest Fund, the total area was 23 ha. In all four cases the fire was superficial. Damage expressed in cubic meters of timber is not noted.

4.6.2 Ukraine

The forest condition survey in Ukraine covered 54 plots with 1 342 trees in 5 administrative regions of Ukraine (about 20% of the total area of the country). These monitoring plots are located in eastern and southern parts of Ukraine, where natural conditions are unfavourable for forest growth and the atmosphere pollution level is the highest in the country.

Mean defoliation of conifers was 17.4% and that of broadleaved trees was 22.7%. In general, some improvement in tree condition was observed for the total sample as compared to 2002. In 2003, the percentage of healthy trees was higher than in 2002 (18.4% against 8.9%). At the same time, the share of moderately to severely defoliated trees increased from 25.6% to 25.9%. These changes may be considered, however, as being related to a change of sample size. For the sample of common sample trees (CSTs) (970 trees) changes with a slight tendency to improvement were observed. Mean defoliation of all species in 2003 (22.2%) was less than in 2002 (22.5%), but this difference is insignificant. Changes are characterised by decreasing shares in defoliation classes 1, 3 and increasing classes 0, 2 and 4. Some improvement in tree condition was registered for *Quercus robur*. A statistically significant change was observed in classes 1 and 3 (decrease by 7.4 and 1.2 percent points) against an increase in all other classes. The same tendency (except for class 3) was observed for the CSTs of *Pinus sylvestris*. For *Fraxinus excelsior* an increase in class 0 and 1 was observed and a decrease in class 2. For *Pinus Pallasiana* the decrease in class 0 was related to an increase in classes 1 and 2.

4.7 Northern America

4.7.1 Canada

The Canadian Forest Service (CFS) does not currently carry out a national forest health survey program. Emphasis is on regional issue-based surveys. Canada, along with the provinces is in the initial stages of a new plot-based National Forest Inventory. Pilot studies are currently under way to finalize plot designs, logistics and measurement and compilation of appropriate attributes to monitor. These attributes will include ones related to forest health and biodiversity.

Currently, two regional ecological gradient initiatives related to anthropogenic and natural stresses on forest health are being carried out by CFS in collaboration with partners.

Forest Indicators of Global Change

The CFS Forest Indicators of Global Change Project (FIGCP) was initiated in 1998 to (i) develop new, early warning indicators of forest condition, (ii) relate patterns of global change to forest health, function and productivity, and (iii) establish an array of permanent research-monitoring plots on which to conduct more detailed studies, particularly of nutrient/carbon cycling in eastern Canada.

The project comprises 26 eastern Canadian forested, permanent sample plots. The 1 800 km transect features a 2 - 7 degree C variation of mean annual temperature, and a 700-1 500 mm variation of mean annual precipitation. Sugar maple is contiguous as a dominant species across the gradient; white pine dominates as the coniferous species in Ontario with red spruce predominating in Quebec and New Brunswick. Sugar maple and red spruce have been the most prominent northeastern species suffering decline since the 1960s.

Indicators assessed within the project include tree condition, leaf surface condition, leaf litter fall, leaf litter decomposition, ion leaching, nitrogen mineralization, soil microbial respiration, and ozone monitors. Basically, three years of data have been compiled. Thus, in-depth analyses of the data have yet to take place.

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

Trembling aspen (*Populus tremuloides* Michx.) is the most widely distributed tree species in North America, and the most abundant deciduous tree species in the Canadian boreal forest. Thus aspen is both ecologically and commercially important. Since the 1980s, dieback and reduced growth of aspen has bee noted, especially along the southern edge of the boreal forest and the aspen parkland. Studies to date suggest that dieback in these areas is caused by a combination of climatic factors and defoliation by insects.

CCIPHA is a research and monitoring initiative of CFS in collaboration with Environment Canada and other partners. It aims to (i) provide early detection of climate change impacts, (ii) understand how climatic variation, insects and other factors have affected health and growth of aspen forests of western Canada (iii) predict future changes in biomass, productivity and health of aspen forests of western Canada, (iv) provide a framework linking research and monitoring. It consists of a system of long-term research plots along a regional climate gradient extending from the cold, moist boreal forest to the warmer and drier aspen parkland.

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