CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

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

United Nations
Economic Commission
for Europe

Commission of the
European Communities

Forest Condition in Europe

Results of the 1992 Survey

1993 Executive Report

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CONTENTS

PREFACE

The present report is the second of the new series of common Forest Condition Reports of the United Nations Economic Commission for Europe (UN/ECE) and the European Community (EC). The report describes the results of both the national and transnational surveys, which are conducted annually within the International Cooperative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) of UN/ECE and under Council Regulation (EEC) 3528/86 on the Protection of the Community's Forests against Atmospheric Pollution of EC. The objective of the two programmes is a continuous monitoring and documentation of the extent and development of recent forest damage in Europe, as well as a contribution to cause-effect studies.

The ICP Forests was launched under the Convention on Long-range Transboundary Air Pollution in 1985. 29 states of its 35 Parties, including the European Community, are participating in the ICP Forests. Also participating are 6 states which have been recently established and which are expected to sign the Convention in the near future (the Czech Republic, Estonia, Latvia, Lithuania, the Russian Federation, the Slovak Republic). The participating 34 countries report annually on the results of their national forest damage surveys to ICP Forests. Canada and the United States of America cooperate with the ICP and are conducting major research and forest health monitoring programmes in North America.

Several countries of the European Community started surveying forest damage annually in 1987 on the plots of a uniform large-scale transnational grid net, along with a number of site parameters. Since 1988 all EC countries have been participating in this survey. Since 1990 this network has been gradually extended, as 11 non-EC countries have joined this survey. These countries are Austria, the Czech Republic, Finland, Hungary, Lithuania, Norway, Poland, Romania, the Slovak Republic, Sweden and Switzerland. Consequently, 23 European countries are now taking part in the transnational survey.

The participating countries submit their data and reports either to the Commission of the European Communities or directly to the Programme Coordinating Centre West (PCC-West) of ICP Forests. At PCC-West the data are evaluated for the preparation of the annual report and its summaries.

The preparation of this report was made possible thanks to

- the submission of forest condition data by the countries participating in the two programmes,
- financial support granted by the European Community,
- voluntary financial contributions granted by UN/ECE member states,
- the calculation of geographical coordinates of the inventory grid intersection points by the Commission of the European Communities, Corine project, DG XI.

SUMMARY

The main objective of the present report is a condensed description of the condition of forests in Europe, as it has been assessed by transnational and national surveys of EC and UN/ECE. The report presents survey results from 34 European countries, referring to about 33 000 sample plots with about 620 000 sample trees. Of 222 million hectares of forests in Europe as reported by the participating countries, around 184 million hectares have been covered by the surveys (16 million more than in 1991). The results of the 1992 survey indicate that a significant proportion of forests in Europe shows signs of defoliation and/or discolouration.

The transnational survey results of 1992 revealed that 23.5% of the total sample of around 95 000 trees had a defoliation of more than 25% and are thus classified as damaged. The respective value in 1991 was 22.2% which represents an increase by 1.3 percent points within a year.

In 1992 the share of trees with a discolouration of more than 10% was 10.1 of the total tree sample, which is a decrease by 0.5% percent points as compared with the previous year (10.6%).

As regards the two main species groups, 22.2% of the total broadleaves were in defoliation classes 2-4 in 1992. This indicates that the broadleaves are no longer in a better condition than the conifers (24.3%). Among the most common species, the most affected broad-leaved species was *Quercus suber* with 32.7% damaged trees followed by *Quercus* spp. (deciduous) with 23.7% trees in defoliation classes 2-4. Among the conifers, *Abies* spp. and *Picea* spp. showed the highest percentages of trees classified as damaged (29.8% and 25.7%, respectively).

In the subsample of common trees of the period from 1988 to 1992, 11 out of the 12 species analyzed showed a more or less obvious increase in the proportion of damaged trees.

Among the conifers *Picea sitchensis* had the highest percentage of damaged trees in all years and at the same time showed an obvious increase in this percentage, namely from 28.8% in 1988 to 36.8% in 1992. The most obvious increase in the share of damaged trees was found for *Pinus nigra* with 4.1% in 1988 and 21.3% in 1992. As regards the broad-leaved species, the sharp increase of the share of damaged trees in *Quercus suber* from 0.6% in 1988 to 42.6% in 1990 was very obvious. Among the other broadleaved species, *Quercus robur* had the highest percentage of damaged trees all of the time, and showed also a conspicuous increase in this percentage from 27.0% in 1988 to 35.3% in 1992.

In the national surveys a loss of needles/leaves has been observed to different extent in all of the participating countries. Direct comparison of data between countries is not appropriate, however participating countries have been placed into three groups. In three of the 31 countries having reported survey results, the percentage of sample trees classified as damaged was lower than 10%. In 14 countries the respective percentage ranged between greater 10% and 20%. In another 14 countries this percentage was greater than 20%.

In both the national and the transnational survey the most important probable causes for the observed defoliation and discolouration have been reported to be adverse weather conditions, insects, fungi, forest fire, action of man, game and air pollution. Very little direct impact from known pollution sources has been reported, but this does not exclude the possibility of more widespread effects of air pollution. In 69% of the cases no evident source of damage was identified. Nevertheless, some countries regard air pollution as the essential factor causing forest damage in their countries. The majority of the remaining countries considers air pollution as a factor leading to the weakening of forest ecosystems

because of impaired nutrient uptake, increased soil acidification and reduced base elements.

The great spatial and temporal variability observed calls for continued monitoring of defoliation and discolouration and additional assessment of various ecological data which may contribute to a better understanding of cause-effect relationship. In the years to come the already existing close cooperation between UN/ECE and the European Community will be intensified. In addition to the assessment of the condition of sample trees (defoliation and discolouration), first steps will be taken towards an integrated monitoring system by means of a soil inventory, foliar analyses, deposition measurements and increment studies.

1. INTRODUCTION

There is increasing evidence of the effects of air pollution on forest ecosystems. The symptoms of forest decline were initially interpreted in connection with air pollution effects, mainly because of the following reasons:

- the rapid dynamics of forest decline at certain locations under various site conditions
- increasing awareness that air pollutants occur in many parts of Europe, also on sites remote from industry
- seemingly missing symptoms of the classical factors of damage in forests (insects and fungi)

The assumed relationship of forest damage with air pollution has led to large-scale representative surveys of forest condition by UN/ECE and EC as part of a number of environmental programmes under the Convention on Long-range Transboundary Air Pollution and European Community legislation. Meanwhile, a wealth of scientific studies has revealed a multitude of interacting damaging factors, the importance of which differs strongly between sites. While most countries consider air pollutants at least as a contributing or predisposing factor leading to forest damage, previous reports of the EC and UN/ECE have revealed a wide range of opinions about the importance of air pollution for the symptoms observed.

Because of the use of the local reference trees and of the ways in which the common methodology is applied, direct comparisons of forest condition between participating countries are not possible. Similarly the symptoms which are assessed are non specific, so that cause-effect relationships cannot be inferred from the data presented here.

In the future, cause-effect relationships will be investigated by means of long-term obervations and ecosystems analysis on permanent plots. Council Regulation (EEC) 3528/86 also provides for pilot projects and field experiments in order to improve the understanding of the effects of atmospheric pollution, to improve methods of observing and measuring damage and to establish methods for the restoration of damaged forests. The ICP Forests of UN/ECE and EC also strive for special investigations and ecosystems analysis, for which methodological components have already been integrated into the ICP Manual and EC Regulations. EC Regulations and Sub-manuals of the ICP Forests on soil surveys and of foliar analysis as well as on deposition and increment have been drafted or will be drafted.

2. METHODS OF THE 1992 SURVEYS

2.1 Transnational survey

In the transnational survey both data on tree condition and data on a number of site parameters are annually assessed in order to document the development of forest condition in Europe. This is achieved by means of a uniform 16x16 km grid of sampling points covering more than 70% of the total forest area of those European countries participating in ICP Forests. In several countries the transnational plots are a subsample of a denser national grid network. Grid densities lower than 16x16 km in certain countries are currently causing deviations from the otherwise uniform transnational grid network.

2.2 National surveys

The national surveys aim at results looked upon as the best estimate for the respective country. These surveys are based on the national grids, the densities of which range from 1x1 km to 16x16 km due to differences in the size of forests area, in the structure of forests and in forest policies. The survey results are presented as mean values for the respective country. Because of differences in species composition, site conditions and climate, however, comparisons between the two surveys and between different countries should be made with great care.

2.3 Selection of sample trees

Within both the national and transnational surveys, at each sampling point positioned on forest land, sample trees are selected according to a stringently defined statistical procedure. The sample includes all tree species provided the sample trees have a minimum height of 60 cm. Only predominant, dominant, and co-dominant trees (according to the system of KRAFT) without significant mechanical damage qualify as sample trees. Trees removed within management operations or blown over by wind must be replaced by newly selected trees.

2.4 Assessment parameters and presentation of data

On each sample plot the sample trees are assessed with respect to defoliation and discolouration. Defoliation is reported in 5% in the transnational and in 10% steps in the national surveys in comparison to a reference tree of full foliage. If no reference tree can be found in the vicinity of the sample trees, photo guides suitable for the region under investigation may be used. This assessment down to the nearest 5 or 10% permits studies of the annual variation of foliage with far greater accuracy than the traditional classification using only five classes. Table 2.4-1 shows the traditional classification of defoliation and discolouration classes.

Defoliation class	needle/leaf loss	degree of defoliation
0	up to 10 %	none
1	> 10 - 25 %	slight (warning stage)
2	> 25 - 60 %	moderate
3	> 60 %	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	100 %	dead

Table 2.4-1: Defoliation and discolouration classes according to UN/ECE and EC classification

On the plots of the transnational survey following parameters are assessed and have to be submitted for each plot:

country, plot number, plot coordinates, altitude, aspect, water availability, humus type, soil type (optional), mean age of dominant storey, tree numbers, tree species, observations of easily identifiable damage, date of observation.

The transnational survey results are expressed mainly in terms of the percentages of the tree sample falling into the defoliation or discolouration classes. In many cases only a distinction has 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. The reason for this is that the defoliation in classes 0 and 1 can not necessarily be looked upon as a sign of reduced health status, e.g. due to insect or fungi attack, climatic stress or air pollution. This means that a defoliation of up to 25% is considered as "undamaged", class 1 indicating a "warning stage", whereas classes 2, 3 and 4 represent considerable defoliation and are thus referred to as "damaged".

A sample point is referred to as "damaged" if the mean defoliation of its trees (expressed as percentages) falls into class 2 or higher. Otherwise the sample point will be considered as "undamaged".

The most important results have been tabulated separately for all countries having participated (called "total Europe") and for the EC-member states.

3. RESULTS OF THE 1992 SURVEYS

3.1 Transnational survey results

3.1.1 General results

In the 1992 survey, 23.5% of the trees had a defoliation of more than 25% and are thus considered to be damaged if the whole transnational data set is regarded. For the EC this percentage was 19.1%. The conifers had a higher proportion of trees (24.3%) in defoliation classes 2-4 than the broadleaves (22.2%), and thus appeared less healthy than the broadleaves in terms of defoliation. This difference was less pronounced in the EC countries (Table 3.1.1-1).

10.1% of the total transnational tree sample had a discolouration of more than 10%. In terms of discolouration, however, conifers appeared less damaged than the broadleaves. Again, this difference was less pronounced in EC countries (Table 3.1.1-2).

	Species type	Defoliation							No. trees
		0-10%	>10-25%	0-25%	>25-60%	>60%	dead	>25%	
EC	Broadleaves	51.0	30.3	81.3	16.3	1.5	0.9	18.7	25294
	Conifers	47.8	32.5	80.3	17.9	1.0	0.8	19.7	22939
	All species	49.6	31.3	80.9	17.1	1.2	0.8	19.1	48233
Total Europe	Broadleaves	46.5	31.3	77.8	18.9	2.4	0.9	22.2	37817
	Conifers	40.7	35.0	75.7	22.0	1.8	0.5	24.3	56882
	All species	43.0	33.5	76.5	20.8	2.1	0.6	23.5	94699

Table 3.1.1-1: Percentages of defoliation for broadleaves, conifers and all species

	Species type	Discolouration						No. trees
		0-10%	>10-25%	>25-60%	>60%	dead	>10%	
EC	Broadleaves	86.3	10.3	1.9	0.5	1.0	13.7	25294
	Conifers	89.9	7.9	1.2	0.2	0.8	10.1	22939
	All species	87.9	9.2	1.6	0.4	0.9	12.1	48233
Total Europe	Broadleaves	86.1	10.1	2.4	0.5	0.9	13.9	37817
	Conifers	92.5	5.6	1.0	0.3	0.6	7.5	56882
	All species	89.9	7.5	1.6	0.3	0.7	10.1	94699

Table 3.1.1-2: Percentages of discolouration for broadleaves, conifers and all species

Figure 3.1.1-1 gives an overview of the percentage of trees damaged. As compared to last year's report, the map has been expanded by Lithuania and Romania. For the first time the plots in Norway could be included. As no data could be made available for 1992 by the Czech Republic, no plots of this country are shown in the map. The pie diagram reveals that on nearly half of the plots the share of damaged trees (i.e. with defoliation greater than 25%) is 10% or lower. These plots are mainly located in southern Scandinavia, in south-western Europe and in the eastern part of the Alps. On the other hand, the share of damaged trees ranges from 51%-75% on 9% of the plots, and from 76%-100% on 7% of the plots. This means that on 16% of all plots more than half of the trees are damaged. As in previous years, the areas with the highest proportion of damaged trees are located in Central Europe. Also a relatively high proportion is to be found in parts of the new areas included in the map.

Figures 3.1.1-2 and 3.1.1-3 show maps of the distribution of the mean plot defoliation and plot discolouration over the entire area. The mean plot defoliation is classified according to the five defoliation classes. On 37% of the plots the mean defoliation is larger than 25% (classes 2-4 with 36%, 1% and 0%, respectively). The main part of these plots is located in Central Europe.

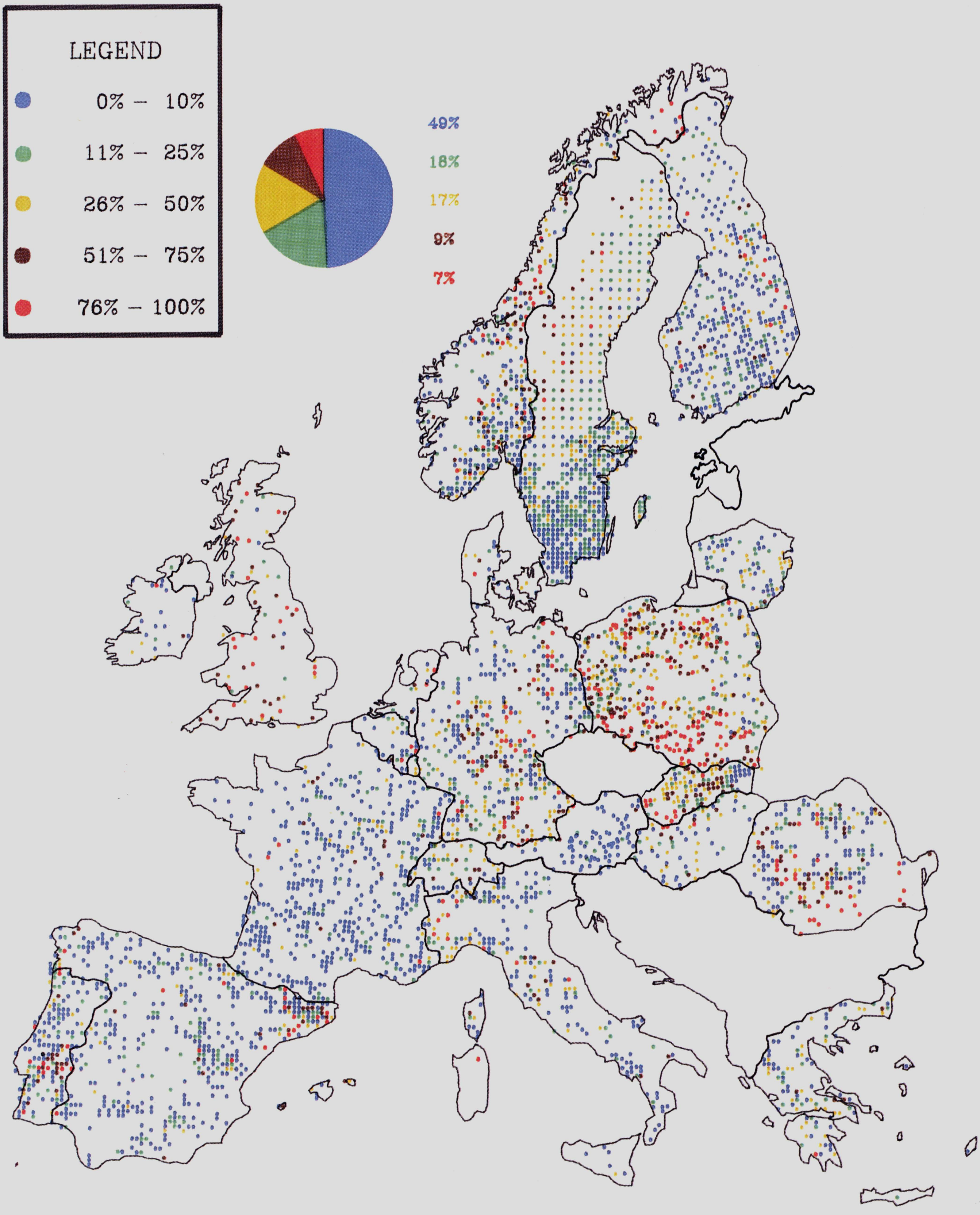

Figure 3.1.1.-1: Percentage of trees damaged in 1992. The percentages are the basis for the transnational evaluation and not suitable for comparisons between countries.

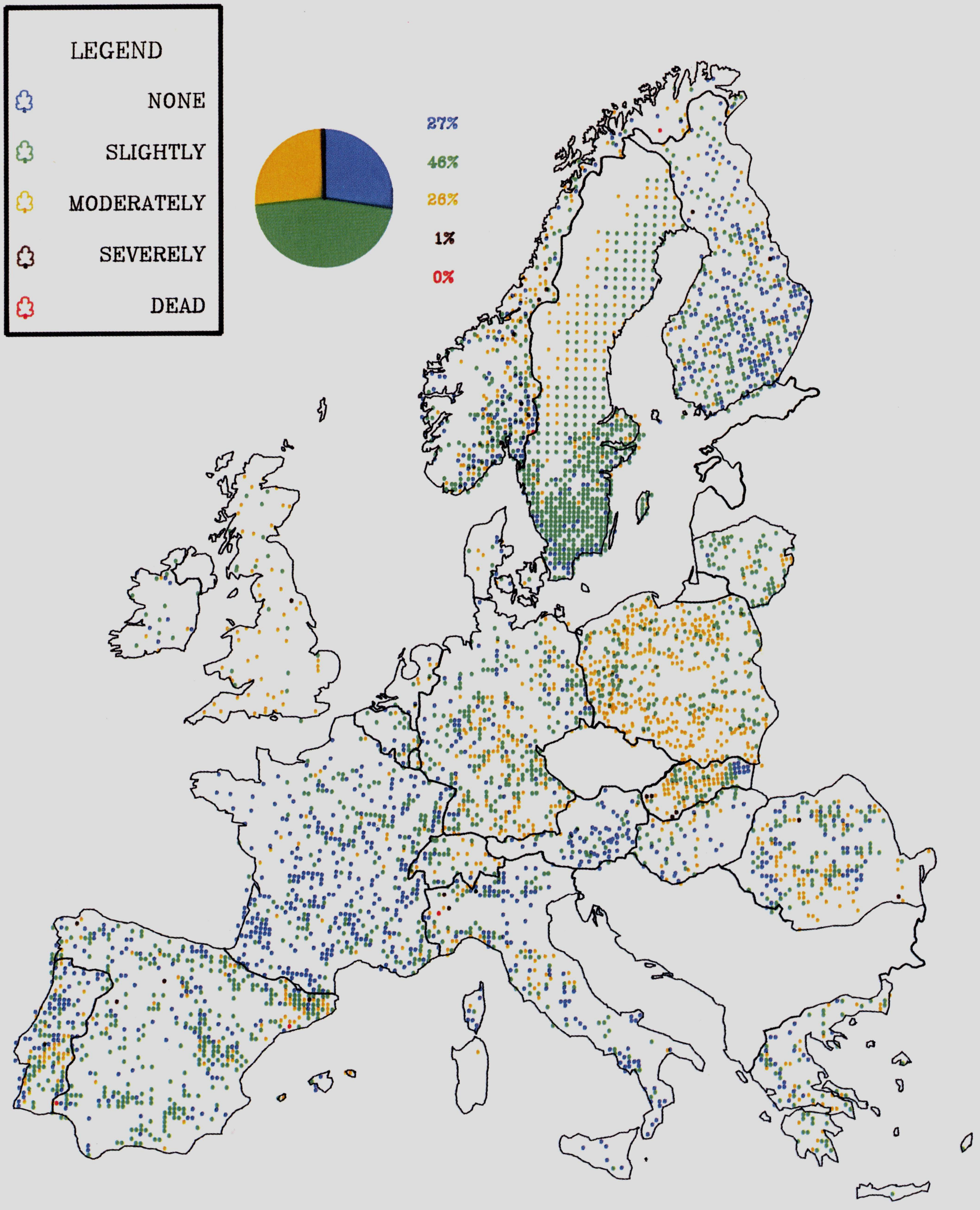

Figure 3.1.1-2: Plot defoliation (1992). The figures for defoliation are the basis for the transnational evaluation and not suitable for comparisons between countries.

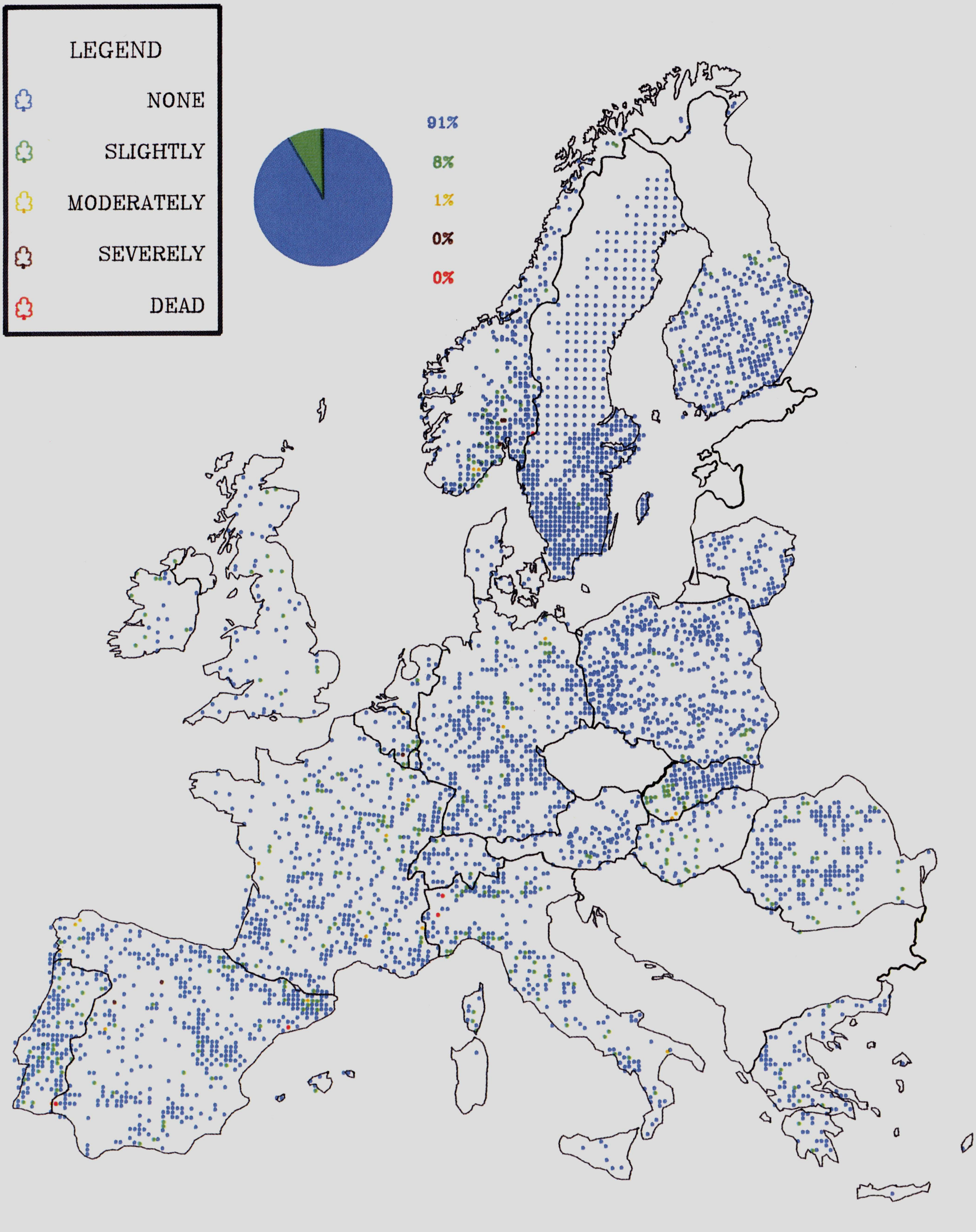

Figure 3.1.1-3: Plot discolouration (1992). The figures for discolouration are the basis for the transnational evaluation and not suitable for comparisons between countries.

3.1.2 Forest condition by species groups

In total Europe as well as in the EC countries, defoliation among the broadleaved species groups was least severe for *Quercus ilex* (8.1% in classes 2-4). The highest percentage of damage trees was found for *Quercus suber* (32.7% in classes 2-4). Of all coniferous species groups in total Europe, *Abies* spp. and *Picea* spp. showed the highest percentages of trees in defoliation classes 2-4 (29.8% and 25.7% respectively), suggesting a generally poorer condition. The share of damaged trees was lowest for *Larix* spp.(8.2%).

Discolouration among the broadleaved species groups in total Europe and in the EC countries was most prevalent for *Eucalyptus* spp.(7.9% of the trees discoloured, i.e. showing discolouration greater than 10%). *Quercus ilex* showed the lowest percentage of trees discoloured (6.0%). For coniferous species groups the variation among the species was small. In total *Abies* spp. was the species group with the highest percentage of trees (11.7%) in discolouration classes 1-4. The least discolouration was found in *Picea* spp. and *Pinus* spp. with 5.3% and 8.7% of the trees being more than 10% discoloured, respectively.

3.1.3 Forest condition by mean age

Table 3.1.3-1 shows the percentages of trees in each defoliation class for 7 classes of different mean stand age and for a class of irregular age composition.

The share of dead and severely defoliated trees is very small compared to the total number of sample trees, but the steep decrease between defoliation classes 0, 1, and 2 on the one hand and classes 3 and 4 on the other hand is a result of the conventional classification.

The percentages of trees with defoliation of >25% show a gradual increase with increasing mean age. However, this trend is obvious only from age class 0-20 to age class 61-80. With higher ages the increase in defoliation becomes less obvious. This confirms the strong positive correlation between age and defoliation which has been described for a slightly smaller data set already in the previous reports.

As in previous years, the comparison of discolouration does not lead to conclusive results. Therefore no results of this comparison are presented in this report.

	Mean age [years]	Defoliation							No.of trees
		0-10%	>10-25%	0-25%	>25-60%	>60%	dead	>25%	
EC	0 - 20	67.3	23.3	90.6	6.8	0.7	1.9	9.4	7350
	21 - 40	56.3	28.1	84.4	13.2	1.3	1.1	15.6	12935
	41 - 60	47.3	33.8	81.1	17.5	1.1	0.3	18.9	8471
	61 - 80	39.5	37.5	77.0	21.6	1.1	0.3	23.0	5387
	81 -100	35.0	36.2	71.2	27.2	1.1	0.5	28.8	4533
	101-120	27.7	41.0	68.7	29.5	1.8	0.0	31.3	2299
	>120	27.8	32.5	60.3	37.1	2.3	0.3	39.7	2636
	Irregular	55.1	31.1	86.2	10.9	1.4	1.5	13.8	4622
	Subtotal	49.5	31.3	80.8	17.1	1.2	0.9	19.2	48233
Total Europe	0 - 20	65.8	22.6	88.4	8.8	1.2	1.7	11.7	8621
	21 - 40	56.9	26.7	83.6	13.7	1.7	1.0	16.4	16811
	41 - 60	40.6	34.3	74.9	22.1	2.5	0.5	25.1	17322
	61 - 80	32.3	37.5	69.8	27.3	2.5	0.4	30.2	14584
	81 -100	31.0	37.4	68.4	29.1	2.0	0.5	31.6	10303
	101-120	33.1	36.5	69.6	28.1	2.1	0.2	30.4	5003
	>120	32.1	33.5	65.6	30.5	3.5	0.4	34.4	5174
	Irregular	54.8	31.0	85.8	11.2	1.5	1.5	14.2	4646
	Subtotal	43.7	32.4	76.1	21.1	2.1	0.7	23.9	82464
	Total	43.0	33.5	76.5	20.8	2.1	0.6	23.5	94699

Table 3.1.3-1: Percentages of defoliation of all species by mean age

3.1.4 Forest condition by easily identifiable damage

Types of damage to sample trees that could easily be identified have been divided into eight categories:

- game and grazing (damage to trunk, bark, etc.)
- presence or traces of an excessive number of insects
- fungi
- abiotic agents (wind, drought, snow, etc.)
- direct action of man (poor silvicultural practices, logging)
- fire
- known local or regional pollution (classical smoke damage)
- other types of damage

For these categories, only the presence of such damage is indicated. It is presented in Table 3.1.4-1 in terms of the percentage of the total tree or plot sample that is affected. No indication is given of the intensity of the damage. It is possible that more than one type of identifiable damage occurs on a single tree. Such trees will therefore be represented more than once in the damage table. As no damage types were inventoried at all in two countries, 416 plots, representing 4 641 trees, had to be excluded from Table 3.1.4-1.

Damage type	Defoliation % in classes 2,3+4		Discolouration % in classes 1,2,3+4		Observations [% of total] Total Europe		EC	
	Total Europe	EC	Total Europe	EC	Trees	Plots	Trees	Plots
Classical smoke damage	42.9	51.6	37.6	57.8	0.2	0.3	0.1	0.2
Fire	22.9	22.9	13.3	13.3	0.7	1.6	1.4	3.1
Game/Grazing	18.9	23.5	11.8	14.4	1.7	5.5	2.4	5.5
Action of man	23.8	26.1	15.7	19.0	5.3	22.0	6.9	18.1
Fungi	25.5	20.4	18.7	17.6	5.5	18.9	7.7	22.4
Abiotic agents	38.7	40.8	22.5	25.0	6.8	24.7	8.9	22.1
Other	15.5	11.9	8.7	9.2	10.5	29.4	16.1	27.5
Insects	30.5	26.4	15.3	14.6	12.7	26.1	19.5	38.8
Any ident.damage	27.4	24.9	15.3	16.6	30.7	65.3	41.6	64.3
No ident. damage	23.6	15.2	8.0	8.7	69.3	34.7	58.4	35.7
Total	24.7	19.2	8.1	9.5	90058	4040	48137	1988

Table 3.1.4-1: Percentages of trees with defoliation >25% and discolouration >10% by identified damage types, based on a total of 4040 plots with 90 058 sample trees

Interpretation of the data related to identifiable damage is difficult. The main problem is that some of the damaging agents are more easily identified, or identified with more certainty than others. Moreover, it is not always clear from the data reported if no obvious damage could be identified or if no assessment has been made. Damage types were observed on a low proportion of sample trees (0.2 to 12.7%) only. Therefore, the data presented here only give a general indication of the effect of the several damage types.

Among the trees showing any identifiable damage, the proportions of trees in defoliation classes 2-4 ranged between 15.5% (other types of damage) and 42.9% (classical smoke damage) in total Europe. For most of the damage types the respective proportions increased as compared with the 1991 survey results. This increase in the percentages of trees in classes 2-4 was particularly high for abiotic agents (from 25.5% in 1991 to 38.7% in 1992) and for insects (from 21.1% to 30.5%).

When regarding all trees with any identifiable damage together, the percentage of trees in defoliation classes 2-4 (27.4%) was 3.8 percent points higher as compared to trees with no damage type identified (23.6%). In the EC countries, 9.3 percent points more trees appear to be damaged (defoliation more than 25%) in the presence of any identifiable damage (24.9%) than when no damage type has been identified (15.2%).

As regards discolouration, in total Europe the share of trees in discolouration classes 1-4 showing any identifiable damage (15.3%) was 7.3 percent points larger than the one without identifiable damage (8.0%). In the EC countries, the respective shares of discoloured trees were 16.6% and 8.7%, yielding a 7.9 percent point difference between the subsamples with any and no identifiable damage types.

The most pronounced negative effect in terms of discolouration was observed for trees affected by classical smoke damage with 37.6% of the trees in discolouration classes 1-4 in total Europe. The respective figure for the EC countries is 57.8%.

3.1.5 Changes in defoliation and discolouration from 1991-1992

The results presented under Chapter 3.1.5 are based on simple differences in the proportions of trees defoliated between the two years. In interpreting the results of temporal changes in defoliation and discolouration care should be taken as no statistical significance tests have been performed so far.

3.1.5.1 Changes by climatic region

In order to be able to compare the results of 1991 and 1992, a subsample is defined containing all trees that are common to both surveys: the Common Sample Trees (CSTs). This common sample consists of 66 141 trees, representing 79.6% of the total tree sample of 1991 and 69.8% of the total tree sample of 1992. This is 4 746 or 7.7% more CSTs than in the 1991 survey, which is mainly a result of the inclusion of Finland in 1991.

The classification of the total tree sample and Common Sample Trees (CSTs) into climatic regions introduces a plot variable permitting evaluations with respect to climatic site conditions. A total of 9 climatic regions was specified, which largely match the most important forest vegetation types. Figure 3.1.5.1-1 shows the percentages and distribution of all plots over the climatic regions.

Regarding defoliation, the proportion of damaged CSTs (defoliation classes 2-4) has increased in all climatic regions but the Boreal region, where it decreased by 0.8 percent points (Figure 3.1.5.1-2). The highest increases of damaged trees occurred in the Mediterranean (higher) region (3.5 percent points) and the Continental region (3.2 percent points), followed by the Mountainous regions (2.5 percent points) and the Atlantic (north) region (2.4 percent points). In the Mediterranean (lower), Sub-atlantic and Atlantic (south) regions, the proportions of damaged trees were 2.0, 1.2 and 0.4 percent points, respectively. The average increase of the proportion of damaged trees for all regions is 1.7 percent points. It is remarkable that the highest proportion of dead trees occurred in the Continental region, although this is one of the regions with the lowest percentages of trees in defoliation classes 1 and 2.

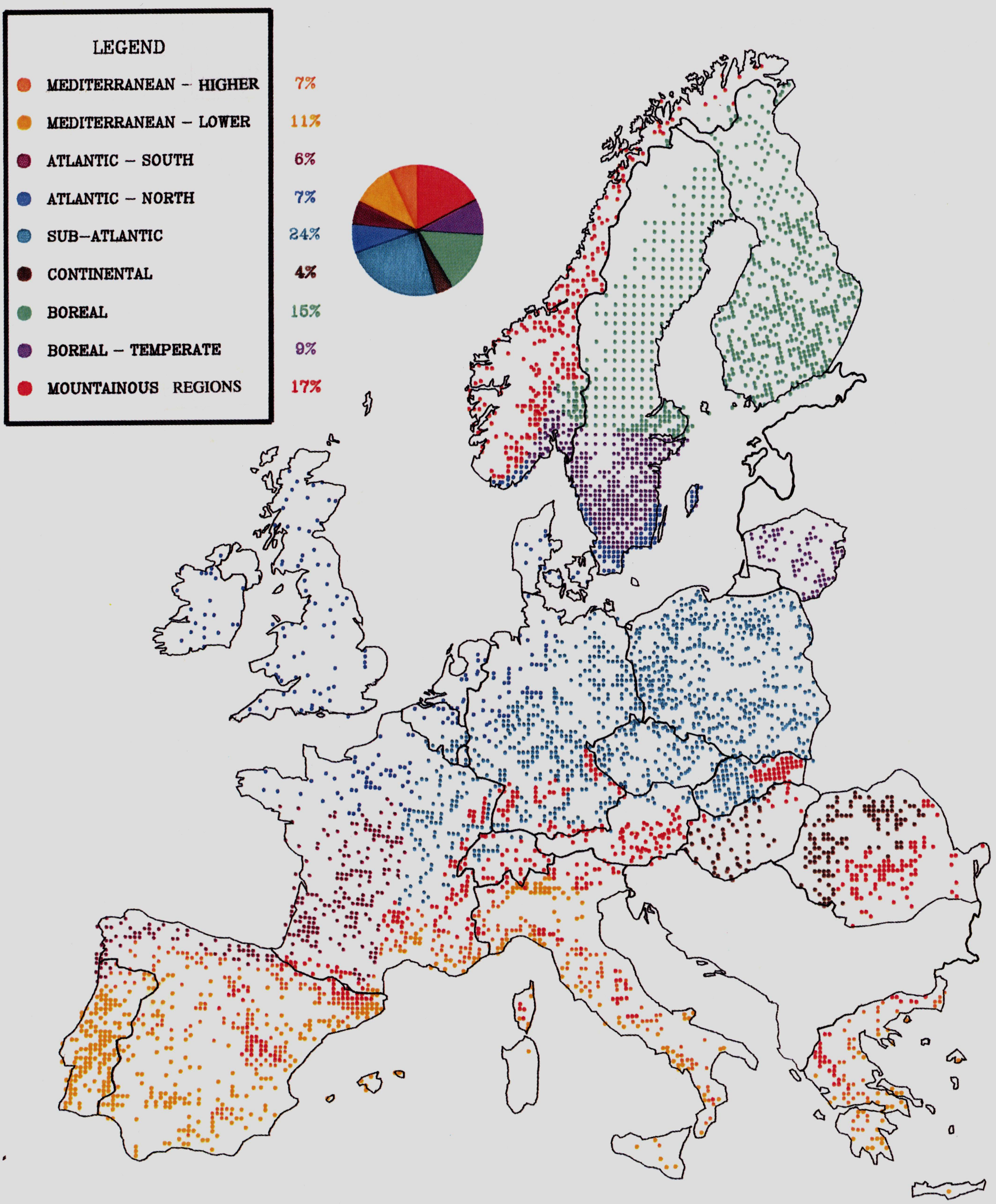

Figure 3.1.5.1-1: Climatic regions

As to discolouration, only slight changes occurred among the CSTs from 1991 to 1992 except for the Continental region, where the proportion of discoloured trees (discolouration classes 1-4) increased by 11.7 percent points , and for the Boreal region, where it decreased by 6.9 percent points (Figure 3.1.5.1-3). In all of the other regions, slight decreases of the percentages of discoloured trees were found.

The average increase of the proportion of damaged trees for all regions is 1.3 percent points.

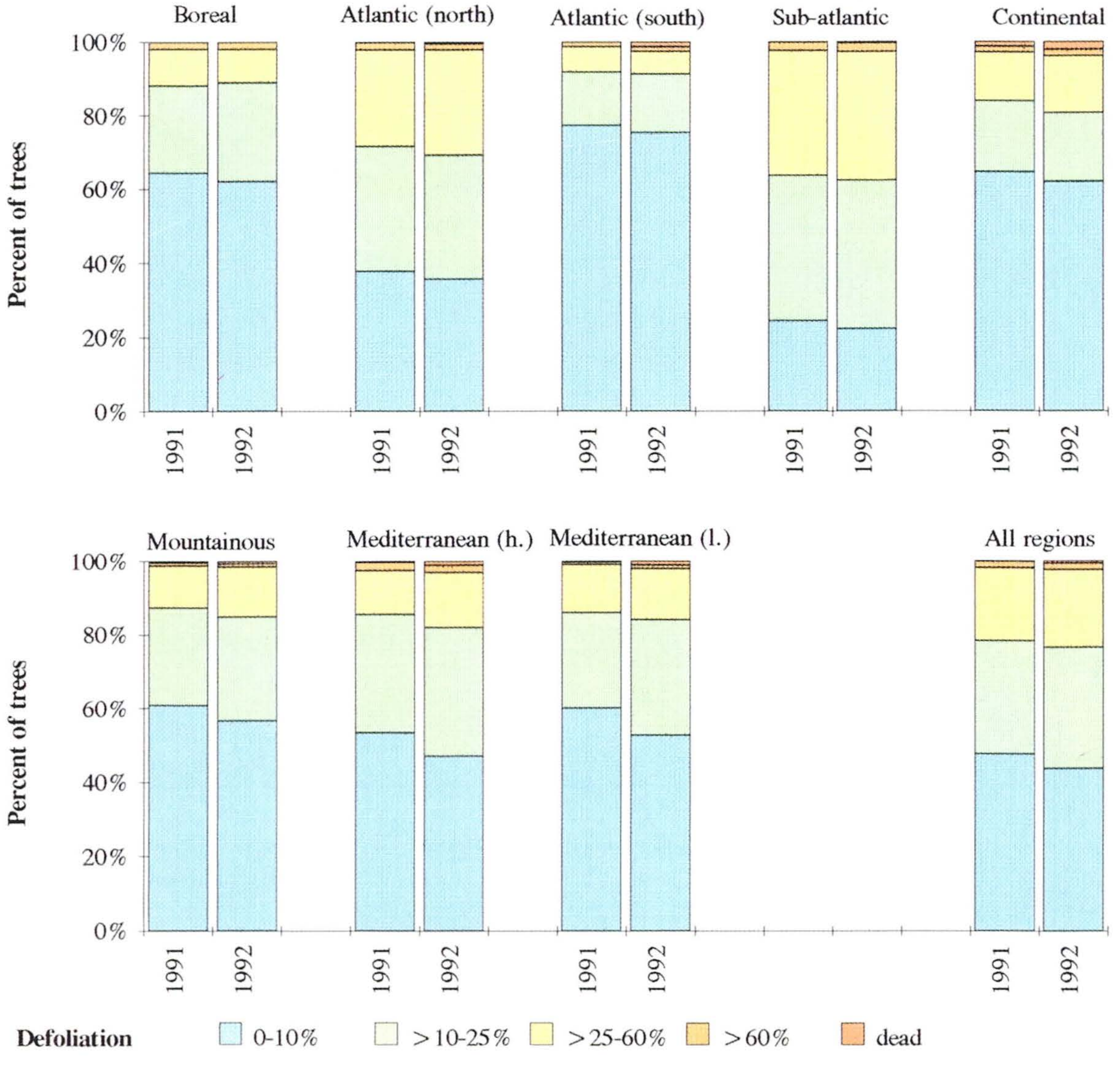

Figure 3.1.5.1-2: Percentages of defoliation of the Common Sample Trees in 1991 and 1992 for each of 8 climatic regions and for the total sample of CSTs

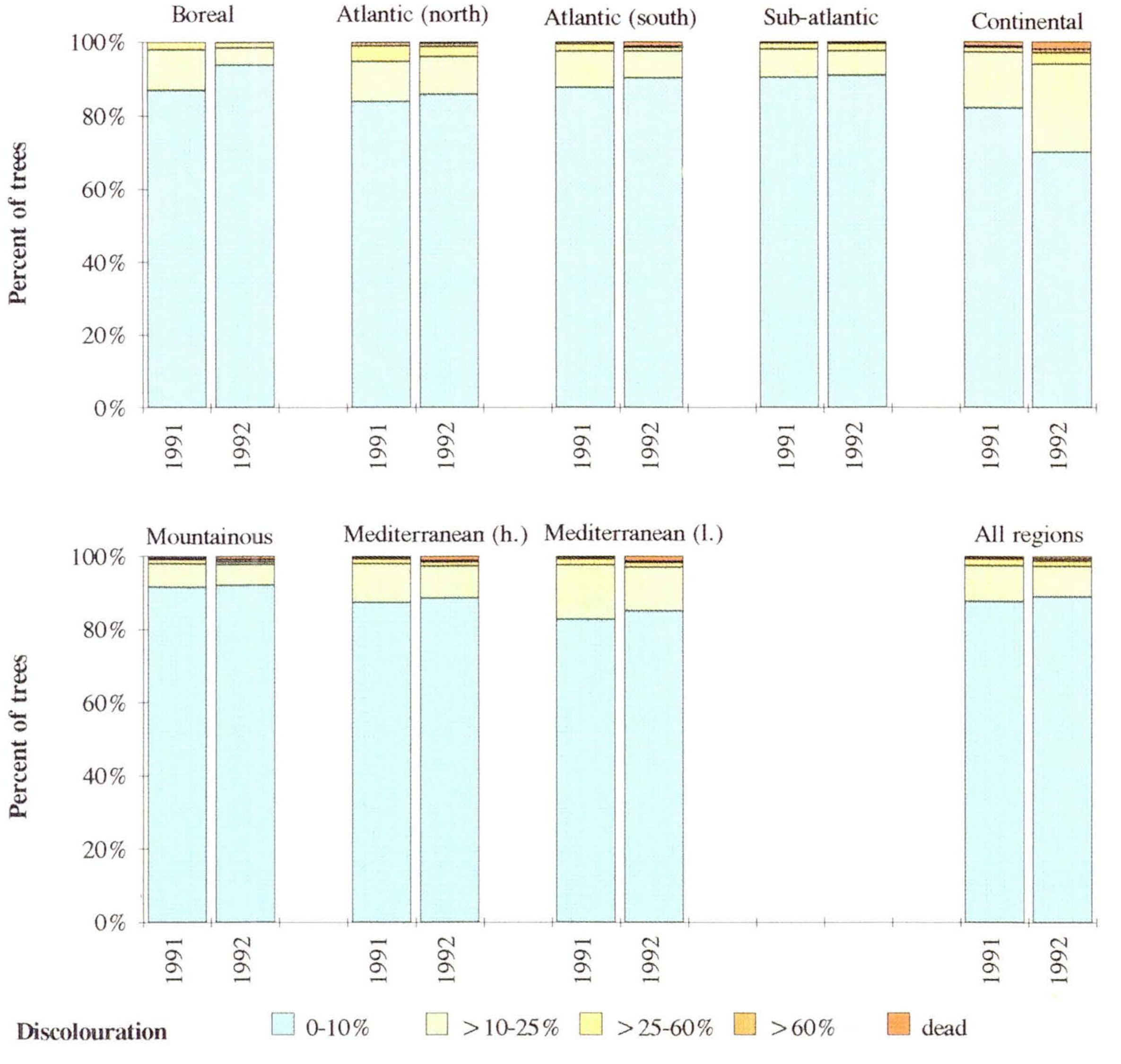

Figure 3.1.5.1-3: Percentages of discolouration of the Common Sample Trees in 1991 and 1992 for each of 8 climatic regions and for the total sample of CSTs

3.1.5.2 Changes by species group

Defoliation increased in nearly all species groups. In the broadleaved CSTs the proportion of trees showing a defoliation greater than 25% rose by 2.5 percent points from 18.0% to 20.5%. In the coniferous CSTs the respective increase was smaller, namely 1.3 percent points from 24.8% to 26.1%.

Among the broadleaved CSTs, the most prominent deterioration, as expressed by the proportion of trees in defoliation classes 2-4, occurred in *Quercus ilex*. The condition of this species had already decreased significantly in the CSTs of 1990 and 1991. Between 1991 and 1992 the proportion of damaged trees increased from 4.3% by 3.8 percent points to 8.1%. This indicates that the proportion of damaged trees was nearly twice as large in 1992 as in 1991 but remained on a moderate level.

Another prominent increase in the proportion of damaged trees occurred in *Castanea sativa*, namely from 14.6% by 5.7 percent points to 20.3%.

In contrast to the other broadleaved species groups, the CSTs of *Quercus suber* showed a remarkable decrease of the proportion of damaged trees, namely from 41.8% by 7.3 percent points to 34.5%.

The largest number of broadleaved CSTs is represented by 9 009 *Quercus* spp.trees, with an increase in the proportion of damaged trees from 19.4% by 2.0 percent points to 21.4%. The second largest number of CSTs is represented by Other broadleaves (8 009 trees), the proportion of damaged trees of which increased from 20.2% by 2.1 percent points to 22.3%.

As regards the coniferous CSTs, the most prominent change was the increase of the proportion of damaged *Larix* spp. trees from 8.1% by 4.0 percent points to 12.1%. This rapid increase, however, refers to the relatively small subsample of 832 *Larix* spp. trees, and therefore influences the total result far less than the development of the more frequent *Pinus* spp., *Picea* spp. and the other conifers.

The largest number of coniferous CSTs (23 076) was comprised by *Pinus* spp., showing an increase in the proportion of damaged trees from 25.1% by 1.5 percent points to 26.6%. The respective increase in *Picea* spp. with 10 109 trees, respectively, was of similar size. As a result, the proportion of damaged coniferous CSTs increased from 24.8% by 1.3 percent points to 26.1%.

As to discolouration, some species groups improved over the period 1991-1992, whereas other species groups deteriorated. However, there was an overall lower discolouration in 1992 than in 1991 in the conifers, whereas practically no change occurred on the average in the broadleaves.

Among the broadleaved CSTs, the considerable decrease of discolouration observed in *Quercus suber* already last year continued. The proportion of discoloured trees (discolouration classes 1-4) decreased from 40.1% to 26.0%. Large increases in discolouration occurred in *Quercus ilex* (from 2.7% to 6.1% of the trees in classes 1-4), in *Castanea sativa* (from 15.7% to 24.3%) and in *Eucalyptus* spp. (from 5.4% to 8.1%). As regards *Eucalyptus* spp., rapid changes have occurred in recent years.

In the coniferous CSTs the most prominent change in discolouration occurred in *Larix* spp., namely an increase in discoloured trees from 5.9% to 10.2%. This result, however, may be affected by the small number (832) of CSTs in this species group.

3.1.6 Changes in defoliation since 1988

Similar to the Common Sample Trees (CSTs) of 1991 and 1992 a separate subsample of trees common to the years 1988-1992 was defined in order to study the trends in condition over a longer period. For the total tree sample, 31 530 trees were found with information available for each year between 1988 and 1992. The evaluation was confined to the nine most common species, each of which comprised more than 1 000 common trees. Also evaluated were *Quercus petraea*, *Picea sitchensis* and *Abies alba*. These species had lower tree numbers and were not to be included according to their ranking, but are of importance in particular regions. Figures 3.1.6-1 and 3.1.6-2 show the changes in defoliation for the most common coniferous and broadleaved species, respectively.

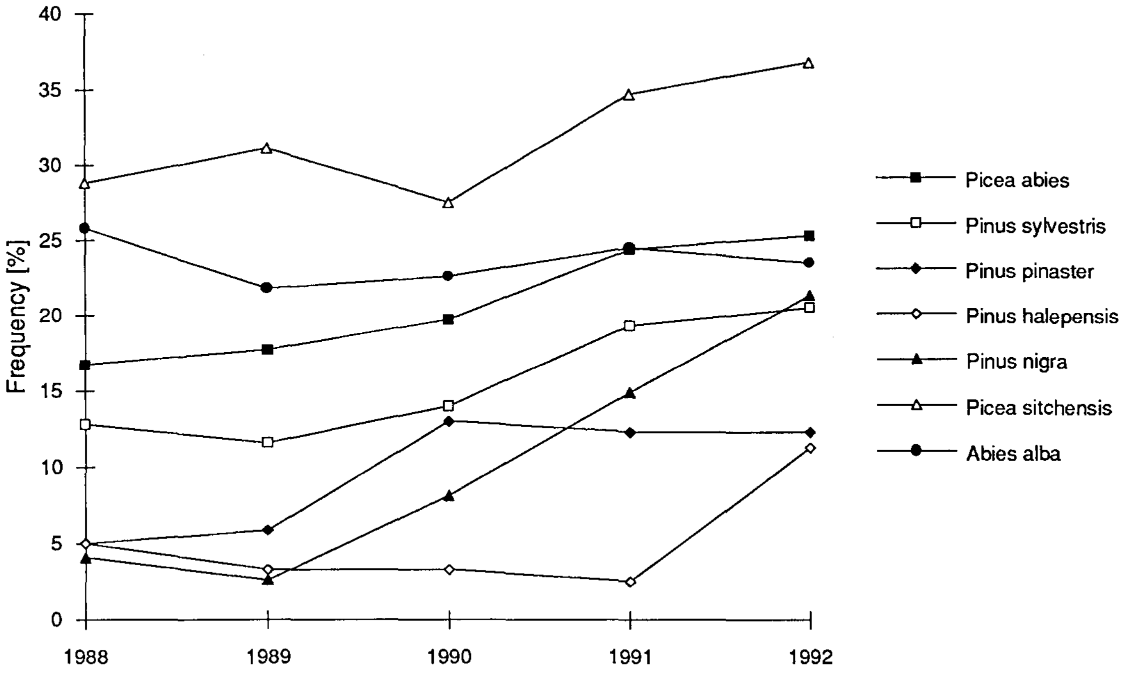

Figure 3.1.6-1: Changes in defoliation for coniferous trees (defoliation classes 2-4) common to 1988-1992

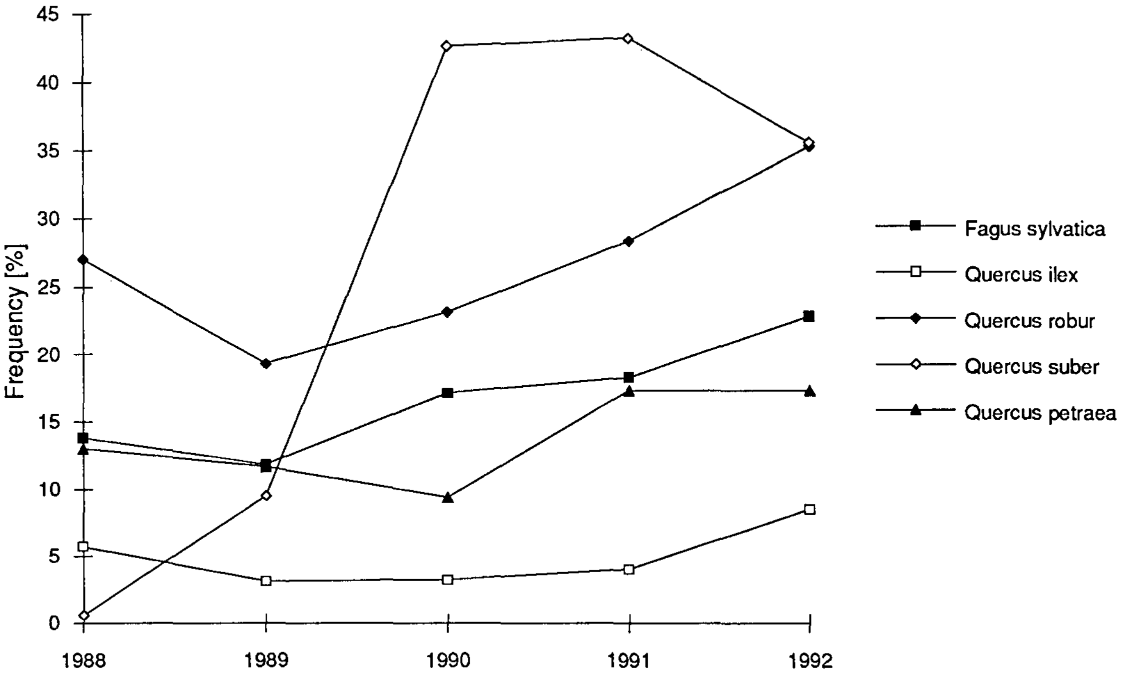

Figure 3.1.6-2: Changes in defoliation for broadleaved trees (defoliation classes 2-4) common to 1988-1992

In the subsample of common trees of the period from 1988 to 1992, the proportions of the trees classified as damaged differed considerably between the individual tree species. Out of the 12 species analyzed all but *Abies alba* showed a more or less obvious increase in the proportion of damaged trees.

Among the conifers *Picea sitchensis* had the highest percentage of damaged trees in all years and at the same time showed an obvious increase in this percentage, namely from 28.8% in 1988 to 36.8% in 1992. The proportion of damaged *Abies alba* trees was also high, but decreased slightly from 25.8% to 23.5% within the five years of observation. The most obvious increase in the share of damaged trees was found for *Pinus nigra* with 4.1% in 1988 and 21.3% in 1992. The share of damaged *Picea abies* and *Pinus sylvestris* trees showed a gradual increase from 16.7% to 25.3% and from 12.8% to 20.5%, respectively.

As regards the broadleaved species, the sharp increase of the share of damaged trees in *Quercus suber* from 0.6% in 1988 to 42.6% in 1990 was very obvious. Among the other broadleaved species, *Quercus robur* had the highest percentage of damaged trees all of the time, and showed also a conspicious increase in this percentage from 27.0% in 1988 to 35.3% in 1992. The proportion of damaged *Fagus sylvatica* and *Quercus petraea* trees increased from 13.8% to 22.8% and from 13.0% to 17.3%, respectively.

3.2 National survey results

Important data from the national surveys are given in the tables in the Annex. Annex 1 gives an overview of the participating countries, forest areas, density of grids and extent of survey activities. Annexes 2-4 contain results for all species, conifers and broadleaves. The changes in the survey results from 1986 on are presented also for all species, conifers and broadleaves in Annexes 5-7.

The national survey results of all species assessed (Annex 2) can be summarized as follows:

Although it is not possible to make direct comparisons between different countries because of the way in which the common methodology is applied and because of general differences in climatic and site factors, the data show that countries fall into three groups.

In three of the 31 countries from which survey results were reported the percentage of sample trees classified as damaged (defoliation classes 2-4) was lower than 10%. These countries are Austria, France and the Russian Federation.

In 14 of the countries the percentage of sample trees classified as damaged ranged between greater 10% and 20%. These countries are Belarus, Belgium, Croatia, Finland, Greece, Ireland, Italy, Liechtenstein, Lithuania, Romania, Spain, Sweden Switzerland and Ukraine.

In another 14 countries, i.e. in nearly half of the member states from which survey results were reported, the percentage of sample trees classified as damaged was greater than 20%, with a maximum of 58.3%. These countries are Bulgaria, the Czech Republic, Denmark Estonia, Germany, Hungary, Latvia, Luxembourg, the Netherlands, Norway, Poland, Portugal, the Slovak Republic and the United Kingdom. In most of these countries the defoliation was particularly high in coniferous stands. The broadleaved stands were particularly affected in Germany, Luxembourg, Norway, Portugal, Romania and the United Kingdom.

As in 1991, the overall tendency in 1992 has been a deterioration in the majority of countries. The following table describes the changes of defoliation that were observed between 1991 and 1992 in classes 2 to 4 (more than 25 % of needles/leaves lost). Changes are rated as unimportant if equal to or less than 5 percent points, as slight between 5.1 and 10.0 percent points, as moderate between 10.1 and 20 percent points and as substantial if exceeding 20 percent points from one year to the next.

	Number of countries						
	No or unimportant change	Increase of defoliation			Decrease of defoliation		
		Slight	Moderate	Substantial	Slight	Moderate	Substantial
All species	16	4	-	-	2	-	-
Conifers	18	2	1	-	1	1	-
Broadleaves	14	3	1	1	2	-	-

Table 3.2-1: Changes in defoliation observed between 1991 and 1992 in classes 2-4.

As regards all species, a slight increase of defoliation occurred in four countries, whereas a slight decrease was observed only in 2 countries. The increase of defoliation is particularly evident in the broadleaves. As regards the broadleaves, an increase occurred in five countries, whereas a decrease was observed only in two countries. The increases in the broadleaves were moderate and substantial in one country each.

4. INTERPRETATION

As regards the spatial distribution of the defoliation observed over the previous years, differences in its intensity were found between various climatic regions. Though the climate and particularly the weather are known to influence crown condition significantly, the differences in defoliation observed between the various climatic regions can not be readily explained as of mainly climatic origin (as opposed to weather) for the following reasons:

Firstly, the use of local reference trees should compensate for the climatic influence to a certain degree. This effect becomes particularly evident in the Mountainous region. At high altitudes crown density is usually diminished as a consequence of a generally harsher climate. This is already taken into account by the use of respective reference trees, so that there is no particularly high defoliation to be found in the Mountainous region. On the contrary, the survey results reveal lower defoliation at higher altitudes. This has already been described in the literature and may be explained by the fact that there is a tendency to underestimate defoliation on sites where crown transparency is naturally high.

Secondly, as the climatic impact on defoliation has been partly eliminated, those differences in defoliation between individual regions which can not be explained by climatic influences become particularly evident, feigning defoliation of climatic origin. This is the case in the Sub-atlantic region, where defoliation is particularly high due to local air pollution effects in some of the main damage areas. In some of the Central Highlands defoliation and dieback of trees has been explained by influences of nearby point sources of emissions and thus as classical smoke damage rather than as recent forest decline. This second reason becomes the more important the smaller the climatic regions are, because peculiarities of the damage situations in individual countries could be erroneously ascribed to climatic effects.

Because of the above mentioned reasons, the direct comparison of the defoliation between different climatic regions is unlikely to reveal climatic effects. Moreover, whilst weather fluctuations are known to influence crown condition, the long term climatic factors characterizing a particular region are unlikely to be the cause of recent defoliation. Nevertheless, the stratification of the total tree sample according to climatic regions remains undispensable, because the classification into climatic regions provides an additional variable for multivariate analyses.

Stand age was found to be of particular influence on the intensity of defoliation. The thinning of the crown with increasing age, however, is a well known natural phenomenon and does not necessarily imply a disease. The defoliation assessment in its present shape must leave the question open as to which degree the natural loss of needles with increasing age masks a defoliation caused by damaging agents. Among the severely defoliated and dead trees there is a relatively high proportion of younger trees. The reason for this is probably the high degree of competition in younger stands even within canopy classes 1-3, which leads to high natural mortality. This implies that the already low proportion of severely defoliated and dead trees comprises a large share of trees with natural losses of foliage.

The results of the national and transnational surveys reveal that there is a large number of stresses and site conditions influencing the extent of defoliation and discolouration. The most important probable causes for the observed defoliation and discolouration have been reported to be adverse weather conditions, insects, fungi, forest fire and air pollution. In accordance with the mandate of the two Programmes particular attention is being paid to the effects of air pollution as one of the many factors causing the symptoms observed. The degree to which air pollution among the other factors has contributed to defoliation and discolouration, however, cannot be quantified as a consequence of the lacking specifity of these two symptoms.

Classical smoke damage was reported for a very small number of trees (0.2%), but on those trees for which it had been diagnosed, the defoliation was very obvious. This suggests that air pollution effects have been observed particularly in areas and on trees of high defoliation. In 69.3% of the trees no evident source of damage was identified; this does not exclude the possibility of more widespread direct effects of air pollution also in the 30.7% of trees with identified damage (by e.g. insects, drought, etc.). Indirect or synergistic effects of air pollution are not proven, but can not be excluded either.

Some countries consider long range transboundary air pollution as the essential factor destabilizing forest health in their countries. The majority of the remaining countries considers air pollution as a factor leading to the weakening of forest ecosystems, while indirect influences on plant nutrition, soil acidification, eutrophication by nitrogen and leaching of base elements can be considerable .

A direct comparison of the proportion of damaged trees (23.5%) in the total tree sample of 1992 with that of the previous year would be inconclusive due to differing annual sample sizes. For the 1992 survey results the increase in the proportion of damaged trees could be proven to have been partly caused by the extension of the grid network into areas of Europe with obvious symptoms of forest decline. Moreover, the proportion of damaged trees would probably have been even larger, had not one country been excluded from the survey, which had reported high defoliation in 1991. However, the evaluation of both the Common Sample Trees (CSTs) of the 1991 and 1992 surveys, and of the common trees of the surveys from 1988 to 1992 give evidence for a deterioration of forest condition as expressed in terms of defoliation.

As regards the 66 141 CSTs, the share of the damaged trees increased from 21.9% in 1991 by 1.7 percent points to 23.6% in 1992. This means that there were 7.8% more damaged trees in the 1992 survey than in the 1991 survey, which in turn indicates that the deterioration of forest condition observed between the two surveys is not merely an artefact caused by the inclusion of damaged trees in the course of the extension of the grid.

A deterioration of forest condition can also be inferred for a longer period of time from the evaluation of the trees common to the 1988 to 1992 surveys. 11 out of the 12 species analyzed show a more or less obvious increase in the proportion of damaged trees.

In summing up the results gained from the 1992, however, it must be stated that the trend towards the deterioration of forest condition observed already in earlier years continues. It is this trend which cannot be readily explained by site conditions and damaging agents. Although there is no direct evidence of this being an effect of air pollution, this phenomenon deserves special attention because a continuous and large scale weakening of forest health by long-range transboundary air pollution is likely to manifest itself in effects like the ones observed.

5. CONCLUSIONS AND RECOMMENDATIONS

Forest damage in terms of defoliation and discolouration continues to be a problem in the countries participating in the surveys of UN/ECE and EC. Forest damage has been reported to a different extent from many regions of Europe, however, there is a concentration of main damage areas in some countries of Central Europe. In each of these main damage areas, several thousand hectares of forest have died. Besides a multitude of natural and anthropogenic stressors such as insects, fungi, adverse weather conditions and forest fires, air pollution is considered as one of the possible causes for the symptoms observed. Following their mandates, the two programmes of UN/ECE and EC pay special attention to air pollution stress.

According to the opinion of several countries, the atmospheric concentrations and the depositions of several air pollutants in many areas exceed the critical levels/loads at which disturbance to forest ecosystems would be expected. Therefore, a continuation or an increase of the present pollution load for extended periods of time is expected to threaten the condition of forests over large areas of Europe.

The present forest condition and the pollution load in several parts of Europe indicates a clear need for continued monitoring and measures against air pollution. The recent surveys of the forest condition in Europe of UN/ECE and EC have already led to the following successes:

- a more accurate knowledge of the extent, dynamics and spatial distribution of the symptoms of forest damage in Europe
- a database for future time series analyses of defoliation and complex studies in combination with ecological parameters
- impetus to forest damage research.

However, there remains the problem in separating defoliation and discolouration due to air pollution and due to other factors because of the unspecifity of the symptoms assessed. Consequently, though defoliation and discolouration will remain the only parameters to be assessed at a large scale with reasonable effort, the two programmes have launched monitoring activities the results of which should also contribute to a better understanding of cause-effect relationships. These activities are

- the intensified monitoring on the existing gridnet and on a second network of permanent sample plots by means of harmonized methods
- the merging of the comprehensive set of large-scale representative data on forest and site condition with those databases of ecological parameters established by other international programmes which are monitoring air pollution and its effects.

These activities are in full agreement with the goals stipulated by the European Ministers at the Ministerial Conference on the Protection of Forests in Europe, at Strasbourg, in December 1990.

The first steps taken by ICP Forests - in cooperation with EC - were the implementation of Expert Panels on Soil, on Foliar Analysis, on Increment and on Deposition. The programme on soil analysis has already been started in several countries, based on harmonized methodologies specified in a particular submanual. First results will be available by 1995. Submanuals on foliar analysis, increment studies and deposition measurements are under preparation. These new activities will mainly focus on a network of permanent sample plots established for intensive monitoring of ecological parameters in order to provide insight into the complex cause-effect relationships between air pollution and forest condition. As further steps the full implementation of these activities requires a common strategy for the work of all four Expert Panels, especially with respect to the assessment, transfer, storage and evaluation of data.

Deeper insight into cause-effect relationships is also to be expected from the collection of more detailed information on site and stand parameters. Therefore the complete and correct collection of annual data in the future is of paramount importance for the understanding of the dynamics of forest condition. The parameters presently recorded in the survey do not yet provide a complete and extensive description of site conditions. Not all parameters assessed by most of the participating countries have been evaluated so far, because their evaluation in previous years has not led to conclusive results. Considering the importance of time series, however, these parameters should be continued to be assessed and should even be started to be assessed by those countries which have not yet done so. For instance, since 1990 the soil type has been inventoried on a voluntary basis by two countries. Faced with the differences found between the reported soil types, it is strongly recommended to include information on soil type and soil properties in future surveys of forest condition. These surveys will fill a serious gap which has hampered the evaluation considerably up to now.

The complete data sets of the two programmes of UN/ECE and EC should be utilized in further cooperation e.g. by means of a common data bank. This should also include the superimposition of the own data sets with those of other ICPs running under the Working Group on Effects of UN/ECE, utilizing modern techniques such as a Geographical Information System (GIS).

In order to assure purposeful assessments and evaluations, however, the planned monitoring activities require precise definitions of the objectives, possibilities and limitations of the programme.

It must be noted that besides the intensive studies on permanent plots the large scale assessment have to be continued. Time series of many consecutive years are expected to give evidence of the potential impact of transboundary air pollution and other factors. Moreover, the large scale spatial and temporal variation can only be scrutinized by means of time series of observations detached from the constraints of national borders. From the political point of view, evidence of transnational effects is the precondition for common abatement strategies.

As regards abatement strategies, a reduction of the air pollution load should improve the condition of endangered forests and postpone further disruption to ecosystems. Sulphur dioxide, ammonia, nitrogen oxides (as precursors of ozone and acid deposition) and others may all be important in particular areas. Many countries have emphasized the importance of dry conditions in recent years, both in terms of drought stress to trees and increased frequency of forest fires. Any atmospheric changes that increased the frequency of dry conditions in Europe would have serious consequences for many forests, particularly in the south. The ICP-Forests of UN/ECE and the Commission of the European Communities therefore support any moves that might help to reduce the rate of global warming and other effects of global climatic change.

Annexes

Annex 1
Forests and surveys in European countries (1992)

Participating countries	Total area (1000 ha)	Forest area (1000 ha)	Conifer. forest (1000 ha)	Broadleav. forest (1000 ha)	Area surveyed (1000 ha)	Grid size (km x km)	No. of sample plots	No. of sample trees
Austria	8385	3857	2922	935	3857	8.7 x 8.7	219	6732
Belarus	20760	7028	4757	2271	6016	$1^2/16^2$	602	16272
Belgium	3057	602	302	300	602	8^2 / 16^2	86	2384
Bulgaria	11100	3314	1172	2142	3314	16^2 / 8^2	186	7262
Croatia	5654	1789	494	1295	1073		100	24261
Czech Republic	7886	2630	2051	579	2630	$8^2/16^2$	151	10976
Denmark	4300	466	308	158	466	$7^2/16^2$	67	1558
Estonia	4510	1815	1135	680	1135	16 x 16	91	2159
Finland	30464	20059	18484	1575	20059	varying	412	4515
France	54919	14440	4840	9600	13100	16^2 /16x1	506	10113
Germany	35562	10189	6946	3243	10189	4 x 4	4464	103422
Greece *	13204	2034	954	1080	2034	16 x 16	81	1912
Hungary	9300	1684	264	1420	1684	4 x 4	1027	21172
Ireland	6889	380	334	46	285	16 x 16	22	460
Italy	30126	8675	1735	6940	7154	16 x 16	217	5857
Latvia	6450	2797	1633	1164	2797	8 x 8	394	9247
Liechtenstein	16	8	6	2	8	varying	338	3937
Lithuania	6520	1823	1073	750	1823	16 x 16	74	1807
Luxembourg	259	88	31	57	88	4 x 4	48	1152
Netherlands	4147	311	208	103	281	1 x 1	1364	32875
Norway	30686	13700	7000	6700	13700	$9^2/18^2$	931	8612
Poland	31270	8654	6895	1759	8654	7.75x7.75	1493	29880
Portugal	8800	3372	1340	2032	3060	16 x 16	153	4518
Romania	23750	6244	1929	4315	6244	2x2/2x4	9688	242273
Russian Feder. b)	80330	31592	25518	6074	31592	varying	51	1224
Slovak Republic	4901	1885	816	1069	28	$1^2/16^2$	111	5032
Slovenia	2008	1071	500	571	1071	4x4	549	13176
Spain	50471	11792	5637	6155	11792	16 x 16	462	11088
Sweden	40800	23700	19400	4300	19900	varying	8200	126111
Switzerland	4129	1186	818	368	1186	4 x 4	686	8217
Turkey	77945	20199	9426	10773	no survey in 1992			
Ukraine	60370	6151	2931	3220		16 x 16	133	2707
United Kingdom	24100	2200	1550	650	2200	random	369	8856
Yugoslavia a)	25600	6100	900	5200	6100	16 x 16	190	4547
TOTAL	728668	221835	134309	87526	184122	varying	33465	620814

*) excluding maquis
a) former Yugoslavia excluding Croatia and Slovenia
b) only regional survey

Annex 2

Defoliation of all species by classes and class aggregates (1992)

Participating countries	Area surveyed (1000 ha)	No. of sample trees	0 none	1 slight	2 moderate	3+4 severe and dead	2+3+4
Austria	3857	6732	56.4	36.7	6.3	0.6	6.9
Belarus	6016	16272	26.4	44.4	28.3	0.9	19.2
Belgium	602	2384	36.7	46.4	15.6	1.3	16.9
Bulgaria	3314	7262	42.8	34.1	21.6	1.5	23.1
Croatia		24261	56.9	27.5	12.8	2.8	15.6
Czech Republic	2630	10976	8.7	34.8	51.8	4.6	56.4
Denmark	466	1558	44.1	30.0	20.5	5.4	25.9
Estonia	1135	2159	40.8	30.7	27.2	1.3	28.5
Finland	20059	4515	65.0	20.5	12.7	1.8	14.5
France	13100	10113	75.1	16.9	6.8	1.2	8.0
Germany	10189	103422	32.0	41.6	25.0	1.4	26.0
Greece *	2034	1912	42.8	39.1	15.4	2.7	18.1
Hungary	1684	21172	42.4	36.1	17.4	4.1	21.5
Ireland	285	460	only conifers assessed				
Italy	7154	5857	57.0	24.8	14.5	3.7	18.2
Latvia	2797	9247	30.0	33.0	36.0	1.0	37.0
Liechtenstein	8	3937	52.0	32.0	12.0	4.0	16.0
Lithuania	1823	1807	16.3	66.2	15.9	1.6	17.5
Luxembourg	88	1152	48.7	30.9	16.6	3.8	20.4
Netherlands	281	32875	63.0	12.5	20.7	3.8	24.5
Norway	13700	8612	40.3	33.5	22.1	4.1	26.2
Poland	8654	29880	8.0	43.2	46.5	2.3	48.8
Portugal	3060	4518	54.4	23.1	20.9	1.6	22.5
Romania	6244	242273	48.9	34.4	13.5	3.2	16.7
Russian Feder.	31592	5472	only conifers assessed				
Slovak Republic	28	5032	23.0	41.0	28.0	8.0	36.0
Slovenia	1071	13176	no survey in 1992				
Spain	11792	11088	50.6	37.1	9.5	2.8	12.3
Sweden	19900	12611	51.0	28.5	14.1	2.4	16.5
Switzerland °	1186	7963	38.0	46.0	14.0	2.0	16.0
Turkey			no survey in 1992				
Ukraine		2707	40.8	42.9	15.1	1.2	16.3
United Kingdom	2200	8856	5.0	36.7	55.3	3.0	58.3
Yugoslavia a)							

°) weighted according to dbh *) excluding maquis a) former Yugoslavia excluding Croatia and Slovenia

Note: Because of the use of local reference trees and of the ways in which the common methodology is applied, direct comparisons of forest condition between participating countries are not possible.

Annex 3

Defoliation of conifers by classes and class aggregates (1992)

Participating countries	Conifer. forest (1000 ha)	No. of sample trees	0 none	1 slight	2 moderate	3+4 severe and dead	2+3+4
Austria	2922	5895	57.9	35.5	6.0	0.6	6.6
Belarus	4757	12383	18.9	47.4	32.8	0.9	33.7
Belgium	302	1216	29.7	47.3	16.5	6.5	23.0
Bulgaria	1172	4841	38.4	36.1	24.2	1.3	25.5
Croatia	494	3883	62.0	21.8	20.6	5.7	26.3
Czech Republic	2051	10176	7.7	33.9	53.6	4.8	58.4
Denmark	308	992	50.7	20.8	20.4	8.2	28.6
Estonia	1135	2083	38.6	31.9	28.2	1.3	29.5
Finland	18484	3860	65.2	19.5	13.3	1.9	15.2
France	4840	3408	78.2	14.7	6.6	0.5	7.1
Germany	6946	68795	35.1	41.1	22.5	1.3	23.8
Greece *	954	1039	45.2	42.5	9.9	2.4	12.3
Hungary	264	3436	47.6	32.3	16.9	3.2	20.1
Ireland	334	460	49.2	35.1	14.5	1.2	15.7
Italy	1735	1274	60.1	22.8	12.8	4.4	17.2
Latvia	1633	6810	24.0	31.0	43.0	2.0	45.0
Liechtenstein	6	2978	49.0	33.0	14.0	4.0	18.0
Lithuania	1073	1245	13.4	69.1	16.3	1.2	17.5
Luxembourg	31	384	71.1	22.6	5.2	1.1	6.3
Netherlands	208	22125	49.3	16.1	29.3	5.4	34.7
Norway	7000	7037	44.7	31.9	19.8	3.6	23.4
Poland	6895	25280	7.3	42.5	47.9	2.4	50.3
Portugal	1340	1674	65.5	23.2	10.0	1.3	11.3
Romania	1929	52424	57.6	31.5	8.9	2.0	10.9
Russian Federation	25518	1224	55.9	38.7	3.8	0.8	5.4
Slovak Republic	816	2132	14.0	42.0	34.0	10.0	44.0
Slovenia	500						
Spain	5637	5520	55.6	30.9	11.0	2.5	13.5
Sweden	19400	11004	50.5	32.6	14.6	2.3	16.9
Switzerland °	818	5085	37.0	46.0	15.0	2.0	17.0
Turkey	9426						
Ukraine	2931	1661	37.8	48.4	13.5	0.3	13.8
United Kingdom	1550	5544	6.6	40.7	49.6	3.1	52.7
Yugoslavia a)							

°) weighted according to dbh

*) excluding maquis a) former Yugoslavia excluding Croatia and Slovenia

Note: Because of the use of local reference trees and of the ways in which the common methodology is applied, direct comparisons of forest condition between participating countries are not possible.

Annex 4
Defoliation of broadleaves by classes and class aggregates (1992)

Participating countries	Broadleav. forest (1000 ha)	No. of sample trees	0 none	1 slight	2 moderate	3+4 severe and dead	2+3+4
Austria *	935	837	45.8	44.9	8.5	0.8	9.3
Belarus	1878	3889	50.0	35.2	14.0	0.8	14.8
Belgium	300	1168	43.9	44.3	11.2	0.6	11.8
Bulgaria	2142	2421	51.7	30.3	16.2	1.8	18.0
Croatia	1295	20378	57.8	28.6	11.3	2.3	13.6
Czech Republic	6	800	21.8	46.3	29.9	2.0	31.9
Denmark	158	566	32.5	46.3	20.7	0.5	21.2
Estonia	680	76	100.0	0.0	0.0	0.0	0.0
Finland	1575	655	63.7	26.3	8.9	1.2	10.1
France	9600	6705	73.5	18.0	6.9	1.6	8.5
Germany	3243	34627	25.5	42.5	30.3	1.7	32.0
Greece **	1080	873	40.0	35.0	22.0	3.0	25.0
Hungary	1420	17736	41.4	36.8	17.5	4.3	21.8
Ireland	46	only conifers assessed					
Italy	6940	4583	56.1	25.4	15.0	3.5	18.5
Latvia	522	2437	45.1	35.9	18.0	1.0	19.0
Liechtenstein	2	959	64.0	28.0	6.0	2.0	8.0
Lithuania	750	562	22.8	59.6	14.9	2.7	17.6
Luxembourg	57	768	35.2	34.3	25.8	4.7	30.5
Netherlands	103	10750	32.7	36.2	27.5	3.6	31.1
Norway ***	6700	1575	20.9	40.2	32.2	6.7	38.9
Poland	1759	4600	12.3	47.3	38.4	2.0	40.4
Portugal	2032	2844	47.8	23.1	27.4	1.7	29.1
Romania	4315	189849	46.4	35.2	14.8	3.6	18.4
Russian Federation	6074	only conifers assessed					
Slovak Republic	1069	2900	30.0	40.0	23.0	7.0	30.0
Slovenia	571						
Spain	6155	5568	45.7	43.1	8.1	3.1	11.2
Sweden ***	4300	1607	54.7	31.8	10.5	3.0	13.5
Switzerland	368	2878	39.0	49.0	11.0	1.0	12.0
Turkey	10773						
Ukraine	3220	1046	45.6	34.2	17.5	2.7	20.2
United Kingdom	650	3312	2.3	29.9	64.8	3.0	67.8
Yugoslavia a)							

*) only trees 60 years and older assessed **) excluding maquis

***) special study on birch a) former Yugoslavia excluding Croatia and Slovenia

Note: Because of the use of local reference trees and of the ways in which the common methodology is applied, direct comparisons of forest condition between participating countries are not possible.

Annex 5
Changes in defoliation of all species (1986-1992)

Participating countries	All species							% change
	Defoliation classes 2-4							
	1986	1987	1988	1989	1990	1991	1992	1991/1992
Austria			3.6	4.4	9.1	7.5	6.9	-0.6
Belarus				67.2	54.0		19.2	
Belgium				14.6	16.2	17.9	16.9	-1.0
Bulgaria	8.1	3.6	7.4	24.9	29.1	21.8	23.1	1.3
Croatia							15.6	
Czech Republic							56.4	
Denmark		23.0	18.0	26.0	21.2	29.9	25.9	-4.0
Estonia		only conifers assessed					28.5	
Finland		12.1	16.1	18.0	17.3	16.0	14.5	-1.5
France *	8.3	9.7	6.9	5.6	7.3	7.1	8.0	0.9
Germany a)	18.9	17.3	14.9	15.9	15.9	25.2	26.0	0.8
Greece			17.0	12.0	17.5	16.9	18.1	1.2
Hungary			7.5	12.7	21.7	19.6	21.5	1.9
Ireland	only conifers assessed							
Italy						16.4	18.2	1.8
Latvia					36.0	-	37.0	
Liechtenstein	19.0	19.0	17.0	11.8			16.0	
Lithuania			3.0	21.5	20.4	23.9	17.5	-6.4
Luxembourg	5.1	7.9	10.3	12.3	-	20.8	20.4	-0.4
Netherlands	23.3	21.4	18.3	16.1	17.8	17.2	24.5	7.3
Norway	only conifers assessed				18.2	19.7	26.2	6.5
Poland			20.4	31.9	38.4	45.0	48.8	3.8
Portugal			1.3	9.1	30.7	29.6	22.5	-7.1
Romania						9.7	16.7	7.0
Russian Federation	only conifers assessed							
Slovak Republic							36.0	
Slovenia				22.6	18.2	15.9		
Spain			7.0	3.3	3.8	7.3	12.3	5.0
Sweden			10.6		16.2	12.0	16.5	4.5
Switzerland	13.0	15.0	12.0	12.0	17.0	19.0	16.0	-3.0
Turkey								
Ukraine						6.4	16.3	9.9
United Kingdom		22.0	25.0	28.0	39.0	56.7	58.3	1.6
Yugoslavia b)						9.8		

*) 16x16 km network after 1988
a) for 1986-1990, only data for former Federal Republic of Germany
b) former Yugoslavia; Croatia and Slovenia excluded from 1991 results

Annex 6
Changes in defoliation of conifers (1986-1992)

Participating countries	Conifers							% change
			Defoliation classes 2-4					
	1986	1987	1988	1989	1990	1991	1992	1991/1992
Austria	-	-	12.0	10.1	8.3	7.0	6.6	-0.4
Belarus	-	-	-	76.0	57.0	-	33.7	
Belgium	-	-	-	20.4	23.6	23.4	23.0	-0.4
Bulgaria	4.7	3.8	7.6	32.9	37.4	26.5	25.5	-1.0
Croatia							26.3	
Czech Republic							58.4	
Denmark	-	24.0	21.0	24.0	18.8	31.4	28.6	-2.8
Estonia	-	-	9.0	28.5	20.0	28.0	29.5	1.5
Finland	-	13.5	17.0	18.7	18.0	17.2	15.2	-2.0
France *	12.5	12.0	9.1	7.2	6.6	6.7	7.1	0.4
Germany a)	19.5	15.9	14.0	13.2	15.0	24.8	23.8	-1.0
Greece	-	-	7.7	6.7	10.0	7.2	12.3	5.1
Hungary	-	-	9.4	13.3	23.3	17.8	20.1	2.3
Ireland	-	0.0	4.8	13.2	5.4	15.0	15.7	0.7
Italy	-	-	-	-	-	13.8	17.2	3.4
Latvia	-	-	-	-	43.0	-	45.0	
Liechtenstein	22.0	27.0	23.0	12.4	-	-	18.0	
Lithuania	-	-	3.0	24.0	22.9	27.8	17.5	-10.3
Luxembourg	4.2	3.8	11.1	9.5	-	-	6.3	
Netherlands	28.9	18.7	14.5	17.7	21.4	21.4	34.7	13.3
Norway	-	-	20.8	14.8	17.1	19.0	23.4	4.4
Poland	-	-	24.2	34.5	40.7	46.9	50.3	3.4
Portugal	-	-	1.7	9.8	25.7	19.8	11.3	-8.5
Romania	-	-	-	-	-	6.9	10.9	4.0
Russian Federation	-	-	-	-	-	4.2	5.2	1.0
Slovak Republic							44.0	
Slovenia	-	-	-	-	34.6	31.3	-	
Spain			7.3	3.5	3.1	7.3	13.5	6.2
Sweden		5.6	12.3	12.9	16.1	12.3	16.9	4.6
Switzerland	16.0	14.0	15.0	14.0	19.0	21.0	17.0	-4.0
Turkey							.	
Ukraine	-	-	-	1.4	3.0	6.4	13.8	7.4
United Kingdom	-	23.0	27.0	34.0	45.0	51.5	52.7	1.2
Yugoslavia b)	23.0	16.1	17.5	39.1	34.6	15.9	-	

*) 16x16 km network after 1988
a) for 1986-1990, only data for former Federal Republic of Germany
b) former Yugoslavia excluding Croatia and Slovenia

Annex 7
Changes in defoliation of broadleaves (1986-1992)

Participating countries	Broadleaves							% change
	Defoliation classes 2-4							
	1986	1987	1988	1989	1990	1991	1992	1991/1992
Austria	-	-	16.6	15.7	14.9	11.1	9.3	-1.8
Belarus	-	-	-	33.4	45.0	-	14.8	
Belgium	-	-	-	8.7	10.0	13.5	11.8	-1.7
Bulgaria	4.0	3.1	8.8	16.2	17.3	15.3	18.0	2.7
Croatia							13.6	
Czech Republic							31.9	
Denmark	-	20.0	14.0	30.0	25.4	27.3	21.2	-6.1
Estonia			only conifers assessed					
Finland	-	4.7	7.9	12.6	11.6	7.7	10.1	2.4
France *	4.8	6.5	5.3	4.8	7.7	7.4	8.5	1.1
Germany a)	16.8	19.2	16.5	20.4	23.8	26.5	32.0	5.5
Greece	-	-	28.5	18.4	26.5	28.5	25.0	-3.5
Hungary	-	-	7.0	12.5	21.5	19.9	21.8	1.9
Ireland			only conifers assessed					
Italy	-	-	-	-	-	17.1	18.5	1.4
Latvia	-	-	-	-	27.0	-	19.0	
Liechtenstein	10.0	7.0	5.0	9.0	-	-	8.0	
Lithuania	-	-	1.0	16.0	15.8	14.9	17.6	2.7
Luxembourg	5.6	10.1	12.3	13.9	-	33.9	30.5	-3.4
Netherlands	13.2	26.5	25.4	13.1	11.5	9.4	31.1	21.7
Norway	-	-	-	-	18.2	25.1	38.9	13.8
Poland	-	-	7.1	17.7	25.6	34.8	40.4	5.6
Portugal	-	-	0.8	8.6	34.1	36.6	29.1	-7.5
Romania	-	-	-	-	-	10.4	18.4	8.0
Russian Federation			only conifers assessed					
Slovak Republic							30.0	
Slovenia	-	-	-	-	4.4	5.8	-	
Spain			6.8	3.2	4.4	7.4	11.2	3.8
Sweden	-	-	5.2	-	22.1	9.1	13.5	4.4
Switzerland	8.0	15.0	7.0	6.0	12.0	13.0	12.0	-1.0
Turkey								
Ukraine	-	-	-	1.4	2.7	6.5	20.2	13.7
United Kingdom	-	20.0	20.0	21.0	28.8	65.6	67.8	2.2
Yugoslavia b)	-	7.3	9.0	8.2	4.4	8.2	-	

*) 16x16 km network after 1988

a) for 1986-1990, only data for former Federal Republic of Germany

b) former Yugoslavia excluding Croatia and Slovenia from 1991/1992 results

Annex 8
Main species referred to in the text

Latin	English	German	French	Spanish	Italian
Fagus sylvatica	Common beech	Rotbuche	Hêtre	Haya	Faggio
Quercus petraea	Sessile oak	Traubeneiche	Chêne rouvre	Roble albar	Rovere
Quercus robur	European oak	Stieleiche	Chêne pédonculé	Roble común	Farnia
Quercus ilex	Holm oak	Steineiche	Chêne vert	Encina	Leccio
Quercus suber	Cork oak	Korkeiche	Chêne liège	Alcornoque	Sughera
Pinus sylvestris	Scots pine	Gemeine Kiefer	Pin sylvestre	Pino silvestre	Pino commune
Pinus nigra	Corsican/Austrian black pine	Schwarzkiefer	Pin noir	Pino laricio	Pino nero
Pinus pinaster	Maritime pine	Seestrandkiefer	Pin maritime	Pino negral	Pino marittimo
Pinus halepensis	Aleppo pine	Aleppokiefer	Pin d'Alep	Pino carrasco	Pino d'Aleppo
Picea abies	Norway spruce	Rotfichte	Epicéa commun	Abeto rojo	Picea comune
Picea sitchensis	Sitka spruce	Sitkafichte	Epicéa de Sitka	Picea de Sitka	Picea di Sitka
Abies alba	Silver fir	Weißtanne	Sapin pectiné	Abeto común	Abete bianco
Larix decidua	European larch	Europäische Lärche	Mélèze d'Europe	Alerce	Larice europeo

Annex 8
Main species referred to in the text

Latin	Dutch	Danish	Portuguese	Greek	Russian
Fagus sylvatica	Beuk	Bøg	Faia	Οξυά δασική	бук лесной
Quercus petraea	Wintereik	Vintereg	Carvalho branco Americano	Δρυς απόδισκος	дуб скальный
Quercus robur	Zomereik	Stilkeg	Carvalho roble	Δρυς ποδισκοφόρος	дуб черещатый
Quercus ilex	Steeneik	Steneg	Azinheira	Αριά	дуб каменный
Quercus suber	Kurkeik	Korkeg	Sobreiro	Φελλοδρύς	дуб пробковый
Pinus sylvestris	Grove den	Skovfyr	Pinheiro silvestre	Δασική πεύκη	сосна обыкновенная
Pinus nigra	Oostenrijkse/ Corsicaanse zwarte den	Østrisk fyr	Pinheiro Austríaco	Μαύρη πεύκη	сосна чёрная
Pinus pinaster	Zeeden	Strandfyr	Pinheiro bravo	Θαλασσία πεύκη	сосна приморская
Pinus halepensis	Aleppo den	Aleppofyr	Pinheiro de alepo	Χαλέπιος πεύκη	сосна алеппская
Picea abies	Fijnspar	Rødgran	Picea	Ερυθρελάτη υψηλή	ель европейская
Picea sitchensis	Sitkaspar	Sitkagran	Picea de Sitka	Ερυθρελάτη	ель ситхинская
Abies alba	Zilverden	Ædelgran	Abeto branco	Λευκή ελάτη	пихта белая
Larix decidua	Europese lariks	Lærk	Larício Europeu	Λάριξ ευρωπαϊκή	лиственница европейская

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