CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

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

United Nations
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Forest Condition in Europe

1992 Report

CONTENTS

PREFACE

The present report is a follow-up of the series of Forest Damage Reports of the United Nations Economic Commission for Europe (UN/ECE) and the Forest Health Reports of the Commission of the European Communities (CEC), which had been issued separately since 1987 by these two institutions.

The former Forest Damage Reports of UN/ECEdescribed the results of the **national 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. This ICP Forests was launched under the Convention on Long-range Transboundary Air Pollution in 1985. 28 states, including the European Community, of the 34 Parties to the Convention 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 Russian Federation, Croatia, Estonia, Latvia, Lithuania and Slovenia). The total would then come to 33 states. Canada and the United States of America cooperate with the ICP and are conducting major research and forest health monitoring programmes in North America.

The ICP Forests aims at assessing, monitoring and documenting the extent and development of recent forest damage in Europe. These objectives are accomplished by means of harmonized survey methods laid down in the Manual on Methodologies and Criteria for Harmonized Sampling, Assessment, Monitoring and Analysis of the Effects of Air Pollution on Forests (hereafter referred to as the ICP-Forests Manual), which was adopted by the Programme Task Force of ICP Forests in 1986 and was updated in 1989. Plot densities differ from country to country. Plot data are converted into mean values related to the specific member state.

Two Programme Coordinating Centres (PCCs), PCC-East in Prague (CSFR) and PCC-West in Hamburg (Germany) are responsible for the compilation and evaluation of data and reports supplied by the member states, the composition of the annual report, its executive summary, and the organization of regional training courses on forest damage assessment. For the work of the PCCs, the ICP Forests has received funding from the United Nations Environment Programme (UNEP) until 1990. From that year on UN/ECEmember states have provided annual voluntary financial contributions to support the PCCs (ECE/EB. AIR/29).

The former Forest Health Report of the Commission of the European Communities was an outcome of the application of Council Regulation (EEC) 3528/86 of November 1986 on the protection of the Community's forests against atmospheric pollution. Based on this Regulation, the member states of the European Community (EC) have been surveying forest damage annually since 1986 on sample plots of a uniform large-scale transnational grid, and have submitted data and reports to CEC for evaluation.

As laid down under Commission Regulation (EEC) 1696/87 of June 1987, the methods for this **transnational survey** are based on the guidelines of the ICP-Forests Manual. In contrast to the country-related evaluation of the UN/ECEnational assessments, the plot and tree related data of the large-scale transnational survey of CEC have been reported by the **countries** and evaluated by EC. In 1990 also five non-member states of the European

Community participated in the transnational EC survey on a voluntary basis for the first time. These countries were Austria, Czechoslovakia, Hungary, Poland and Switzerland.

In 1990 the 6th Meeting of the Programme Task Force of ICP Forests and the European Community agreed to invite all UN/ECEmember states to participate in the transnational survey formerly only conducted by EC countries, that the data of both the national assessments of UN/ECEand the transnational survey should be evaluated at PCC-West of ICP Forests, and that the results of the two evaluations should be jointly published in a series of common annual reports by EC and UN/ECE. With new independent states being established in Eastern Europe, 33 countries presently participate in the activities of the two programmes.

The present report is the first common report of EC and UN/ECE to describe the condition of forests in Europe, based on the results of both the national assessments and the transnational survey. The main results of the transnational survey are presented for Europe as a whole and separately for the EC countries.

The preparation of this report was made possible thanks to:

- the execution of the forest health surveys by the forest services of 33 European countries including the 12 member states of EC, and of Canada and the United States of America,
- the capture and processing of the tree related forest inventory data by James Duncan & Associates, as a contractor to the Commission of the European Communities
- the assistance in the evaluation including the preparation of tables and graphics by Oranjewould International B.V., as a contractor to the PCC-West
- the calculation of the geographical coordinates of the inventory grid intersection points by the Commission of the European Communities, Corine project, DG XI.
- financial support granted by the European Community and voluntary financial contributions received from the UN/ECE member states.

Hamburg, September 1992 *The editors*

1. INTRODUCTION

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

- missing symptoms of the classical factors of damage in forests (adverse climatic conditions, insects and fungi)

- similarities of the symptoms to the well known symptoms of classicial smoke damage having been reported for more than a century from the immediate vicinity of point sources of air pollutants

- increasing concentrations of air pollutants in many parts of Europe, also on sites remote from industry

- the rapid dynamics of recent forest decline at many locations under various site conditions.

The suspected connection of recent 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. Moreover, besides existing differences in the damaging agents, different attention is being paid to various symptoms and causes by individual countries. While most countries consider air pollutants at least as a contributing detrimental factor, previous reports of the EC and the UN/ECE have revealed a wide range of opinions about the importance of air pollution effects for the symptoms observed. The difficulties encountered when trying to disentangle the causes of the symptoms assessed are a direct consequence of an absence in specifity of the symptoms themselves and an insufficient knowledge of the effects of natural stresses (UN/ECE, 1991).

To improve the comparability of the results of the EC and UN/ECE surveys, field training courses have been regularly conducted. The first training course was held in Usti nad Labem (CSFR) as early as 1987. Subsequent international courses took place in the Federal Republic of Germany for Central European species, in France, Italy and Spain for the Mediterranean vegetation, and in Austria for Nordic and subalpine forests. Also several national training courses have been held with foresters participating from neighbouring countries. Such opportunities to exchange views and experiences during assessment work in the field have considerably improved and accelerated the process of harmonization. Joint field training will therefore be continued at the regional level in order to refine those guidelines in the ICP-Forests Manual which relate to forest damage assessment in the field.

Several expert panels have been set up to deal with assessment problems specific to certain regions and to help design instructions for in-depth investigations on permanent sample plots. In 1992, instructions on the assessment of soil and increment were approved as amendments to the Manual. Information exchange, attendance of meetings and cooperation in the harmonization of assessment methods is actively pursued with the Task Force on Mapping of Critical Loads, and expert groups within the EC.

The main objective of the present report is a description of the condition of forests in Europe, as it has been assessed in the framework of the national and transnational surveys of UN/ECE and EC by means of the methods and criteria laid down in the ICP-Forests Manual and in Commission Regulation (EEC) 1696/87. The report presents survey results from 28 European countries, referring to about 36 000 sample plots with about 700 000 sample trees. Of 214 million hectares of forests in Europe (including major parts of the forests in the western Russian Federation), around 168 million hectares or roughly 78 % have been covered in the 1991 surveys (6 million hectares more than in 1990). This means that the first objective of the UN/ECE and EC programmes has been achieved.

The survey results, however, hardly permit conclusions to be drawn about causal factors, because of the problems already mentioned. In the future, cause-effect relationships will be investigated by means of long-term observations 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 the EC also strive for special investigations and ecosystems analysis, for which methodological components have already been integrated into the ICP-Forests Manual. Submanuals on soil surveys and on increment analyses have been drafted, the submanual on soil studies being in its final stage of editorial work.

The search for causal effects calls for a synopsis of the comprehensive set of representative data on forests and site conditions for the whole of Europe with those databases established by other international programmes which are monitoring air pollution and its effects. The close cooperation between EC and UN/ECE can be a first step towards an approach for an integrative evaluation of data compiled by various programmes in years to come.

The content of the present report has been structured as follows:

Chapter 2 describes the principles of the methods of both the transnational and the national surveys. For methodological details the ICP-Forests Manual and the above mentioned Council Regulations of EC should be consulted.

Chapter 3 presents the results of the 1991 surveys. Particular emphasis has been put on the results of the transnational survey, because they are representative for the overwhelming part of Europe, especially now that the database has been greatly enlarged due to the participation of many non-EC countries. Correlations between the vitality and site parameters are documented, though not yet interpreted. The results of the national surveys are presented in a different way from the former UN/ECE Forest Damage Reports, although the main tables have been maintained for comparative purposes. For the first time national survey results have been grouped according to geographical regions (Northern Europe, Central Europe, Southern Europe, Western Europe, Southeastern Europe, Eastern Europe) in order to facilitate the comparison of results within a region and to stress regional comparabilities.

An interpretation of all survey results is contained in chapter 4, paying particular attention to the role of air pollutants as damage factors. The conclusions drawn from the survey results ate presented in chapter 5.

2. METHODS OF THE 1991 SURVEYS

2.1 Grid survey method

2.1.1 Transnational survey

The transnational survey aims at the collection of representative data on the development of forest condition in Europe. This is achieved by means of an assessment over a number of years of tree vitality and a number of site parameters on a 16x16 km grid of sampling points covering nearly the entire forest area of Northern, Western, Central, Southern and Southeastern Europe. This grid network was created in Gauss-Kriiger projection. The latitude and longitude of the sampling points were then obtained by means of a reprojection of the grid points to geographical coordinates. These coordinates were calculated and provided to the participating countries by the Corine project of the EC.

The member states of the EC have been assessing forest condition on the 16x16 km grid in application of Council Regulations (EEC) 3528/86 and Commission Regulation (EEC) 1696/87 since 1987. However, member states which had already established a systematic network before that date retained the corresponding sampling points of these networks for the purpose of establishing the 16 x 16 km network. Sampling points retained should either coincide with those of this Community grid, or be closest to them. In such a case results from the replacement grids are accepted for the transnational survey, provided that the mean point density resembles the one of a 16 x 16 km grid, and that the assessment methods correspond to those of the Commission Regulations.

In 1987, the first year of the inventory, 1 216 plots of the common grid were sampled and a total of 26 389 sample trees was assessed in terms of defoliation and discolouration. In the subsequent years the grid was expanded and the European Community received data from an increasing number of sample trees. In 1989 the grid in the EC had reached near-completion.

As a consequence of the reunification of the two German states, the grid was extended by another 115 plots in the former German Democratic Republic in 1990. Moreover, as agreed with ICP Forests of UN/ECE, the transnational grid survey was extended to Austria, Czechoslovakia, Hungary and Switzerland in the same year. Thus the entire data set of 1990 comprised 2 883 plots with 67 335 sample trees.

By implementing the decision of the 7th Task Force Meeting the transnational survey was extended on a voluntary basis to all other countries of the ICP Forests, so that besides the EC-member states 7 non-EC member states are participating. The present common report now relies on a database of 3 846 plots comprising 83 134 sample trees on a 16x16 km grid covering the majority of forests in Western and Central Europe. EC-member states are obliged to provide annual reports, in which the results from both the transnational grid and other grids (if existing) are presented. The participating countries are encouraged to collect additional information on denser networks using the common methodology, as this has been done in the national surveys by ICP Forests described in the following section.

2.1.2 National surveys

The national surveys are also based on systematic sampling according to the guidelines of the ICP-Forests Manual. The grid densities, however, range from lxl km to 16x16 km.

In 1991, national surveys were conducted in 28 countries participating in the ICP Forests (Annex II-1). In the national surveys, more than 700 000 trees were assessed on about 36 000 plots.

The results of the national surveys are looked upon as the best estimate for the specific region or country in which they have been obtained. Also, because of differences in species composition, site conditions and climate, comparisons between the two surveys and between different countries should be made with great care.

2.2 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 (e.g. four point cross clusters oriented along the main compass directions with comer points at 25 m distance from the grid point, using a six-tree sampling process on each subplot or sample trees chosen following a spiral from the plot centre).

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.

2.3 Assessment parameters

2.3.1 Defoliation and discolouration

On each sample plot the sample trees are assessed with respect to defoliation and discolouration according to the instructions of the ICP-Forests Manual and EC-regulations.

Defoliation is assessed in 5% (obligatory for EC-member states) or 10% steps 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 4 classes. In 1991, 17 countries submitted their national survey results in 10% classes as shown in Annex II-6.

The traditional classification reflects to a certain extent the experience gathered in Central Europe between 1980 and 1983. At that time, any loss of foliage exceeding 10% was considered as abnormal, indicating an incipient stage of impaired forest health. Furthermore, assumptions based on physiological observations of the vitality of differently defoliated trees led to the establishment of the uneven class widths. For example, a defoliation of

60% was selected as the border between defoliation classes 2 and 3, because it had been found that trees having lost more than 60% of foliage could remain alive for a variable time, but generally did not recover sufficiently to re-enter into defoliation class 2. Because of these reasons and in order to ensure comparability with previous presentations of survey results the traditional classification of both defoliation and discolouration has been retained for comparative purposes (tables 2.3-1 and 2.3-2), although it is considered arbitrary by some countries.

During the past years of survey work it has become clear that a loss of up to 20-25% of the foliage of a tree is not necessarily a sign of deteriorating health or vitality. Conifers regulate the amount of foliage carried according to the availability of moisture and nutrients or as a response to favourable or unfavourable weather conditions. Broadleaves, having lost foliage due to late frost or insect attack, may replace part of the loss with new leaves or may compensate for the loss without showing any reduction of growth. Consequently, defoliation class 1 is no longer regarded as indicating reduced vitality. For example, in the Federal Republic of Germany class 1 is designated as "slight defoliation - warning stage".

In some national surveys defoliation classifications different from the one described above are used. The results of these surveys, however, are adjusted to ECE guidelines. Field assessment methods , and damage symptomatology are subject to continuous discussion and periodic revision by the Programme Task Force of ICP Forests.

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 tree

Table 2.3-1: Defoliation classes according to UN/ECE and EC classification

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 2.3.-2: Discolouration classes according to UN/ECE and EC classification

There is a major problem in separating changes in crown density or colouration attributable to air pollution from those caused by other factors. Mechanical damage is ruled out as a cause due to the exclusion of such trees from the sample (section 2.2). However, defoliation due to any other causes is included, although known causes should be recorded during the assessment. Only a small fraction of the sample trees showed damage known to have been caused by air pollution. Cause-effect studies indicate that the stresses experienced by forest ecosystems can be divided into three broad categories: predisposing, inciting and contributing. The role of air pollution in forest health clearly varies depending on its nature and concentration. In some countries of Central and Eastern Europe, air pollution is considered as an inciting factor and the most important affecting forest health. Elsewhere in Europe, air pollution levels are lower and can only be considered as one of the factors predisposing forest to decline. Several countries emphasized that factors other than air pollution are considered more important to forest health, although they regard air pollution as a possible predisposing factor.

2.3.2 Additional parameters

On the plots of the transnational survey, additional parameters have to be assessed as laid down in Commission Regulation (ECE) 1696/87. The following information has to be submitted for each plot (section 2.4):

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 indentifiable damage, date of observation.

2.4 Submission, input and screening of data

The results of the transnational survey are to be submitted to the Commission of the European Communities in a digital format. The Commission has issued a "Note on the Submission of the Forest Vitality Inventory Data in a Digital Format" for this purpose, which introduces the digital format and reviews the complete methodology, the parameters, codes, etc. to be used in the survey.

The arriving information received is screened, and incomplete and obviously faulty data are excluded from further evaluation. If a single and less vital parameter is missing, the tree and plot data are excluded only from the detailed evaluation concerning the missing parameter. Because of this screening the total number of trees in some of the detailed analyses is less than the grand total of 83 134 sample trees.

The results of the national surveys should be submitted to PCC-East or PCC-West, respectively, on the appropriate census forms. The tabulated results of the national survey should be accompanied by a written text which should not repeat the information to be drawn from the tables, but should refer to the interpretation of the results with respect to cause-effect relationships.

2.5 Evaluation and presentation of data

The transnational survey results are expressed mainly in terms of the percentages of the tree sample falling into the defoliation or discolouration classes (tables 2.3-1 and 2.3-2). In some cases there is only a distinction being 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. It may be a transient phase of natural variation in crown density, but may also indicate that trees are passing a stage of slight defoliation on their way into classes 2 and higher. This means that a defoliation of up to 25% is considered as "undamaged", class 1 indicating a "waming-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".

Whenever time trends in defoliation are presented in the transnational evaluation, the mean percentages per plot of trees in a certain defoliation class will be considered for individual tree species. These percentages indicate the variation in defoliation between plots. Additionally, when time trends are presented with respect to some environmental variables, only plots will be included which contain at least 10 individuals of the tree species concerned. In this way, only stands are included in which the species represents a major stand component. Furthermore, extreme values for plot percentages, due to the presence of only a few individuals of a particular species, will be avoided.

The transnational defoliation and discolouration data sets are scrutinized for correlations with the additional parameters assessed, i.e. tree species, water availability, humus type, soil type, mean age, altitude and aspect.

In order to allow certain comparisons to be made between results of subsequent years, subsamples have been defined which consist of those sample trees that have been observed over two or more consecutive years. For the period of 1990-1991 this subsample contains 61 395 trees, that will be referred to as Common Sample Trees (CSTs).

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

For those countries, from which suitable data sets of their national survey have been received, the basic results of the national surveys are presented in 10% defoliation classes in order to enhance resolution and thus be able to study changes in defoliation.

3. RESULTS OF THE 1991 SURVEY

3.1 Transnational survey

3.1.1 The sample trees in 1991

The total tree sample of the transnational survey has been greatly enlarged since the first assessment in 1987, when it consisted of 26 389 trees (Table 3.1.1-1). Thus, the participation of 5 non-EC member states from 1990 led to an increase of nearly 48%, from 45 572 trees in 1989 to 67 335 in 1990.

In 1991 a grand total of 83 134 sample trees was assessed on 3 846 plots within the framework of the transnational survey. This is an increase of 15 799 trees, or 23.4%, compared to 1990, which has been caused mainly by the inclusion of Sweden and Finland. A share of 36.7% of this sample accounted for broadleaved trees and a share of 63.3% for coniferous trees. Annex 1-1 documents the spatial distribution of the three groups of species, namely broadleaves, conifers and maquis, over the area surveyed. To each plot the species group with the majority of trees was assigned.

Country	No. of plots					No. of sample trees				
	1987	1988	1989	1990	1991	1987	1988	1989	1990	1991
Belgium	11	33	33	29	29	264	792	791	684	686
Denmark	20	19	19	19	19	480	456	456	449	449
France	75	228	509	514	513	1806	4465	10192	10280	10255
Germany	300	299	298	412	411	8062	7919	7883	10616	10664
Greece		84	104	101	101		1979	2463	2392	2392
Ireland	22	22	22	22	22	535	461	462	458	458
Italy	189	208	206	206	208	5059	5536	5695	5759	5799
Luxemburg	4	4	4	4	4	96	96	96	96	96
Netherlands	14	14	14	14	14	280	280	278	279	280
Portugal	108	154	152	152	151	2274	4621	4569	4563	4587
Spain	398	386	454	460	437	5730	9211	10876	11100	10578
United Kingdom	75	75	76	72	74	1803	1791	1811	1726	1770
EC	1216	1526	1891	2005	1983	26389	37607	45572	48402	48014
Austria				72	79				2132	2244
Czechoslovakia				219	217				5475	5425
Finland					358					3899
Hungary				67	66				1351	1371
Poland				475	476				9496	9520
Sweden					622					12166
Switzerland				45	45				479	495
Total Europe	1216	1526	1891	2883	3846	26389	37607	45572	67335	83134

Table 3.1.1-1: Numbers of plots and sample trees from 1987 to 1991

The number of **species** assessed in 1991 was 111, so that the relative occurrence of the most species was generally low (Annex 1-2). However, the six most frequent species accounted for about two thirds of all trees assessed. These species were *Pinus syl-*

vestris(24.3%), *Picea abies* (24.3%), *Fag us sylvatica* (7.19%), *Pinus pinaster* (4.40%), *Quercus robur* (4.24%) and *Quercus ilex* (3.57%). Although *Pinus sylvestris* and *Picea abies* were the most frequent species assessed in previous years, their share has even increased further in 1991 due to the inclusion of Finland and Sweden in the survey. These two species now account for nearly half of the trees assessed;

The inclusion of Finland and Sweden as an own climatic region, which comprised 19.3% of all sample trees, has also decreased the proportion of the sample trees in the **climatic regions.** As in the previous years, the Sub-atlantic region still comprises the majority of the sample trees with a share of 40.3% of the total tree sample (49.5% in 1990). It is followed by the Mediterranean region with 241% (30.2% in 1990). The Atlantic region comprised 11.8% (14.8% in 1990) and the Mountainous region 4.5% (5.4% in 1990) of the trees.

Mean age has been reported for 85.0% of all trees assessed. This percentage is considerably smaller than in 1990 (97.6%), because from Scandinavia mean age has only been reported for a small fraction of the trees.

Water availability has been assessed for 59.7% of all plots. In 1990, the respective share was 74.8%.

As in 1990, **soil type** has again only been reported by Austria and Germany, so that this parameter was only available for 3.5% of all sample trees.

No assessment results of **easiliy identifiably damage types** have been made available for 5 669 trees, i.e. 6.8% of the total tree sample.

In order to allow the calculation of changes in defoliation and discolouration within the last years despite different databases, a subsample of so called **Common Sample Trees (CSTs)** has been defined which consists of those sample trees which have been observed over two or more consecutive years. For the period of 1990-1991 this subsample contains 61 395 trees or 73.9% of the grand total of trees. This is an increase by 14.0 percent points compared to the previous period, which is due to the participation of non-EC countries since 1990.

Separate comparisons have been made for **long-term observations** on some of the most common tree species in the transnational survey. For these species, a separate subsample has been defined for sample trees observed over the period of 1988-1991. This subsample comprised 16 667 or 20.0% of the grand total. A similar study has been carried out in last year's Report for the period of 1987-1990, however, with only 10 585 trees, because in 1987 the grand total of trees assessed was considerably smaller than in 1988.

No results are being documented in this year's Report regarding **attitude, aspect** and **humus type,** because the analysis of defoliation and discolouration with respect to these parameters has not led to conclusive results in recent years. This does not mean, however, that these parameters should not be assessed any more in the future. On the contrary, these parameters may become of importance for future extended evaluations of trends in particular regions or for particular species.

3.1.2 Defoliation and discolouration

In the 1991 survey, 22.2% 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 is 18.4%. The broadleaves have a higher proportion of trees in defoliation classes 0 and 1 than the conifers and thus appear healthier than the conifers in terms of defoliation. This difference is less pronounced in the EC countries (Table 3.1.2-1).

10.6% of the total transnational tree sample had a **discolouration** of more than 10%. In terms of discolouration, however, conifers appear slightly more healthy than the broadleaves. Again, this difference is less pronounced in EC countries (Table 3.1.2-2).

	Species type	Defoliation							No. trees
		0-10%	>10-25%	0-25%	>25-60%	>60%	dead	>25%	
EC	Broadleaves	55.0	27.4	82.4	15.2	1.9	0.5	17.6	25295
	Conifers	51.6	29.0	80.6	17.4	1.2	0.8	19.4	22719
	All species	53.5	28.1	81.6	16.2	1.6	0.6	18.4	48014
Total Europe	Broadleaves	52.8	28.7	81.5	16.0	L9	0.6	18.5	30532
	Conifers	42.3	33.3	75.6	22.1	1.8	0.5	24.4	52602
	All species	46.2	31.6	77.8	19.9	1.8	0.5	22.2	83134

Table 3.1.2-1: 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	84.9	11.6	2.2	0.8	0.5	15.1	25295
	Conifers	86.9	10.1	1.8	0.4	0.8	13.1	22719
	All species	85.9	10.9	2.0	0.6	0.6	14.1	48014
Total Europe	Broadleaves	85.4	11.2	2.1	0.7	0.6	14.6	30532
	Conifers	91.6	6.5	1.2	0.2	0.5	8.4	52602
	All species	89.4	8.2	1.5	0.4	0.5	10.6	83134

Table 3.1.2-2: Percentages of discolouration for broadleaves, conifers and all species

In total Europe as well as in the EC countries, **defoliation** among the **broadleaved species groups** was least severe for *Quercus ilex* (4.4% in classes 2-4). The highest percentage of damaged trees was found for *Quercus suber* (43.0% in classes 2-4)(Annex 1-3). Of all **coniferous species groups** in total Europe, *Abies sp.* and *Picea sp.* showed the (highest percentages of trees in defoliation classes 2-4 (27.5% and 26.9% respectively), suggesting a generally poorer health condition. The share of damaged trees was lowest for *Larix sp.* (8.2%). In the EC countries also *Picea sp.* and *Abies sp.* showed the highest percentages of trees in classes 2-4 (27.3% and 18.7%, respectively). *Larix sp.* was the least defoliated species group with 8.6% of the trees in defoliation classes 2-4 (Annex 1-3).

Discolouration among the **broadleaved species groups** in total Europe and in the EC countries was most prevalent for *Quercus suber* (41.7% of the trees discoloured, i.e. showing discolouration greater than 10%). *Quercus ilex* showed the lowest percentage of trees discoloured (2.8%) (Annex 1-4). For **coniferous species groups** the variation among the species is small, especially in the European Community. In total Europe *Abies sp.* was the species group with the highest percentage of trees (15.0%) in discolouration classes 1-4. The least discolouration was found in *Picea sp.* and *Larix sp.* with 5.9% and 6.0% of the trees being more than 10% discoloured, respectively. In the EC countries *Pinus sp.* had the largest share of the trees (15.0%) in discolouration classes 1-4, whereas *Larix sp.* performed best with 7.6% of the trees showing discolouration greater than 10% (Annex I-4).

The distribution over the entire survey area of the percentages of damaged trees per plot is shown in Annex 1-5. Annexes 1-6 and 1-7 show maps of the distribution of the plot defoliation and plot discolouration over the entire area. No plot discolouration has been mapped for Scandinavia, as sufficient data sets were not available.

3.1.3 Defoliation and discolouration by climatic region

Each sample plot has been attributed a climate type. The climate type assigned is a function of the geographic location, including altitude, of the plot. In order to avoid excessive splitting of the data set, only five large climatic regions have been distinguished. These have been defined as:

- **Atlantic region**
- **Sub-atlantic region**
- **Mediterranean region**
- **Mountainous region**
- **Scandinavian region**

The **Scandinavian** region comprises Norway, Sweden and Finland and has been included in the transnational survey for the first time due to the participation of Sweden and Finland. The climate on the west coast of Scandinavia is maritime and characterized by high precipitation and mild winters, whereas the inland is continental with cold winters. Consequently, Scandinavia cannot be considered a uniform climatic region as the ones mentioned above, and its inclusion as a climatic region in the present report is only preliminary. Figure 3.1.3-1 shows the distribution of all plots over the climatic regions except Scandinavia.

The Atlantic region comprises a broad belt along the Adantic coast. It starts at the northern border of Portugal, runs across the northern part of Spain and the western part of France and Belgium, and covers all of the Netherlands, Denmark, the United Kingdom and Ireland. The northern part of the Federal Republic of Germany is also included in this region. The climate in this region is generally moist and windy with moderate temperatures in both summer and winter, and with long transitional seasons. In 1991, about 12% of all the sample trees were located within the Atlantic region.

The Sub-atlantic region comprises Luxembourg, Poland, Czechoslovakia, Hungary, the greater part of the Federal Republic of Germany, and parts of Belgium, France, Italy, Switzerland and Austria. The climate in this region generally shows larger differences between summer and winter temperatures, and has less wind as compared to the Atlantic region. In 1991, 40% of all the sample trees were located in this region.

The Mediterranean region comprises areas with rather dry summers and periods of extensive drought. Rainfall is mainly confined to the winter season. This region covers Greece and Portugal, the greater parts of Italy and Spain, and a small part of France. In 1991, about 24% of all the sample trees were located within this region.

The Mountainous region consists of plots that have been excluded from their original climatic region because of their location at high altitudes. In the south of Europe (up to the latitude running along the southern edge of the Alps and through Lyon) plots situated at more than 1 500 m above sea level have been considered Mountainous. North of this latitude, plots situated at more than 1 000 m above sea level have been considered Mountainous. In 1991, only about 4% of the sample trees were assigned to this region.

The mean percentages of trees of the broadleaved and coniferous species in the five defoliation classes are subdivided by climatic region in Table 3.1.3-1 and Figure 3.1.3-1. Considering the total data set, it can be observed from the table that the highest frequency of damaged trees occurred in the Sub-atlantic region (31.7% of all species in classes 2-4), indicating a generally poorer vitality in this region. The lowest percentage of trees with leaf or needle loss greater than 25% was found in the Mountainous region (11.7%). In all climatic regions except the Mediterranean, and in the total data set coniferous species showed more damaged trees than broadleaved species. The results of Table 3.1.3-1 can be further explained by considering the differences between species groups (see for details Annex 1-3). These differences are especially large in the Sub-atlantic region. The large number (11 414) of *Pinus sp.* trees and their relatively high percentage of damaged trees (41.8% in classes 2-4) had a negative influence on the total percentages for conifers and all sample trees in this region.

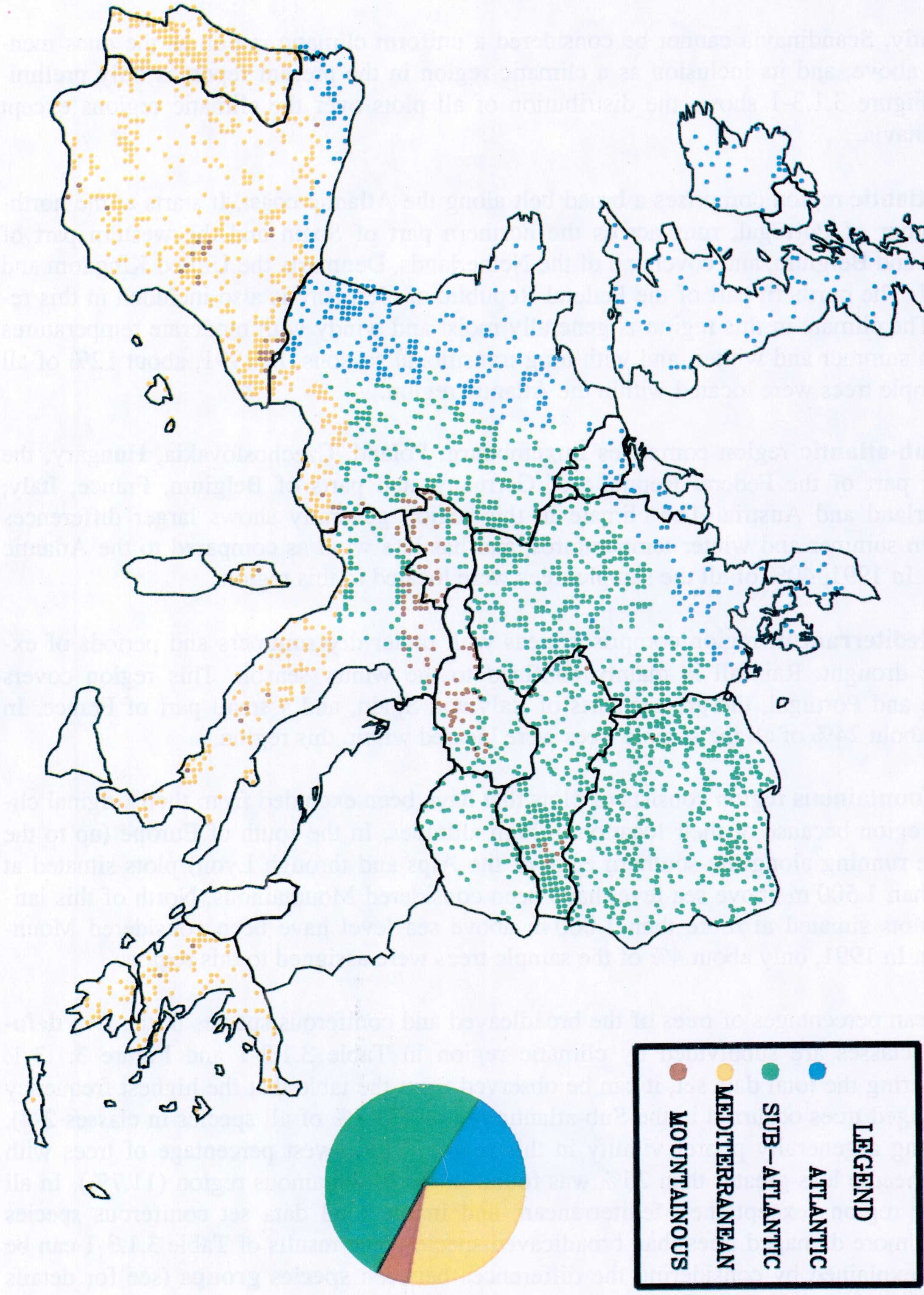


Figure 3.1.3-1: Climatic regions

In the Atlantic region defoliation of coniferous species is relatively strong due to the impact of a number (1 495) of *Picea sp.* trees of which 36.9% were classified as damaged (classes 2-4).

In the Mediterranean region, *Pinus sp.* is the dominant coniferous species group (6 808 trees), showing a relatively low percentage of damaged trees (10.3% in classes 2-4), whereas the broadleaved species are strongly influenced by *Quercus suber* (1 457 trees), with a very high percentage of damaged trees (43.0% in classes 2-4). Thus the situation is the opposite of that in the other regions: the broadleaves show higher defoliation than the conifers.

In the Mountainous region the total percentage of damaged trees for coniferous species is mainly influenced by the relatively low percentage of damaged trees of *Picea sp.* (1 817 trees, 14.1% in classes 2-4).

Climatic region	Defoliation							No. trees	
	0-10%	**>10-25%**	**0-25%**	**>25-60%**	**>60%**	**dead**	**>25%**	**Total Europe**	**EC**
Scandinavian									
Broadleaves	70.8	24.4	95.2	4.6	0.2	0.0	4.8	504	
Conifers	47.7	37.0	84.7	14.0	1.3	0.0	15.3	15561	
All species	48.3	36.6	84.9	13.8	1.3	0.0	15.1	16065	
Atlantic									
Broadleaves	62.7	21.0	83.7	14.2	1.7	0.4	16.3	5105	5105
Conifers	49.3	26.0	75.3	21.8	1.7	1.2	24.7	4755	4755
All species	56.1	23.5	79.6	17.9	1.7	0.8	20.4	9860	9860
Subadantic									
Broadleaves	46.9	32.0	78.9	18.6	2.0	0.5	21.1	12042	7360
Conifers	26.0	36.8	62.8	34.4	2.6	0.2	37.2	21391	8460
All species	33.5	34.8	68.3	29.0	2.4	0.3	31.7	33433	15820
Mountainous									
Broadleaves	71.6	19.0	90.6	8.8	0.3	0.3	9.4	604	553
Conifers	62.1	25.6	87.7	10.3	0.8	1.2	12.3	3107	1716
All species	63.8	24.5	88.3	10.0	0.7	1.0	11.7	3711	2269
Mediterranean									
Broadleaves	52.9	29.2	82.1	15.2	2.0	0.7	17.9	12277	12277
Conifers	64.5	25.3	89.8	8.1	0.9	1.2	10.2	7788	7788
All species	57.3	27.7	85.0	12.5	1.6	0.9	15.0	20065	20065

Table 3.1.3-1: Percentages of defoliation for broadleaves, conifers and all species as well as total tree numbers by climatic region

Like the Mountainous region, the Scandinavian region shows a relatively low percentage (15.1%) of damaged trees because of the high proportion of *Picea sp.* and *Pinus sp.*, 21.5% and 6.4% of which are in classes 2-4, respectively. The broadleaves have an even lower percentage of damaged trees (4.8%), but their number is very small as compared to the conifers.

Table 3.1.3-2 and figure 3.1.3-1 show the discolouration for broadleaves, conifers and total sample trees by climatic region. Detailed data for the EC-member States and the five non-EC countries are given in Annex 1-4. The percentage of not-discoloured trees (class 0) is lowest in the Mediterranean region (83.9%). Of influence is *Quercus suber* which shows only 58.3% of not-discoloured trees in this region (see Annex 1-4). The Scandinavian region shows the highest percentage of not-discoloured trees (96.1%). 94.1% of the *Picea sp.* and 99.6% of the *Pinus sp.* trees are not-discoloured. The percentage of not-discoloured trees in the broadleaves is clearly smaller (87.5%), but this is of practically no influence on the total result, because of the very small number of broadleaved trees in the sample.

Climatic region	Discolouration						No. trees	
	0-10%	**>10-25%**	**>25-60%**	**>60%**	**dead**	**>10%**	**Total Europe**	**EC**
Scandinavian								
Broadleaves	87.5	10.9	1.6	0.0	0.0	12.5	504	
Conifers	96.4	2.9	0.7	0.0	0.0	3.6	15561	
All species	96.1	3.2	0.7	0.0	0.0	3.9	16065	
Atlantic								
Broadleaves	87.1	8.3	3.3	0.9	0.4	12.9	5105	5105
Conifers	84.6	10.9	2.9	0.4	1.2	15.4	4755	4755
All species	85.8	9.6	3.1	0.7	0.8	14.2	9860	9860
Subadantic								
Broadleaves	87.2	9.8	1.9	0.6	0.5	12.8	12042	7360
Conifers	92.2	6.2	1.2	0.2	0.2	7.8	21391	8460
All species	90.3	7.5	1.5	0.4	0.3	9.7	33433	15820
Mountainous								
Broadleaves	88.8	8.3	2.6	0.0	0.3	11.2	604	553
Conifers	90.6	6.9	0.7	0.6	1.2	9.4	3107	1716
All species	90.3	7.2	1.0	0.5	1.0	9.7	3711	2269
Mediterranean								
Broadleaves	82.8	14.1	1.7	0.7	0.7	17.2	12277	12277
Conifers	85.7	11.4	1.3	0.4	1.2	14.3	7788	7788
All species	83.9	13.0	1.6	0.6	0.9	16.1	20065	20065

Table 3.1.3-2: Percentages of discolouration for broadleaves, conifers and all species as well as total tree numbers by climatic region

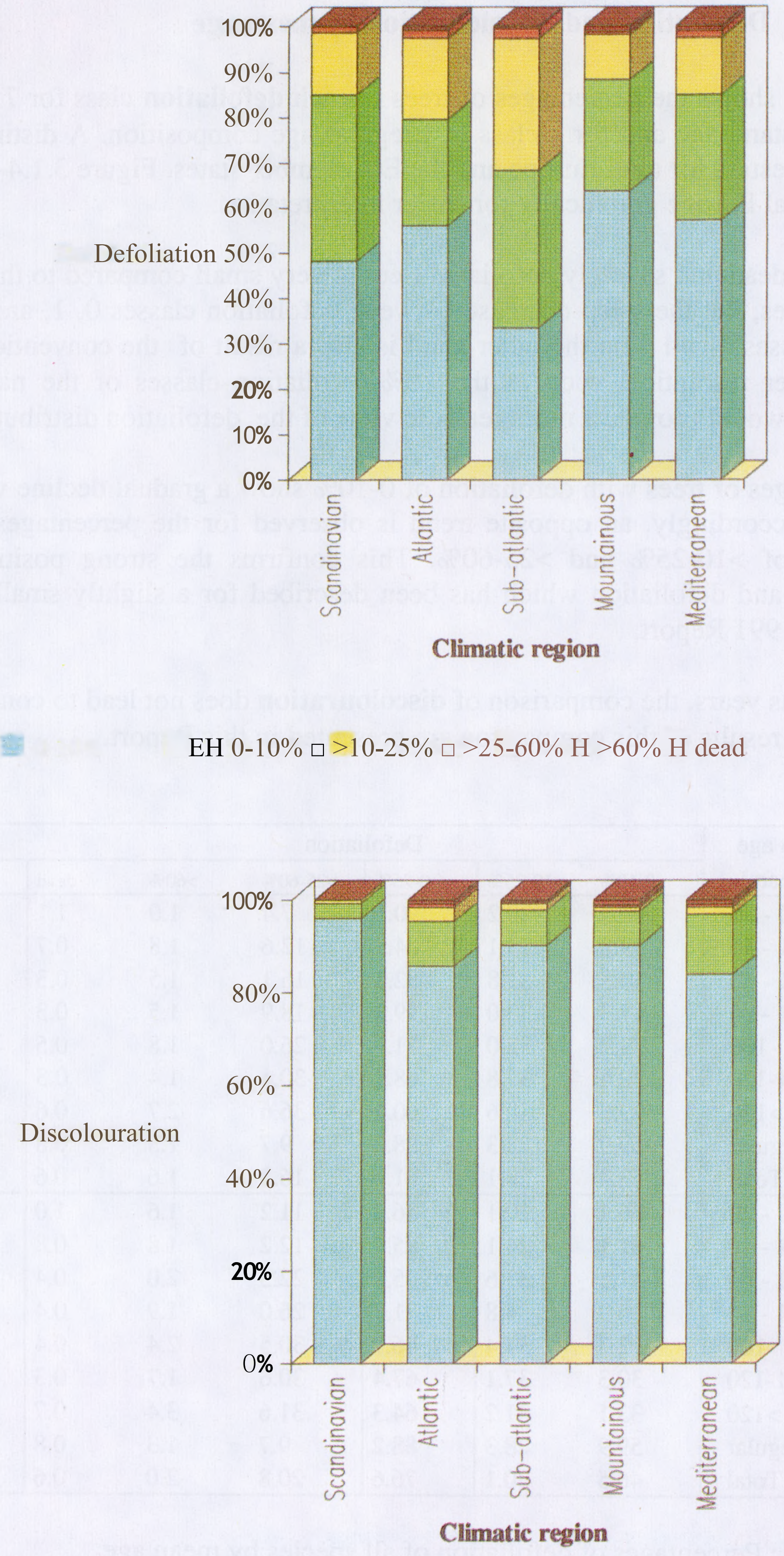


Figure 3.1.3-1: Defoliation and discolouration by climatic region.

3.1.4 Defoliation and discolouration by mean age

Table 3.1.4-1 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. A distinction is made between the results for total Europe and the EC-member states. Figure 3.1.4-1 presents the results for total Europe graphically for easier interpretation.

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 also a result of the conventional classification. A higher resolution, such as the 10%-defoliation classes of the national surveys (Annex II-6) would provide a more realistic view of the defoliation distribution.

The percentages of trees with defoliation of 0-10% show a gradual decline with increasing mean age. Accordingly, an opposite trend is observed for the percentages of trees with defoliations of >10-25% and >25-60%. This confirms the strong positive correlation between age and defoliation which has been described for a slightly smaller data set already in the 1991 Report.

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	70.3	20.2	90.5	7.4	1.0	1.1	9.5	7334
	21-40	59.8	25.1	84.9	12.6	1.8	0.7	15.1	12649
	41-60	50.3	31.8	82.1	16.1	1.5	0.3	17.9	8442
	61-80	47.3	32.0	79.3	18.9	1.5	0.3	20.7	5293
	81-100	39.7	32.0	71.7	26.0	1.8	0.5	28.3	4578
	101-120	30.4	37.8	68.2	30.1	1.4	0.3	31.8	2296
	>120	29.5	30.6	60.1	36.6	2.7	0.6	39.9	2641
	Irregular	59.9	28.3	88.2	9.7	1.3	0.8	11.8	4607
	Total	53.4	28.1	81.5	16.3	1.6	0.6	18.5	47840
Total Europe	0-20	66.1	20.1	86.2	11.2	1.6	1.0	13.8	8768
	21-40	61.1	24.1	85.2	12.2	1.8	0.8	14.8	14204
	41-60	41.5	33.6	75.1	22.5	2.0	0.4	24.9	14395
	61-80	36.9	34.8	71.7	26.0	1.9	0.4	28.3	11753
	81-100	32.3	34.4	66.7	30.5	2.4	0.4	33.3	9086
	101-120	30.3	37.1	67.4	30.6	1.7	0.3	32.6	4051
	>120	33.1	31.2	64.3	31.6	3.4	0.7	35.7	3855
	Irregular	59.9	28.3	88.2	9.7	1.3	0.8	11.8	4607
	Total	46.5	30.1	76.6	20.8	2.0	0.6	23.4	70719

Table 3.1.4-1: Percentages of defoliation of all species by mean age

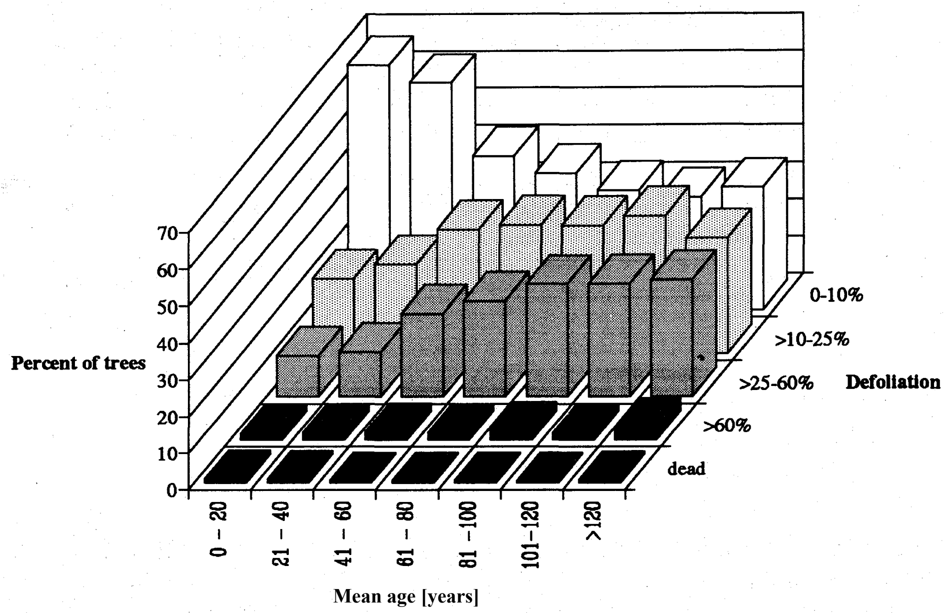


Figure 3.1.4-1: Percentages of trees in defoliation classes for different age classes

3.1.5 Defoliation and discolouration by water availability

Water availability refers to the relative availability of water to the principal species in a plot, and is determined at the date of observation. In 1991 water availability has been reported for 49 609 trees or 59.7% of the total number of trees. Table 3.1.5-1 shows the percentages of trees of different defoliation and discolouration classified according to sites with insufficient, sufficient and excessive water availability.

In 1991 85.3% of the trees have been classified as stocking on sites with sufficient water availability.

The highest proportion of trees with defoliation greater than 25% and of trees with discolouration greater than 10% were found on sites with insufficient water availability. These trees accounted for 13.2% of the total sample. Their share is twice as large in the Mediterranean region as in the Atlantic region.

Water availability	Defoliation		Discolouration		Sample trees	
	0-25%	>25%	0-10%	>10%	Number	%
Insufficient	**80.8**	**19.2**	**96.7**	**3.3**	**6547**	**13.2**
Sufficient	**82.8**	**17.2**	**97.1**	**2.9**	**42309**	**85.3**
Excessive	**82.6**	**17.4**	**98.4**	**1.6**	**753**	**1.5**
Total	**82.8**	**17.5**	**97.0**	**3.0**	**49609**	**100.0**

Table 3.1.5-1: Percentages of trees of different defoliation and discolouration by water availability

3.1.6 Defoliation and discolouration by soil type

Soil type was for the first time included in the survey on a voluntary basis in 1990. In 1991, information on soil type was reported for 112 plots in the survey area representing 3 036 trees (112 more than in 1990) or 3.6% of the total of 83134 trees. For these plots, situated in the Federal Republic of Germany and in Austria, the dominant soil type at the site of the plot was determined by means of the Soil Map of the European Communities (1985) (in accordance with the FAO soil classification system). The percentages of trees in the defoliation and discolouration classes on these soil types are shown in Table 3.1.6-1.

One more soil type than in 1990 has been assessed, namely the Calcaric Lithosols, which occurs in the Mountainous region, often in association with bare rock. The sample trees stocking on this soil type show by far the highest defoliation of the total sample trees, which may be explained by the shallowness of Calcaric Lithosols. This explanation, however, should be taken with great care, because the number of trees represented on this soil type is very low.

As in 1990, on the sandy Arenosols (Cambic and Luvic) the percentage of trees showing high defoliation is relatively high, indicating a generally poorer health condition on these soils. In contrast to last year's results, however, discolouration is now also by far at its highest on the Arenosols. In good agreement with last year's results, the poorly drained Planosols and the peaty Histosols also appear less favourable in tree vitality. The percentages of not-defoliated trees on the infertile Podzols is also higher than on the Cambisols, which commonly provide more favourable site-conditions.

The relatively low percentages of defoliated trees on Gleyic Cambisols and Gleyic Luvisols is surprising, as these are soils with a high groundwater table, limiting the rootable depth. However, defoliation is comparatively high on the Chromic Luvisols.

Given the differences in defoliation between the various soil types, it is strongly recommended that the observation on soil type is included in future surveys.

Soil type	Defoliation			Discolouration		Number of trees
	0-10%	>10-25%	>25%	0-10%	>10%	
Calcaric Lithosols	**27.3**	**36.4**	**36.4**	**100.0**	**0.0**	**11**
Gambie Arenosols	**45.2**	**39.3**	**15.5**	**85.7**	**14.3**	**168**
Luvic Arenosols	**57.5**	**22.5**	**20.0**	**82.5**	**17.5**	**120**
Orthic Rendzinas	**68.6**	**26.2**	**5.2**	**99.1**	**0.9**	**351**
Eutric Cambisols	**78.3**	**19.4**	**2.3**	**99.7**	**0.3**	**351**
Dystric Cambisols	**84.9**	**12.7**	**2.4**	**98.7**	**1.3**	**379**
Gleyic Cambisols	**80.0**	**19.3**	**0.7**	**100.0**	**0.0**	**150**
Calcic Cambisols	**73.4**	**23.3**	**3.3**	**100.0**	**0.0**	**30**
Chromic Luvisols	**58.5**	**35.5**	**6.0**	**96.2**	**3.8**	**234**
Gleyic Luvisols	**83.9**	**15.4**	**0.7**	**98.7**	**1.3**	**149**
Orthic Podzols	**83.3**	**15.6**	**1.1**	**94.4**	**5.6**	**90**
Leptic Podzols	**81.8**	**16.6**	**1.6**	**99.1**	**0.9**	**571**
Humic Podzols	**60.5**	**33.9**	**5.6**	**96.9**	**3.1**	**360**
Eutric Planosols	**54.1**	**41.7**	**4.2**	**100.0**	**0.0**	**24**
Dystric Histosols	**66.6**	**29.2**	**4.2**	**93.7**	**6.3**	**48**
Total	**72.3**	**23.1**	**4.6**	**97.1**	**2.9**	**3036**

Table 3.1.6-1: Percentages of defoliation and discolouration by soil type

3.1.7 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.)
- insects
- fungi
- abiotic agents (wind, drought, snow, etc.)
- direct action of man (poor silvicultural practices, logging)
- fire
- known local or regional pollution
- other types of damage

For these categories, only the presence of such damage is indicated. It is presented in Table 3.1.7-1 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 some countries, 432 plots, representing 5 699 trees, had to be excluded from Table 3.1.7-1.

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
Game/Grazing	22.3	23.7	9.9	17.1	1.8	6.5	1.6	4.0
Insects	21.1	18.2	14.8	14.9	11.3	24.9	17.5	34.9
Fungi	22.2	19.2	17.5	17.8	4.9	17.3	6.6	20.2
Abiotic agents	25.5	28.5	29.9	40.2	4.7	21.6	5.7	19.9
Action of man	20.1	23.0	18.7	23.4	5.0	17.5	6.8	16.4
Fire	23.8	23.8	16.5	16.3	0.8	16.2	1.3	2.7
Known pollution	57.4	57.4	9.8	13.1	0.1	1.2	1.3	0.2
Other	10.8	9.4	7.1	7.5	8.9	24.2	13.4	23.8
Any ident. damage	21.1	19.9	17.1	19.9	29.2	60.0	38.4	61.9
No ident damage	25.0	18.7	8.2	10.7	70.8	40.0	61.6	38.1
Total	23.8	19.1	11.4	14.6	77435	3386	46244	1975

Table 3.1.7-1: Percentages of trees with defoliation >25% and discolouration >10% by identified damage types, based on a total of 3386 plots with 77 435 sample trees

Of the available data set for total Europe, one or more identifiable causes of damage was reported for 29.2% of the trees. These trees were observed in 60.0% of the plots. As in the 1990 survey, the most commonly observed type of damage was caused by insects (11.3% of the trees, 24.9% of the plots). The second most commonly observed type was "other damage", which was unusually high in 1991 as compared to 1990. The reason was an exceptionally high number of trees of this type having been reported by one country.

Damage attributed to action of man, fungi and abiotic agents was observed less frequently, representing respectively 5.0%, 4.9% and 4.7% of the total tree sample. Damage by "known pollution" (i.e. air pollution by nearby emittents) was recorded on only 0.1% of the trees in 0.2% of the plots. Of the total sample, 8.0% of the trees suffered damage from more than one damage type.

Interpretation of the data related to identifiable damage is difficult, since they only represent trees for which the type of damage has been established conclusively. Trees that are affected as well, but do not show any kind of symptom that can be related to a known damage type are not included. Therefore, the data presented here only give a general indication of the effect of the several damage types. Trees may be affected by some type of damage, but this may not be accounted for. The frequency of observations of the damage types is relatively low (in the range of 0.1 to 11.3%). The identification of damage types results in slight differences in terms of defoliation. However, when discolouration is considered, these differences are much more pronounced.

As expected, most of the damage types identified have some negative influence on foliage density and colouration. However, the effect is small for most types of damage. The percentage of **moderately to severely defoliated** or **dead** trees (classes 2,3 and 4) is lowest for trees affected by unspecified **other types of damage.** In these defoliation classes, the effects of the **action of man, insects, fungi, game and grazing, fire,** and **abiotic agents** were clearly more pronounced. The effects of **local or regional pollution** showed up clearer in defoliation in 1991 than in the previous year. This is because one country has reported a relatively large number of trees to have been affected by air pollution.

When regarding all trees with any type of identifiable damage together, the percentage of **moderately to severely defoliated** and **dead** trees is even 3.9 percent points lower as compared to trees with **no damage** identified. In the EC countries, however, 1.2 percent points more trees appear to be damaged (defoliation classes 2, 3 and 4) in the presence of identifiable damage types than when no damage has been identified. As regards discolouration, the share of trees in defoliation classes 2, 3 and 4 showing any identifiable damage is larger than the one without identifiable damage both in total Europe and in EC countries. The difference between any and no damage type identified is considerably higher for the percentages of discoloured trees than for that of defoliated trees. This difference is 8.9 percent points for total Europe and 9.2 percent points for the EC countries.

The most pronounced negative effect in terms of discolouration is observed for trees affected by abiotic agents with 29.9% of the trees in discolouration classes 1-4.

3.1.8 Changes in defoliation and discolouration from 1990-1991

3.1.8.1 Comparison of the total tree samples and the Common Sample Trees

Any comparison of the total tree samples of 1990 and 1991 will produce biased results since the 1991 survey includes an increased number of observations due to the inclusion of two more non-EC Countries. Furthermore, some of the plots surveyed in 1990 have not been resurveyed in 1991. In order to be able to compare the results of 1990 and 1991, a subsample is defined containing all trees that are common to both surveys: the **Common Sample Trees (CSTs).** This common sample consists of 61 395 trees, representing 91% of the total tree sample of 1990 and 74% of the total tree sample of 1991.

Table 3.1.8.1-1 shows the percentages of trees in the different defoliation and discolouration classes for the **total tree samples** in 1990 and 1991, and the percentages for the trees common to the 1990 and 1991 surveys **(CSTs).**

In 1990, the total tree sample had already been enlarged within the European Community (mainly the inclusion of the former GDR) and due to the participation of Austria, Czechoslovakia, Hungary, Poland and Switzerland. In 1991 the participation of Sweden and Finland caused another increase of the total tree sample by 23.5%.

The percentage of not-defoliated trees decreased by 4.6 percent points within the total tree sample, and by 4.4 percent points among the CSTs. This indicates that the slight deterioration of the vitality of the total tree sample is not merely an artefact caused by the inclusion of a higher number of less vital trees in the course of the extension of the grid network. This is supported by the maps in Annexes 1-5, 1-8 and 1-9. Annex 1-5 illustrates that no unusually high shares of damaged trees were included in the survey with the participation of Scandinavia. Annexes 1-8 and 1-9 indicate that the number of plots showing a deterioration of vitality surpasses that of plots with improved vitality. This is in contrast to the situation in 1990, when the percentage of damaged trees within the total tree sample increased notably because of the extension of the grid network over such countries reporting severely damaged forests.

Similar to the 1990 results, the increase of not-discoloured trees in the total tree sample is slightly higher than in the Common Sample. This implies that the extension of the grid has caused a relative increase of the percentage of not-discoloured trees. This increase is partly due to the slight improvement among the Common Sample Trees.

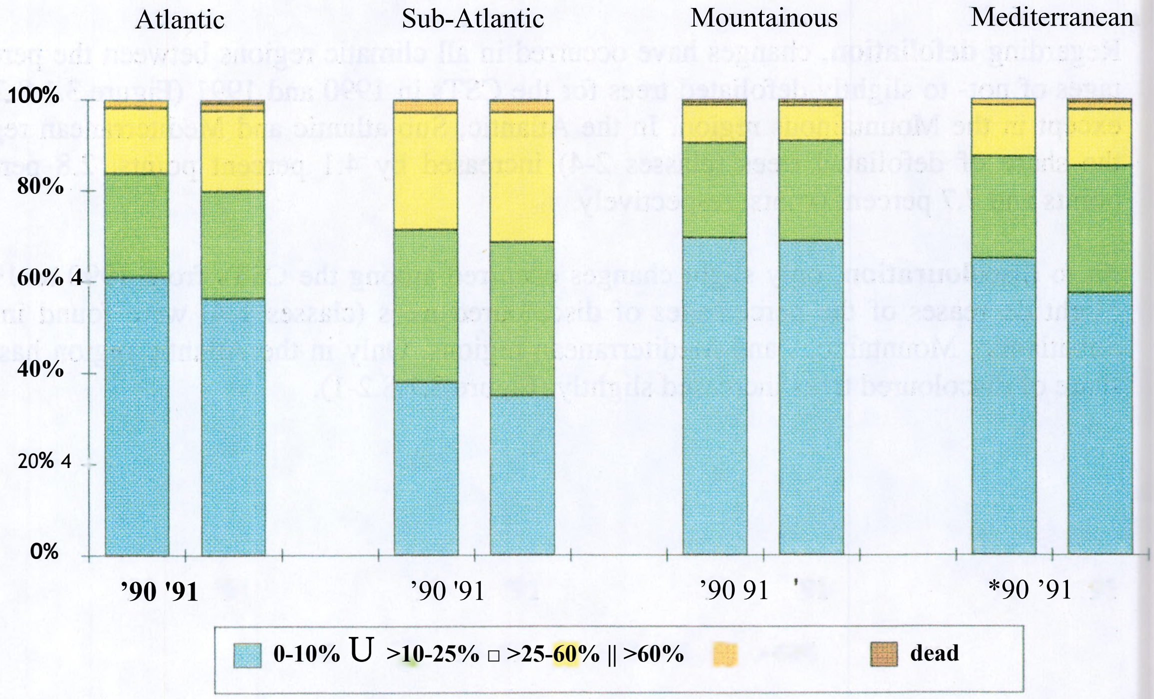
	Total tree sample		Common Sample Trees	
	1990	1991	1990	1991
Defoliation				
0-10%	**50.8**	**46.2**	**51.6**	**47.2**
>10-25%	**28.4**	**31.6**	**27.6**	**29.4**
>25-60%	**18.1**	**19.9**	**18.6**	**20.8**
>60%	**2.1**	**1.8**	**2.0**	**2.0**
dead	**0.6**	**0.5**	**0.2**	**0.6**
Discolouration				
0-10%	**86.3**	**89.4**	**86.1**	**87.2**
>10-25%	**10.1**	**8.2**	**10.4**	**9.9**
>25-60%	**2.5**	**1.5**	**2.7**	**1.8**
>60%	**0.6**	**0.4**	**0.6**	**0.5**
dead	**0.5**	**0.5**	**0.2**	**0.6**
No. of trees	67335	83134	61395	61395

Table 3.1.8.1-1: Percentages of the total tree sample and the Common Sample Trees in different defoliation and discolouration classes in 1990 and 1991

3.1.8.2 Changes in defoliation and discolouration by climatic region

Regarding defoliation, changes have occurred in all climatic regions between the percentages of not- to slightly defoliated trees for the CSTs in 1990 and 1991 (Figure 3.1.8.2-1), except in the Mountainous region. In the Atlantic, Sub-atlantic and Mediterranean region the share of defoliated trees (classes 2-4) increased by 4.1 percent points, 2.8 percent points and 7.7 percent points, respectively.

As to discolouration, only slight changes occurred among the CSTs from 1990 to 1991. Slight decreases of the percentages of discoloured trees (classes 1-4) were found in the Subatlantic, Mountainous and Mediterranean regions. Only in the Atlantic region has the share of discoloured trees increased slightly (Figure 3.1.8.2-1).



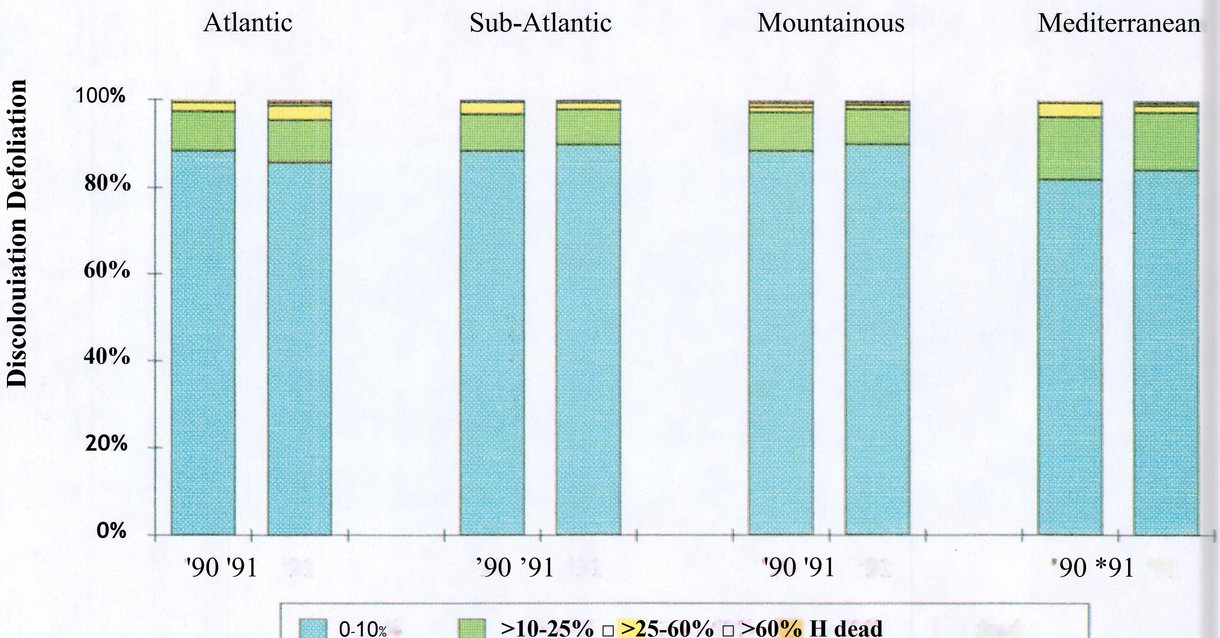


Figure 3.1.8.2-1: Percentages of defoliation and discolouration of the Common Sample Trees in 1990 and 1991 for each of 4 climatic regions

3.1.8.3 Changes in defoliation and discolouration by species group

The differences in defoliation and discolouration between the CSTs in 1990 and 1991 are specified according to species groups in Table 3.1.8.3-1.

Defoliation increased in nearly all species groups. In the broadleaved CSTs the proportion of trees showing a defoliation greater than 25% rose by 1.7 percent points from 16.6% to 18.3%. In the coniferous CSTs the respective increase was larger, namely from 24.3% to 27.7%, i.e. 3.4 percent points.

Among the **broadleaved** CSTs, the most prominent change is the increase of the percentage of *Eucalypt sp.* trees with a defoliation greater than 25%. Though this percentage by itself is comparatively small, its increase from 1.9% to 7.5% means that in 1991 there were nearly 4 times as many trees in defoliation classes 2-4 than in 1990. As the number of *Eucalypt sp.* trees (978) in the Common Sample is small, this dramatic deterioration is not of great influence for the vitality change in the total broadleaves.

Also the percentage of *Quercus ilex* trees with a defoliation greater than 25% increased greatly (from 3.0% to 4.3%) on a low level.

The severe deterioration of *Quercus suber* observed in 1990 did not continue in 1991, but remained on a high level with 42.8% of the trees in classes 2, 3 and 4.

The above mentioned species are typical for the Mediterranean region, and were subject to rapid changes in vitality, partly also including improvements. These rapid changes, especially if only small percentages of the trees are affected, should be interpreted in connection with typical detrimental events in the Mediterranean region, such as drought and fire. This development is different from the continued deterioration of the deciduous *Quercus sp.*. Nearly 9 000 deciduous *Quercus sp.* trees represent the largest share of the CSTs. The percentage of CSTs of *Quercus sp.* in classes 2, 3 and 4 has risen from 14.8% in 1990 to 19.1% in 1991. Though this is an increase of only 4.3 percent points, it corresponds to nearly 30% more trees in classes 2-4 in 1991 than in 1990.

As regards the **coniferous CSTs,** the percentage of trees in defoliation classes 2-4 of more than 20 000 *Pinus sp.* trees increased from 23.0% to 28.0%, which represents 21% more trees in these classes in 1991 than in 1990. The vitality of *Picea sp.* has slightly deteriorated, whereas that of *Abies sp.* has slightly improved. A considerable improvement can be noted in *Larix sp.* with a decrease of trees in classes 2-4 from 12.0% to 7.2%. The other conifers show a notable increase from 10.5% to 13.3% of trees in classes 2-4.

As to **discolouration,** some species groups improved over the period 1990-1991, whereas other species groups deteriorated. However, there was an overall lower discolouration in 1991 than in 1990 in the broadleaves, whereas practically no change occurred on the average in the conifers.

Among the **broadleaved CSTs** the considerable improvement of *Eucalyptus sp.* observed j in 1990 was reversed again. From 1990 to 1991 the percentage of trees of defoliation (greater than 10% increased from 4.1% to 6.3%. On the other hand, the discolouration of *Quercus suber* improved notably, namely from 49.3% to 41.6% of trees in classes 1-4. Also the other broadleaves showed an improvement.

In the **coniferous CSTs** *Abies sp.* showed a considerable improvement from 23.6% to 15.6% in discolouration classes 1-4. *Picea sp.* had a larger discolouration than in 1990, whereas the discolouration of *Larix sp.* and *Pinus sp.* remained unchanged. The unchanged discolouration of *Pinus sp.* contributed greatly to the stability of the result for the total conifers between 1990 and 1991 because of the great number of Pine trees (more than 20 000). The other conifers showed a marked increase of discolouration. The improvement of *Abies sp.* did not affect the result for the total conifers because of the small number of trees.

Species Group	Defoliation						Discolouration		No. of trees
	0-10%		>10-25%		>25%		>10%		
	1990	1991	1990	1991	1990	1991	1990	1991	
Castanea sativa	69.6	65.8	17.6	19.6	12.8	14.6	18.0	16.4	1244
Eucalyptus sp.	92.3	84.1	5.8	8.4	1.9	7.5	4.1	6.3	978
Fagus sp.	52.6	53.3	30.6	30.1	16.8	16.6	13.3	12.5	5548
Quercus (dec.) sp.	58.1	50.4	27.1	30.5	14.8	19.1	14.5	12.3	8915
Quercus ilex	75.3	59.0	21.7	36.7	3.0	4.3	2.0	2.6	2930
Quercus suber	39.0	28.1	18.9	29.1	42.1	42.8	49.3	41.6	1425
Other broadleaves	54.2	53.4	24.2	24.8	21.6	21.8	25.9	20.6	7408
Total broadleaves	58.5	53.4	24.9	28.3	16.6	18.3	17.5	14.9	28448
Abies sp.	44.3	48.8	28.1	25.0	27.6	26.2	23.6	15.6	1614
Larix sp.	66.5	70.7	21.5	22.1	12.0	7.2	7.0	7.0	725
Picea sp.	44.2	41.4	27.0	27.9	28.8	30.7	4.2	6.4	9325
Pinus sp.	44.7	39.2	32.3	32.8	23.0	28.0	13.1	13.0	20399
Other conifers	74.3	65.7	15.2	21.0	10.5	13.3	4.8	9.4	884
Total conifers	45.8	41.9	29.9	30.4	24.3	27.7	10.7	10.9	32947
Total	51.6	47.2	27.6	29.4	20.8	23.4	13.9	12.8	61395

Table 3.1.8.3-1: Percentages of the Common Sample Trees in different defoliation and discolouration classes in 1990 and 1991 by species group

3.1.9 Changes in defoliation and discolouration since 1988

Similar to the Common Sample Trees (CSTs) of 1990 and 1991 (Chapter 3.1.8) a separate subsample of trees common to the years 1988 - 1991 was defined in order to study the trends in vitality over a longer period. In the following chapters 3.1.9.1 - 3.1.9.13 the trends in defoliation and discolouration are described for the 13 species most frequent in this subsample. The ranking of species in this particular survey of changes is based on the number of sample trees common to the years 1988 to 1991 (Table 3.1.9-1).

The survey was carried out for the individual climatic regions as well as separately for the Total Community. The changes within a particular climatic region were only considered when information was available for a species from at least 20 different plots. The number of these common trees is not large enough in all the climatic regions for a meaningful interpretation to be made. Therefore, the reader is advised to consult the relevant figures and also the tables in Annexes I-10 and 1-11, showing the number of plots and sample trees, before drawing any conclusions.

As regards defoliation, special emphasis is put on the abundance of trees having a defoliation of more than 25%, which is then called “notable" defoliation.

Species	Atlantic	Sub-atlantic	Moun-tainous	Mediterra-nean	Total
Fagus sylvatica	438	1330	263	493	2524
Pinus sylvestris	996	561	271	688	2516
Picea abies	599	1527	339		2465
Pinus pinaster	231		24	1919	2174
Quercus ilex				1808	1808
Pinus halepensis			-	1402	1402
Quercus suber				1242	1242
Pinus nigra	20	54	89	955	1118
Quercus robur	684	318		105	1107
Picea sitchensis	655				655
Quercus petraea		466		81	547
Abies alba		332	46	39	417
Larix decidua		133	235		368

Figure 3.1.9-1: Numbers of trees from plots common to the surveys from 1988 to 1991, by species and climatic region

3.1.9.1 Fagus sylvatica (Common beech)

As already indicated in the previous report, the health of *Fagus sylvatica* has constantly declined over the entire Community since 1988. Although the increase of notably defoliated trees (classes 2-4) is only slight with less than 1%, the overall level has now reached 18.2% against 14.2% in 1988 (Figure 3.1.9.1-1). Slight and moderate discolouration affects 8.0% of trees (Figure 3.1.9.1-2).

In the Atlantic region deterioration, as in the previous year, is strong with an increase of 4.7 percent points from 38.6% in 1990 to 43.3% in 1991, 5.8% of trees are slightly discoloured, and 2.1% moderately discoloured.

Fagus sylvatica is most widely spread in the Subatlantic region where, in contrast to the other regions, a slight recovery in defoliation (classes 2-4) from 17.4% in 1990 to 15.0% in 1991 has been observed. Also moderate discolouration (11-25% of foliage affected) receded in this region from 1.3% to 0.6%.

There are not too many beech trees in the Mountainous region but the trees sampled showed a notable increase in defoliation by 8.0 percent points from 2.3% to 10.3%. At the same time slight discolouration decreased from 21.3% to 14.4%, and moderate discolouration remained almost stable, with an increase from 1.1% to 1.5%.

In conclusion it must be stated that for the common trees the health of beech shows a continued slight downward trend in defoliation. Only in its climatic optimum has a slight recovery been observed. Discolouration is at a low level and generally stable.

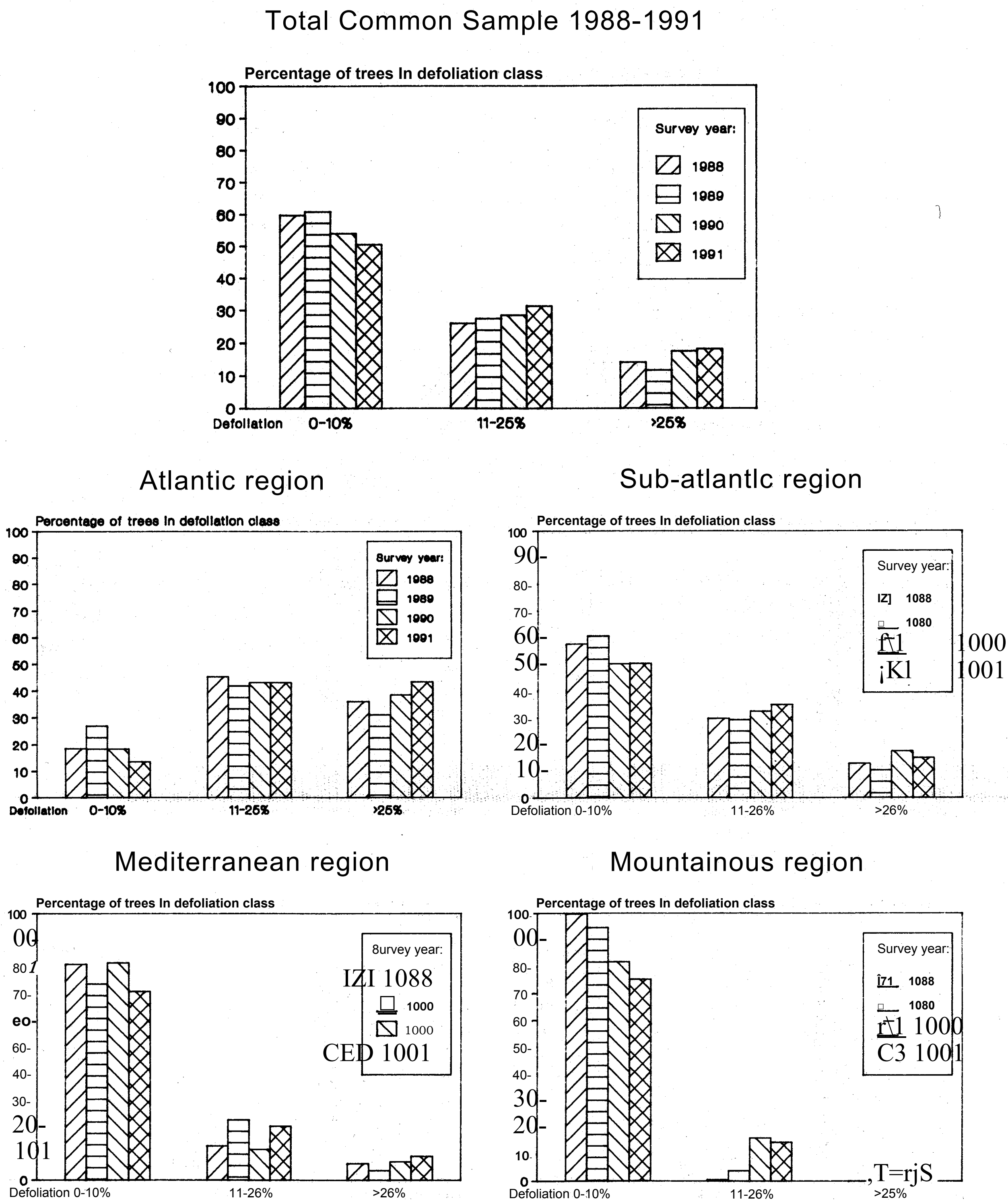


Figure 3.1.9.1-1: Defoliation of *Fagus sylvatica* from 1988-1991

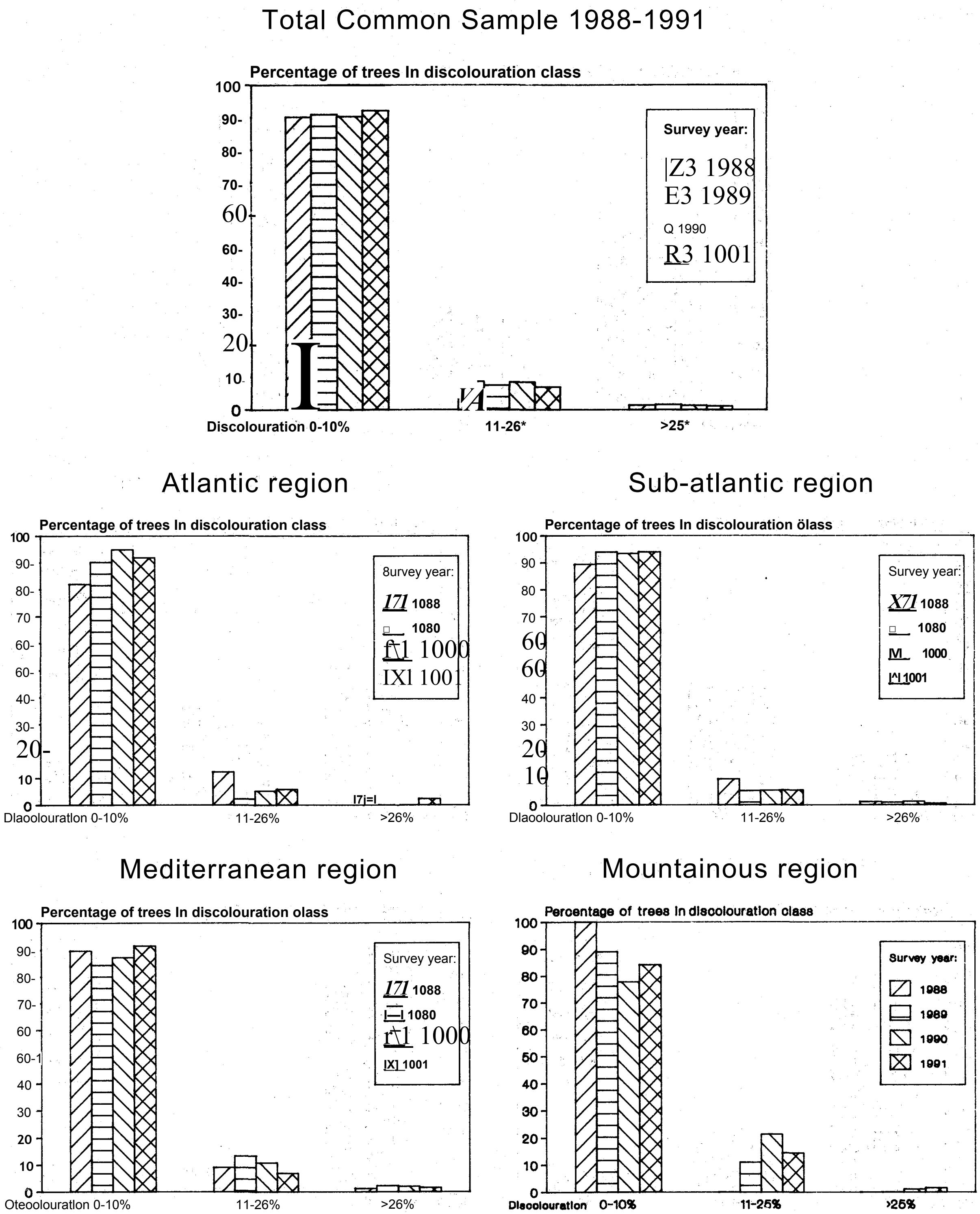


Figure 3.1.9.1-2: Discolouration of *Fagus sylvatica* from 1988-1991

3.1.9.2 Pinus sylvestris (Scots pine)

As for beech, *Pinus sylvestris* is found in all climatic regions. For the entire Community the slight downward trend which started in 1989 continued, with 16.9% of notably defoliated trees (classes 2-4), which is 3.5 percent points more than in 1990 (Figure 3.1.9.2-1). Discolouration increased slightly, with 2 percent points of slightly discoloured trees entering the class of moderately affected trees (Figure 3.1.9.2-2).

Scots pine is the most common species in the Atlantic region. Notable defoliation (classes 2-4) increased by 5 percent points to 24.5%. Discolouration is at a low level, at 3.7% and 4.0%, respectively, with slightly and moderately discoloured trees.

In the Sub-atlantic region defoliation remained stable, with only a 0.4 percent points decrease to 17.6% in classes 2-4. The same holds for discolouration with a decrease from 6.4 percent points to 5.5% of moderately discoloured trees. Slight discolouration remained at the 18% level.

In the Mountainous region defoliation increased by 4.8 percent points from 7.4% to 12.2% in classes 2-4, while discolouration remained practically unchanged with 7% of trees being moderately affected.

The common trees in the Mediterranean region showed a slight increase of 3.4 percent points of notably defoliated trees, the lowest level for Scots pine anywhere. Equally, discolouration is low with 5.4% of slightly and 3.6% of moderately discoloured trees, an increase of about 3 percent points in each class over 1990 results.

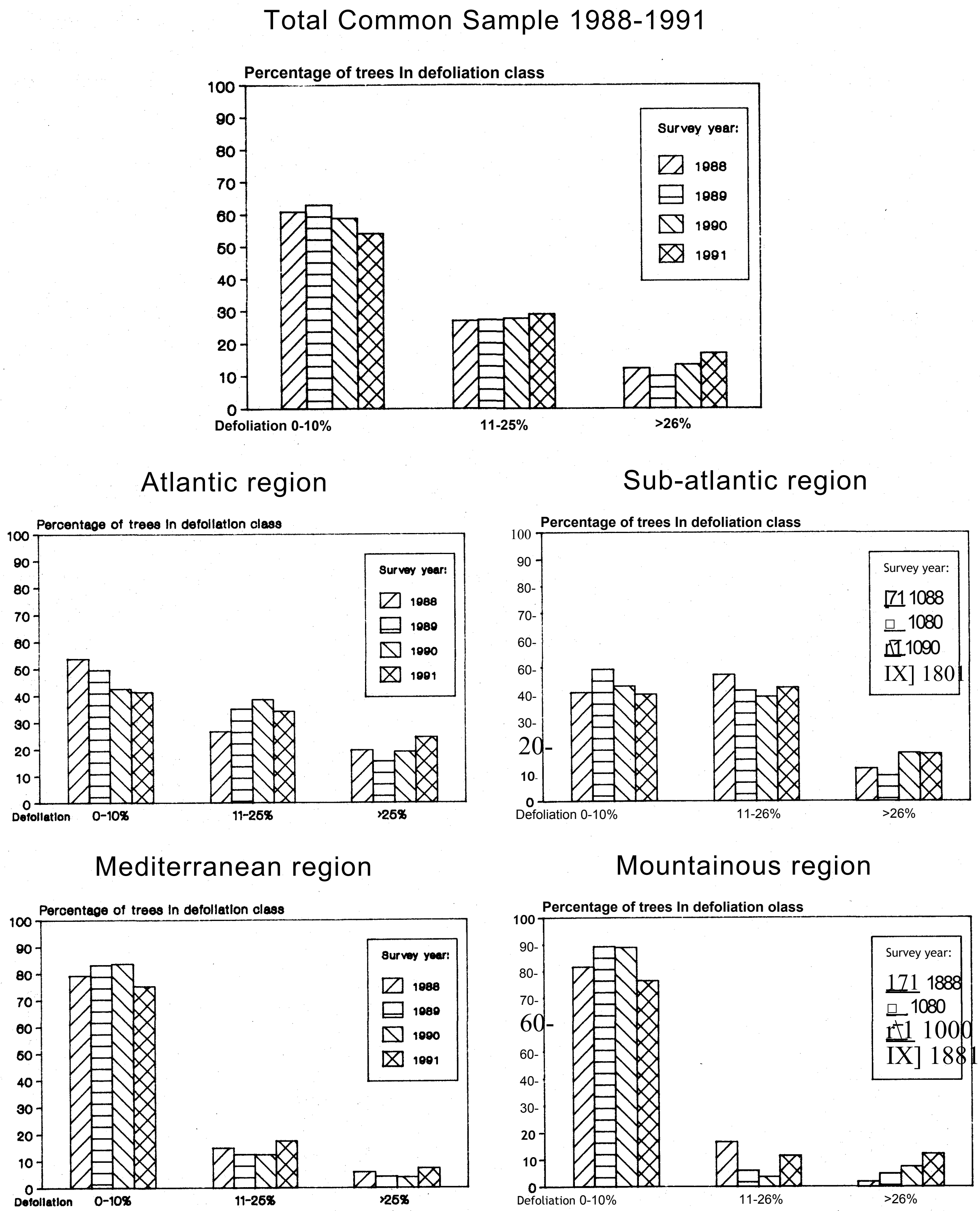


Figure 3.1.9.2-1: Defoliation of *Pinus sylvestris* from 1988-1991

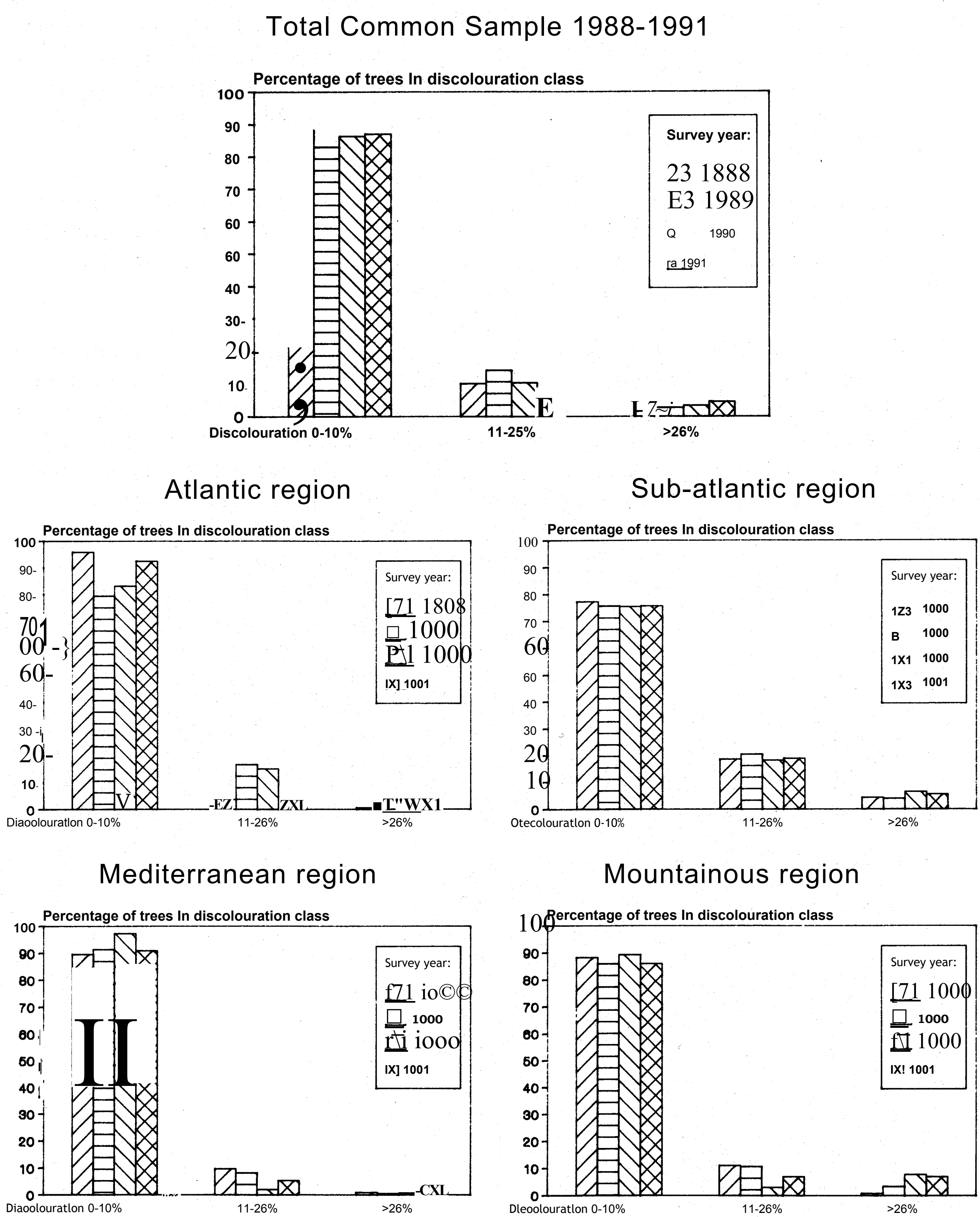


Figure 3.1.9.2-2: Discolouration of *Pinus sylvestris* from 1988-1991

3.1.9.3 Picea abies (Norway spruce)

Picea abies is the leading coniferous species in the Sub-atlantic and Mountainous regions, and it is second to *Picea sitchensis* in the Atlantic region. Over the entire Community notable defoliation increased slightly by 0.6 percent points to 17.2% in 1991 (Figure 3.1.9.3-1). Discolouration changed by the same order of magnitude to 3.2% of moderately discoloured trees; slighdy discoloured were 8.4% of common trees, an increase of 3.8 percent points over 1990 (Figure 3.1.9.3-2).

In the Atlantic region the level of notable defoliation is highest with 34.1% of common trees in classes 2-4, an increase of 5.1 percent points over 1990. Discolouration increased slighdy from 4.6% to 5.1% and from 2.5% to 4.1% for slight and moderate discolouration, respectively; altogether discolouration remained at a low level.

The Sub-adantic and the Mountainous regions in general offer the best growth conditions as reflected in the level of defoliation of 12.3% and 9.1%, respectively, of trees with over 25% of needle loss. In both regions defoliation decreased slightly by 0.8 and 1.5 percent points, respectively. Slight discolouration increased by 5.4 percent points in the Sub-atlantic region, whilst it remained stable, down from 9.7% to 9.2%, in the Mountainous region. Moderate discolouration remained stable at the 2.7% - 2.9% level in both regions.

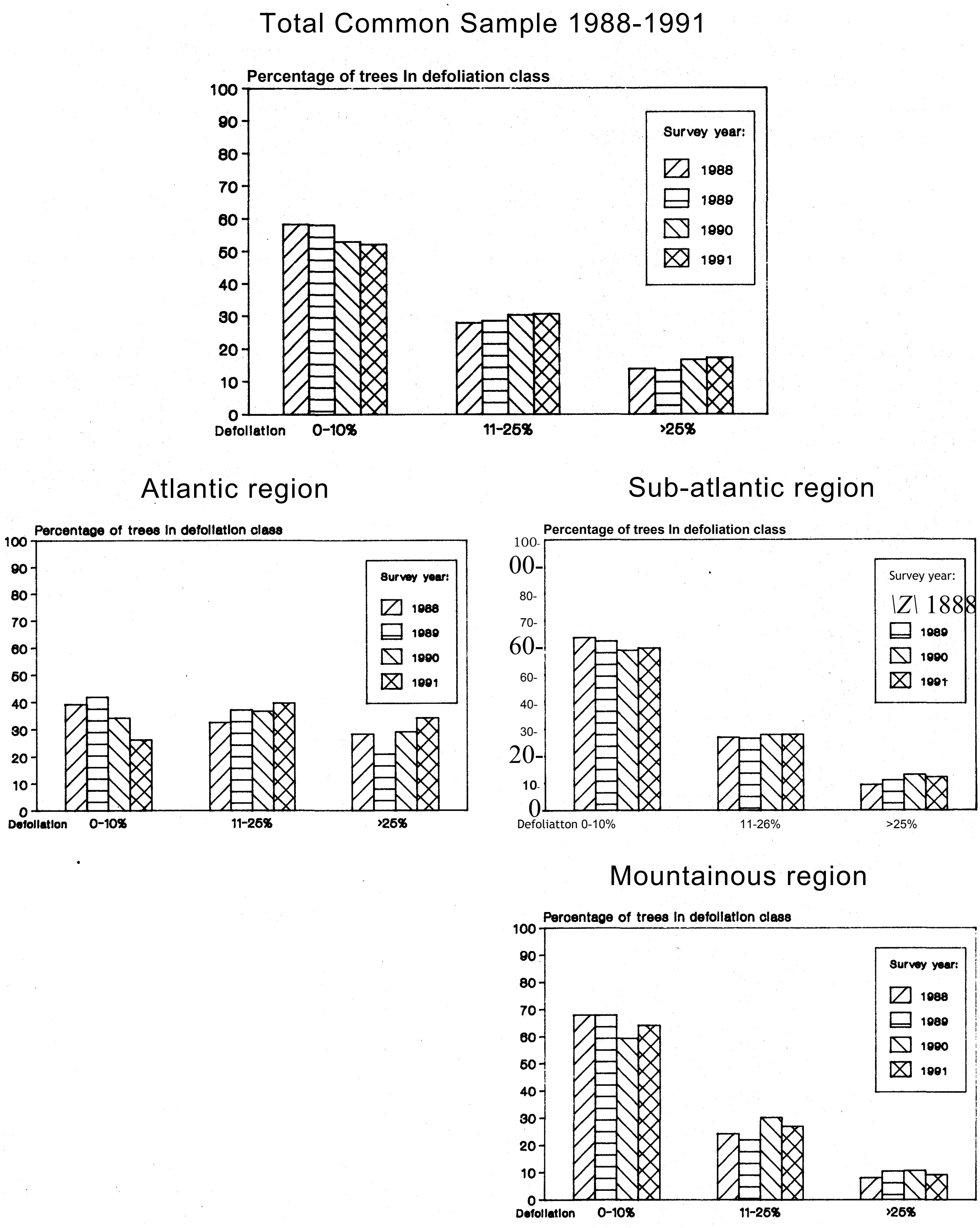


Figure 3.1.9.3-1: Defoliation of *Picea abies* from 1988-1991

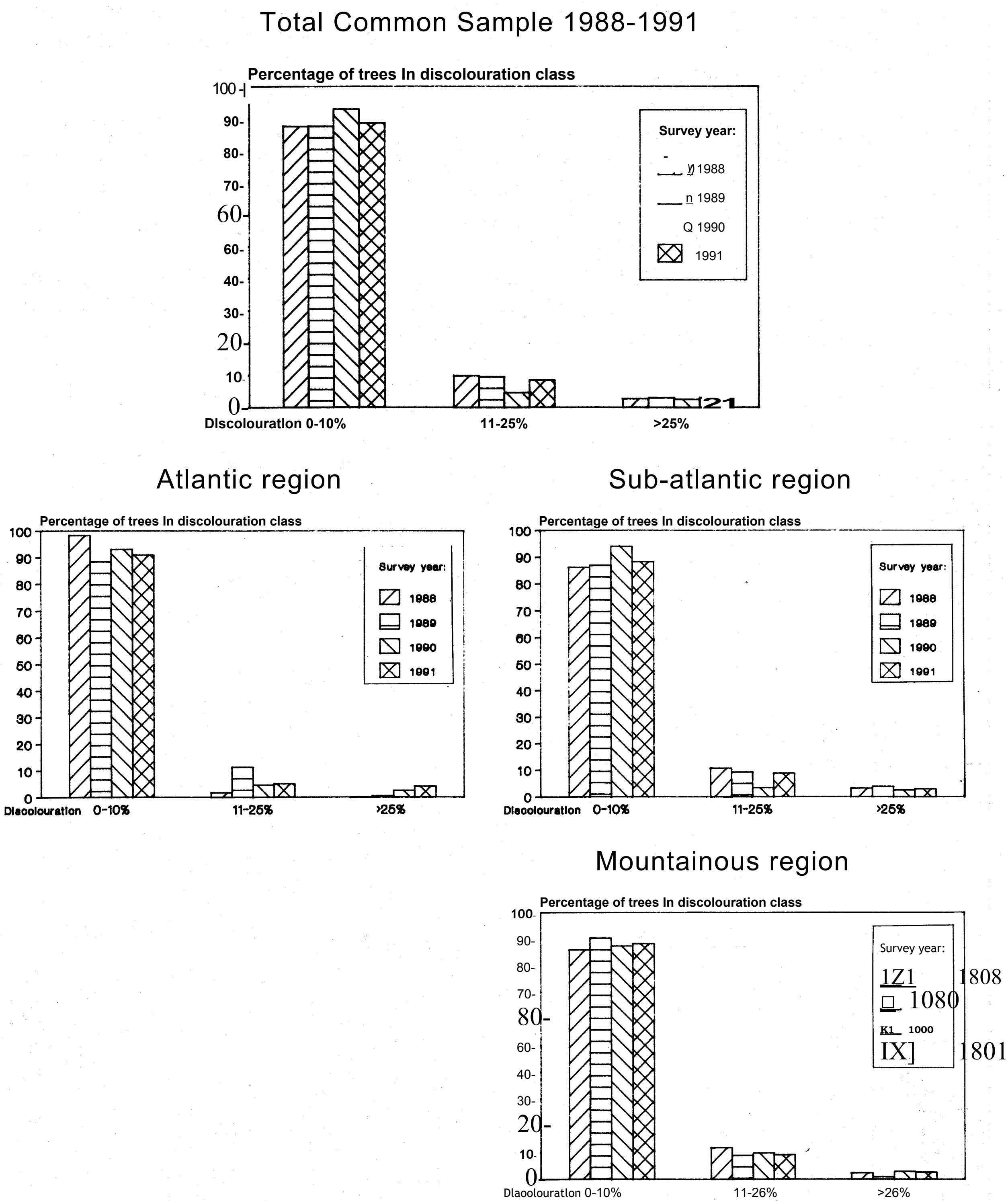


Figure 3.1.9.3-2: Discolouration of *Picea abies* from 1988-1991

3.1.9.4 Pinus pinaster (Maritime pine)

Pinus pinaster is the typical Mediterranean pine for dry and poor sites. 90% of the common trees are recorded in this region, with the remaining 10% in the Atlantic region. Hence, there is practically no difference between the situation for the entire Community and the Mediterranean region.

In the Adantic region the recovery observed from 1989 to 1990 did not last. In 1991 there were again 10.0% of notably defoliated trees (11.7% in 1989, 0.4% in 1990). On the other hand, the overall situation in the Mediterranean region was stable with a slight recovery from 15.6% to 14.9% in classes 2-4 in 1991 (Figure 3.1.9.4-1).

Moderate discolouration increased in the Adantic region from 0% to 7.8%, whereas in the Mediterranean region there was a slight decrease from 7.3% to 5.6%, and 22.5% were classified as slightly discoloured (Figure 3.1.9.4-2).

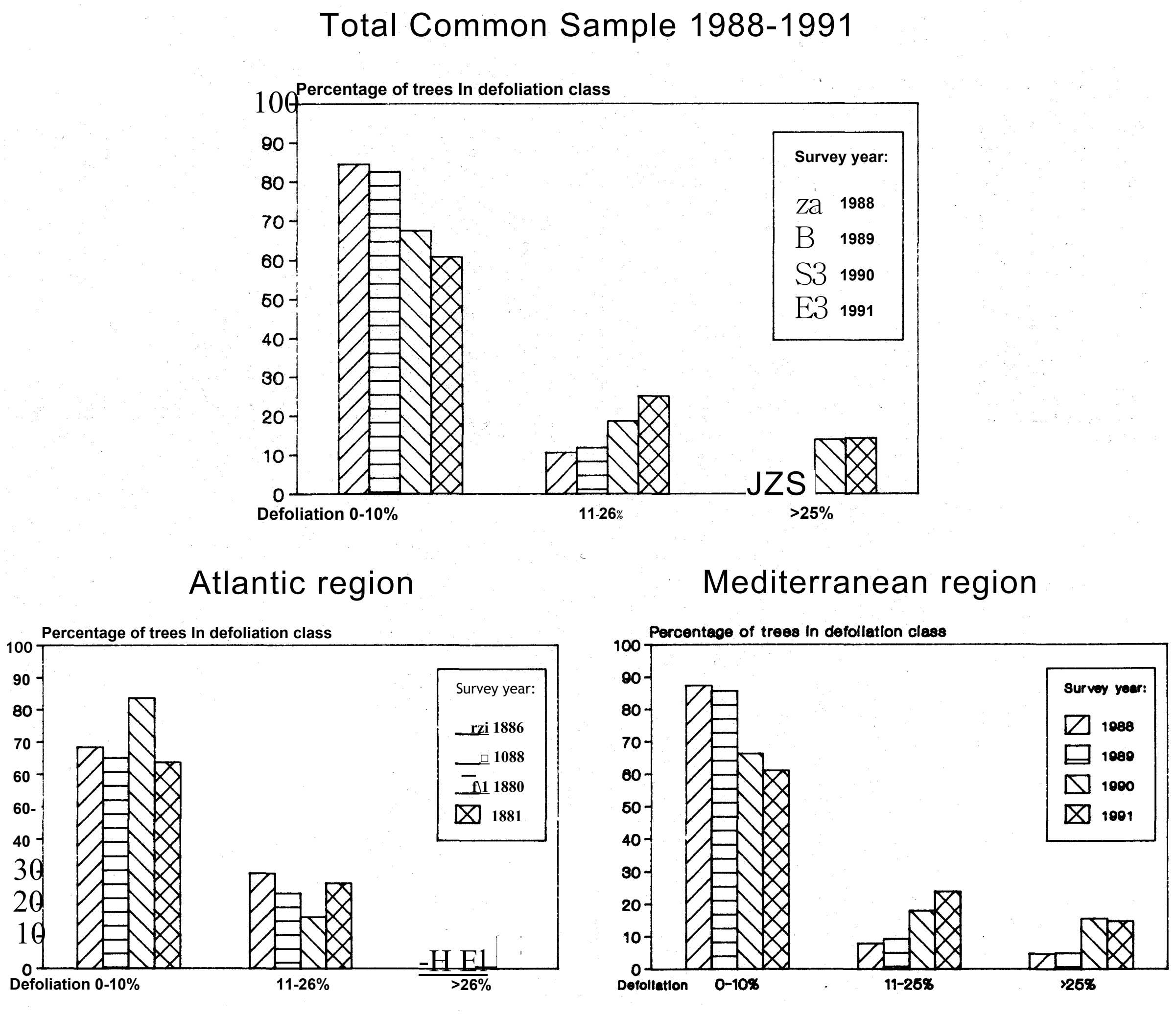


Figure 3.1.9.4-1: Defoliation of *Pinus pinaster* from 1988-1991

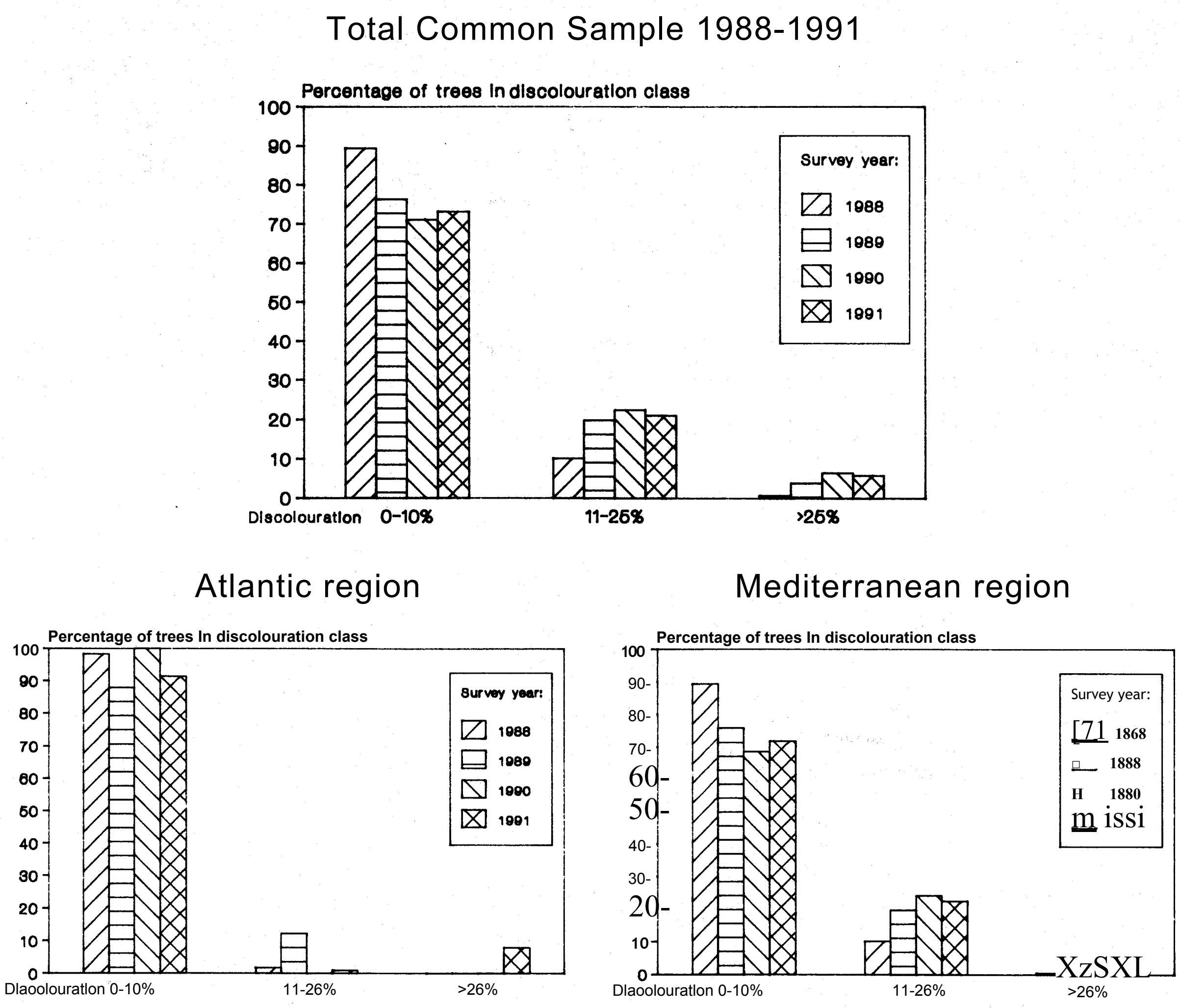


Figure 3.1.9.4-2: Discolouration of *Pinus pinaster* from 1988-1991

3.1.9.5 Quercus ilex (Holm oak)

Quercus ilex is the most widely distributed evergreen oak of the Mediterranean region. Common trees were exclusively assessed in the Mediterranean region. Notable defoliation (>25% of leaf loss) has oscillated around the 4% line, 5.2% in 1988, 3.3% in 1990, 4.0% in 1991 (Figure 3.1.9.5-1). There was, however, a considerable leap of 18 percent points from 19.6% to 37.6% of slightly defoliated trees from 1990 to 1991. Discolouration was at a very low level with 1.5% of slightly discoloured trees, and no trees were found in class 2 or higher (Figure 3.1.9.5-2).

Total Common Sample 1988-1991

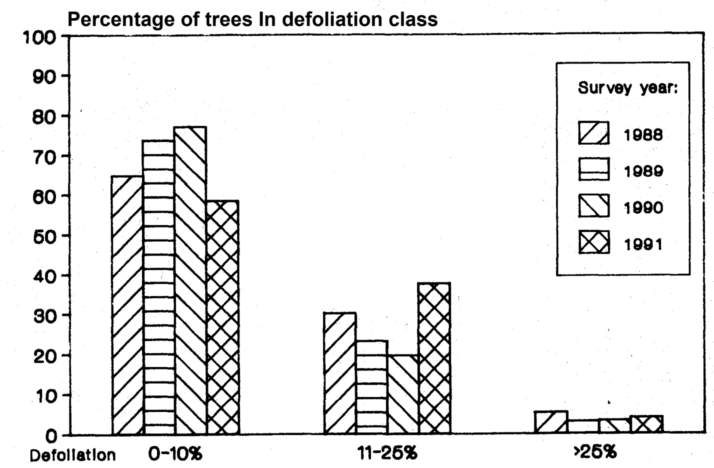


Figure 3.1.9.5-1: Defoliation of *Quercus ilex* from 1988-1991

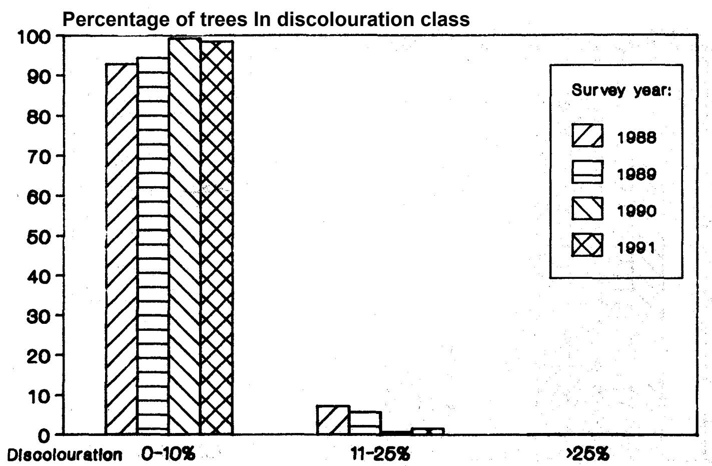


Figure 3.1.9.5-2: Discolouration of *Quercus ilex* from 1988-1991

3.1.9.6 Pinus halepensis (Aleppo pine)

Where it gets hot and dry in the Mediterranean region *Pinus halepensis* still thrives. Common trees were assessed exclusively in the Mediterranean region. The 3.1% level of notable defoliation (classes 2-4) is nearly the same as for Maritime pine (4%). The situation has been stable for the last 4years (Figure 3.1.9.6-1). Discolouration is at a low level, 7.6% of common trees being slightly discoloured, and only 0.7% moderately discoloured (Figure 3.1.9.6-2).

Total Common Sample 1988-1991

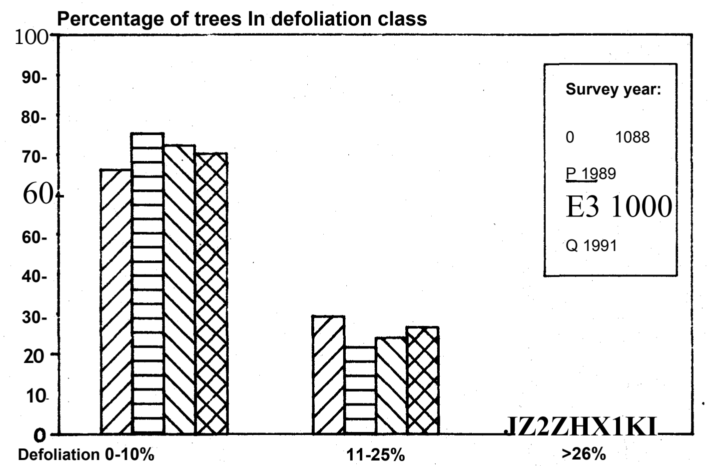


Figure 3.1.9.6-1: Defoliation of *Pinus halepensis* from 1988-1991

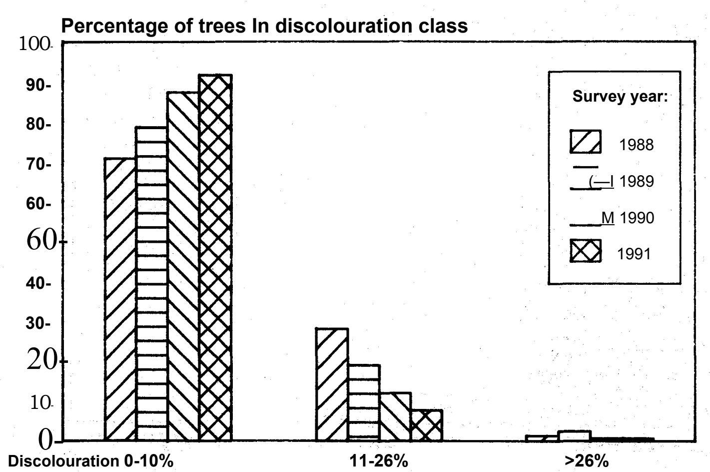


Figure 3.1.9.6-2: Discolouration of *Pinus halepensis* from 1988-1991

3.1.9.7 Quercus suber (Cork oak)

The distribution of *Quercus suber* is limited to the Mediterranean region where it is an economically important species for different landuse systems.

The species has been affected by serious decline. Several Mediterranean countries conduct combined research programmes with financial assistance from the Community. Defoliation increased slightly from 45.2% to 46.6%, which means that almost one half of the common trees shows leaf loss in excess of 25% (Figure 3.1.9.7-1). Slight discolouration affects 35.3% of common trees, i. e. the same percentage as last year, while moderate discolouration receded by 7-5 percent points to 9.4% in 1991 (Figure 3.1.9.7-2).

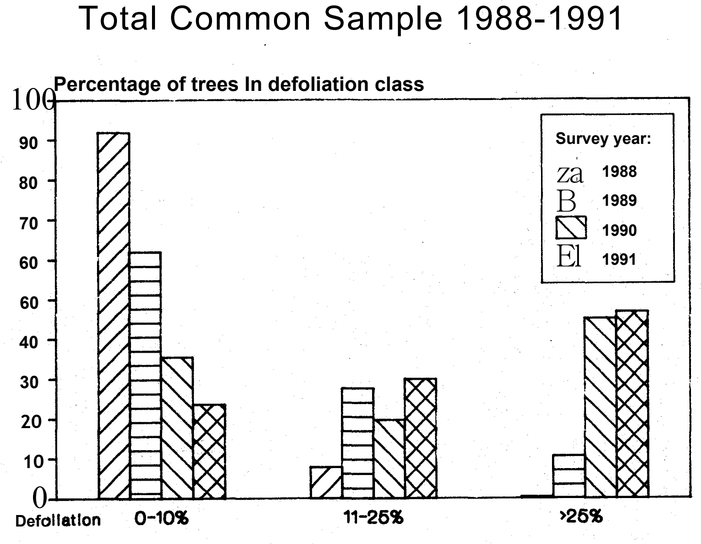


Figure 3.1.9.7-1: Defoliation of *Quercus suber* from 1988-1991

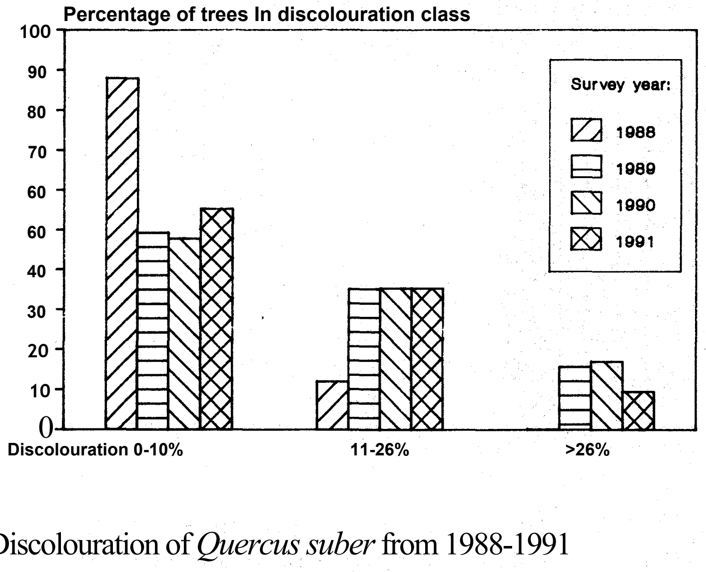
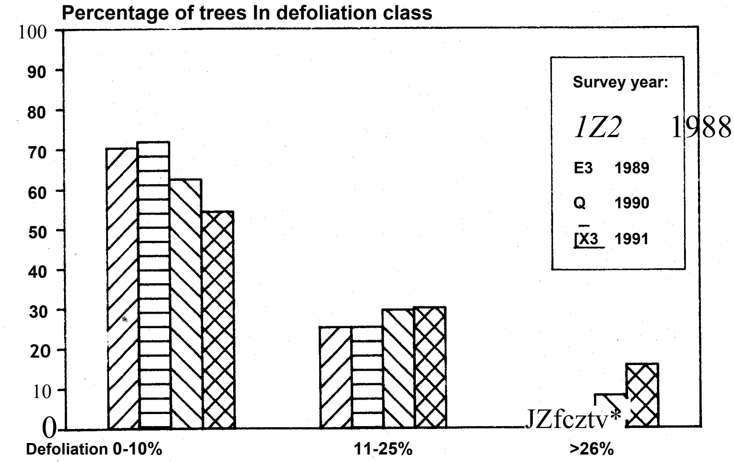


Figure 3.1.9.7-2: Discolouration of *Quercus suber* from 1988-1991

3.1.9.8 Pinus nigra (Austrian pine)

For *Pinus nigra* with several subspecies in many countries, Common trees were predominantly observed in the Mediterranean region. The pronounced deterioration observed between 1989 and 1990, with an increase of 6.1 percent points, continued with a further increase of notable defoliation by 7.7 percent points in the Mediterranean, and by 7.6 percent points for the entire subsample (Figure 3.1.9.8-1). Discolouration improved steadily from 81.1% of the trees showing no discolouration in 1988 to 93.2% in 1991 (Figure 3.1.9.8-2). At the same time slight discolouration decreased from 18.4% to 6.3%. The moderately discoloured trees remained at a level of 0.4- 0.5% in the Mediterranean region.

Total Common Sample 1988-1991



Mediterranean region

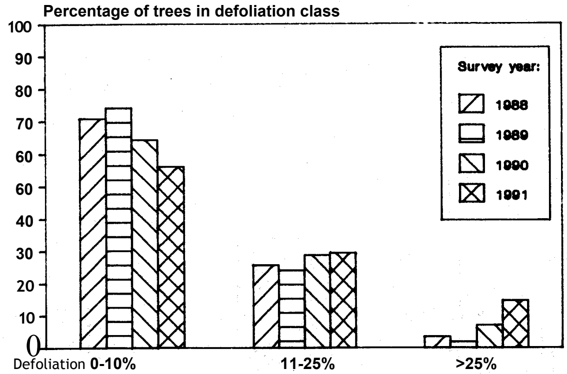
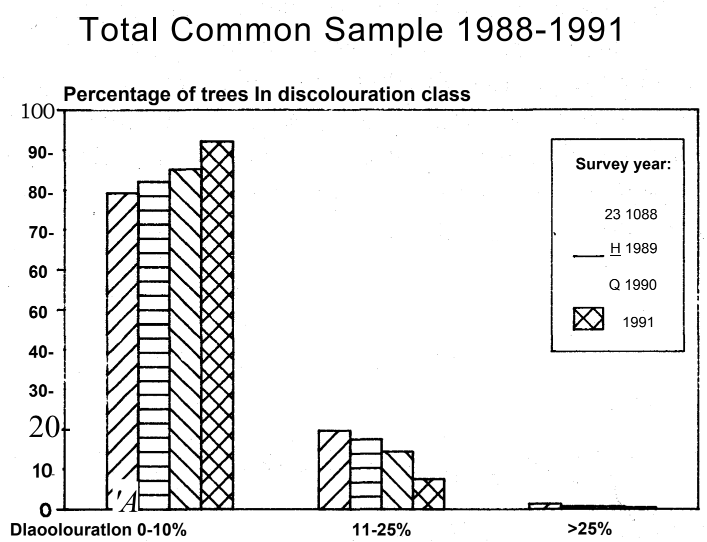


Figure -3.1.9.8-1: Defoliation of *Pinus nigra* from 1988-1991



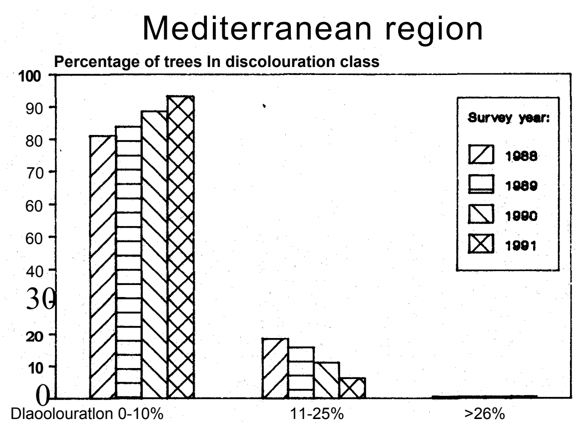


Figure 3.1.9.8-2: Discolouration of *Pinus nigra* from 1988-1991

3.1.9.9 Quercus robur (English oak)

Quercus robur is a typical tree of the summergreen broadleaved forests of Central Europe. This is reflected by its predominant occurrence in the Atlantic, Sub-atlantic and higher elevation sites of the Mediterranean (6 plots) regions. The decline of oak, reported several years ago from Hungary, progressing west through Austria, is also affecting oak forests in the Community. For the entire Community defoliation increased again by 5.6 percent points to reach 34.1% (Figure 3.1.9.9-1). In the Atlantic region the increase was almost the same, by 5.9 percent points to 40.3% of trees with more than 25% foliage loss. In the Sub-atlantic region defoliation increased by 5.7 percent points but with 17.6% the total of notably defoliated trees is half as high as in the Adantic region. Discolouration in the Atlantic region decreased form 2.5% to 0.6%, at Community level it remained stable at 2.0% for moderately discoloured trees (Figure 3.1.9.9-2).

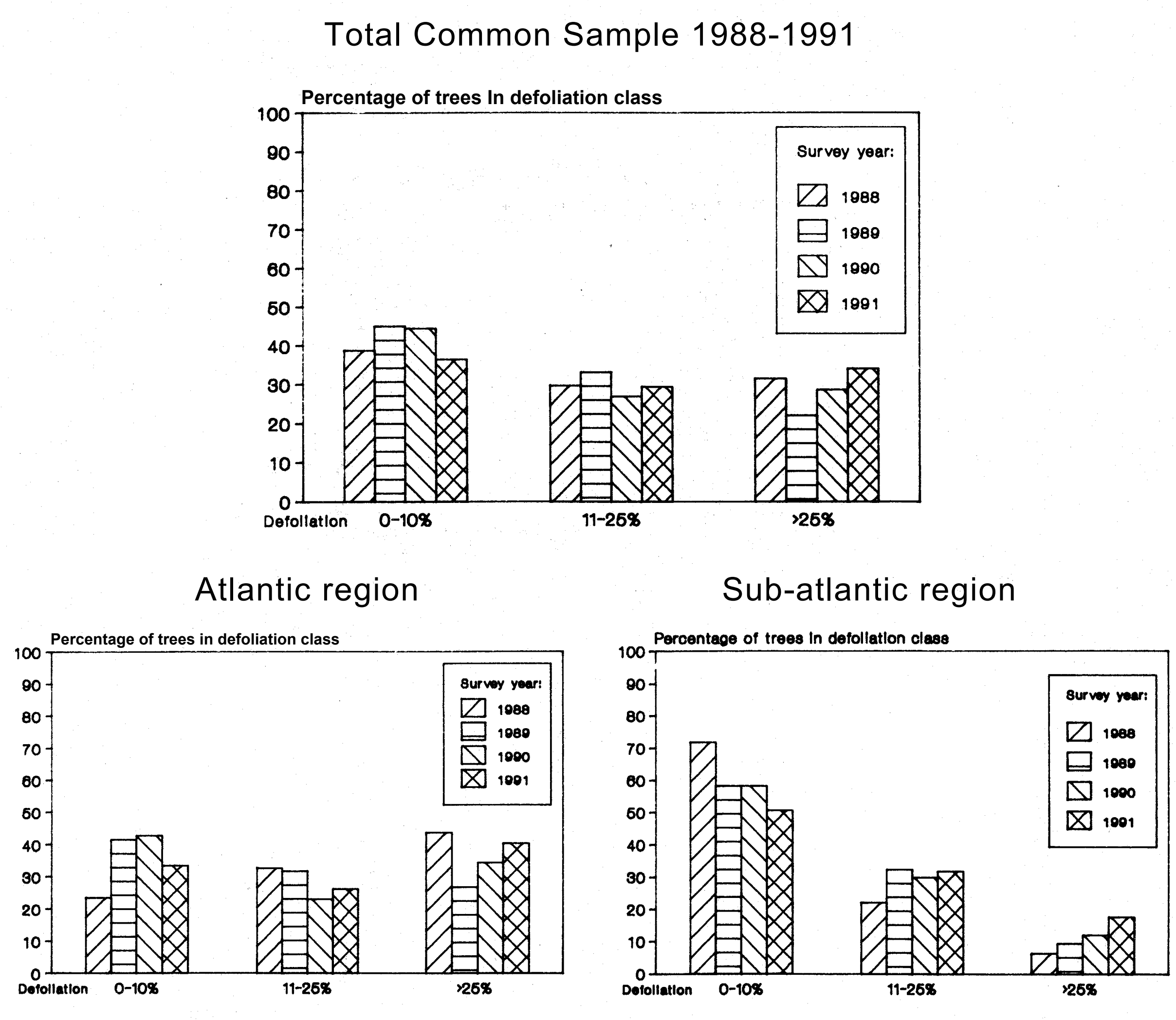


Figure 3.1.9.9-1: Defoliation of *Quercus robur* from 1988-1991

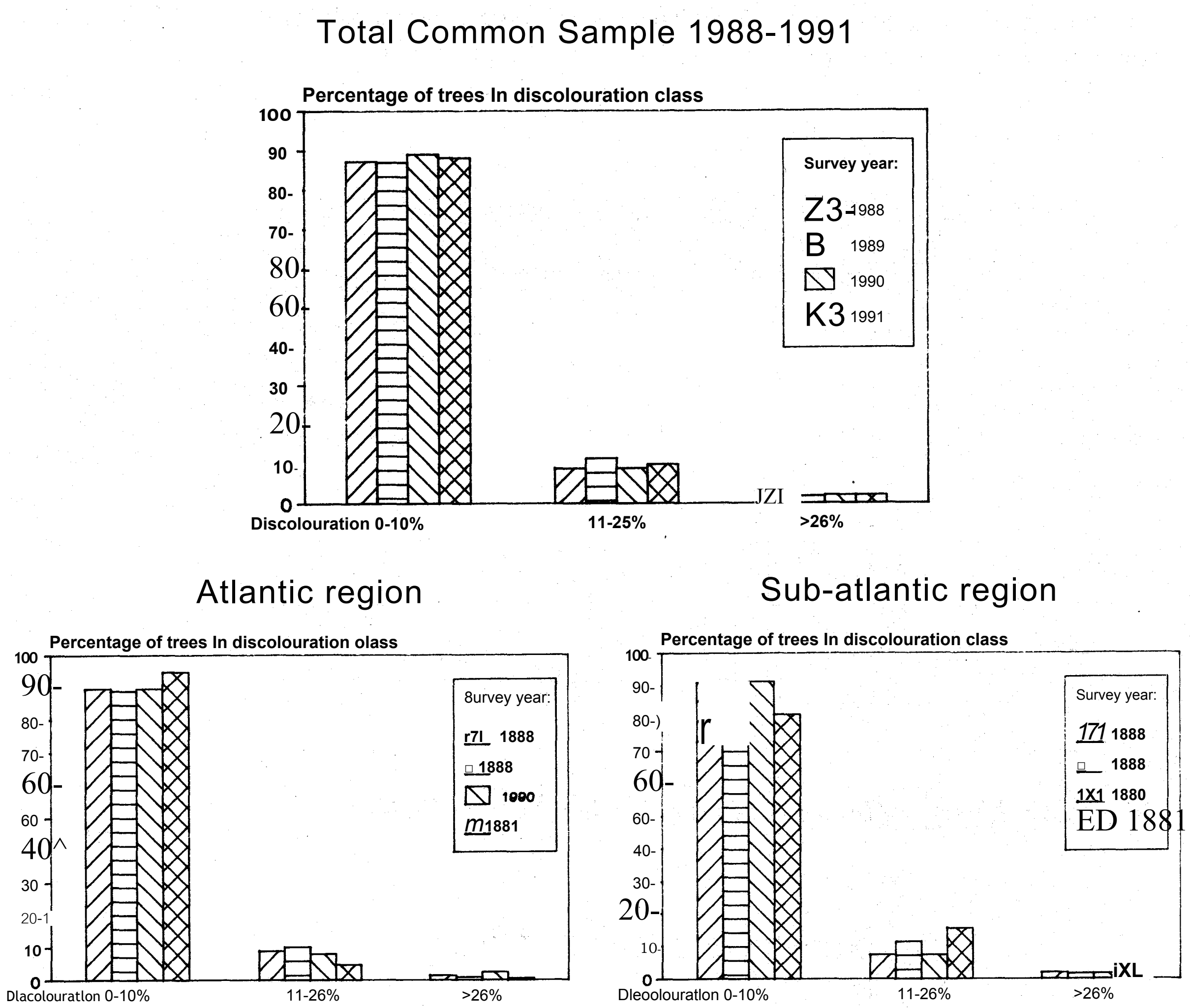


Figure 3.1.9.9-2: Discolouration of *Quercus robur* from 1988-1991

3.1.9.10 Picea sitchensis (Sitka spruce)

Picea sitchensis is an exotic conifer originally from the western United States. This species is the predominant conifer used for afforestation in Ireland and the United Kingdom. Common trees are therefore limited to the Atlantic region. Defoliation, after a slight recovery from 1989 to 1990, has increased again by 6.4 percent points to reach 35.9% (in classes 2-4). The green spruce aphid contributed far less to this increase of defoliation than in previous years, because in the United Kingdom its population had been effectively reduced by a relatively hard winter. Discolouration decreased slightly by 2.0 percent points for the slightly defoliated trees, and it was stable (-0.4 percent points from 3.6% to 3.2%) for moderately discoloured trees.

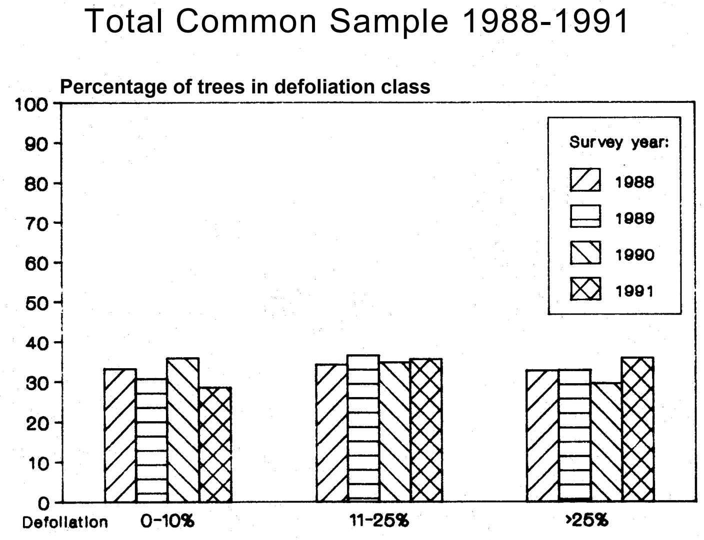


Figure 3.1.9.10-1: Defoliation of ***Picea sitchensis*** from 1988-1991

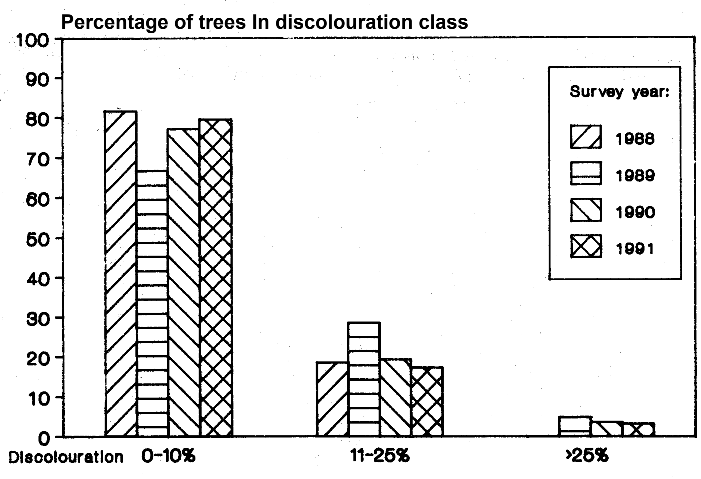


Figure 3.1.9.10-2: Discolouration of *Picea sitchensis* from 1988-1991

3.1.9.11 Quercus petraea (Durmast oak)

Quercus petraea is the predominant broadleaved species found in the Sub-atlantic region, only 4 plots falling into higher elevation forests in the Mediterranean region. The overall level of defoliation is low, an increase of 3.7 percent points occurring from 1990 to 1991, bringing the total of notably defoliated trees to 11.0%. In the Sub-atlantic region the increase was 1.1 percent points from 6.0% to 7.1% (Figure 3.1.9.11-1).

Discolouration receded at the Community level as well as at the regional Sub-adantic level: 6.0% and 7.1% of common trees are slightly, 0.4% and 1.5%, respectively, are moderately discoloured (Figure 3.1.9.11-2).

When considering the figures for the two deciduous oak species it should be borne in mind that they refer to 61 and 34 sample points, respectively. The result for all sample trees of the year 1991 could differ from these figures.

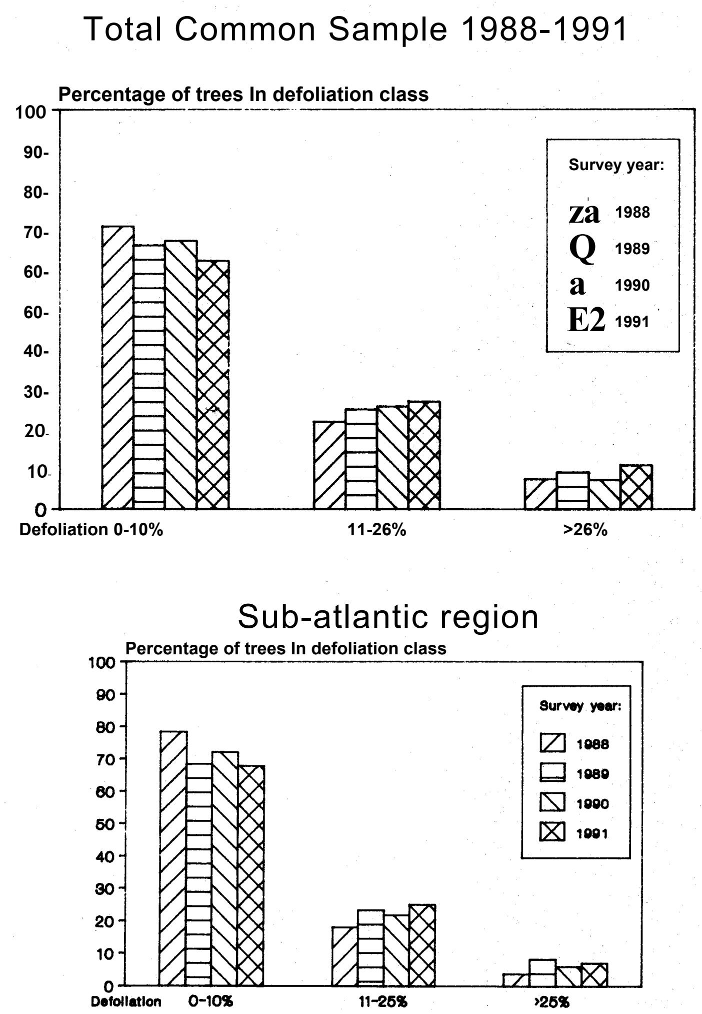
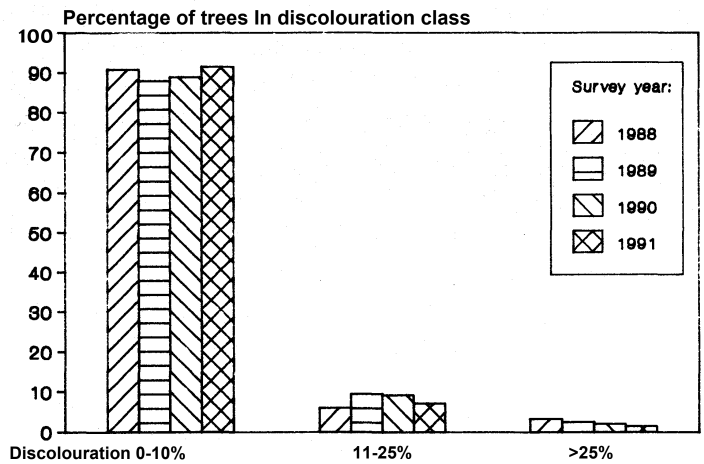


Figure 3.1.9.11-1: Defoliation of *Quercus petraea* from 1988-1991

Total Common Sample 1988-1991



Sub-atlantic region

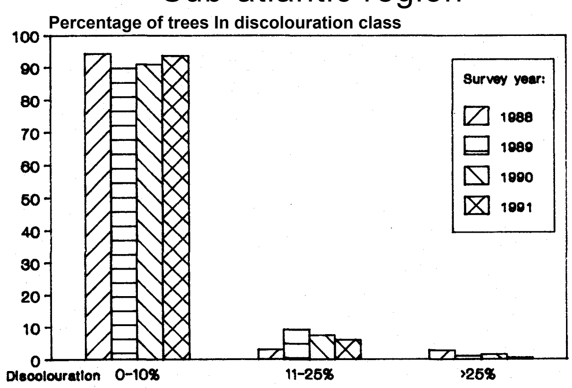
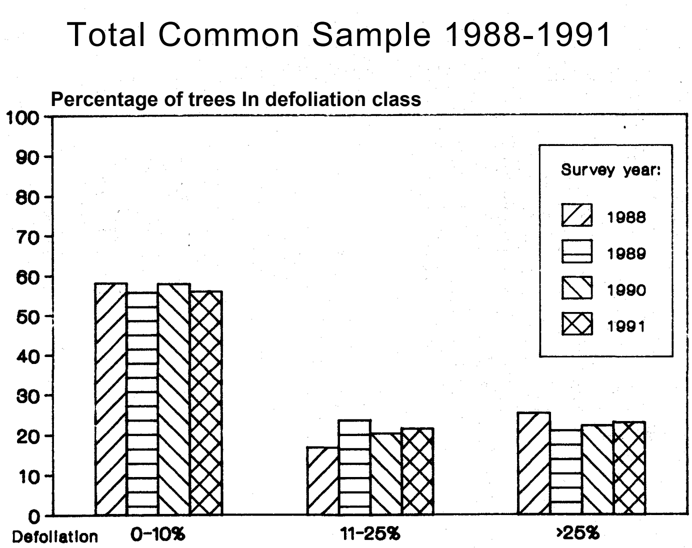


Figure 3.1.9.11-2: Discolouration of *Quercus petraea* from 1988-1991

3.1.9.12 Abies alba (Silver fir)

Abies alba is a highly valuable species of mountain forests of the Sub-atlantic region above 600 m elevation, in the Mountainous region and in the Mediterranean region above 1000 m. It occurs in pure stands or in mixture with Common beech and Norway spruce. It was the first species showing unexplained symptoms of defoliation in the 1960s. Since then, the health of Silver fir has not recovered. There has been a slight increase in classes 2-4 by 0.9 percent points from 26.8% to 27.7% in the Sub-atlantic region and from 22.1% to 22.8% in the entire Community (Figure 3.1.9.12-1). The level of discolouration is low. Moderate discolouration stabilized at 3.6% and 2.9% in the Sub-atlantic region and in the Community, respectively, while 13.9% and 12.2% of common trees are slightly discoloured in the Sub-atlantic region and in the entire Community, respectively (Figure 3.1.9.12-2).



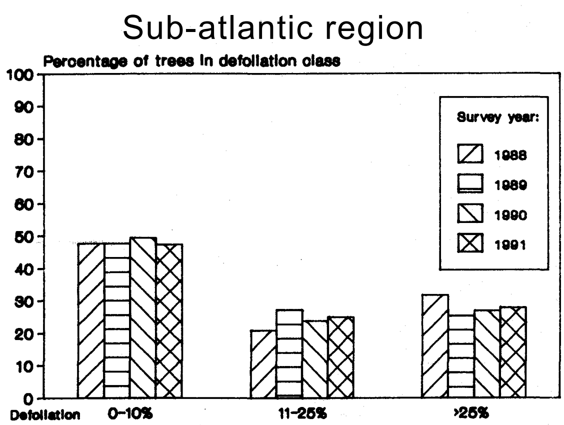


Figure 3.1.9.12-1: Defoliation of *Abies alba* from 1988-1991

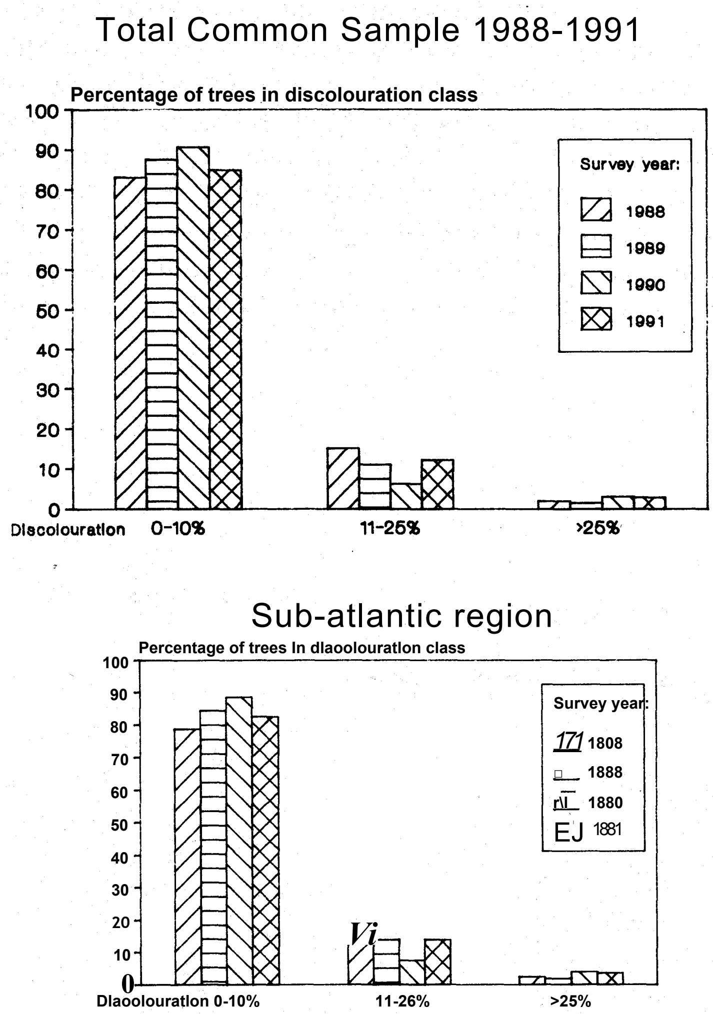
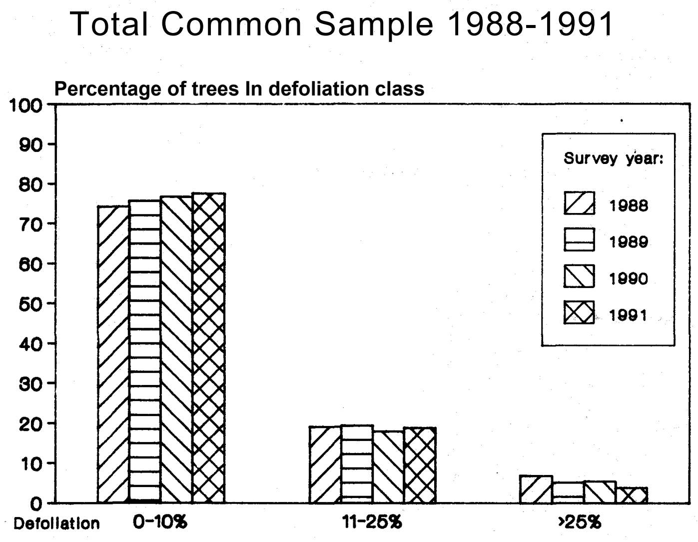


Figure 3.1.9.12-2: Discolouration of *Abies alba* from 1988-1991

3.1.9.13 Larix decidua (European larch)

Common trees of ***Larix decidua*** were observed in 8 plots in the Sub-atlantic and 13 plots in the Mountainous region. Only the 13 plots have been evaluated at the regional level. They show that European larch is the species least affected by defoliation and discolouration. After a high of 10.2% in 1988 and a low of 3.8% in 1990, 5.5% showed notable defoliation in 1991 (Figure 3.1.9.13-1). For the entire Community the corresponding value is 3.8%. Levels of slight discolouration in the Mountainous region and in the total EC amounted to 8.9% and 6.5%, respectively. The related figures for moderate discolouration are 0% and 1.1%, respectively (Figure 3.1.9.13-2).



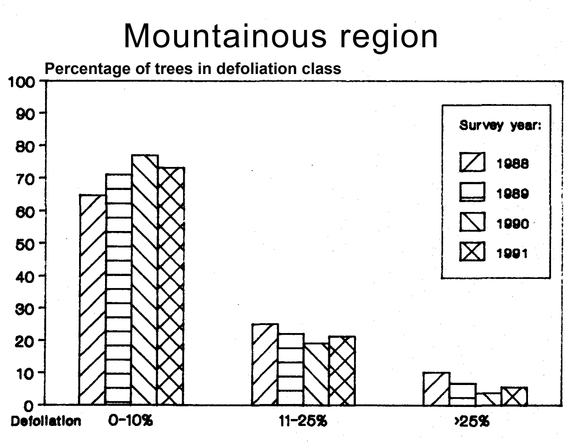


Figure 3.1.9.13-1: Defoliation of *Larix decidua* from 1988-1991

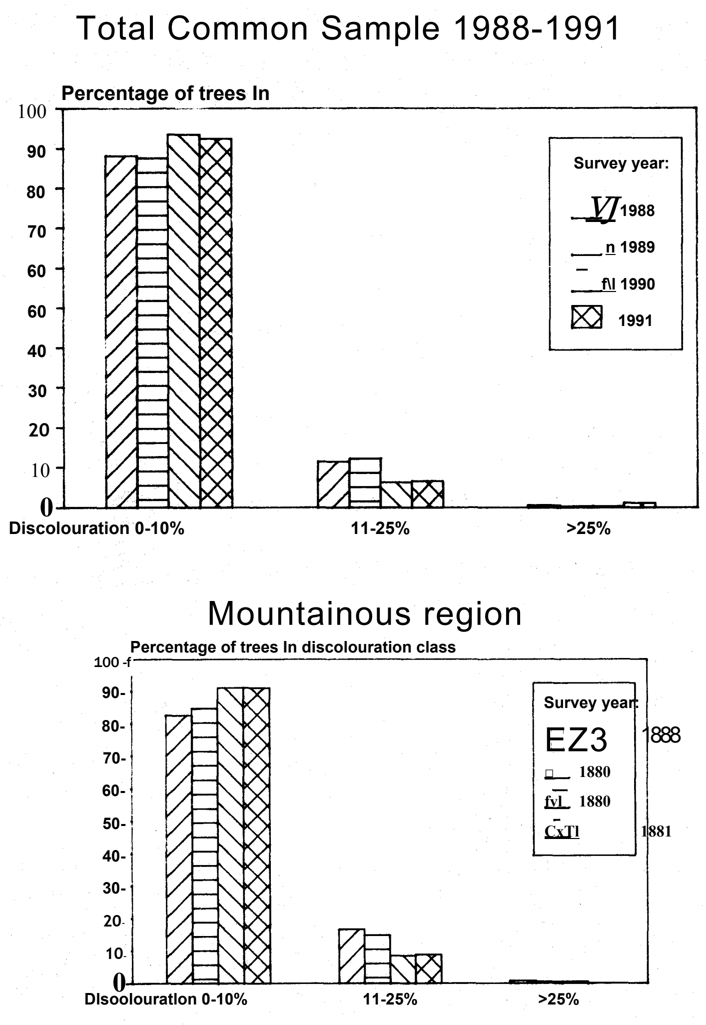


Figure 3.1.9.13-2: Discolouration of *Larix decid.ua* from 1988-1991

3.2 National surveys

Contrary to previous reports, countries are no longer listed in alphabetical order but have been tentatively grouped by geographical location. The basic aim was to combine countries with comparable site and forest conditions, but, evidently, very often these do not stop at national borders. In the future, ecoclimatical criteria will be used for grouping, with the probable result that parts or landscapes of a country are separately grouped. With these intentions in mind the following groupings shall be considered as a first step towards more homogenous reporting units - the present solution is in no way considered as satisfactory or final.

3.2.1 Northern Europe

At present this group combines the Scandinavian countries, except for Denmark, but supplemented by the Baltic States. In Denmark, all coniferous trees are planted, and they are mostly less than 60 years old. Normally the country would have only broadleaved forests, dominated by beech and oak. The climate is largely determined by Atlantic influences, soils are deeper and less stony than in large parts of Norway, Sweden and Finland. Therefore, Denmark is presently listed under Western Europe.

The following table presents forest areas, forest areas relative to the total area, the proportion of coniferous and broadleaved forests and the proportion of trees of all species in classes 2-4. Broadleaved forests in Norway, Sweden and Finland consist mainly of birch and aspen.

(No data were available from Latvia at the time this report was compiled.)

Forests and defoliation in Northern Europe

Country	forest area (1000 ha)	forest cover (%)	conifers (1000 ha)	broad-leaves (1000 ha)	defolia-tion (%) class 2-4
Estonia	1815	40.3	1135	680	28.0
Finland	20059	65.8	18484	1575	16.0
Latvia	1664	25.8	1142	522	n. a.
Lithuania	1823	27.9	1073	750	23.9
Norway	8435	25.0	7700	735	19.7
Sweden	23700	58.1	19400	4300	12.0
Total	57496	48.1	47159	8562	12.0-28.0

With 35.2% of the conifer forest area and 10.7% of the broadleaved forests it is evident that this group of countries represents an important part of forests in Europe. The evergreen conifers, mosdy spruce and pine, very often grow under marginal site conditions in the northern latitudes of Finland, Norway and Sweden. They play significant roles in the economic and ecological sense. It is important that these forests are continuously monitored and air pollution risks imported from Western Europe are gradually reduced. The

following details have been reported by the National Focal Centres of the countries listed in alphabetical order. Details on forest area and on the survey, like density of the sample plot grid, number of plots and sample trees, are contained in Annex II-2 and have therefore been dropped from the country reports.

Estonia

Results

The survey was carried out in September and October 1991. 1 908 trees (1 219 pines and 689 spruce) were assessed. Broadleaved species were not included in the survey. A comparison of the results with those from 1988, 1989 and 1990 indicated that there was a marked increase of needle loss, especially on pine. The crown condition of spruce showed no change. Of the 1 908 trees examined in 1991, 22% of pine and 58% of spruce were healthy, 41% of pine and 30% of spruce were in class 1 (warning stage). Only 1% of pine and 1% of spruce (trees 60 years and older) were severely defoliated. There were considerable regional differences. Forests in NE and NW Estonia, especially spruce stands, are more prove to damage. Needle loss of pine trees, in addition to atmospheric pollution, is predominantly caused by shoot blights and diebacks, especially Ascocalyx abietina and needle cast (Lophodermium seditiosum). in the southeastern part of Estonia the pine looper (Bupalus piniarius) also plays an important role.

The following specific biotic stresses were found: Pine beetle (Tomicus sp.) on 2 sample trees, bark beetle (Typographus sp.) on 8 sample trees, and elk-injury on 12 sample trees. The other biotic factors causing damage have been windbreak and mechanical injury on 3 and 27 sample trees, respectively.

Special investigations

The occurrence of pathogens and insects has been investigated on all sample plots. Monitoring of epiphytic lichens (20 test species) using the same 16x16 km grid is being used for the bioindication of atmospheric pollution. Since 1989 soil chemical indices in the same sample plots have also been investigated. Sixteen special sample plots have been established in the severely damaged pine stands for assessment of causal factors.

Finland

Results

The results presented concern the annual estimates made on 450 mineral soil plots. During the six-year monitoring period (1986-1991) 1.5% of the conifers had died and 9.1% had been cut. From the 3 896 trees examined in 1991, 63.3% of the conifers and 70.8% of the broadleaves were in the 0-10% defoliation class. Extensive needle discolouration was rarely observed. In 85% of the cases, only a small proportion of the needles (under 10%, class 0) were affected.

Interpretation

In 1991, defoliation of spruce and broadleaves remained unchanged compared with the previous year. The slight decrease in defoliation of pine observed since 1990 continued. For the whole monitoring period (1986-1991), defoliation has increased by 8% units for conifers and by 3% units for broadleaves. Defoliation increases towards the north. High stand age and extreme weather and climatic factors greatly affect forest defoliation in remote areas of Finland. No correlation was found between the defoliation pattern and the air pollution gradient on a national scale, but atmospheric deposition is assumed to be a contributing factor. However, at a local scale and in southern Finland, there is some evidence of covariation of air pollution and defoliation degree of conifers. The most defoliated young stands were situated in southern Finland. Bioindicators (epiphytic lichens and algal growth on needles) also indicate pollutant effects in this region.

Latvia

No data were available at the time this report was compiled.

Lithuania

Results

The 1991 forest damage survey in Lithuania was carried out from 20 July to 1 October, assessing 22 836 sample trees (15 882 conifers, 6 954 broadleaves) on 952 plots of a 4x4 km grid.

For **all species,** 24.6% were healthy, 51.5 % were in the warning stage (class 1), 23.9% were notably defoliated, including 0.3% of dead trees (classes 2-4).

Of the **conifers** (Scots pine, Norway spruce and European larch), 18.3% were healthy, 53.9% were in the warning stage, 27.8% were notably defoliated, including 0.3% of dead trees. With 31.0% and 40.4% of young and old trees, respectively in classes 2-4, Scots pine was the most seriously affected coniferous species, against 9.2% and 21.1%, respectively, of Norway spruce in these classes. No larch trees had lost over 25% of foliage.

Of the **broadleaves** (oak, Common ash, White birch, Black and Grey alders, aspen), 39.2% were healthy, 45.9% were in the warning stage, 14.9% were notably defoliated, including 0.3% of dead trees. With 40.4% of trees in classes 2-4 and 0.5% of dead trees, old oak was the most seriously affected species (only 14.9% of young oaks were in classes 2 and 3).

Interpretation

Conifers are more heavily damaged than deciduous species. The deciduous species without defoliation (class 0) amount to 39.1% (among them soft deciduous trees with 37.3% and hard deciduous species with 47.8%), while only 18.3% of the conifers are healthy. In addition, damage is greater in older stands of conifers and deciduous trees than in young plantations.

When the data obtained this year was compared with those of 1989-1990 it was ascertained that the state of health of trees in Lithuania tended to deteriorate: In 1989 the trees in defoliation classes 1-4 constituted 62.3%, in 1990 68.5% and in 1991 75.4%.

Over the last 3 years the number of trees without defoliation decreased by nearly 10-15%, and the number of trees with moderate defoliation increased only in **pine** stands. In other stands defoliation changed only slightly.

Discolouration: Discolouration is not widespread in Lithuania. Nearly 8-9% of conifers and 2-3% of deciduous trees show discolouration to a varying extent. Among deciduous trees, discolouration is most widespread in **oak** stands (particularly in stands aged 60 years or more). Among conifers it is significant in **pine** stands (pines with negligible crown discolouration comprise 10-11% of all pines observed).

Air pollution: The concentration of SO_2 and O_3 were determined in 95 plots distributed in a grid of 32 x 32 km during August-September. In 30 plots changes in the quantity of SO_2 and NO_x were ascertained throughout the year and more than 900 analyses were conducted.

In August 1991 the average diurnal air pollution by SO_2 in the Lithuanian forest was 0.92 mg/m² (19% less than in 1990) while that of NO_x (28 g/m²) did not differ greatly from the average determined at the same time in 1990 (27 g/m²).

The investigations on air pollution were conducted approximately in one third of the plots throughout the year. They indicated that in winter months the concentration of SO_2 and NO_x increased 5-6 times. The maximum pollution by SO_2 was found in February (the average diurnal pollution was 4.9 mg/m²). In the same plots (in the Kaisiadorys, Trakai and Mazeikiai regions) the concentration of SO_2 was more than 10.0 mg/m² per day. At that time heavy pollution (exceeding the average of the Republic by more than 60%) was recorded in Kursiu Nerija (near the Baltic Sea). Particularly high concentrations of SO_2 (as determined in 1990) were detected in the Mazeikiai region (Leckava).

Special investigations

For studies on radioactive contamination samples were taken from 74 plots distributed in a grid of 16 x 16 km. Additionally, samples have been taken form 70 plots for specifying of the areas of more significant contamination determined last year. A total of 292 samples has been analysed.

During dendrochronological studies sampling of cores was performed in 1 200 points on 74 plots and in 600 points of older stands (30 plots aged 100 years or more). The objective was to evaluate changes and to determine tendencies of growth in the past, to supplement the existing dendroscales and to construct new ones.
Monitoring of forest soils was started throughout all of Lithuania (more than 80 plots have been investigated).

In cases of biochemical-physiological signs of damage the amount of proline was ascertained in 930 samples. The analysis was repeated 3-5 times. Results of these special investigations will be published in 1993.

Norway

Results

The survey was performed by the Norwegian Institute of Land Inventory during the period 1 June to 31 October, 1991. Sampling of 4 228 spruce, 2 938 Scots pine, and 981 birch trees gave the following results:

49.4% of all species showed no symptoms of defoliation, 30.9% were in class 1 (warning stage), 19.6% were notably defoliated and 0.1% were dead.

For trees less than 60 years old, 81.8% of spruce were healthy (class 0), and 84.6% of pine were in this group. 5.1% of spruce trees were moderately to severely defoliated (classes 2 and 3), whereas 3.4% of the pines were in these classes.

For trees older than 60 years, 18.4% of spruce and 29.0% of pine were healthy, whereas 45.1% of spruce and 17.7% of pine were moderately to severely defoliated. Dead trees, all ages, averaged 0.1% for both species.

For birch, all ages, 32.5% were without defoliation, 42.4% were in class 1 (warning stage) and 24.9% were moderately to severely defoliated, 0.2% of the trees were dead.

Average crown density for spruce was 82.5% (versus 84.6% in 1990); for pine 86.1% (versus 86.0% in 1990). The percentage of not discoloured trees was for spruce 89.4% (versus 91.4% in 1990); for pine 95.3% (versus 90.8% in 1990).

Interpretation

The Norwegian Focal Centre concluded from the 1991 survey that forest health had slightly deteriorated since 1990. Conifers exhibited rather low crown densities, which were slighdy reduced, in particular for Norway spruce. Crown discolouration increased for spruce, but decreased for Scots pine. The negative trend in vitality was further ascertained when results from all surveys since 1988-1989 were considered.

Causes for this situation might be an interaction of adverse climate, general stress, and air pollution. Air pollution is possibly a predisposing factor, because it may indirectly render the forests more vulnerable to natural stresses. Inciting factors are the marginal conditions for tree growth, low temperatures, desiccating winds, damaging snowstorms and other components of a harsh climate. Extreme natural stresses prevail over large areas of Norway where forests approach their boreal, alpine, and oceanic. Contributing factors are biotic agents like pathogens and pests, which are more successful in attacking weakened trees.

Special investigations

Local county plots: 772 permanent plots, each containing at least 50 coniferous sample trees (mostly Norway spruce), have been subjectively chosen within forest stands well distributed all over Norway. The plots were selected evenly in four different development categories; young, middle-aged, old, and declining stands. About 43 000 sample trees were assessed by 191 forest district officers in September, according to the methodology of the ICP-Forests Manual.

Comparisons between 1991 and 1990 defoliation data revealed for spruce an increase of 0.41 and for pine a decrease of 0.57 percent points. The percentage of not discoloured trees decreased for spruce by 4.0 percent points and increased for pine by 7.9 percent points. Changes were about the same, regardless of the development stage of forest stands, but variation increased with stand age.

It is expected that these plots will show changes over time more readily than the large-scale representative survey. Results indicate an overall but slight reduction in crown density since 1988, despite some deviations in the 1991 results. The negative development in crown colour for spruce is confirmed, as well as the positive development for pine.

Special forest ecosystem analysis: Studies are in progress on 19 permanent plots intended for special forest ecosystem analysis related to cause-effect relationships between forest damage and air pollution. Results are reported annually by the Norwegian Forest Research Institute.

Sweden

Results

The damage survey of conifers was carried out by the national forest survey between May and October 1991 and included 5 528 **Norway spruce** trees and 5 335 **Scots pine** trees. A special survey of damage in **birch** including 880 trees was done in Svealand in the central part of Sweden (the southern part of the country, Gotaländ, was surveyed in 1990).

Of the **conifers,** 53.3% were healthy, 34.4 % were in the warning stage (class 1), 12.3% were notably defoliated. While 27.3% of **Norway spruce** older than 60 years were notably defoliated, only 10.1% of Scots pine were in classes 2-4. In young birch, only 4.0% were notably defoliated, while 12.1% of older trees were in classes 2-4.

In Norway spruce only 1.6% of the trees had more than 10% discolouration. Discolouration was not assessed for Scots pine and birch.

Interpretation

The 1991 survey result implies a slight decrease in the defoliation of conifers compared to 1990. The defoliation scores are very close to the 1984-91 period average and no obvious long-term trend could be recognized. The forest damage level as well as the between-year variation is interpreted as an effect of natural stress factors combined with direct and indirect effects of anthropogenic air pollutants.

As in previous years, the highest defoliation in Norway spruce are found in northern Sweden. This is interpreted as an effect of older stands in combination with a harsher climate. However, the extreme high defoliation recorded in 1990 was not repeated in 1991 and might have been statistically unrepresentative.

The birch survey of Svealand 1991 shows considerably lower defoliation than in Gotaland 1990. However, reference plots assessed in both years also show a drastic decrease in defoliation 1991. This emphasizes the fact that defoliation is not a very useful measure of tree health in deciduous trees. Branch morphological damage symptoms (not reported here) are certainly more consistent.

Special investigations

Defoliation results are also reported from 282 intensive permanent plots including 9 929 Norway spruce trees and 3 424 pine trees. In south Sweden (Götaland) both species have shown a practically continuous increase in defoliation since 1984. No such trend is recognized in mid- or north Sweden. The intensive plots are mainly situated in older stands and preferably in areas with higher defoliation levels than the average. Therefore these plots are likely to represent stress sensitive forests and this might explain why no corresponding trends are evident in the national forest survey reported above.

Soil sampling on all intensive plots was completed in 1991. Also needle analyses, throughfall deposition measurements and soil water analyses are performed in a certain number of plots. The accumulated information will subsequently be analysed with respect to any relationships between change in tree vitality and environmental factors.

Large-scale (1:2000) aerial stereo photographs were taken during late July-Augugst 1991 in two counties (Sk&ne and Halland) in southwest Sweden. Damage classifications of individual tree crowns are assessed from the photographs of 442 plots in a systematic grid. A similar study in the same area was carried out in 1986 and makes it possible to analyse changes in tree vitality. The results will be reported in late 1992.

3.2.2 Central Europe

With 31.2 million ha this group represents 14.6% of the total forest area, 16.2% of the coniferous and 11.8% of the broadleaved forest area.

Forests and defo] liation in Central Europe

Country	forest area (1000 ha)	forest cover (%)	conifers (1000 ha)	broad-leaves (1000 ha)	defolia-tion (%) class 2-4
Austria	3857	46.0	2922	935	7.5
Croatia	1789	31.5	494	1295	n.a.
Czechoslovakia	4491	35.1	2891	1600	41.3
Germany	9828	27.6	6927	2901	25.2
Italy-Bolzano	307	43.6	292	15	5.8
Liechtenstein	8	50.0	6	2	41.3
Poland	8654	27.7	6895	1759	45.0
Slovenia	1071	53.3	500	571	15.9
Switzerland	1186	28.7	818	368	19.0
Total	31191	31.0	21745	9446	5.8-45.0

Austria

Results

Results of single tree crown-assessment: The survey was done in July and August 1991 by seven experienced teams after one week of joint assessment training in the first week of July.

6 890 trees (66% **Norway spruce,** 14% **Scots pine,** 3% **European larch,** 3% **silver fir,** 8% **beech,** 2.5% **oak,** 2.5% others) have been assessed.

Out of all sample trees of **all species** 54.6% (1990 - 50.8%) were not defoliated, 37.9% were slightly defoliated (class 1), 7.5% were notably defoliated (classes 2 and 3). 0.03% of all sample trees died from 1990 to 1991 - a very low rate of mortality. The mean percentage of needle/leaf loss decreased from 12.3% in 1990 to 11.7% in 1991.

The poorest crown condition (the highest percentage of crowns defoliated) was found in Silver fir with a mean percentage of needle loss of 18.9% (26.6% not defoliated) and oak (24.5% not defoliated) with 19%. The best crown condition (65.4% of not defoliated trees) was recorded for European larch with a mean percentage of needle loss of 8.5% and Norway spruce with 10.1% and 61.6% of not defoliated trees).

Interpretation

In comparison to the survey results of 1990 no great changes in mean needle/leaf loss occurred. During a 4-year period (1988-1991) the crown condition of all tree species improved. As in the previous survey periods the percentage of discoloured trees amounted to 1.5% over all species.

In Austria air pollution and damage caused by game and cattle as well as unwise forest management are considered as the main parameters affecting forest health with different regional importance.

Special investigations

Soil analysis: The soil and site survey (Forest Soil Monitoring System) was carried out on all feasible plots of the Forest Damage Monitoring System, totalling 514 sample plots. It includes detailed descriptions of sites and soil profiles and floristic listings for each plot. In addition, soil samples from five defined layers were taken. About 35 parameters, e.g. the most important nutrients and heavy metals were analyzed.

First results from data referring to five Federal Laender were published in 1991 in: FBVA-Berichte, Heft 49 (Vienna). The final report will be published in 1992.

In 1991 some additional parameters as Sulphur and Cadmium were analyzed to ascertain statements on human-related impacts on forest soils: About 10% of the plots are considered to suffer from anthropogenic acidification. Furthermore, it is supposed that a certain amount of lead is accumulated in Austrian forest soils. Varying with conditions, 5-50 ppm of lead in addition to geogene content were found, especially in the organic layers. The concentrations of cadmium found were surprisingly high. In the soils of the Limestone Alps especially cadmium is accumulated perhaps due to decreased mobility caused by high pH-values. Anthropogenic depositions are therefore very strongly suspected although usually limestone-derived soils contain higher geogene concentrations of cadmium.

Foliar analysis: In 1989 from 289 sample plots foliage samples were taken for the first time. The chemical analysis of macro-nutrients (N, P, K, Ca, Mg) was finished this year.

For 275 sample plots with Norway spruce and Scots pine the nutrient supply was classified following national threshold standards. On 45% of the sample plots a deficiency of nitrogen and on 11% of the sample plots a deficiency of phosphorus was found. The supply with nitrogen was sufficient on 8% of the sample plots, with magnesium on 55%, with calcium on 64% and with phosphorus on 70% of the sample plots. Detailed results of foliar analysis are being worked out and will be published in 1992.

Air quality measurements: At 112 sample plots in four federal countries (Carinthia, Styria, Upper-Austria and Lower-Austria) integrated measurement of NO_x, SO_2 and O_3 was continued this year.

Aerial inventory: In 1991, in four areas covering about 1800 km^2, special investigations using CIR-film Kodak SO 131, mb 12000, have been carried out. Using grids of 350 x350 m or 250 x 250 m, 4-9 trees were identified on each sample plot. A large number of parameters of each sample plot and of each selected tree have been recorded with the coordinates in order to make each plot and tree reassessable. Using statistical methods combined with plotting, different regional patterns are showing areas where trees are more defoliated and/or discoloured than elsewhere. On these locations special terrestrial investigations can be done.

Another four areas covering 1700 km^2 were surveyed by CIR-aerial photos with film Kodak Infrared 2443, mb 7500. The special interpretation keys for these four areas have been elaborated. The interpretation of two areas surveyed in 1990 and of some areas surveyed in 1991 will be carried out in winter/spring 1991/92.

Forest-pathological survey: Since 1989 specific forest-pathological investigations have been effected on 140 sample plots indicating symptoms of severe defoliation and yellowing.

In about ***50%*** of the investigated sample plots the bad crown condition could be primarily attributed to biotic and/or weather influences. For the remaining part no definite cause could be established.

The most frequent damaging factors identified were:

- rots in roots and trunks following mechanical injuries or bark peeling by game
- hail and storm
- leaf feeding insects and fungal diseases
- extreme site conditions

The main biotic causes of the yellowing and needle loss for different tree species are listed below. The occurrence of these pathogens is mostly restricted to specific areas of Austria.

Tree species	Pathogen/Insect	Dispersal Area
Norway spruce	***Chrysomyxa rhododendri***	Alps above 1500 m altitude
	Pristiphora abietina	Lower und Upper Austria Salzburg
	Pachynematus montanus	Alps-foreland in Upper Austria and Salzburg
	Bark beetles (different species)	as a consequence of the storm in early spring 1990 in the Northern Alps-foreland
	Sirococcus blight	southeastern parts of the Alps
Scots pine	***Cenangium ferruginosum***	Waldviertel
Austrian pine	***Sphaeropsis blight***	eastern parts of Austria
Beech	***Rhynchaenus fagi***	wide-spread but seldom causing severe damage
	Wooly aphids on leaves and trunks	wide-spread, e.g. Tyrol
Oak	***Loranthus europaeus***	Lower Austria and Burgenland

Croatia

No data were available at the time this report was compiled.

Czechoslovakia

Results

Of **all species** 24.1% were healthy, 34.6% were in the warning stage (class 1), 41.3% were notably defoliated.

Of the **conifers** 19.9% were healthy, 34.1% were in the warning stage, 46.0% were notably defoliated, an improvement of 4.3 percent points over 1990.

Of the broadleaves 39.6% were healthy, 36.7% were in the warning stage, 23.7% were notably defoliated, an improvement of 10.2% over 1990.
At the species level Scots pine is most strongly affected with 57.2% of notably defoliated trees in the age group over 60 years. The situation is serious for the age group of trees less than 60 years old. Here, 48.0%, 51.4% and 100.0% of Norway spruce, Scots pine and Silver fir, respectively, are notably defoliated, indicating serious problems for sustainable stand management.

While only 8.1% and 11.4%, respectively, of young and older beech are notably defoliated, the corresponding figures for oak are 30.0% and 34.6%, respectively.

Interpretation of results: Defoliation in Czechoslovakian forests is not caused only by air pollution. In some parts of the CSFR it is attributed to a continuing drought and long-term aberrations of climate. Symptoms of decline were also observed in pine forests in this year.

Special investigations: Local case studies and extend knowledge about soil conditions and nutrient supplies of forests. Intensive regional monitoring is carried out in two areas. A 1x1 km grid of permanent sample plots covers the Bohemain Forest (530 monitoring plots) and Giant Mts. (210 plots).

Soil samples have been collected on every second monitoring plot of the new network, i.e. in a 16 x 8 km grid in the Czech Republic.

Germany

Results

In 1991, for the first time results were available for the united country. Because of the intensity of the 1991 survey (4 x 4 km network) results can be calculated separately for individual physiographic units like the Black Forest or Harz Mountains.

Country level
In Germany every 4th tree is notably damaged, i.e. foliage loss >25%. For all species

- 25% have lost more than 25% of foliage (defoliation classes 2-4);
- 39% of all species are slightly damaged, i.e. they have lost between 10 and 25% of foliage (defoliation class 1);
- 36% are without notable symptoms, i.e. foliage loss <10% (defoliation class 0).

Regional level
Regionally, considerable differences of damage intensity exist:

- In northwestern Germany only 11% of trees are affected by moderate to severe defoliation (defoliation classes 2-4);

- In southern Germany, however, the situation is serious with moderate to severe defoliation being observed in 24% of all trees, the highest level since 1984, in Rhineland-Palatinate notable defoliation affects 12%, in Baden-Wuerttemberg and Saar 17%, in Hesse and Bavaria 29% and 30%, respectively;

- In eastern Germany the situation is alarming with 38% of all trees in Thuringia and Mecklenburg-Western Pomerania being notably defoliated.

Changes
For moderate to severe defoliation (classes 2-4 = notable defoliation) the comparison with last year's results shows

- in northwestern Germany a defoliation decrease by 4 percent points, supported mainly by a significant recovery in Northrhine-Westphalia and Lower Saxony;

- in eastern Germany a slight increase of 2 percent points;

- in southern Germany an increase by 7 percent points (over 1989, no survey in 1990 due to extensive storm damage); this decrease is mainly due to the deterioration of forest health in Hesse and Bavaria.

Temporal trend
The time series since 1984 for the Federal Republic of Germany (old Laender) reveals for 1991 a notable increase in defoliation, after a stagnation at a rather high level since 1986. For the new Laender.no comparable series exists.

Main damage in the physiographic units (growth areas)
Of the 76 physiogaphic units 23 must be classified as "main damage areas" with notable defoliation observed in over 30% of all trees. These include

- 13 of the 19 (preliminarily defined) east German growth areas;

- 10 of 40 south German growth areas;

but none of the 17 growth areas in northwest Germany. In the old Laender the proportion of notable damage exceeded 30% in 8 out of 58 physiographic units in 1986.

Forest condition is still alarming at higher elevations of the Bayerischer Wald, the Rhoen, Fichtel Mountains, Hessian Hills and Bavarian Alps. In other regions the forest condition has improved. In the Black Forest notable damage has decreased since 1986 by 17 percent points to 22%, but as in the Harz, high elevation sites are still heavily affected. Damage is particularly serious in the Erzgebirge where forests are dead or dying over large areas (7000 ha), and in Thuringian growth areas.

Species groups

In 1991, conifers and broadleaves showed nearly comparably high defoliation intensities. Most seriously affected was Silver fir with 41% of the trees in classes 2-4, followed by European oak (31%), Scots pine (25%), European beech (28%), and Norway spruce (23%).

The development of defoliation differed strongly at regional level. In the conifers the decreasing trend continued in northwestern Germany. However, in most of the eastern and southern Laender-that was not the case and the proportion of notably damaged trees has increased for the first time since 1984 in the south of Germany.

In the broadleaves an improvement was to be noted for the first time in northwestern Germany. In the eastern Laender notable damage is markedly higher than the national average while for the southern Laender the increasing trend continues.

Damage by tree species

Spruce: With a share of 3.7 million ha in the total of forest area, Norway spruce is the most frequent species in Germany. At the national level, every 4th tree (23%) is notably damaged, while 35% are already in the warning stage (class 1 = 10 to 25% needle loss); only 42% are without any signs of defoliation. There is an increasing trend in the damage classes 2-4 from west to east. At the regional level the following developments can be observed:

The average for northwestern Germany has remained at a comparably low level since 1984 with 13% of notably damaged trees (and annual variations of ± 2%).

In eastern Germany notable damage has increased by 7% since 1990, with a high level of 38% of notably damaged trees.

In most parts of southern Germany the long trend of recovery was interrupted. Since 1989 the proportion of notable damage has increased by 8 percent points to 22% which corresponds to the 1984 level. The increase in defoliation was particularly strong with 11 percent points in Bavaria and Hesse while in Baden-Wuerttemberg and Rhineland-Palatinate it was low with 1 to 2 percent points, respectively.

Pine: With an area of 2.9 million ha Scots pine is the second most frequent species. At the national level, 29% of pine trees are notably damaged, 42% are in the warning stage (class 1 with 10-25% of defoliation), only 29% are healthy. This means that pine is now one of the more strongly affected trees. Only west of a line Hannover-Karlsruhe-Lindau pine is comparatively weakly defoliated. East of this line the damage level is three to four times higher. Evidently defoliation increases with increasing continentality of the climate.

Regionally the following developments can be distinguished:

In northwestern Germany, after an initial recovery, notable damage remains at a rather low level with 4%, also annual variations are low.

In eastern Germany notable damage is highest with 39% of trees and an increase by 9 percent points. Investigations revealed a high sensitivity of pine to nitrogen deposition on poor sites.

In southern Germany notable damage decreased by 9 percent points between 1984 (25%) to 14% in 1989 but from 1989 to 1991 defoliation increased again by 11 percent points to 25%, attaining the 1984 level as observed with spruce. Obviously the recovery trend observed in the preceding years has been reversed. As with spruce the deterioration of health is strongest in Bavaria and Hesse with 13 and 19 percent points, respectively, while it is low in Rhineland-Palatinate (1 percent point). In Baden-Wuerttemberg defoliation even decreased by 2 percent points but remains at a high level with 24%.

Of the broadleaves, **beech** with 1.4 million ha is the leading species. At the national level, 28% of beech are notably damaged, 44% are in class 1 (warning stage) and only 28% are healthy. A so far unexplained phenomenon is the fact that beech is most seriously affected in regions with optimum growth conditions. In comparison to the year 1989/90 the following regional developments can be distinguished:

In northwestern Germany the proportion of notably damaged beech increased by 13 percent points from 1989 to 1990 but decreased to 20% in 1991, a change mainly attributed to strong fructification in 1990. Long-term comparisons reveal that beech is the species of strongest annual fluctuations in crown condition.

In eastern Germany the proportion of notable damage decreased by 13 percent points to 41%, which is, however, well above the national average (no figures are available for 1989).

For Southern Germany no results are available for 1990 because of extensive storm damage. In comparison to 1989 notable damage in beech increased by 6 percent points to 28%, the highest level since 1984.

Oak: With 0.7 million ha oak is the 4th most frequent species. At the national level almost every third tree (31%) is notably damaged, 40% are in the warning stage (10-25% defoliation) and 29% are healthy. Oak gives most reason for concern even if many regions reported a distinct recovery in 1991. Also with oak an increasing trend can be observed from west to east, with differences reaching a factor up to four. Regionally the following situation prevails:

In northwestern Germany notable damage to oak increased from 8% (1984) to 22% (1989), decreasing since then to 16% in 1991.

In eastern Germany, with 50% damage in oak, defoliation is over three times higher than in northwestern Germany, although the proportion of notably damaged trees decreased by 19 percent points from 1990 to 1991.

In southern Germany with 32% the level of defoliation in oak is twice as high, with a constant increase over the years from 10% (1984) to 32% in 1991.

Fir is more frequent in southern Germany than in other parts of the country. It remains the most seriously affected species with 41% of notably damaged trees and 35% in the warning stage. While notable damage decreased by 7 percent points to 34% in Baden-Wuerttemberg, defoliation remained high in Bavaria. At the national level notable damage has decreased by 3 percent points since 1989. There is a significant recovery of the crown condition of older firs by 5 percent points to 55% while the warning stage increased by 6 percent points to 35%.

Interpretation

Crown condition in Germany in 1991 deteriorated further; however, levels and dynamics are not uniform in the different parts of the country.

The situation has many causes but air pollution plays an essential role; however, regional differences cannot be explained by pollution load alone. Other factors such as site, stand structure and management are equally important. The Laender report that precipitation deficits, drought-related acidifying processes in the soil, insect attack, late effects of the 1990 storm and fructification affected crown condition in the physiographic regions with varying intensity.

In relation to the effective abatement measures taken since 1984, the increase of defoliation observed in 1991 gives reason for concern. $S0_2$ emissions were reduced from 2.9 million t in 1982 to 1.0 million t in 1989 (60% reduction) in western Germany. Emissions of NO_x have started to diminish slightly by 10%, from 3.0 million t in 1987 to 2.7 million t in 1989, mainly in power plants and the industry. As regards automobiles, 97% of newly registered gasoline-powered cars are equipped with catalytic converters (29% of the total fleet).

In eastern Germany $S0_2$ emissions were reduced by 33% by shutting down of inefficient power plants. Ammonia emissions from cattle and pig industries were reduced by 10% (of 0.3 million total emissions).

The anomaly of increasing defoliation and the progress in reduction of emissions is attributed to the fact that the total load of pollutants deposited in forest ecosystems is still too high. The pollutants accumulate in the soil and continue to increase soil acidification in forests. These interrelationships might explain why the reduction of air pollution has not brought about an improvement of crown condition.

In view of the latest research results there is only one conclusion: further air pollution abatement efforts are necessary, also in view of the risks of global climate change.

Italy-Bolzano

Results

Of all species 77.2% were healthy, 14.2% were in the warning stage (class 1), 8.6% were notably defoliated, including 0.15% of trees died.

Of the conifers, 78.1% were healthy, 16.4% were in the warning stage and 5.5% were notably defoli-ated including 0.1% trees that had died. Of the six conifers assessed, i.e. Norway spruce, Scots pine, Austrian pine, European larch, Arolla pine and Silver fir, the latter exhibits by far the strongest defoliation with only 56.3% of healthy trees and 14.5% of notably damaged trees. For the other conifers, the proportion of healthy trees ranged from 67.7% for Scots pine to 83.4% for European larch.

The broadleaves (5% of the forest area), dominated by beech, are in a worse condition than the conifers, with a further decrease of the healthy trees by 6.7 percent points to 54.6%.

Interpretation

The normal mix of biotic and abiotic factors influences the health of forests in South-Tyrol. ***Fomes sp.*** and ***Armillaria*** affect stands with damage or with previous utilization, e.g. forest grazing. Aphids attacked beech, needle rust fungi infected Norway spruce, ***Zeiraphera rutimitrana*** and ***Choristoneura murinana*** attacked Silver fir, ***Blastophagus sp., Thaumetopoea pityocampa. Diprion pini*** infested Scots pine, also ***Cenangium ferriugino-sum*** and ***Viscum album,*** while Arolla pine showed attack by lachnids. Of the broadleaves, Sweet chestnut suffered from ***Cryphonectria parasitica*** canker, beech from ***Rhynchaenus fagi, Phyllaphis fagi*** aphid, the borer ***Anisandrus dispar*** and the ***Nectria ditissima fungus.*** Abiotic damage causes were late frosts in March after a mild winter, causing damage on young shoots of larch, beech and other broadleaves.

Special investigations

Bolzano operates two permanent monitoring sites, Rittner Horn (1 750 m) and Huehner-spiel (1 800 m), for air quality control, i.e. ozone, SO2 and NO_x, measurement of ions, pH in rainfall and radioactivity and has begun to analyze soil samples on the basis of the draft soils manual of the ICP. Bolzano is also a partner in the MEMOSA inter-alpine modelling project.

Liechtenstein

In Liechtenstein, 90% of forests are mountain forests on steep slopes, of high importance for their protective functions concerning avalanche and erosion control. Only 38% are permanently managed. Above 1000 m elevation **conifers, Norway spruce** and **Silver fir** occupy 90% of the high forest area.

The annual survey of forest health on a systematic grid had to be abandoned for financial and technical reasons. Instead, 16 permanent plots of 0.5 to 1.0 ha size are assessed each year with a variety of parameters.

Results

The proportion of healthy **Norway spruce** decreased further in 1991 to 43.9%, that of **Silver fir** to 23.8%. Over the years there was a notable shift towards moderate to severe defoliation.

51.3% and 57.4%, respectively, of Norway spruce and Silver fir of all ages are in the warning stage, 4.8% of Norway spruce are notably defoliated, including 1.2% dead trees. In Silver fir, 18.8% are notably defoliated, including 5.8% of dead trees.

Interpretation

After a stabilization of the defoliation level during 1987 to 1989 the development has very likely been aggravated by the drought of the last two years.

Special investigations

The next survey in the 0.5 x 0.5 km network of 361 sample plots is foreseen for 1992.

Aerial photography covering the entire forest area with IR-false colour photos in 1985/86 at 1:9000 scale will be flown again in 1995 for comparative analyses.

IR-false colour photography at a scale of 1:3000 is being obtained from 5 sample sites on an annual basis. The results of single tree crown interpretations will be published this year.

Foliar analyses with respect to sulphur content of 2 spruce trees each on 51 sample plots are presendy evaluated.

A **forest soil survey** was carried out in 1986 with the goal of creating a soils data bank. Over 400 parameters per plot have been analyzed and can be used as a reference in future investigations.

The deposition and presence of **heavy metals** was monitored by investigation on livers of roe deer, red deer and chamois. Results have been published in a special volume relating to game management in protection forests of the Grand Duchy of Liechtenstein (ONDERSCHEKA 1990).

Since Liechtenstein is embedded in Switzerland and the overall level of defoliation has been reported as similar, 1991 survey data of Switzerland have been used in the tables for all species and species groups (conifers and broadleaves).

Poland

Results

Assessment of forest condition in 1991 was performed from 10 July to 30 August on 1 493 permanent observation plots for pine, spruce, fir, oak, beech and birch in stands over 40 years old.

For all species, 8.4% were healthy, 44.0% were in the warning stage (class 1), 47.6% were notably defoliated, including 0.2% of dead trees. Of the conifers 7.4% were healthy, 45.8% were in the warning stage, 46.8% were notably defoliated, including 0.2% of dead trees. Of the broadleaves 18.7% were healthy, 46.5% were in the warning stage, 34.8% were notably defoliated, including 1.2% of dead trees. The highest defoliation among conifers was observed in fir, with 78.5% showing moderate to severe defoliation (class 2-4). The highest defoliation among broadleaves was observed in birch, with 38.9% being moderately to severely defoliated (class 2-4). Discolouration (class 1-4) was observed on 9.5% of the conifers and 8.2% of the broadleaves. For broadleaves the most frequent defoliation class was 11%- 20%, for conifers the class 26%-30%.

Interpretation

Results obtained in 1991 confirm the very high level of forest damage in Poland. More than 90% of trees indicate defoliation above 10%, and 45% of trees show defoliation above 25%. When comparing survey results of 1990 and 1991, the percentage of defoliated trees increased by about 10 percent points. Also the number of trees defoliated over 25% increased by about 7%. The rate of deterioration is higher in broadleaved species. The percentage of defoliated trees over 10% increased by 11.4% compared with 5.3% in coniferous species. The number of trees defoliated above 25% (class 2-4) increased in 1991 by about 6.6 percent points in conifers and by 8.2 percent points in broadleaved stands.

Special investigations

In 1990, needle samples from 380 plots were taken by tree climbers in pine, spruce and fir stands. Foliar chemical analysis and interpretation of data will be carried out during 1992.

Slovenia

The following results represent the facts given in the respective forms submitted by the Slovenian NFC. Assessment includes discolouration and other morphological changes. No distinction between age groups had been made in the survey.

Slovenian forest damage inventory includes many observations and measurements besides the assessment of defoliation and discolouration of trees. The main items of the forest damage inventory are:

1. dendrometrical measurements,
2. analyses of lichens, pests and insects,
3. damage due to forest management,
4. injuries and damage caused by weather.

All tree species over dbh 10 cm are included in the inventory. The 1991 forest damage inventory was made on 549 plots, including 13 176 trees, in the period from July 15th to August 20th. For each plot an extensive ecological and forest stand description has been made.

Results

Of all species 62.9% were healthy, 21.2% were in the warning stage (class 1), 15.9% were notably damaged (classes 2-4), including 2.0% of trees which had died between 1990 and 1991.

In the conifers, 29.5% were healthy, 39.2% were in the warning stage, 31.3% were notably damaged, including 4% of dead trees.

In the broadleaves, 85.1% were healthy, 9.1% were in the warning stage, 5.8% were notably damaged, including 0.7% of dead trees.

At the species level, Silver fir with 62.3% of notably damaged trees is surely in a critical condition. Scots pine with 33.6% of notably damaged trees, including 2.9% of dead trees, and Norway spruce with 22.9% of notably damaged trees, including 1.9% of trees which had died, are somewhat better off than Silver fir, which improved by 1.1 percent points. Also Norway spruce recovered by 7.6 percent points while in Scots pine overall damage increased by 4.2 percent points from 1990 to 1991.

Besides the data presented in the annex it was also found out that:

1. The severest damage occurs in forests with a high proportion of Silver fir and on sites with extreme growing conditions (e.g. in the mountains);
2. one third of all trees is damaged by pests and insects. The most affected part of the tree is the tree crown. The most frequent injuries are caused by primary insects;
3. more than one third of all trees shows injuries caused by forest management operations;

4. weather effects (excluding drought and frost) are present on 10% of all trees;
5. pests, insects and mechanical injuries represent only 3% of the whole damage.

Research is being conducted on mycorrhiza, phyology, pigments, soil, game damage, cytogenetical and phytogenetical changes. Foliar analyses are carried out on samples from the 16 xl6 km network and on experimental plots (level 2).

Interpretation

On approximately 3% of the Slovenian forests direct effects of air pollution can be established without doubt. It is assumed that global air pollution has caused changes in weather and climate. The second effect after these changes is a much stronger attack of pests and insects on forest trees. Both reasons lead to the weakening of forests and the main symptoms of these processes are defoliation and discolouration of trees. The following conclusions are drawn: The main cause for the present forest condition in Slovenia, Europe and in the world as well, is the indirect influence of air pollution over climate on forests. In Slovenia damage resulting from inappropriate forest management is also considerable and such damage is still increasing. Many, especially private forests, are strongly affected by careless management.

Switzerland

Results

The survey was carried out from 1 July to 30 August 1991.

Of **all species,** 32% were not defoliated, 49% were slightly defoliated (class 1), 19% were notably defoliated, an increase of 2 percent points over 1990. Of the **conifers,** 31% were not defoliated, 48% were slightly defoliated, 21% were notably defoliated. Of the **broadleaves,** 35% were not defoliated, 52% were slighdy defoliated, 13% were notably defoliated.

The situation of **Norway spruce** and **beech,** the dominating conifer and broadleaved species, remained practically unchanged. However, **Scots pine, Silver fir** and **oak** deteriorated further, while in mountain areas defoliation increased only slightly. A considerable increase of defoliation occurred in the remaining parts and in the Mittelland where defoliation more than doubled from 6 to 14%.

At the species level notable defoliation in **Scots pine** was even stronger than in **Silver fir** with 25%. **Norway spruce** and **European larch** took 3rd and 4th place with 21% and 16% of notably defoliated trees (classes 2-4).

Of the **broadleaves, oak** showed the highest level of defoliation with 25% of notably defoliated trees, followed by **beech, ash** and **maple** with 11%, 9% and 7% respectively.

While **oak** deteriorated further, **beech** showed a slight improvement, and **ash** and **maple** exhibited an improving shift from classes 2-4 towards class 1.

The development of notable defoliation (classes 2-4) has been showing an increasing trend during the last 6 years. This is true for the mountains and the plains, for **conifers** and **broadleaves.** However, there is no evidence of a widespread abnormal change in growth or in the mortality rate. What is of concern is that the reasons of the defoliation increase are practically unknown. Present scientific knowledge for the causes of crown defoliation is insufficient for recommendations on priorities in environmental policy.

At the three sites Laegeren, Alptal and Davos of the National Research Program 14+, Davos (Alps) has the least atmospheric pollution but a relatively high crown defoliation, while at Laegeren in the densely populated Mittelland, atmospheric pollution is high but defoliation low. **Norway spruce** is not affected by excessive nitrogen at any of the three sites. Also, leaching by acid rain does not seem to have induced nutrient deficiencies. Nevertheless, atmospheric pollution in Switzerland is regarded as a risk factor for forest ecosystems. Experimental studies with young plants indicate that today's ozone concentrations are not harmless for sensitive tree species (e.g. **Scots pine, birch).** The atmospheric deposition (in particular nitrogen) could be a long term risk for certain ecosystems.

3.2.3 Southern Europe

With 45.8 million ha this group represents 21.7% of the total forest area, 14.5% of the coniferous and 33.6% of the broadleaved forest area.

Forests and defoliation in Southern Europe

Country	forest area (1000 ha)	forest cover (%)	conifers (1000 ha)	broad-leaves (1000 ha)	defolia-tion (%) class 2-4
Greece**	2034	15.4	954	1080	16.9
Italy*	8368	29.5	1443	6925	16.4
Portugal	3060	34.8	1315	1745	29.6
Spain**	11792	23.4	5637	6155	7.3
Turkey	20199	25.9	9426	10773	n.a.
Total	45453	25.4	18775	26678	7.3-29.6

*)excluding Bolzano
**)excluding maquis

Greece

Results

The 1991 survey was accomplished from mid June to the end of August (except for three sites taken in September). A total of 1960 trees and 432 shrubs (83 sample plots in high forests and 18 sample plots in maquis) were assessed according to Commission Regulation (EEC) 1696/87.

83% of the total sample trees showed none to slight defoliation and are considered healthy, 16.9% were notably defoliated of which 1.1% were dead.

A comparison of defoliation results between 1991 and 1990 reveals the following:

When **all species** are taken together an increase of about 13 percent points in the number of trees in class **0** was observed with a corresponding decrease in the number of trees in class 2. This shift in tree distribution was more pronounced in the **conifers** (15%) than in the **broadleaves** (9%). A similar shift was also observed in the maquis.

Concerning the health of species important to Greek forestry the following has been observed: **Fir** trees (Abies cephalonica) in class 0 increased by 15 and 7% in stands aged less than 60 and over 60 years, respectively. An increase of 19 percent points was observed in **beech** (Fagus sylvatica), older than 60 years, in class 0. Similarly, the number of **pine** trees in class 0 increased by 45% and 31 percent points in stands less than and over 60 years old, respectively. Finally, an increase of 4.3 percent points in the number of **oak** trees (Quercus conferta) in class 0 was observed in stands less than 60 years old.

In summary, if percent tree defoliation is an indicator of forest vitality then the over-all state of health of the Greek forests and of individual species in 1991 was much better than in 1990 due mainly to rains which occurred during 1991.

Interpretation

Evidence of traditional causes: From the total number of trees inspected in the 1991 survey, about 19.8% showed signs of insect attack, 0.8% showed some fungal disease (known or unknown) whereas 2.6%, 1.2% and 6.5% showed signs of adverse effects by abiotic, human or by other agents, respectively. From the total number of maquis plots observed, 22.0% showed signs of intense grazing, 5.8% showed signs of adverse effects by abiotic agents, 8.3% showed signs of insect attack and 0.2% showed signs of fungal disease. What follows is a brief description of factors which to our knowledge contributed significantly to the health condition of Greek forests during 1991:

- Forest fires, which during the hot, dry and windy summer of **1991** destroyed **21000** ha of maquis vegetation and high forests of **Pinus halepensis** and **Pinus brutia.**

- Forest grazing, mostly overgrazing by flocks of goats and sheep, which is particularly damaging during the regeneration period and in early stages of stand development of fir and deciduous oak forests.

- Lack, for a long period, of proper management, combined with "negative cuttings" of forest trees by nearby villages in the past.

- Due to sufficient rains during 1991 the over-all state of health of Greek forests is considered very good and all the broadleaves affected by the 1990 drought have recovered. The only health problem in 1991 was the widespread attack by the insect Phylloxera sp. on Quercus conferta, mainly in central and northern Greece.

Italy (without Bolzano)

Only tabular results from the 16x16 km EC network data were available for Italy, evaluation of the national 3 x 3 km had not been completed at the time this report was written.

Results

Of all species, 58.4% were healthy, 25.2% were in the warning stage (class 1), 16.4% were notably defoliated, including 0.4% of dead trees. Of the conifers, 62.9% were healthy, 23.3% were in the warning stage, 13.8% were notably defoliated including 1.3% of dead trees. Of the broadleaves, 57.2% were healthy, 25.7% were in the warning stage, 17.1% were notably defoliated including 0.1% of dead trees.

At the species level, the pines were the most heavily defoliated, with 24.7% of trees in classes 2-4, including 3.5% of trees having died. Silver fir has only 2.5% of trees being notably defoliated. However, no separation of age classes has been made for any species.

21.4% of the pines are notably discoloured. Discolouration affected only 9.5% and 8.1% respectively of larch and Norway spruce.

Of the broadleaves, 19% of deciduous oaks and 22.1% of chestnut trees were notably defoliated, while only 10.9% of beech were in classes 2-4. Notable discolouration (classes 2-4) affected less than 4.0% of broadleaved species.

Portugal

As in previous years (since 1988) the forest damage survey, training of assessors and the evaluation and interpretation of data are the responsibilty of the Directorate General of Forests in Lisbon.

Results

Of **all species** 47.5% were healthy, 22.9% were in the warning stage (class 1), 29.6% were notably defoliated, including 1.3% of dead trees.

Of the **conifers 57.4%** were healthy, **24.8%** were in the warning stage, **17.8%** were notably defoliated, including 1.2% of dead trees.

Of the **broadleaves** 41.6% were healthy, 21.8% were in the warning stage, 36.6% were notably defoliated, including 1.3% of dead trees.

At the species level, **Cork oak** is by far the most severely affected broadleaved species with 42.0% (excluding 1% of dead trees) and 59.2% (excluding 0.8% of dead trees), respectively, of notably defoliated trees in both age groups. The same holds for **Holm oak** (Quercus ilex = Quercus rotundifolia) with 37.1% (including 1.4% dead trees) and 48.5% (including 1.0% dead trees), respectively, of notably defoliated trees up to and over 60 years.

Maritime pine is the most affected coniferous species with 16.2% of notably defoliated trees up to 60 years (excluding 1.2% of dead trees) and 58.6% in the age group over 60 years. On the other hand 90.0% of **old Stone pine** are without defoliation.

Interpretation

A comparison between the 1990 and 1991 results reveals negligible increases of slight, moderate and severe defoliation and discolouration while the number of dead trees decreased from 4.1% in 1990 to 1.3% in 1991. Portugal is a country severely affected by forest fires and of course also sample trees from the forest survey plot network suffered from fire effects. Consequently the number of trees in classes 3 and 4 has increased, but also the number of trees affected by pests and degraded by fire scars. The slight defoliation and discolouration increases are related to more intensive attacks by fungi and insects. These attacks took place under changed physiological conditions of the forest, aggravated by meteorological factors such as the alternation of drought and excess rainfall and the frequency and intensity of forest fires. In conclusion it can be stated that some of the phenomena observed can be explained by the effects of successions of dry and very dry years (1991) and of forest fires, notably in 1990 and 1991. This is not synonymous with a sick forest, but with a one Weakened by biotic and abiotic influences.

Special investigations

A special project has been launched in southern Portugal with the assistance of the EC to investigate causes and potential remedies for the Cork oak decline. Cooperation exists with the other Mediterranean countries having observed similar symptoms in this species.

Spain

Work started with the training of observers in the second half of June. The field survey lasted from July to September with intermittent inspections. A trial check survey was carried out between September and October. Major problems resulted from the loss of 10 of the 1990 sample plots, nearly all destroyed by forest fire. Three had been located in the Province of Vizcaya where technical problems related to fires made it impossible to assess the Community network.

Results

Of all **species,** 64.3% were healthy, 28.4% were in the warning stage (class 1), 7.3% were notably defoliated.

Of the **conifers,** 67.8% were healthy, 24.9% were in the warning stage, 7.3% were notably defoliated, an increase of 4.2 percent points over 1990.

Of the **broadleaves,** 60.8% were healthy, 31.8% were in the warning stage, 7.4% were notably defoliated, an increase of 3.0 percent points over 1990.

At the species level, young **Austrian pine,** with 20.0% defoliation, is the most affected species. In the broadleaves, 10.8% of young **Pyrenean oak** are notably defoliated, while **cork oak** is remarkably healthy with only 3.0% of old trees notably defoliated. **Beech** has 5.6% of trees under 60 years of age and 9.1% of trees older than 60 years in classes 2 - 4. Overall, the condition of Spanish forests appears satisfactory despite a small increase of defoliation during the past year.

Interpretation

Between 1990 and 1991 defoliation as well as discolouration showed a slight increase. Defoliation increased notably in the high values particularly with broadleaved species which showed a slight deterioration of health already in 1990. This trend is not as pronounced in discolouration, although discolouration assessment is nearly impossible in burnt or dead trees. But the increase is notable in the higher discolouration classes, where again the broadleaves seem to be more sensitive.

Possible causes

Two factors are responsible for most of the damage observed

- the high incidence of forest fires in 1990/91 with a total of nearly 250 000 ha burnt of which 125 000 ha were stocked forest land;

- a prolonged drought which lasted for most of the year 1991.

Although small in number, late-frost events came late in the year shortening the transition period to full summer so that plants could hardly develop before a long and very hot summer with only few rain-carrying thunderstorms. Even the autumn of 1991 was very dry. The year can be described as low in frosts and precipitation.

Besides the traditional forest pests in Spanish forest ecosystems, pine forests were strongly defoliated by Thaumeotopoea pityocampa, particularly in the north and by a variety of insects on the broadleaves, in particular by Lymantria dispar. Infestation of trees by mistletoe (Viscum album) and the fungus Thyriopsis halepensis is still increasing.

Finally it must be pointed out that the increasing population density of scolitid beetles in stands already weakened by fire, drought or other climatic stress is increasing.

Remedial action: At the regional level, the responsible forest administrations are undertaking measures of reforestation and stand improvement, mostly directed at fire areas. In several autonomous regions integrated management operations (Forestry Plan - Andalucía, e.g.) aiming at improvement and protection of stands against biotic and abiotic agents are carried out. ICONA continues to conduct studies of vegetation degradation particularly in sensitive areas.

Turkey

No data were available at the time this report was compiled.

3.2.4. Western Europe

With 18.5 million ha this group represents 8.8% the total forest area, 5.7% of the coniferous and 13.7% of the broadleaved forest area.

Forests and defoliation in Western Europe

Country	forest area (1000 ha)	forest cover (%)	conifers (1000 ha)	broad-leaves (1000 ha)	defolia-tion (%) class 2-4
Belgium	602	19.7	302	300	17.9
Denmark	466	10.8	308	158	29.9
France	14440	26.3	4840	9600	7.1
Ireland	380	5.5	334	46	15.0
Luxembourg	88	34.0	31	57	20.8
Netherlands	311	7.5	208	103	17.2
United Kingdom	2200	9.1	1550	650	60.4
Total	18487	18.9	7573	10914	7.1 -60.4

Belgium

The 1991 results at the national level have been supplied by the Ministry of Agriculture, Brussels. The situation in Flanders and Wallonia as presented by the Focal Centres has been presented below.

Results

For all species it was found that 43.4% were healthy, 38.7% were in the warning stage (class 1), 17.9% were notably defoliated (classes 2-4), including 0.1% of dead trees.

Of the conifers, 31.1% were healthy, 45.5% were in the warning stage, 23.4% were notably defoliated, no trees had died.

Of the broadleaves, 53.2% were healthy, 33.0% were in the warning stage, 13.5% were notably defoliated, including 0.2% of dead trees.

Norway spruce, with 36.2% and 31.1% of notably defoliated trees in the age groups up to 60 and over 60 years, respectively, is the most affected coniferous species. In American Red oak over 60 years 22.2% are notably defoliated.

Flanders

Results

Overall, 12.9% of all species showed more than 25% of leaf-/needle loss and were considered to be damaged, 32.2% showed no defoliation and 54.9% were slightly defoliated. Compared to 1990 the proportion of damaged trees increased by 4.6 percent points.

In conifers there was a slight increase in the proportion of damaged trees. 12.0% of the trees were damaged, this means an increase by 1.3% compared to 1990. 27.8% were without needle loss (-7.0%), 60.2% showed slight defoliation (+5.7%).

Especially in broadleaves an increase in the amount of defoliation was observed. The proportion of damaged trees amounts to 13.9% and increased by 8.7 percent points compared to 1990. 37.7% showed no defoliation (-21.1%) and slight defoliation occurred in 48.4% (+12.4%).

At the individual species level, the following results were obtained:

- in beech 28.6% of the sample trees were in defoliation classes 2-4, an increase by 11.5 percent points compared to 1990

- in **oak** there was also an increase in the proportion of damaged trees: 12.4% compared to 3.9% in 1990
- in **Red oak** 15.7% of the trees had lost more than 25% of their foliage, this means an increase by 13.9 percent points
- in **poplar** 14.1% were in defoliation classes 2-4
- in **Corsican pine** the proportion of damaged trees remained more or less the same: 15.8% in 1991 and 16.7% in 1990
- in **Scots pine 11.1%** of the trees were damaged, this means an increase by **1.9** percent points

Interpretation

The weather in the period September 1990 to August 1991 was relatively dry and mild. In April 1991 a late frost period caused considerable damage to fresh leaves and flowers, especially in **oak** and **ash.** Although most of the trees recovered and formed new leaves afterwards, this took a lot of energy and may have delayed the recovery of trees already weakened by other stress factors.

Because of this late frost period there was very low production of acorns in the **oak** stands. In late summer, symptoms of damage caused by drought (yellowing, leafloss) were observed. **Beech, birch, poplar, lime** and **mountain-ash** were amongst the most affected species, but **Scots pine** and **Corsican pine** also suffered from drought.

Insect attacks occurred in **beech** (Rhynchaenus fagi), **oak** (Tortrix viridiana), **poplar** (Melasoma populi), **Red oak, maple** (scale aphid, probably Eupulvinaria hydrangea) and **Scots pine** (Tomicus piniperda). Although in most cases there was only slight damage, locally moderate to severe damage was observed in **oak, beech, poplar** and **Red oak.** In many places maple was heavily attacked by scale aphids.

Damage by fungi was observed in **poplar** (Melampsora sp. and Marssonina sp.), **oak** (Microsphaera alphitoides), **Red oak** (Gloeosporium sp.) and **Scots pine** (Sphareopsis sapinea).

Because of the complexity of forest ecosystems it is very difficult to quantify the extent of the influence of the biotic and abiotic factors on forest health. This surely applies to the role of air pollution. Although no clear symptoms of direct damage caused by air pollution have been observed in the survey plots, there is no doubt that air pollution may affect the functioning of forest ecosystems.

Special investigations: The results of the acidification research programme, started in 1988 in 10 permanent plots, reveal that 90% of the plots have a pH of the top mineral soil layer between 3.8 and 4.2 (Aluminum buffer range) and that C.E.C. and base saturation are low in all the plots. Nutritional deficiencies occurred in Scots pine, beech and oak. Results of this project will be published shortly. Research continues and focusses on soil; a soil monitoring programme was started in 1991 and includes:

- description of soil profiles
- particle size analysis
- chemical analysis of organic horizons
- chemical analysis of mineral horizons
- chemical analysis of soil water
- assessment of physical soil properties
- evolution of mineral N in the profile
- chemical analysis of leaves/needles
- study of root systems
- phytosociological survey

Wallonia

Results

Of all species 52.0% were without defoliation, 26.2% were in the warning stage (class 1), 21.8% were notably defoliated (classes 2-4), less than 0.1% had died.

In the conifers, 34.8% were healthy, 28.8% were in the warning stage, 36.4% were notably defoliated.

In the broadleaves, 62.4% were healthy, 24.7% were in the warning stage, 12.9% were notably defoliated.

Against 1990 there was a slight increase of the notably defoliated trees of all species by 2.9 percent points, by 12.5 percent points in the conifers and by 1.8 percent points in the broadleaves. The deterioration of the conifers affected primarily the old stands.

With respect to discolouration the situation was favourable with only 12% and 4% of conifers and broadleaves, respectively, discoloured.

Interpretation

There are a number of biotic and abiotic causes affecting the health of trees notably game, insects, fungi, but also climate, felling damage and unknown causes.

At the species level defoliation in Norway spruce increased slightly with 31.2% now in classes 2-4; in Scots pine, 51.9% of old trees were notably defoliated. Although there was an improvement over 1990, damage increased in young stands against 1990.

European beech deteriorated slighdy but in comparison to spruce or pine, only 21% are notably defoliated. In the oaks, English oak is in good condition (9.1% notably defoliated) while Durmast oak has 18.8% of notably defoliated trees in the age group over 60 years. The reasons for this difference are being investigated.

Denmark

Results

Of the 1620 trees assessed of all species, 41.5% were healthy, 28.6% were in the warning stage (class 1), 29.9% were notably defoliated, an increase of 8.9% against 1990. 0.9% of trees had died. In the conifers, 50.1% were healthy, 18.6% were in the warning stage, 30.4% were notably defoliated including 1.5% of trees that had died. The increase for classes 2-4 is 10.4 percent points. In the broadleaves, 26.4% were healthy, 46.4% were in the warning stage, 27.3% were notably defoliated (+1.9 percent points), but no trees had died. In conifers as well as in broadleaves, stands under 60 years of age are considerably less affected than old stands.

In 1990 Norway spruce, in particular in Jutland, suffered from a strong reddening of needles often entailing complete needle loss and death of the trees.

On the basis of the information available at present it seems most likely that the red-colouring is due to a combination of mild winters (1987/88, 1988/89 and 1989/90), drought and the rather high concentrations of ozone, measured close to the surface (and in the forests) in 1988-89 and perhaps an additional effect in this stress situation by salt deposition.

In the spring of 1991 large areas with newly planted Sitka spruce (Picea sitchensis) suffered severe damage. The damage appeared as dieback from the top of the plants with living branches in the 2-3 lower whirls. Rushing shoots dried out. The damage was caused by an early start of growth season in March-April with high temperatures, followed by a considerable drop in temperature down to-7° C.

In beech, a number of west-facing stand-edges showed brown leaves. This was also observed in the upper crownparts on trees within the stands. The phenomenon is attributed to a gale on May 21-22,1991. The strong wind caused mechanical damage and dry-out damage as newly flushed leaves were tom off or appeared with dry (brown) leaf-edges.

High concentrations of air pollution may result in the death of trees. Fortunately, however, we do not normally have such high concentrations of air pollution in Denmark. Ozone measurements, carried out by the National Environmental Research Institute, Division of Emissions and Air Pollution, show that in 1988 and 1989 the air pollution component ozone occurred in high concentrations, but in 1990 and 1991 concentrations were on a lower level.

It is the general view that air pollution, all in all, has a negative influence on our ecosystems and buildings and on human beings, particularly those with respiratory ailments. Thus, there are various good reasons for reducing air pollution, and considerable amounts of money are spent both nationally and internationally for this purpose.

Until reduction of air pollution and altered silviculture have produced results - which may take decades - it may be necessary in certain areas to apply fertilizers and/or lime as a countermeasure against air pollution effects on forest soils and forest nutrition.

The National Forest and Nature Agency will continue to support, and the Danish Forest and Landscape Research Institute will make research in this sphere in order to elucidate causes better and find countermeasures, particularly with regard to silviculture. This means that in the future our choice of tree species and other methods of silviculture must match with climate and soil conditions. This applies particularly to the poor soils of Jutland.

France

Results

In 1991,10 255 sample trees of all species were assessed on 513 sample plots. 76.4% were healthy, 16.5% in the warning stage (class 1), 7.1% were notably defoliated (classes 2 to 4).

In the conifers, 78.9% were healthy, 14.4% were in the warning stage, 6.7% were notably defoliated. The overall assessment for conifers shows a notable deterioration in the colour of foliage, while needle loss remains at the same level as in the previous years. Discolouration reflects the drought of 1989 and 1990, although the 1991 needle set somewhat masks the actual losses.

In the broadleaves, 75.1% were healthy, 17.5% were in the warning stage (class 1), 7.4% were notably defoliated. The relative stability of the condition of the broadleaves, after a notable deterioration in 1990, shows that the effects of the drought have not yet been overcome.

The 1991 results fit into the general trend of renewed deterioration which began in 1989. However, a recovery can be expected in the coining year provided no new climatic accidents occur.

Mortality has increased from 8 sample trees in 1989 to 29 in 1990 to 40 in 1991, i.e. trees that dieid in the past year. The previous losses were replaced by new sample trees. Evidently these 25 broadleaves and 15 conifers were too much weakened as to recover.

Strongest affected were poplars (4.1%), birch (1.1%) and other broadleaves (1.2%); in the conifers, maritime pine with 1.2% and Aleppo pine (0.9%) suffered most.

With respect to defoliation, age is a depressing factor exerting a slight influence in the broadleaves with 6% more of perfectly healthy trees in the age group under 60 years, but with a notable effect in the conifers with 22% more of perfecdy healthy trees in the age group under 60 years than in the group over 60 years old.

At the species level, defoliation accelerated in Quercus robur (14.7% in a worse condition, only 4.6% having improved). In Quercus pedunculata, which deteriorated in 1990, the condition is stable with a slight improvement of discoloured trees. Obviously, pedunculate oak reacts faster to a change of site condition than red oak (75.9% against 80.7% of unchanged sample trees).

Beech, which deteriorated in 1990, improved in discolouration as well as reduced foliage loss. However, these global results differ markedly at the regional level and decline is considerable in Normandy and Picardy. While abnormal discolouration in chestnut receded, it increased in pubescent and green oak.

While Norway spruce maintains a generally stable and satisfactory condition, Silver fir shows increased discolouration and an overall serious condition with 13.5% of all trees in defoliation classes 2 to 4.

Maritime pine recovered with respect to defoliation but discolouration increased. This may be the result of drought and heavy infestation by the caterpillars of the pine processionary moth which caused damage in numerous stands in southwestern France in 1989 and 1990. As of mid August 1990 mortality of differing intensity was observed in the centre of the Laudes's forests. In fall and winter of 1990 about 6 000 ha were hit by serious decline in stands 15 to 30 years old. Salvage felling became necessary and continued into 1991 although at a slower pace. Based on the Community network (16 x 16 km), mortality increased from 0% in 1989 to 0.8% in 1990 and 1.2% in 1991, reflecting the above described deterioration.

For Scots pine there has been a strong increase in discolouration (21.8% more discoloured trees against only 81% of improved trees). This is a disquieting situation since 38% of the trees are discoloured but the species shows very frequently and far-reaching colour changes, while only 0.1% actually die.

Regional results: In the **hills of the East,** defoliation increased, slightly in **Norway spruce** and **Silver fir,** but much more pronounced in **Scots pine.** For the majority of conifers and broadleaves discolouration increased. This is being interpreted as the effects of the drought of 1991 in this area. The slight improvements of **Norway spruce** and **Silver fir** coincide with the relatively favourable climatic conditions in 1990.

Plains and hills of the Northeast: In this region continued increases of defoliation and discolouration were observed in **oaks, beech, ash** and **cherry.** On the other hand reduced defoliation and increased discolouration was observed on **hornbeam, poplars** and other **broadleaves.** These symptoms reflect the effects of a drought in the region during the last three years.

Plains of the West and Northwest: Defoliation increased here also in the **oaks, ash, poplars** and other **broadleaves.** On the other hand, defoliation receded in **birch, hornbeam** and **chestnut.** Discolouration decreased in the **oaks, beech, birch, chestnut, ash** and **cherry** but increased in **hornbeam, poplars** and other **broadleaves.** Overall mortality increased from 0% in 1989 to 0.4% in 1990 and 0.6% in 1991, attributed to the drought of 1989 and 1990.

Massif Central: Health condition continues to improve in the Massif Central except for discolouration in **Scots pine, Douglas fir** and **pubescent oak,** which deteriorated notably.

Southwest and Pyrenees: The drought continued in this great region in 1989 and 1990 and resulted in a very strong increase of discolouration in **maritime pine** and increased mortality of 1.3% in this species. Deterioration affects also **pubescent oak** which was already in an unsatisfactory condition in 1990.

Mediterranean South: In the Mediterranean region stabilization of forest health continues, there is even an improvement in **pubescent oak, beech, maritime pine** and above all in **Aleppo pine,** which improved remarkably during the last two years. On the other hand defoliation increased in **Austrian pine** while discolouration increased in **green oak** and the other **broadleaves.** In this region mortality increased from 0.2% in 1989 and 1990 to 0.6% in 1991, an effect attributed to the droughts of 1989 and 1990.

Conclusion

The effects of the droughts of 1989 and 1990 continue to be felt in large parts of the country, the drought of 1991 affected the eastern half of France. The economic effects are presently negligible. Mortality observed in the Community network amounts to 0.4% of which about 20% are sudden death cases (trees assessed as class 0 in one year and class 4 in the next), which is not considered to be a problem of forest decline. The notable increase of mortality observed in 1990 (0.3%) and 1991 (0.4%) over 1989 (0.1%) is in line of the expected effects of such an extended drought, 1989, 1990 and 1991 for eastern France. The increase in mortality attributed to forest decline, i.e. trees assessed in defoliation classes 1 to 3 in the respective previous years has doubled within two years, increasing from 41% to 80% in 1991. But again this reflects a process of decline initiated in 1989 or 1990 resulting in death in 1991.

Ireland

The Irish Forestry Board has not published a comment on the 1991 forest health report prior to the copy deadline. The following text refers to the data of the tables submitted. The survey did not include broadleaved species.

Results

Conifers have been planted and comprise Sitka spruce, Norway spruce and Lodgepole pine plantations, all below 60 years of age. Of all conifers together, 53.8% are healthy, 31.2% are in the warning stage (class 1), 15.0% are notably defoliated, no trees have died.

The health of Norway spruce with 12.5% of notably defoliated trees is somewhat better than that of Sitka spruce and Lodgepol pine with 15.4% each of notably defoliated trees. However, Norway spruce covers only 10% of the total area planted to spruce.

Luxembourg

The storms of 1990 destroyed a large part of the national 2x2 km network of sample plots in Luxembourg so that in 1990 no survey had been carried out. In 1991 the network was restored at the 4 x 4 km level with 48 plots and 1151 sample trees.

The former "red network" with orginally 15 plots and 1500 Norway spruce on marginal sites had to be abandoned when only 600 trees were left after several storms.

Results

For all species, 55.8% were healthy, 23.4% were in the warning stage, 20.8% were notably defoliated.

In the conifers, only pole timber stands and stands 60 years and younger have been assessed. This is reflected in the higher percentage of healthy trees of 86.7%, 8.7% in the warning stage and only 4.4% of notably damaged trees.

In the broadleaves, 36.5% were healthy, 29.6% were in the warning stage, 33.9% were notably defoliated. Assuming a linear trend of defoliation the health condition of Luxembourg's forests deteriorated again in 1991 compared to 1989/90. In timber stands of beech and oak defoliation continued to increase.

Interpretation

Investigation of causes of forest decline are carried out by research institutes of the universities and forest research stations in neighbouring countries. However, it must be pointed out that the drought in the summer 1991 has certainly affected the health of forests. The year 1991 was exceptional in temperature with a mean of 16.1° C between May and September against a 30 year average of 15.3° C. August was particularly hot, with 20 days of maximum temperatures between 25.0 and 29.9° C and 6 days of tropical temperatures above 30° C, the long year average being 19.5° C.

With 227 mm precipitation on the other hand rainfall was below average during the vegetation period by 31% against the 329 mm average. In August only 14 mm of rain fell against the average of 75.8 mm.

The 1991 result of the forest damage survey thus indicates that exceptional climatical conditions can at least partially explain the decline of forests.

Netherlands

Results

The survey was carried out from July 15th to August 16th. A total of i34 100 sample trees has been assessed. Combined defoliation and discolouration for all tree-species showed no major changes compared to the 1990 survey. In spite of the combined assessment of defoliation and discolouration, the figures presented here are only for defoliation.

For **all species,** 52.5% were healthy, 30.3% were in the warning stage (class 1), 17.2% were notably damaged, including 1.1% of dead trees. Overall, damage decreased by 1.6 percent points.

Of the **conifers,** 48.7% were healthy, 29.9% were in the warning stage, 21.4% were notably damaged, including 1.0% of dead trees.

Of the **broadleaves,** 59.5% were healthy, 31.1% were in the warning stage, 9.4% were notably damaged, including 1.3% of dead trees.

As to coniferous trees, the health of **Scots pine** has deteriorated compared to 1990. For **Austrian** and **Corsican pines, Douglas fir** and **Norway spruce,** there seems to be an improvement in 1991; statistically, however, there are no significant differences compared to last year for these species. **Austrian** and **Corsican pines** and **Douglas fir** still belong to the least healthy tree species in the Netherlands.

Concerning the broadleaved species, the health of **oak** has improved compared to 1990. The health of the other broadleaved trees remained the same.

Interpretation

Deterioration of forest health is considered to be the result of interactions between air pollution and traditional factors such as drought, insects, frost etc. In 1991, the general decrease of insect and fungal damage has influenced the health of some species in a positive way. As to the weather situation last year it is likely that the generally dry year has caused some negative effects on some species.

United Kingdom

Results

The Forestry Commission published the following results obtained from the survey of the national network of sample plots. Of all of the 5 species investigated, 6% were healthy, 37.3% were in the warning stage, 56.7% were notably defoliated.

Of the conifers, 6.5% were healthy 42.0% were in the warning stage, 51.5% were notably defoliated. Of the broadleaves, 5.0% were healthy, 29.4% were in the warning stage, 65.6% were notably defoliated.

An overall analysis revealed that the number of trees with deteriorating crown density occurred mainly amongst trees previously not defoliated. Shoot mortality in conifers and crown dieback in broadleaves is a significant index of crown condition and considered superior to crown density. Shoot mortality in 1991 exceeded that of 1990 except for beech which showed a slight improvement. While shoot death decreased in all conifers, meterological events such as late spring frost and heavy snow combined with strong winds caused considerable damage in some regions. Sitka spruce severely defoliated in 1990. In beech the incidence of unusually small leaves was much less in 1991 than in the previous year as was mast production. Norway spruce suffered from mechanical, friction-related damage of the crowns, often the major part of the crown was broken off. It is assumed that weather preceding the assessment period has negative impacts on the results. Heavy snow fall in December 1990 followed by strong winds, also severe frost in late May resulted in broken crowns and reddened needles of spruce. On the other hand, a comparatively hard winter effectively reduced the green aphid populations in Sitka spruce in the summer. The summer droughts of 1989 and 1990 are expected to exert continued influence on forest health in the coming years. Climatic conditions continue to be the most important factor affecting trees. However, the possibility of air pollution having adverse effects on forest condition cannot be excluded.

3.2.5 Southeastern Europe

With 17.3 million ha this group represents 8.2% of the total forest area, 3.2% of the coniferous and 16.4% of the broadleaved forest area.

Forests and defoliation in Southeastern Europe

Country	forest area (1000 ha)	forest. cover (%)	conifers (1000 ha)	broad-leaves (1000 ha)	defolia-tion (%) class 2-4
Bulgaria	3314	29.9	1172	2142	21.8
Hungary	1684	18.1	264	1420	19.6
Romania	6244	26.3	1929	4315	9.7
Yugoslavia*	6100	23.8	900	5200	9.8
Total	17342	29.2	4265	13077	9.7-21.8

*) former Yugoslavia excluding Croatia and Slovenia

Bulgaria

The 1991 survey took place in July and August. 4 724 sample trees were assessed on 116 plots. The total number of permanent plots is 246,116 of them were investigated in 1991.

Results

In general the health of the **coniferous forest** deteriorated in 1991 compared to the 1990 results: 66% of the trees were damaged versus 59.9% in 1990. The percentage of slighdy defoliated trees increased from 22.5% in 1990 to 39.5% in 1991 while the percentage of the moderately to severely damaged trees decreased from 37.4% in 1990 to 26.5% in 1991.

In the **broadleaves** health deteriorated too. The number of damaged trees increased from 36.6% in 1990 to 40.7% in 1991. Severely damaged and dead trees increased by 2.7 percent points. The number of discoloured trees increased by 5.5 percent points compared to the 1990 results. Severely discoloured trees increased from 0.9% in 1990 to 1.9% in 1992.

Changes in the intensity of defoliation at the species level was notable. The health of **Scots pine, Norway spruce** and **Silver fir** declined in the age group of trees under 60 years. In the broadleaves the percentage of damaged trees of common **beech** increased in the age group under 60 years from 17.5% in 1990 to 23.6% in 1991. The same trend was observed in the age group over 60 years. There was a slight recovery of the health of **oak** in the age group under 60 years. The percentage of discoloured **Scots pine** and **Silver fir** decreased compared to the 1990 results. There was an increase in the percentage of discoloured **Norway spruce** and **Austrian pine,** respectively, by 5.8 percent points and 24.8 percent points.

Interpretation

In 1991 the climatic conditions changed in all vegetation regions in Bulgaria. Precipitation was below the normal rate while temperature was higher than normal. The percentage of acid rains increased, and higher concentrations of some heavy metals such as Mn, Cu, Pb, Cd and Zn were registered in soil samples, especially at the altitude 700-900 m. Compared to the 1990 results the increase of Mn is by 14,2 mg/kg year, of Cu by 4,7 mg/kg year, of Pb by 2,7 mg/kg year, and of Cd by 0,015 mg/kg year.

In the conifers, **Scots and Austrian pines,** pest attacks caused by ***Tomicus piniperda, Leocaspis lewi, Cerambicidae, Heterobasidium annosum, Lophodermium sp., Cenangium sp.*** were observed. **Oaks** in1991 were seriously attacked by ***Ceratocyctis*** and ***Hypoxilon sp.,*** common **beech** by ***Orchestes fagi.*** Soil chemical analyses continue, aiming at identifying the critical heavy metal concentrations of Cu and Zn for Scots and Austrian pines. Heavy metal concentrations were analysed in some herb indicator species.

Hungary

Results

The forest damage survey on level 1 was undertaken from 1 to 31 August, 20 858 sample trees were assessed (3 403 **conifers** and 17 455 **broadleaves).**

Of all species, 48.3% were healthy, 32.1% were in the warning stage, 19.6% were notably defoliated (classes 2 to 4), 1.8% of which had died.

47.2% of the **broadleaves** and 53.5% of the **conifers** were without defoliation and the proportions in the other damage classes were similar to the overall figures, but the conifers were slightly better in each damage class.

81.1% of the sample trees were without discolouration, while 19.0% showed slight to severe discolouration of which 4.6% were moderately to severely discoloured. The combined score for defoliation and discolouration was 52.4% for classes 1-4 and 20,5% for moderately to severely damaged or dead trees (classes 2-4).

At the individual species level **robur oak, Sessile oak, black locust** and **Scots pine** were the most defoliated (30.4%, 29.8%, 24.3%, 20.6% above 25% defoliation, respectively). **Beech, hornbeam** and **spruce** were the least defoliated (8.1%, 8.9%, 9.7% above 25% defoliation, respectively).

A comparison of the survey results for 1988-1991 shows nearly 15% defoliation increase annually except for the last year. In 1991 the tendency has continued in the case of **oaks -** 10% worsening was registered. **Hornbeam** and **Scots pine** improved while the other species stagnated or improved slightly. Outstanding improvement - above 20% - can be seen in the discolouration scores.

Interpretation

In the 1990 report the 10 year drought period was pointed out as a contributing factor of forest damages. The precipitation in 1991 was about normal (close to the 630 mm/year average). It seems to support the hypothesis about the importance of water supply, because the negative tendency of defoliation turned into stagnation in 1991. The fast growing tree species like improved **poplars, black locust** or **Scots pine** responded quickly, at least a slight improvement was observed. Natural leaf-fall was normal, no unusual early falls were registered. For the **oaks** the precipitation was not enough, more rainy or especially snowy years are necessary. **Spruce** seems to be the healthiest of all, but most of our stands are young, the elder stands are usually in a bad condition and should be cut at the age of 70-80. The higher precipitation seems to be the only explanation to the low discolouration rates.

Some words about the biotic damage factors: Game can be considered as a general damaging factor affecting especially the young and middleaged stands. Outstanding damage was observed in **oak, ash, lime, poplar** and **spruce** species. More than 50% of the broadleaved species were damaged by leaf eaters, e.g. **English oak** and other softwood above 70%, but **beech** and **black locust** were only slightly damaged. **Oak** decline affected 21% of **Sessile (Durmast) oaks** and 9% of **English oaks.** It is assumed that insects constitute the reason of the high mortality with 4% and 3.4% of the sample trees, respectively, having died.

Heterobasidion annosum is a basic problem in most of the **spruce** and **Scots pine** stands, making it necessary to reduce the rotation period in large areas. Scleroderris and Diplodia are the main causes of the **Austrian pine** dieback (with drought predisposing surely most of the trees). **Poplars** - especially improved varieties - were damaged by cancers (***Dothiciza***) and wood destroying beetles ***{Saperda, Paranthrene***, ***Aegeria***). Bark injuries, unfortunately common symptoms on **beech** - affected more than 30% of the sample trees.

Soil survey: On all level II plots a description of soil profiles was performed. Based on the preliminary manual for soil investigation (ECE/ICP) a systematic sampling was carried out with 16 replicates in 1991. Half of the large scale survey plots - 520 - were also supplemented by soil profiles. The other half will be surveyed in 1992. The soil samples of both levels are presendy under analysis in the labs.

Research work is going on at the second and third level of the forest damage survey, by collecting data in a more accurate way. A longer period of observation is necessary to take all the possible damage factors and effects into consideration and to obtain a more accurate scientific explanation of the phenomena observed.

Romania

Romania participated for the first time in the European forest damage survey in 1991. The survey was carried out in conjunction with the National Forest Inventory (NFI) using 2x2 km and 2x4 km networks in flat and hilly terrain, respectively. The NFI sampling unit consists of 2 satellites, located at 30 m distance east and west of the grid point. At the grid point 30 trees are selected according to EGE guidelines and assessed for defoliation. In 1991 a total of 243 473 sample trees were selected on 9333 sample plots.

Results

For **all species,** 61.6% were not defoliated (class 0), 28.7% were in the warning stage (class 1), 9.7% were notably defoliated (classes 2 to 4).

In the **conifers,** 63.4% were not defoliated, 29.6% were in the warning stage, 6.9% were notably defoliated (classes 2 to 4).

In the **broadleaves,** 61.1% were not defoliated, 28.4% were in the warning stage, 14.8% were notably defoliated.

At the species level, **Silver fir** was the most seriously affected coniferous species with 56.9% of healthy trees, 34.2% in the warning stage and 9% of all trees in classes 2-4.

Quercus spp. were strongly affected among the broadleaved species with 54.4% of trees showing no defoliation, 28.4% in the warning stage and 14.8% notably defoliated (classes 2 to 4).

Individually, **Quercus pedunculiflora** and **Quercus pubescens** were seriously defoliated with 32.2% of trees in classes 2-4, followed by **Populus sp.** (21.3%), **oaks** (20.9%), **Quercus frainetto** (19%), **Black locust** (15.4%), **Quercus sessiliflora** (13.3%), **black** and **white poplars** (12.2%) and **Quercus cerris** (10.9%).

The forest administration reports that in 1991 species groups and species improved by about 5.5 percent points in comparison to 1990.

Defoliation was highest on sites affected by drought or other climatic stress factors. However, local industrial sources and transboundary air pollution are contributing factors.
Special investigations: As of 1991 a network of permanent plots will be established particularly in order to investigate the influence of climatic stress. However, also deposition and soils will also be investigated. For this reason sample plots will be established in the vicinity of metereological stations.

Yugoslavia

The data for Yugoslavia concern Bosnia and Herzegovina, Montenegro, Macedonia and Serbia. The dominant conifer species in the continental part are Silver fir and Norway spruce and in the Mediterranean part Austrian and Scots pines. Of broadleaved trees, common beech, sessile-flowered and common oaks dominate the continental part, and Holm oak and Downy oak (Quercus virgiliana) the Mediterranean part.

Results

74.5% of **all species** were not defoliated, 15.7% were in the warning stage (class 1), notable defoliation was found in 9.8%. For **conifers,** 62.5% were healthy, 21.6% were in the warning stage, 15.9% were notably defoliated (classes 2-4). For **Silver fir,** 22.9% of the trees are in class 1, notable defoliation was found in 22.5% of the trees. In other conifer species defoliation is more moderate. As regards **broadleaves,** 77.1% were without defoliation, and 0.6% of trees were dead. For **oak,** defoliation was registered in 22.9% and for **beech** in 19.2% of all trees. In (evergreen) broadleaved forests in the Mediterranean 25.3% were notably defoliated.

Interpretation

The 1991 survey results demonstrate, that after a recovery in 1990, forest damage was again slightly on the rise. Evergreen broadleaved Mediterranean forests have been shown to be more sensitive to the impact of air pollution than continental deciduous broadleaved forests. The assumed cause is leaf retention and the extreme conditions of the habitat prevalent in the Mediterranean. Eumediterranean forests are more damaged than the submediterranean types.

Of great relevance for the forest dieback process is the warm and dry period from 1981 to 1988, the impact of increased sulphur emissions and deposition and the incidence of diseases and pests. Of **pine** diseases the fungus ***Sphaeropsis sapinea*** is most dangerous, but also Cenangium ferruginosum in 1986. **Norway spruce** is constandy threatened by ***Herobasidium annosum.*** In **broadleaved** species, the major threats are **beech** bark cancer ***Nectria coccinea,*** on **chestnut** ***Cryphonectria parasitica,*** and on **oaks** ***Ophiostoma sp.*** which has been harming oak forests since 1918.

Of insects, the most dangerous species for **conifer** forests are ***Scolitidae*** and for **oak** forests leaf defoliators. Especially damaging to **beech** were ***Agrilus viridis*** and ***Rhynchaenus fagi-***

Special investigations

Since 1988 an integrated scientific programme, P-271, has been implemented in Yugoslavia for establishing the causes of forest dieback. The research encompasses the impact of air pollution, diseases and pests on forests and their effects as reflected in tree increment and biogenic elements uptake.

3.2.6 Eastern Europe

With 43.7 million ha this group represents 20.4% of the total forest area, 24.3% of the coniferous and 12.7% of the broadleaved area.

Forests and defoliation in Eastern Europe

Country	forest area (1000 ha)	forest cover (%)	conifers (1000ha)	broad-leaves (1000 ha)	defolia-tion (%) class 2-4
Belarus	6002	28.9	4124	1878	n.a.
Russian Federation	31592	39.3	25518	6074	n.a.
Ukraine	6151	10.2	2931	3220	n.a.
Total	43745	25.5	32573	10172	n.a.

Belarus

No data were available at the time this report was compiled.

Russian Federation

Arkhangelsk Region

Climate and soils: The Arkhangelsk region covers an area of 58.7 million ha in the northeast of the European part of the Russian Federation. The climate is not uniform throughout the territory. In the northern part it is arctic while in the south it is temperate-continental. The mean air temperature in January ranges from -12 to -18° C, in July from +8 to +17° C. Annual precipitation amounts to 500 mm. The vegetation period lasts 50-60 days in the north and 150-155 days in the south. The annual sum of above zero temperatures in the forest zone attains 1,500 - 1,600° C. In winter southwestern winds prevail whereas in summer western and northwestern winds dominate.

The quantity of precipitation exceeds evaporation. Consequently, in plains boggy-podzol and gley-podzol soils prevail. The hills are dominated by podzols, and peaty soils prevail in the lowlands.

Forestry: The total forest area in the Arkhangelsk region covers 21.8 million ha. The stocked area covers 19.8 million ha of the total area. Conifers comprise 85.7% of all forests. Spruce stands occupy 11.7 million ha (or nearly 59% of all forests), whereas pine stands occur on 5.3 million ha (26.7% of all forests). Vaccinium (Myrtillus sp.) on well-drained areas and Sphagnum forest types are widespread.

Air pollution: Because of a significant number of industrial enterprises (most of them near the city of Arkhangelsk) air pollution in the region is mainly of local origin, but long-range transport from Central Europe is also important. Emission of dust particles approximately attains 0.6 t/km² annually and that of nitric oxides about 0.1 t/km² yearly. The cellulose and paper industries in Arkhangelsk and Novodvinsk cause a high level of contamination of these towns by furufol and methyl mercaptan. Due to the low level of development of the road network, traffic-induced air pollution is slight (excluding towns).

Survey design: 56 plots with 1344 sample trees were randomly established. Of these, 55 plots were located in coniferous stands (30 in pine, 25 in spruce), 1 plot was established in birch.

Results

Only conifers (spruce and pine) were assessed in the 1991 survey. Broadleaves, about 14.3% of the forest area, consist mainly of birch, alders and poplar. 30.0% of the conifers were healthy, 45.3% were in the warning stage (class 1), 24.7% were moderately defoliated, no trees had died. It seems notable that 32.5% and 25.2% of young pine and spruce, respectively, were moderately defoliated while in older pine and spruce, the figures are only 17.8% and 5%. No explanation for these differences has been given.

Kaliningrad

Results

The 1991 survey was carried out from 1 August to 30 September on 102 permanent observation sites. A total of 2 453 trees were assessed. Defoliation, discolouration and other biometric parameters were determined. For all species 30.3% were healthy, 48.9% were in the warning stage (class 1), 20.8% were notably defoliated, including 0.3% of trees that had died. Of the conifers (Scots pine, Norway spruce, European larch) 8.4% were healthy, 57.3% were in the warning stage (class 1), 34.3% were moderately defoliated, including 0.4% of dead trees. Of the broadleaves (White birch, Black and Grey alder, poplar) 44.0% were healthy, 44.8% were in the warning stage, 11.2% were moderately defoliated, including 0.2% of dead trees. In both age groups, poplar with 22.0% and 52.9%, respectively, of moderately defoliated trees was most affected. The Lithuanian NFC, responsible for the survey in the Kaliningrad region, reports that 1991 has been a very dry year; this may explain the exceptionally strong defoliation in older poplar.

Interpretation

In 1991 **pine** sustained stronger damage than **spruce.** In contrast to spruce stands, forest decline was observed in pine stands aged 60 years and over. Since 1989 the proportion of healthy pine and spruce stands has been decreasing stepwise. In comparison to 1990, the number of healthy and moderately damaged trees diminished in 1991, whereas that of slightly and severely damaged trees increased insignificantly. The number of dead trees increased, too. The condition of **ash** was better than that of **oak.** However, the number of healthy trees decreased markedly in 1991 as compared to 1990. The condition of **Black alder** was rather good. However, in 1991 a negligible decrease in the number of healthy and moderately damaged trees occurred. A comparison of **aspen** (estimated from the presence of healthy trees) in 1990 and in 1991 showed that in 1991 defoliation slightly increased. Since 1989 the number of severely damaged aspen has been increasing particularly in older stands. The condition of **lime** (Tilia sp.) is characterized as good. In **Grey alder,** trees are healthy. 50% of **Hornbeam** and **maple** are found to be the most resistant. It is assumed that the condition of deciduous trees was slightly better in 1991 than in 1990. Over a period of 3 years a stepwise improvement of the health of deciduous trees was observed.

In order to improve the work associated with forest monitoring in the Kaliningrad region in 1992, it is indispensable:

1. to conduct forest monitoring in a grid of 4 x 4 km;

2. to measure the loads of $S0_2$ and NO_x (the method has been tested by scientists of the Lithuanian Forest Institute) in different forest zones;

3. to pass on to the second level of forest monitoring, i.e. soil and foliar analysis on permanent plots.

Training and control of work could be organized by the Lithuanian Forest Research Institute.

Murmansk Region

Climate and soils: The Murmansk region of the Russian Federation covers 11.5 million ha; it is situated beyond the polar circle, occupying the Cola Peninsula and adjacent regions along the boundaries with Norway and Finland. The climate is temperate-continental, damp and cool seasons prevailing. Mean temperatures range from -8 to -13° C in January and from +8° C to +14° C in July. The vegetation period comprises 107 to 125 days, i.e. 3.5 to 4 months, but does not reach 90 days in the mountains. The snow cover remains for 180-200 days, up to 220 days in the mountains. In the forest zone, southern and western winds prevail in winter, northern and eastern winds in summer. Precipitation exceeds evaporation and swampy podsolic, boggy, tundra and tundra-mountain soils prevail, with soil cover rarely exceeding 30-50 cm in thickness. In the mountains, shallow sites predominate.

Forestry: The total forest land is 5.02 million ha, 3.9 million ha are stocked forests, i.e. 34% of the total area. Of these, 73.7% are conifer forests, 26.3% are "soft" broadleaves, birch, alder and poplar. Scots pine forests are of low densitiy (stems/ha) with open canopy and of very low site class indices of V.4, with branchy stems and low, thin crowns. Average volume ranges from 50-70 m^3/ha.

Air pollution: Emissions of noxious substances from local pollution sources and traffic is 837 000 t/year composed of 74 0001 of heavy metals, of 568 0001 of sulphuric acid anhydride, of 114 0001 of carbon monoxide, of 24 0001 of nitric oxides and of 14 0001 of hydrocarbon. Emissions from metallurgical industries as stationary pollution sources constitute 78.4%. The impact of air pollutants with sourth-western winds cannot be quantified.

Survey design: Because of the different terrain conditions it has not been possible to establish a regular 16 x 16 km grid. Instead, 20 plots have been randomly established in **Scots pine,** 1 plot in a **Norway spruce** stand. These plots represent 2 025 million ha and 1 563 million ha of pine and spruce forests, respectively.

Results

For all **conifers,** 6.2% were healthy, 26.2% were in the warning stage (class 1), 66.6% were notably defoliated, no trees had died. Of 480 **pine** trees sampled, 13 plots with 24 trees each fell under young stands. Here, 2.9% were healthy, 10.8% were in the warning stage (class 1), 76.3% were notably defoliated, no trees had died. Of the trees in the plots in stands older than 60 years, 10.1% were healthy, 31.0% were in the warning stage, 58.9% were notably defoliated, no trees had died. Defoliation is highest in the central and southern parts with over 37%.

Discolouration is practically absent, only 1-2% of trees are slightly affected (up to 10% of needles affected).

St. Petersburg Region

The St. Petersburg region is situated on a plate, nearly 100 m above sea level with the exception of a few hills about 200 m high. The St. Petersburg region displays an extremely great variety of soils caused by a mix of glacial relief, heterogeneity of soil-forming rocks and hydrological conditions. Pine forests stock on the following soil types: 1) minimal podzolic humus sandy soil (26% area), 2) weakly, moderately, or strongly podzolic soils (16%), 3) peaty-podzolic soil (18%), 4) swampy (14%), 5) sod-podzolic soil (14%), 6) burozem on granite-residual (8%), 7) sod-gleyed soil (2%).

Climate, relief, soil: The St. Petersburg region is situated in the transition zone between the maritime and continental climates. Mean annual temperature is +4.5° C in the western part and +2.6° C in the northern and northeastern parts. Mean precipitation is 550-600 mm near the coast of the Finnish Gulf and Lake Ladoga, 800-850 mm near the Karelian Isthmus and the easthem part. The snow cover persists for 130 days in western and southwestern zones and up to 160 days in the eastern zone. The vegetation period extends from 160 to 175 days.

Forestry: Forests cover 4 565 million ha or 53.1% of the St. Petersburg region. **Conifer** forests cover 3.1 million ha, roughly 51% **Scots pine** (Pinus sylvestris) and other conifers 49%, comprising mainly **Norway spruce** (Picea abies) and **larch** (Larix spp.). **Broad-leaved** forests (1.46 million ha) consist mainly of **birch** (Betula spp.) and other species, mainly **aspen** (Populus tremula) and **alder** (Alnus spp.). Only **conifers** were assessed in 1991.

Survey design: In 1990 St. Petersburg State University with assistance of St. Petersburg Forestry Academy, General Geological Institute carried out a forest damage survey. Plots were arranged in 32 x 32 km and 16 x 16 km grids (bioindicator network) and 8x8 km in critical regions.

Results

The survey was carried out in August and September 1991. While discolouration was insignificant in comparison to Central Europe, defoliation was pronounced in some parts of the country. Of the **conifers,** 63.4% trees were healthy, 32.4% were in the warning stage (class 1), 4.2% trees were notably defoliated (classes 2-4) including 0.5% trees that had died.

Interpretation

Sources of air pollution are power plants (working on oil, solid fuel), oil- and oil-shale-processing plants, the metallurgical and metal-working industry, pulp and paper factories, chemical plants, glass manufacture, mining of bauxites, phosporites and their processing plants, cement and ceramic plants, traffic. The total emission of gaseous pollutants (official data) amounts to over 900 0001 per year.

Considerable influence is attributed to long-range air pollution from Southwestern countries and districts. There is a large-area of forest damage extending from the southwestern border to northeastern districts. **Pine** forests show the strongest damage and some of them have died near industrial pollutant sources and on forest land with a disturbed recovery system, particularly near construction sites and roads. Soil conditions are very important for the potential of pine trees to resist air pollution impacts. For example, in the Svetogorsk industrial zone with strong air pollution where pine forests grow on rich soil - burozem, there exist practically no forest stands that have died.

Special investigations

On a few sites investigations of snow, fall-out, insects, parasitic fungi, heavy metals in mosses and soil, radionuclids, fauna of animals and birds, flora of lichens on trees have been carried out.

Within the bioindicator network, 50 plots with 1171 sample trees were studied. In two areas with a total of near 52 000 ha, 5500 sample trees were observed more in detail (impact monitoring). All plots were established for investigations of air pollution effects on tree vitality, including soil, bark, needle and moss chemical analysis, tree ring analysis, needle necrosis and forestry pathology analysis, and licheno-indication of air pollution.

Ukraine

No data were available at the time this report was compiled.

3.2.7 Canada and United States

Extensive information on survey activities in Canada (ARNEWS-Project) and the United States of America (NAPAP-Project) was presented in the 1990 UN/ECE Forest Damage Report.

In **Canada,** Forestry Canada, the responsible agency for forest health monitoring, is presently compiling the 1991 ARNEWS Annual Report. The forest administration indicated that a modest extension of the present 107 monitoring plot network has been started to cover adequately important forest ecosystems across Canada. Also, a "Strategy plan for research on climate change" is being designed to cover this important aspect of preventive forest management.

A report on forest health monitoring in the **United States of America** will very likely be available when the final editing of the 1991 draft report is being undertaken.

4. INTERPRETATION OF RESULTS

4.1 Interpretation of transnational results

The transnational survey results of 1991 revealed that 22.2% of the total tree sample (about 83 000 trees on 3 800 plots) had a **defoliation** larger than 25% (defoliation classes 2-4) and are thus classified as damaged. This value is 1.4 percent points larger than the respective value in 1990 (20.8%), which means that the number of trees considered as damaged has risen by 6.7% within a year. This increase is even larger if only the EC countries are considered. In the EC countries the percentage of damaged trees increased from 15.1% in 1990 to 18.4% in 1991, i.e. 3.3 percent points resembling an increase of the proportion of damaged trees by nearly 22%.

In 1991 a **discolouration** of more than 10% (discolouration classes 1-4) was observed in 10.6% of the total tree sample, which is a decrease by 3.2 percent points as compared with the previous year (13.8% in 1990). This resembles a shrinkage of the proportion of defoliated trees by 23.2%. In the EC countries the share of trees with a discolouration greater than 10% was 14.1%, which is nearly no change against the respective value of 1990 (14.4%).

As regards **species groups,** 18.5% of the total **broadleaves** were in defoliation classes 2-4 in 1991, which indicates a higher vitality than the respective share of the total **conifers,** namely 24.4%. In the EC the respective values are 17.6% and 19.4%.

Quercus suber has remained the most defoliated species with 43.0% of the trees in classes 2-4 in 1991 (41.6% in 1990), followed by ***Abies sp.*** (27.5%) and ***Picea sp.*** (26.9%). The least defoliated species were ***Quercus ilex*** (4.4% in classes 2-4), ***Eucalyptus sp.*** (6.75%) ***andLarixsp.*** (8.2%).

Quercus suber was also the most discoloured species in 1991 (41.7% of the trees in discolouration classes 1-4), followed by ***Castanea sativa*** (16.1%) and ***Abies sp.*** (15.0%.). The least discoloured species was ***Quercus ilex*** with 2.8% of the trees in classes 1-4.

Among the climatic regions, the Sub-atlantic region stands out clearly as the most damaged one with 31.7% of the trees in defoliation classes 2-4. The percentage of damaged trees in the other climatic regions ranges from 11.7% (Mountainous region) to 20.4% (Atlantic region).

The subsample of the 61 395 **Common Sample Trees (CSTs)** of the 1990 and 1991 surveys accounted for 74 % of the total tree sample of 1991. The CSTs showed an increase of trees in defoliation classes 2-4 by 2.6 percent points, namely from 20.8% in 1990 to 23.4% in 1991. This resembles an increase by 12.5%, which is even larger than the respective increase by 6.7% of the total tree sample. This indicates that the slight deterioration of the total tree sample is not merely an artefact caused by the inclusion of a higher number of less vital trees in the course of the extension of the grid network. This is supported by the maps in Annexes 1-5, 1-8 and 1-9. Annex 1-5 illustrates that no unusually high shares of damaged trees were included in the survey with the participation of Finland and Sweden. Annexes 1-8 and 1-9 document that the number of plots showing a deterioration of vitality surpasses that of the plots with improved vitality.

The increase of the percentages of CSTs in defoliation classes 2-4 occurred mainly in the Atlantic, Sub-atlantic and Mediterranean regions, whereas no changes in defoliation were found in the Mountainous region. As regards discolouration, slight decreases of the percentages of trees in discolouration classes 1-4 were observed in the Sub-atlantic, Mountainous and Mediterranean regions. Only in the Atlantic region did the share of discoloured trees increase slightly.

The increase defoliation of the CSTs occurred in nearly all species groups. In the broadleaves the share of CSTs in defoliation classes 2-4 rose from 16.6% to 18.3%. In the coniferous CSTs the respective increase was larger, namely from 24.3% to 27.7%.

For several of the species represented in the **common trees of 1988-1991,** an increase of the percentage of trees in defoliation classes 2-4 over these years was found. The greatest deterioration occurred in ***Quercus suber***, followed by ***Pinus nigra*** and ***Pinus pinaster***. A slight deterioration was observed for ***Fagus sylvatica, Pinus sylvestris*** and ***Picea abies***. No important changes occurred in ***Quercus robur*** and ***Quercus petraea*** as well as in ***Pinus halepensis, Picea sitchensis*** and ***Abies alba***. The defoliation of ***Larix decidua*** even decreased slightly. As regards discolouration, notable fluctuations and differences are revealed over the years without showing a clear trend.

In an interpretation of the survey results the question must be addressed as to how reliable the results are and what can be derived from them. There has been some criticism with respect to the multitude of factors which may cause the unspecific symptoms which are assessed in the survey. This raises the question, if the results obtained are conclusive because of the harmonized assessment methodologies, or if the harmonization has only hidden individual reactions and therefore rendered inconclusive results.

As to the suitability of the harmonized methods it should be stated that their results should be interpreted only as deviations from local standards. Of course, there remains the problem in separating changes in the density and the colouration of the foliage which is attributable to air pollution from those caused by other factors. Most of these factors, however, are subject to periodic and regional changes, so that their effects are also likely to show a high spatial and temporal variation. The results of the transnational survey, however, show a clear trend: a continuing overall deterioration of the vitality. It is this trend which cannot be readily explained by the above mentioned factors, and which requires an explanation. Continuing impact of air pollution is one of the possible explanations.

The above considerations also raise the question, if the large-scale approach is suitable to tackle the questions which have to be answered. It is evident that cause-effect relationships can be better scrutinized on permanent sample plots. On the other hand, any effects showing large scale spatial and temporal variation can only be scrutinized by means of a 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.

The above considerations clearly reveal that it is not the forest condition in a particular year, but a time series of many consecutive years that can best give evidence of the potential impact of transboundary air pollution and other factors. It is therefore indispensable for both scientific and political reasons to continue the transnational survey of forest condition in years to come. This means that the complete and correct collection of annual data in the future is of paramount importance for an understanding of the dynamics of forest condition.

In the present Report not all parameters assessed by most of the participating countries have been evaluated, because their evaluation in previous years has ijot led to conclusive results. Considering the importance of time series, however, the assessment of parameters should be continued to be assessed and even started to be assessed by those countries which have not yet already done so. For future in-depth analyses the complete data set will be needed.

The parameters presendy recorded in the survey do not provide a complete and extensive description of site conditions. The collection of more detailed information on site and stand parameters deserves high priority in order to provide insight into the complex cause-effect relationships between air pollution and forest condition. For instance, in 1990 and 1991 the soil type was inventoried on a voluntary basis by two countries. Given 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.

4.2 Interpretation of national results

Important figures of the **national results** are listed in the tables in Annex II. Annex II-l gives an overview of participating countries, forest areas, density of grids and extent of survey activities. Annexes II-2 to II-4 contain results for all species and species groups (conifers and broadleaves). Annex II-5 documents the changes in defoliation having occurred in coniferous and broadleaved species between 1986 and 1991.

The table in Annex II-2 gives evidence of the defoliation of all species and its spatial distribution over Europe:

5 of 28 countries have reported that the proportion of trees with needle/leaf loss of over 25 % (defoliation classes 2 to 4) is less than 10 %. These countries are Austria, France, Romania, Spain and Yugoslavia. 12 countries, i.e. Belgium, Finland, Greece, Hungary, Ireland, Italy, Liechtenstein, Netherlands, Norway, Slovenia, Sweden and Switzerland have reported that from 10 to 20 % of all trees have lost more than 25 % of foliage. Another 9 countries, i.e. Bulgaria, Czechoslavakia, Denmark, Estonia, Germany, Lithuania, Luxembourg, Poland, Portugal and Russia have submitted results showing that the proportion of trees in defoliation classes 2 to 4 ranges from 20 % to 45 %. In the United Kingdom, nearly 57 % of the trees have defoliation greater than 25 %.

The majority of highly and critically affected forests occurs in Bulgaria, Czechoslovakia, Germany, Poland and the UK. Here, defoliation in coniferous forests is particularly high. In the broadleaves, beech in Denmark and birch in Sweden show high levels of defoliation. Some species of oak show deterioration, particularly in Portugal, which is the result of adverse climatic conditions, frequent forest fires and the soil exploitation typical for this Mediterranean forest type. Some Mediterranean countries reported forest destruction, mainly caused by fires (almost 420 000 ha in Greece, Portugal and Spain) and degradation caused by drought.

The overall tendency in 1991 has been a deterioriation in the majority of countries. The following table describes the changes of defoliation that were observed between 1990 and 1991 in classes 2 to 4 (more than 25 % of needlesAeaves 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, moderate between 10.1 and 20 percent points, 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
all species	15	3	1	-	2	-
conifers	13	5	1	-	2	2
broadleaves	15	2	-	1	-	2

Table 4.2-1: Numbers of countries showing increase, decrease or no change in defoliation by species groups

The differences in the spatial and temporal development of forest damage which became particularly evident in 1988 still exist. They support the opinion of many scientists that forest decline can best be described as a process of high causal complexity, involving both abiotic and biotic factors.

In 4 countries, namely Czechoslovakia, Germany, Lithuania and Poland, air pollution is considered as an essential factor in the determination of the quality of forest stands. Forest ecosystems are negatively affected by depositions of sulphur dioxide, nitrogen compounds and their atmospheric transformation products, acids and ozone. Forest management decisions are strongly influenced where air pollution risks are high.

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 mission of the two Programmes, particular attention is being paid to the effects of air pollution as one of the many factors having caused the symptoms observed. Very little direct impact from known air pollution sources has been reported. However, some countries consider 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 (UN/ECE, 1991).

The statements made in the previous reports of UN/ECE on the higher risks in old stands are still valid. However, the above species-related results indicate that increasingly considerable defoliation occurs also in younger stands.

5. CONCLUSIONS

Due to the agreement between UN/ECE and EC to extend the transnational survey also to the Non-EC member states of UN/ECE, the transnational database has increased considerably in 1991. Transnational survey results have been reported for about 83000 trees on about 3800 plots in 20 countries. Including the national surveys, the total database of the ICP Forests of UN/ECE and the Directorate General for Agriculture of EC meanwhile comprises about 700 000 sample trees on about 36 000 plots in 33 European countries, representing approximately 168 million ha of forests. Canada and the United States of America cooperate with the ICP and conduct forest health monitoring programmes in North America. This means that the first objective of the two UN/ECE and EC programmes has been achieved. As the complete and correct collection of annual data on forest health is considered to be of paramount importance, both the national and transnational surveys will be continued in years to come. Only time series of many consecutive years will allow final conclusions on the trends in forest condition.

Forest damage, expressed as a loss of needles or leaves, has been observed to a different extent in all of the participating countries. In many regions forests at higher elevations and forests older than 60 years continue to be considerably more heavily defoliated than younger stands and forests at lower elevations. Several thousand hectares of forests on mountain tops in Czechoslovakia, the Federal Republic of Germany and in Poland are most heavily affected.

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. Some countries consider 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.

A continuation of the present pollution load for extended periods of time or an increase in pollution levels is expected to threaten the vitality of forests over large areas of Europe. The atmospheric concentrations and the deposition of certain pollutants in many areas exceed the levels at which disturbance to forest ecosystems would be expected. In such situations, a reduction of the air pollution load should improve the condition of endangered forests and postpone further disruption to ecosystems. Sulphur dioxide, ammonia nitrogen oxide (as a precursor of ozone and acid deposition) and others may all be important in particular areas (UN/ECE, 1991). Many countries have emphasized the importance of dry conditions in 1990 and 1991, 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 Task Force therefore supports any moves that might help to reduce the rate of global warming.

The overall situation of forests in Europe indicates a clear need for continued monitoring. This monitoring should not only describe forest condition, but should also contribute to better understanding of cause-effect relationships. Therefore, the following actions will be taken:

- intensified cause-effect research in a second network of permanent sample plots by means of harmonized methods

- a synopsis 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 goals are in full agreement with stipulations made by European Ministers at the Ministerial Conference on the Protection of Forests in Europe, at Strasbourg, in December 1990.

The two Programmes under the UN/ECE and EC have taken up this challenge. The ICP Forests will adopt a submanual containing instructions on the sampling and chemical analysis of soil in European forests. Further submanuals on increment studies as well as the sampling and analysis of needles and leaves and deposition measurements are presently being prepared. The difficult economical and political situation in many parts of Eastern Europe gives reason for concern with respect to continued cooperation. Special efforts are necessary to warrant cohesion of the ICP Forests.

The close cooperation between UN/ECE and the European Community which is apparent in the joint assessment of forest condition (and monitoring of forest ecosystems) in Europe is the first step towards an integrative evaluation of ecological data compiled by various programmes in years to come.

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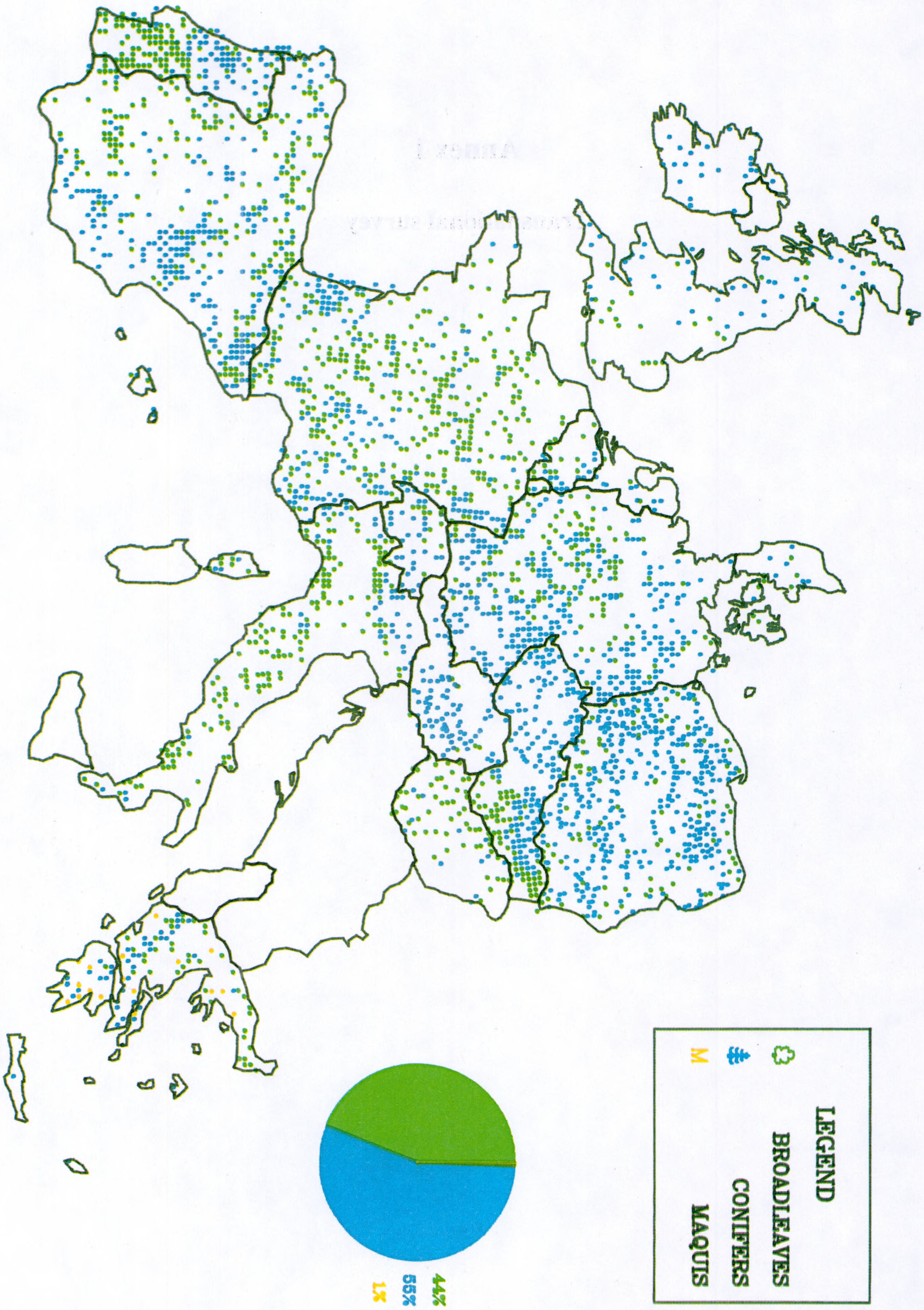
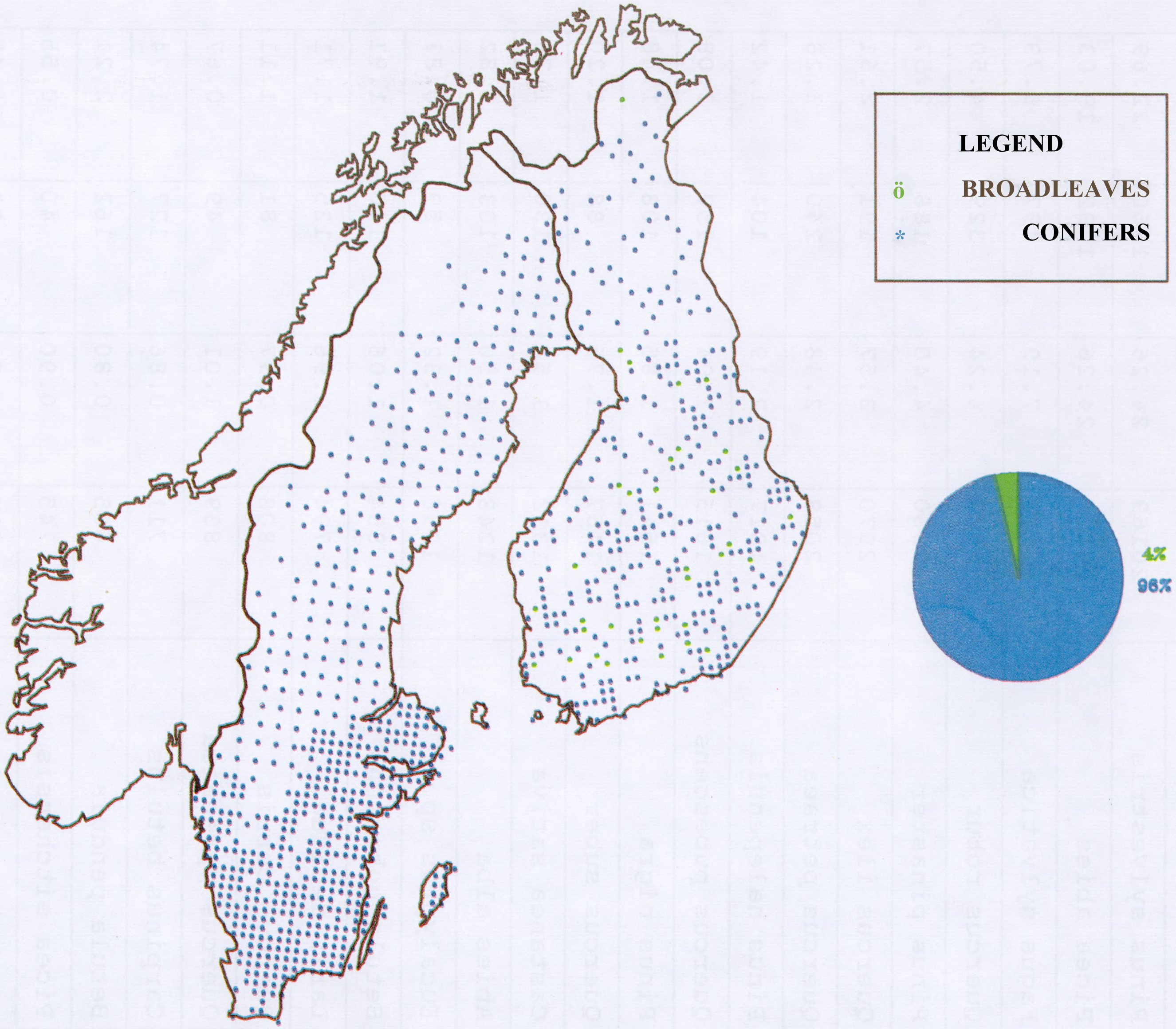
Annex I

Transnational survey

Annex 1-1

Broadleaves and conifers (1991)




LEGEND
ö BROADLEAVES
* CONIFERS
4%
96%

Annex 1-2

Species assessed (1991)

EUROPEAN COMMUNITY AND ICP	OBSERVED TREES		OBSERVED PLOTS	
	COUNT	%	COUNT	%
SPECIES				
Pinus sylvestris	20169	24.26	1660	22.69
Picea abies	20172	24.26	1392	19.03
Fagus sylvatica	5978	7.19	497	6.79
Quercus robur	3527	4.24	329	4.50
Pinus pinaster	3660	4.40	188	2.57
Quercus ilex	2970	3.57	191	2.61
Quercus petraea	2058	2.48	240	3.28
Pinus halepensis	1817	2.19	104	1.42
Quercus pubescens	1615	1.94	152	2.08
Pinus nigra	1541	1.85	108	1.48
Quercus suber	1457	1.75	88	1.20
Castanea sativa	1313	1.58	130	1.78
Abies alba	1248	1.50	133	1.82
Eucalyptus sp.	1096	1. 32	59	0.81
Betula pubescens	884	1.06	140	1.91
Larix decidua	794	0.96	125	1.71
Quercus cerris	808	0.97	81	1.11
Quercus pyrenaica	839	1.01	49	0. 67
Carpinus betulus	711	0.86	127	1.74
Betula pendula	665	0.80	162	2.21
Picea sitchensis	745	0.90	40	0.55
Quercus rotundifolia	689	0.83	33	0.45
Fraxinus excelsior	586	0.70	118	1.61
Robinia pseudacacia	596	0.72	57	0.78
Pseudotsuga menziesii	472	0.57	42	0.57

EUROPEAN COMMUNITY AND ICP	OBSERVED TREES		OBSERVED PLOTS	
	COUNT	%	COUNT	%
SPECIES				
Populus hybrides	451	0.54	26	0.36
Ainus glutinosa	400	0.48	48	0.66
Quercus faginea	361	0.43	44	0.60
Acer pseudoplatanus	288	0.35	83	1.13
Pinus pinea	305	0.37	29	0.40
Quercus frainetto	290	0.35	18	0.25
Abies cephalonica	292	0.35	14	0.19
Populus tremula	220	0.26	76	1.04
Quercus coccifera	265	0.32	19	0.26
Ostrya carpinifolia	242	0.29	37	0.51
Prunus avium	194	0.23	72	0.98
Juniperus thurifera	243	0.29	20	0.27
Other broadleaves	192	0.23	60	0.82
Abies borisii-regis	179	0.22	10	0.14
Tilia cordata	150	0.18	30	0.41
Pinus contorta	162	0.19	10	0.14
Acer campestre	111	0.13	43	0.59
Pinus uncinata	142	0.17	10	0.14
Fagus moesiaca	145	0.17	7	0.10
Quercus rubra	127	0.15	19	0.26
Olea europaea	121	0.15	17	0.23
Fraxinus ornus	89	0.11	25	0.34
Ainus cordata	98	0.12	8	0.11
Pinus brutia	100	0.12	6	0.08
Pinus radiata	98	0.12	5	0. 07

EUROPEAN COMMUNITY AND ICP	OBSERVED TREES		OBSERVED PLOTS	
	COUNT	%	COUNT	%
SPECIES				
Populus nigra	73	0.09	12	0.16
Juniperus oxycedrus	67	0.08	18	0.25
Platanus orientalis	76	0.09	5	0.07
Populus alba	69	0.08	5	0.07
Larix kaempferi	63	0. 08	7	0.10
Sorbus aria	41	0.05	24	0.33
Arbutus unedo	54	0.06	10	0.14
Pinus cembra	56	0.07	7	0.10
Acer monspessulanum	43	0.05	15	0.21
Alnus incana	44	0.05	14	0.19
Pinus strobus	52	0. 06	5	0.07
Juniperus phoenica	4 5	0.05	9	0.12
Salix caprea	36	0.04	15	0.21
Quercus trojana	44	0.05	5	0. 07
Populus canescens	44	0.05	3	0.04
Ulmus minor	40	0.05	7	0.10
Juniperus communis	34	0.04	9	0.12
Tilia platyphyllos	32	0.04	9	0.12
Salix sp.	31	0.04	10	0.14
Sorbus aucuparia	28	0.03	12	0.16
Abies nordmanniana	37	0.04	3	0. 04
Phillyrea Latifolia	32	0.04	7	0.10
Sorbus torminalis	20	0.02	18	0.25
Cupressus sempervirens	3 0	0.04	4	0.05
Ulmus glabra	16	0.02	13	0.18

EUROPEAN COMMUNITY AND ICP	OBSERVED TREES		OBSERVED PLOTS	
	COUNT	%	COUNT	%
SPECIES				
Corylus avellana	20	0. 02	8	0.11
Acer platanoides	16	0.02	11	0.15
Buxus sempervirens	23	0.03	4	0.05
Arbutus andrachne	23	0.03	3	0. 04
Pinus mugo	24	0.03	í	0.01
Quercus macrolepsis	21	0. 03	1	0.01
Sorbus domestica	13	0.02	8	0.11
Acer opalus	12	0.01	8	0.11
Pyrus communis	13	0.02	6	0.08
Other conifers	15	0.02	4	0 é 05
Quercus fruticosa	18	0.02	1	0.01
Carpinus orientalis	14	0.02	4	0.05
Phillyrea Augustifolia	17	0.02	1	0.01
Rhamnus alaternus	14	0.02	1	0.01
Cercis siliquastrum	11	0.01	2	0.03
Tsuga sp.	11	0.01	1	0.01
Fagus orientalis	11	0.01	1	0.01
Pinus leucodermis	11	0.01	1	0.01
Pistacia terebinthus	10	0.01	1	0.01
Ilex aquifolium	6	0.01	3	0.04
Prunus dulcis	8	0.01	1	0.01
Abies grandis	6	0.01	2	0.03
Ainus viridis	7	0.01	1	0.01
Salix alba	4	0.00	3	0.04
Salix eleagnos	5	0.01	1	0.01

EUROPEAN COMMUNITY AND ICP	OBSERVED TREES		OBSERVED PLOTS	
	COUNT	%	COUNT	%
SPECIES				
Thuya sp.	4	0.00	1	0.01
Juniperus sabina	4	0.00	1	0.01
Pistacia lentiscus	2	0.00	1	0.01
Prunus serotina	2	0.00	1	0.01
Cedrus atlantica	1	0.00	1	0.01
Taxus baccata	1	0.00	1	0.01
Prunus padus	1	0.00	1	0.01
Picea omorika	1	0.00	1	0.01
Cedrus deodara	1	0.00	1	0.01
Juglans regia	1	0.00	1	0.01
Ceratonia siliqua	1	0.00	1	0.01
TOTAL SPECIES	83134	100.00	7316	100.00

Annex 1-3
Defoliation by species group and climatic region (1991)

TOTAL CLIMATIC REGIONS	DEFOLIATION					TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	
	%	%	%	%	%	%
SPECIES						
Castanea sativa	64.97	20.64	11.12	2.51	0.76	100.00
Eucalyptus sp.	85.22	8.03	4.38	0.36	2.01	100.00
Fagus sp.	50.78	31.82	16.09	• 1.14	0.16	100.00
Quercus (deciduous) sp	49.59	30.56	17.43	2.00	0.42	100.00
Quercus ilex	58.69	36.90	4.11	0.17	0.13	100.00
Quercus suber	28.00	28.96	39.53	2.68	0.82	100.00
Other broadleaves	53.89	25.30	16.98	2.93	0.90	100.00
TOTAL BROADLEAVES	52.79	28.69	16.06	1.90	0.56	100.00
Abies sp.	47.05	25.43	24.01	2.50	1.02	100.00
Larix sp.	67.79	24.04	7.82	0.23	0.12	100.00
Picea sp.	39.05	34.04	24.44	2.22	0.25	100.00
Pinus sp.	42.96	33.94	20.99	1.50	0.61	100.00
Other conifers	64.55	21.23	13.04	0.86	0.32	100.00
TOTAL CONIFERS	42.33	33.31	22 .11	1.79	0.47	100.00
TOTAL EEC & ICP	46.17	31.61	19.89	1.83	0.50	100.00

TOTAL CLIMATIC REGIONS - EEC	DEFOLIATION					TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	
	%	%	%	%	%	%
SPECIES						
Castanea sativa	66.15	19.66	11.15	2.57	0.47	100.00
Eucalyptus sp.	85.22	8.03	4.38	0.36	2.01	100.00
Fagus sp.	50.87	30.45	17.27	1.30	**0.11**	100.00
Quercus (deciduous) **sp**	54.18	28.02	15.36	2.13	0.32	100.00
Quercus ilex	58.69	36.90	4.11	0.17	0.13	100.00
Quercus suber	28.00	28.96	39.53	2.68	0.82	100.00
Other broadleaves	56.24	24.31	15.95	2.73	0.76	100.00
TOTAL BROADLEAVES	55.06	27.36	15.23	1.87	0.48	100.00
Abies sp.	57.91	23.43	16.05	1.31	1.31	100.00
Larix sp.	68.60	22.77	8.33	0.15	0.15	100.00
Picea sp.	39.20	33.92	25.31	1.39	0.18	100.00
Pinus sp.	54.61	28.23	14.81	1.27	1.07	100.00
Other conifers	64.51	21.25	13.03	0.88	0.33	100.00
TOTAL CONIFERS	**51.57**	**29.01**	17.37	1.25	0.80	100.00
TOTAL	53.41	28.14	16.24	1.58	0.63	100.00

ATLANTIC	DEFOLIATION					
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	TOTAL
	%	%	%	%	%	%
SPECIES						
Castanea sativa	83.75	10.16	3.61	2.03	0.45	100.00
Eucalyptus sp.	92.37	7.63	•	•	•	100.00
Fagus sp.	36.48	32.99	29.22	1.31	•	100.00
Quercus (deciduous) sp	62.48	21.54	14.09	1.71	0.19	100.00
Quercus ilex	100.00	•	•	•	•	100.00
Other broadleaves	66.82	18.78	11.35	2.11	0.94	100.00
TOTAL BROADLEAVES	62.61	21.08	14.20	1.74	0.37	100.00
Abies sp.	74.49	15.31	8.16	2.04	•	100.00
Larix sp.	65.91	31.82	2 .27	•	•	100.00
Picea sp.	27.36	35.72	33.65	2.68	0.60	100.00
Pinus sp.	58.95	22.10	15.97	1.26	1.72	100.00
Other conifers	56.27	17.11	25.86	0.38	0.38	100.00
TOTAL CONIFERS	49.25	26.06	21.79	1.66	1.24	100.00
TOTAL EEC & ICP	56.17	23.48	17.86	1.70	0.79	100.00

SUB-ATLANTIC	DEFOLIATION					
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	TOTAL
	%	%	%	%	%	%
SPECIES						
Castanea sativa	45.50	34.46	15.77	3.38	0.90	100.00
Fagus sp.	47.24	35.39	16.33	0.90	0.15	100.00
Quercus (deciduous) sp	43.86	33.47	20.68	1.48	0.51	100.00
Other broadleaves	49.75	26.55	19.24	3.50	0.96	100.00
TOTAL BROADLEAVES	46.91	32.01	18.56	1.98	0.54	100.00
Abies sp.	34.31	26.61	35.38	3.41	0.29	100.00
Larix sp.	64.55	25. 18	9.78	0.49	•	100.00
Picea sp.	35.66	30.26	31.02	2.79	0.26	100.00
Pinus sp.	15.88	42.32	39.00	2.57	0.24	100.00
Other conifers	71.01	18.49	9.24	0.84	0.42	100.00
TOTAL CONIFERS	25.98	36.29	34.84	2.64	0.25	100.00
TOTAL EEC & ICP	33.52	34.75	28.98	2.40	0.35	100.00

MOUNTAINOUS	DEFOLIATION					TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	
	%	%	%	%	%	%
SPECIES						
Fagus sp.	60.75	21.61	8.85	0.52	0.26	100.00
Quercus (deciduous) sp	93.75	3.12	3.12	.	.	100.00
Other broadleaves	73.40	16.49	9.57	•	0.53	100.00
TOTAL BROADLEAVES	71.52	19.04	8.77	0.33	0.33	100.00
Abies sp.	74.14	14.66	8.62	1.72	0.86	100.00
Larix sp.	70.84	22.51	6.39	•	0.26	100.00
Picea sp.	58.45	27.41	12.33	0.77	1.05	100.00
Pinus sp.	65.32	23.73	7.82	1.04	2.09	100.00
Other conifers	37.50	56.25	•	6.25	•	100.00
TOTAL CONIFERS	62.18	25.56	10. 27	0. 80	1.19	100.00
TOTAL EEC & ICP	63.70	24.49	10.02	0.73	1.05	100.00

MEDITERRANEAN	DEFOLIATION					TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	
	%	%	%	%	%	%
SPECIES						
Castanea sativa	65.73	17.14	14.08	2.11	0.94	100.00
Eucalyptus sp.	84.36	8.08	4.91	0.41	2.25	100.00
Fagus sp.	69.59	19.38	8.35	2.36	0.32	100.00
Quercus (deciduous) sp	45.05	35.10	16.41	2.93	0.51	100.00
Quercus ilex	58.67	36.91	4.11	0.17	0.13	100.00
Quercus suber	28.00	28.96	39.53	2.68	0.82	100.00
Other broadleaves	48.78	27.51	19.45	3.25	1.01	100,00
TOTAL BROADLEAVES	52.82	29.24	15.21	2.03	0.70	100.00
Abies sp.	60.92	27.39	8. 05	0.96	2.68	100.00
Larix sp.	84.62	7.69	7.69	•	•	100.00
Picea sp.	100.00	•	•	•	•	100.00
Pinus sp.	64.39	25.35	8.21	0.88	1.16	100.00
Other conifers	67.15	24.09	7.54	0.97	0.24	100.00
TOTAL CONIFERS	64.50	25.28	8.13	0.89	1.21	100.00
TOTAL EEC & ICP	57.35	27.70	12.46	1.58	0.90	100.00

SCANDINAVIAN	DEFOLIATION					TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	
	%	%	%	%	%	%
SPECIES						
Other broadleaves	70.83	24.40	4.56	0.20	.	100.00
TOTAL BROADLEAVES	70.83	24.40	4.56	0.20	.	100.00
Picea sp.	39.94	38.58	19.52	1.93	0.02	100.00
Pinus sp.	58.92	34.66	6.02	0.40	.	100.00
TOTAL CONIFERS	47.62	37.00	14.06	1.31	0.01	100.00
TOTAL EEC & ICP	48.35	36.60	13.76	1.28	0.01	100.00

Annex 1-4
Discolouration by species group and climatic region (1991)

TOTAL CLIMATIC REGIONS	DISCOLOURATION					TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD .	
	%	%	%	%	%	%
SPECIES						
Castanea sativa	83.85	12.64	2.06	0.69	0.76	100.00
Eucalyptus sp.	93.89	3.83	0.18	0.09	2.01	100.00
Fagus sp.	88.20	8.66	2.18	0.80	0.16	100.00
Quercus (deciduous) sp	87.86	9.90	1.38	0.44	0.42	100.00
Quercus ilex	97.24	2.56	0.03	0.03	0.13	100.00
Quercus suber	58.34	32.26	6.66	1.92	0.82	100.00
Other broadleaves	80.33	14.82	3.02	0.92	0.90	100.00
TOTAL BROADLEAVES	85.43	11.24	2.10	0.67	0.56	100.00
Abies sp.	84.96	11.24	2.38	0.40	1.02	100.00
Larix sp.	94.05	4.78	1.05	•	0.12	100.00
Picea sp.	94.06	4.32	1.06	0.31	0.25	100.00
Pinus sp.	90.21	7.78	1.22	0.18	0.61	100.00
Other conifers	89.98	8.94	0.75	•	0.32	100.00
TOTAL CONIFERS	91.63	6.49	1.18	0.23	0.47	100.00
TOTAL EEC & ICP	89.35	8.23	1.52	0.39	0.50	100.00

TOTAL CLIMATIC REGIONS - EEC	DISCOLOURATION					TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	
	%	%	%	%	%	%
SPECIES						
Castanea sativa	83.85	12.87	2.11	0.70	0.47	100.00
Eucalyptus sp.	93.89	3.83	0.18	0.09	2.01	100.00
Fagus sp.	86.70	9.59	2.54	1.06	0.11	100.00
Quercus (deciduous) sp	87.32	10.30	1.55	0.44	0.40	100.00
Quercus ilex	97.24	2.56	0.03	0.03	0.13	100.00
Quercus suber	58.34	32.26	6.66	1.92	0.82	100.00
Other broadleaves	79.93	15.22	2.98	1.11	0.76	100.00
TOTAL BROADLEAVES.	85.02	11.58	2.16	0.75	0.50	100.00
Abies sp.	85.48	11.14	2.00	0.08	1.31	100.00
Larix sp.	92.41	6.10	1.34	•	0.15	100.00
Picea sp.	90.40	6.91	1.78	0.72	0.18	100.00
Pinus sp.	84.99	11.66	1.96	0.31	1.07	100.00
Other conifers	90.36	8.54	0.77	*	0.33	100.00
TOTAL CONIFERS	86.87	10.10	1.85	0.38	0.80	100.00
TOTAL	85.90	10.88	2.01	0.57	0.64	100.00

ATLANTIC	DISCOLOURATION					TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	
	%	%	%	%	%	%
SPECIES						
Castanea sativa	89.84	7.45	2.03	0.23	0.45	100.00
Eucalyptus sp.	100.00	•	•	•	•	100.00
Fagus sp.	71.66	16.57	8.43	3.34	\ 7 •	100.00
Quercus (deciduous) sp	92.01	5.47	1.90	0.43	0.19	100.00
Quercus ilex	100.00	•	•	•	•	100.00
Other broadleaves	83.57	10.80	3.99	0.70	0.94	100.00
TOTAL BROADLEAVES	87.15	8.34	3.27	0.86	0.37	100.00
Abies sp.	89.80	10.20	•	•	•	100.00
Larix sp.	97.73	2.27	•	•	•	100.00
Picea sp.	84.55	10.10	3.68	1.07	0.60	100.00
Pinus sp.	84.48	10.79	2.84	0.18	1.72	100.00
Other conifers	79.47	18.63	1.52	♦	0.38	100.00
TOTAL CONIFERS	84.46	10.91	2 .94	0.44	1.24	100.00
TOTAL EEC & ICP	85.85	9 . 58	3.11	0.66	0.79	100.00

SUB-ATLANTIC	DISCOLOURATION					TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	
	%	%	%	%	%	%
SPECIES						
Castanea sativa	86.26	10.14	2.03	0.68	0.90	100.00
Fagus sp.	91.2 3	7.07	1.38	0-. 17	0.15	100.00
Quercus (deciduous) sp	90.09	8.06	1.18	0.16	0.51	100.00
Other broadleaves	79.80	14.36	3.34	1.55	0.96	100.00
TOTAL BROADLEAVES	87.14	9.76	1.95	0.61	0.54	100.00
Abies sp.	83.63	12.28	3.12	0.68	0.29	100.00
Larix sp.	96.33	2.69	0.98	•	•	100.00
Picea sp.	95.57	3.09	0.72	0.35	0.26	100.00
Pinus sp.	90.20	8.06	1.40	0.11	0.24	100.00
Other conifers	92.86	5.88	0.84	•	0.42	100.00
TOTAL CONIFERS	92.11	6.21	1.21	0.22	0.25	100.00
TOTAL EEC & ICP	90.32	7.49	1.47	0.36	0.35	100.00

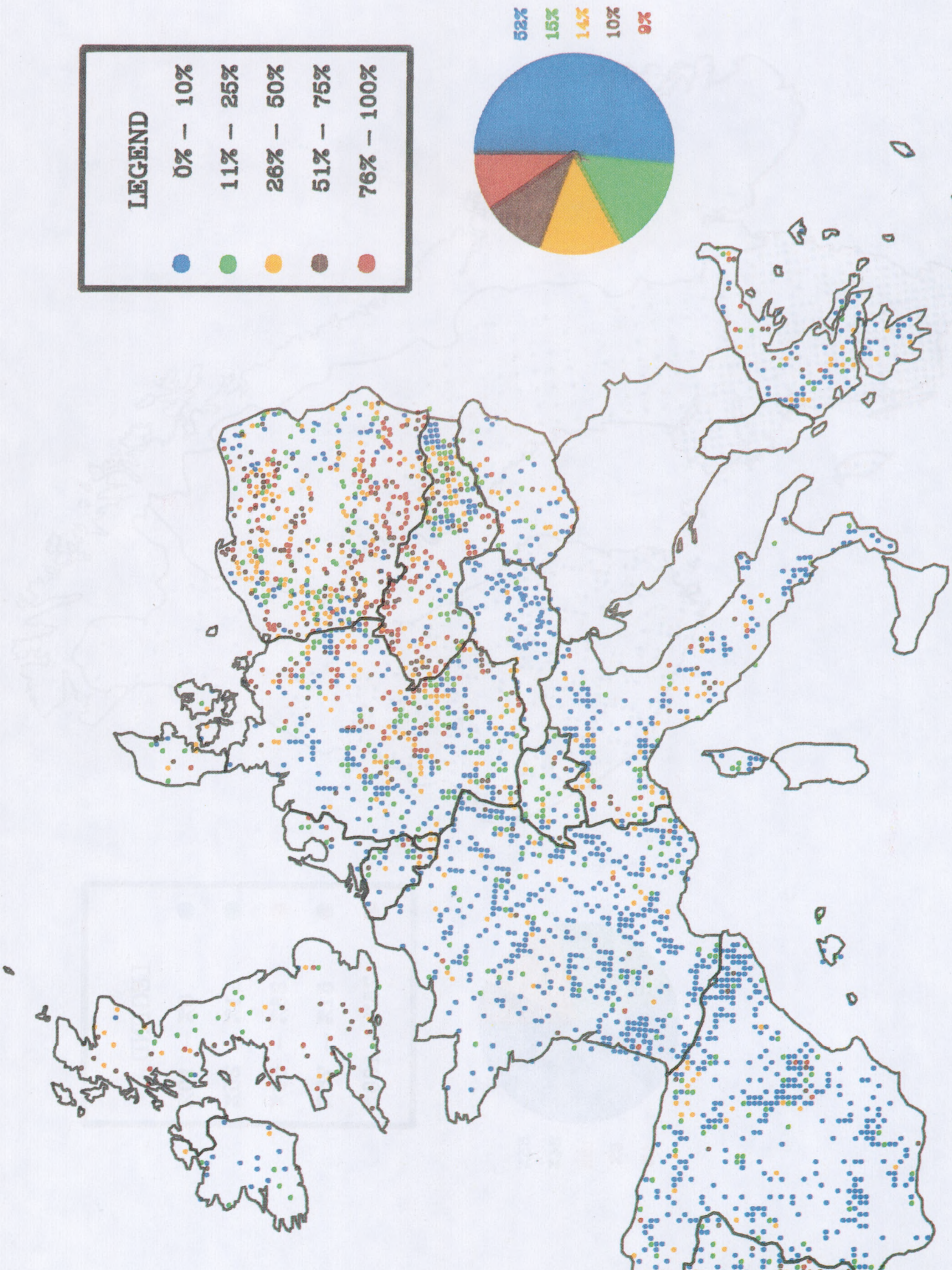
MOUNTAINOUS	DISCOLOURATION					TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	
	%	%	%	%	%	%
SPECIES						
Fagus sp.	88.54	10.16	1.04	•	0.26	100.00
Quercus (deciduous) sp	100.00	•	•	•	•	100.00
Other broadleaves	87.23	5.85	6.38	•	0.53	100.00
TOTAL BROADLEAVES	88.74	8.28	2.65	•	0.33	100.00
Abies sp.	87.07	11.21	0.86	•	0.86	100.00
Larix sp.	91.30	7.16	1.28	•	0.26	100.00
Picea sp.	94.55	2.86	0.61	0.94	1.05	100.00
Pinus sp.	80.96	16.04	0.52	0.39	2.09	100.00
Other conifers	100.00	♦	•	•	•	100.00
TOTAL CONIFERS	90.54	6.95	0.68	0.64	1.19	100.00
TOTAL EEC & ICP	90.25	7.17	1.00	0.54	1.05	100.00

MEDITERRANEAN	DISCOLOURATION					TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	
	%	%	%	%	%	%
SPECIES						
Castanea sativa	75.12	20.66	2.11	1.17	0.94	100.00
Eucalyptus sp.	93.15	4.29	0.20	0.10	2.25	100.00
Fagus sp.	86.83	9.21	1.61	2.03	0.32	100.00
Quercus (deciduous) sp	81.24	16.23	1.19	0.82	0.51	100.00
Quercus ilex	97.24	2.56	0.03	0.03	0.13	100.00
Quercus suber	58.34	32.26	6.66	1.92	0.82	100.00
Other broadleaves	77.61	18.91	2.13	0.35	1.01	100.00
TOTAL BROADLEAVES	82.79	14.06	1.74	0.71	0.70	100.00
Abies sp.	86.21	9.39	1.72	•	2.68	100.00
Larix sp.	92.31	7.69	•	•	•	100.00
Picea sp.	100.00	•	•	*	•	100.00
Pinus sp.	84.96	12.07	1.35	0.46	1.16	100.00
Other conifers	94.65	4.87	0.24	•	0.24	100.00
TOTAL CONIFERS	85.63	11.45	1.31	0.40	1.21	100.00
TOTAL EEC & ICP	83.89	13.05	1.57	0.59	0.90	100.00

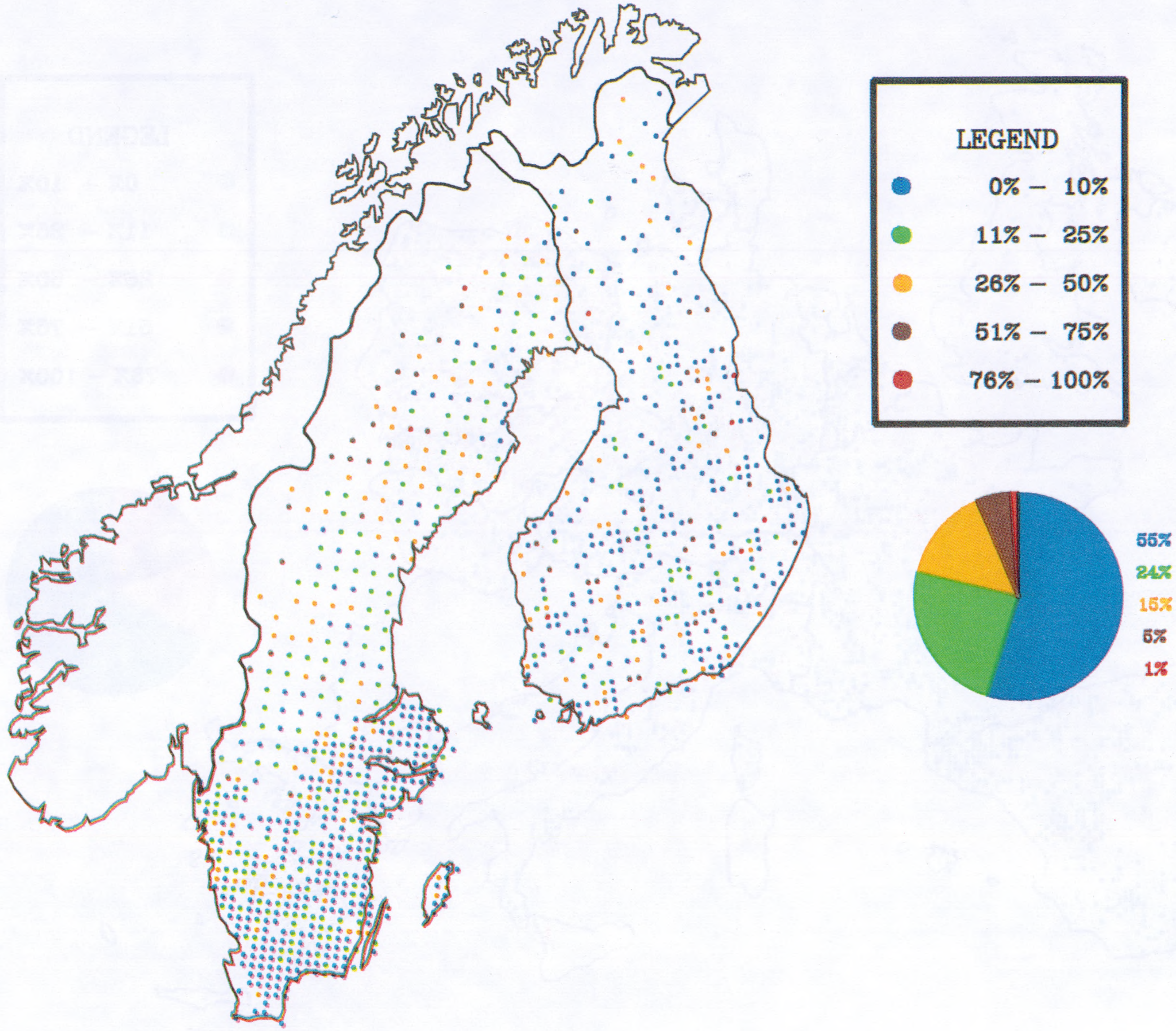
SCANDINAVIAN	DISCOLOURATION					TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	
	%	%	%	%	%	%
SPECIES						
Other broadleaves	87.50	10.91	1.59	.	.	100.00
TOTAL BROADLEAVES	87.50	10.91	1.59	.	.	100.00
Picea sp.	94.13	4.79	1.03	0.03	0.02	100.00
Pinus sp.	99.65	0.24	0.11	.	.	100.00
TOTAL CONIFERS	96.36	2.95	0.66	0.02	0.01	100.00
TOTAL EEC & ICP	96.08	3.20	0.68	0.02	0.01	100.00

Annex 1-5

Percentage of trees damaged (1991)

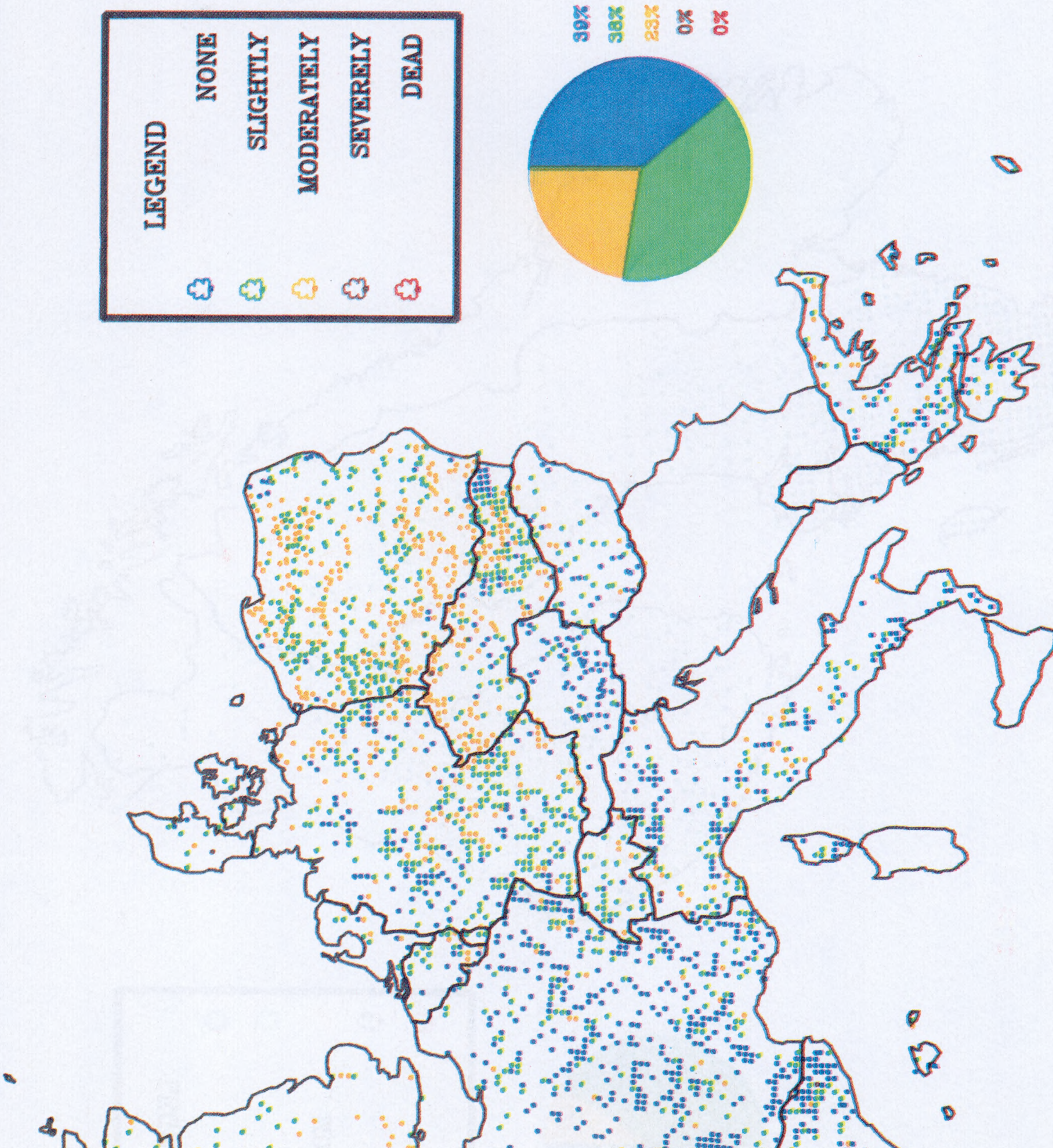


Percentage of trees damaged (1991)

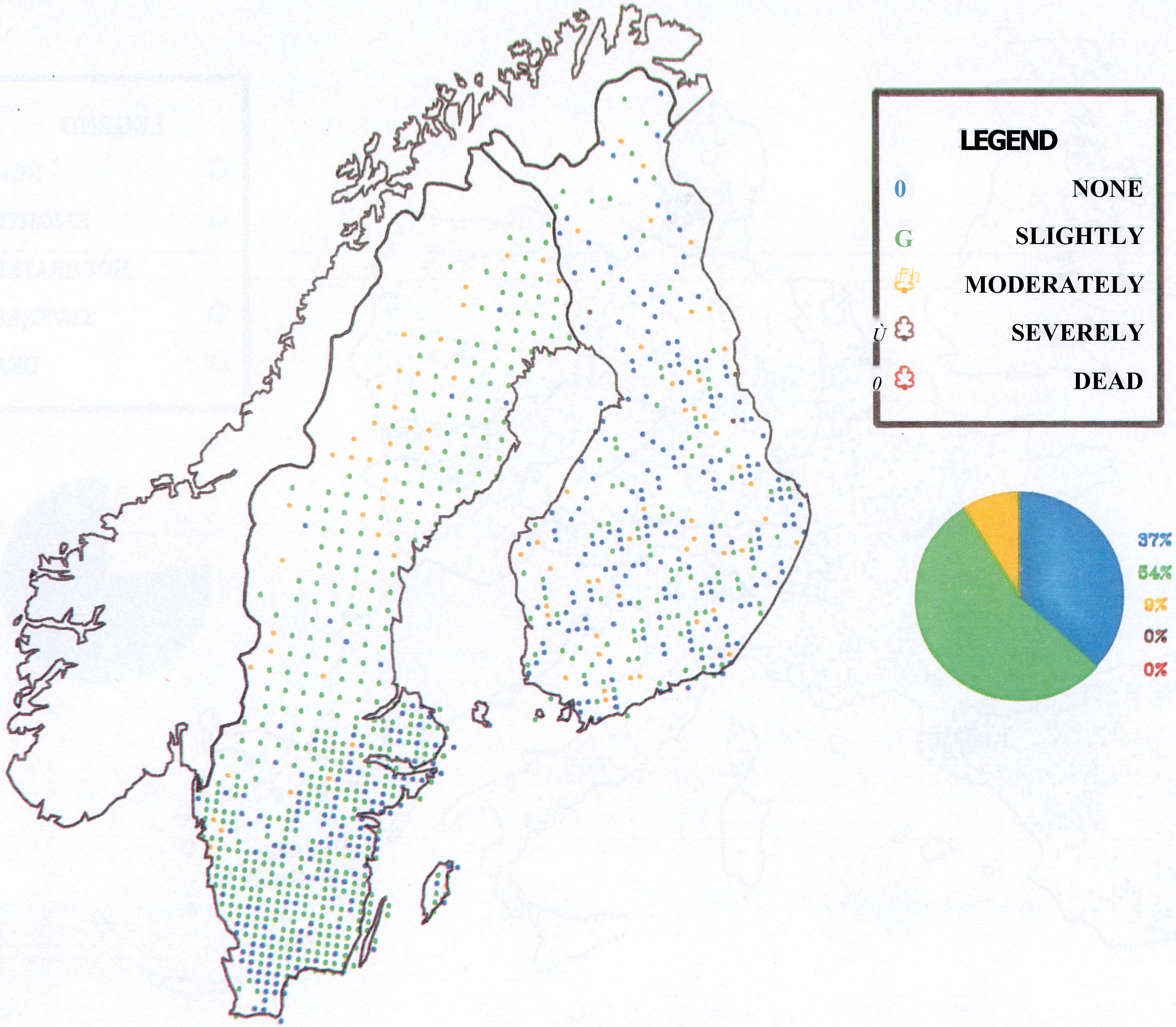


Annex 1-6

Plot defoliation (1991)

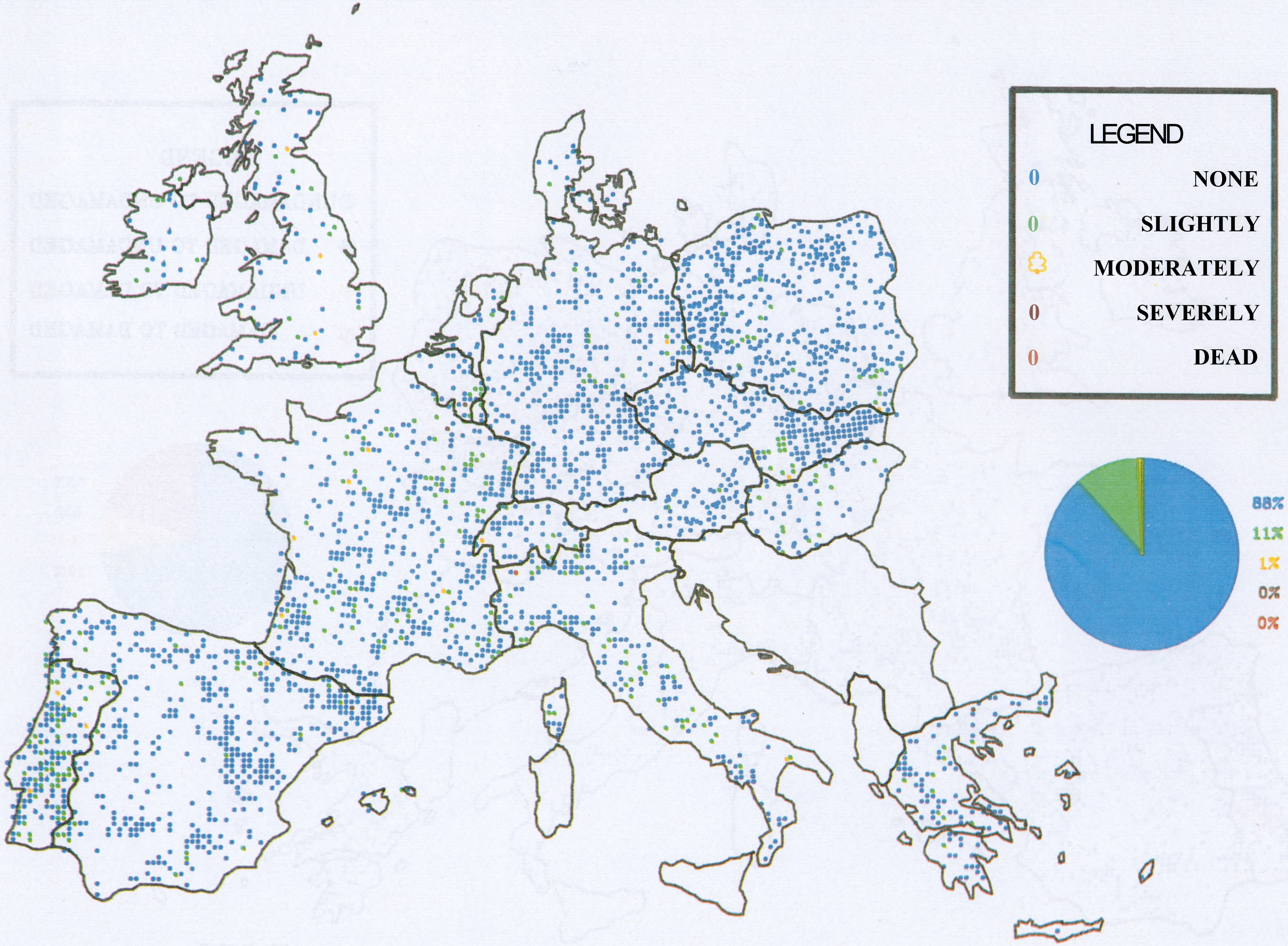


Plot defoliation (1991)



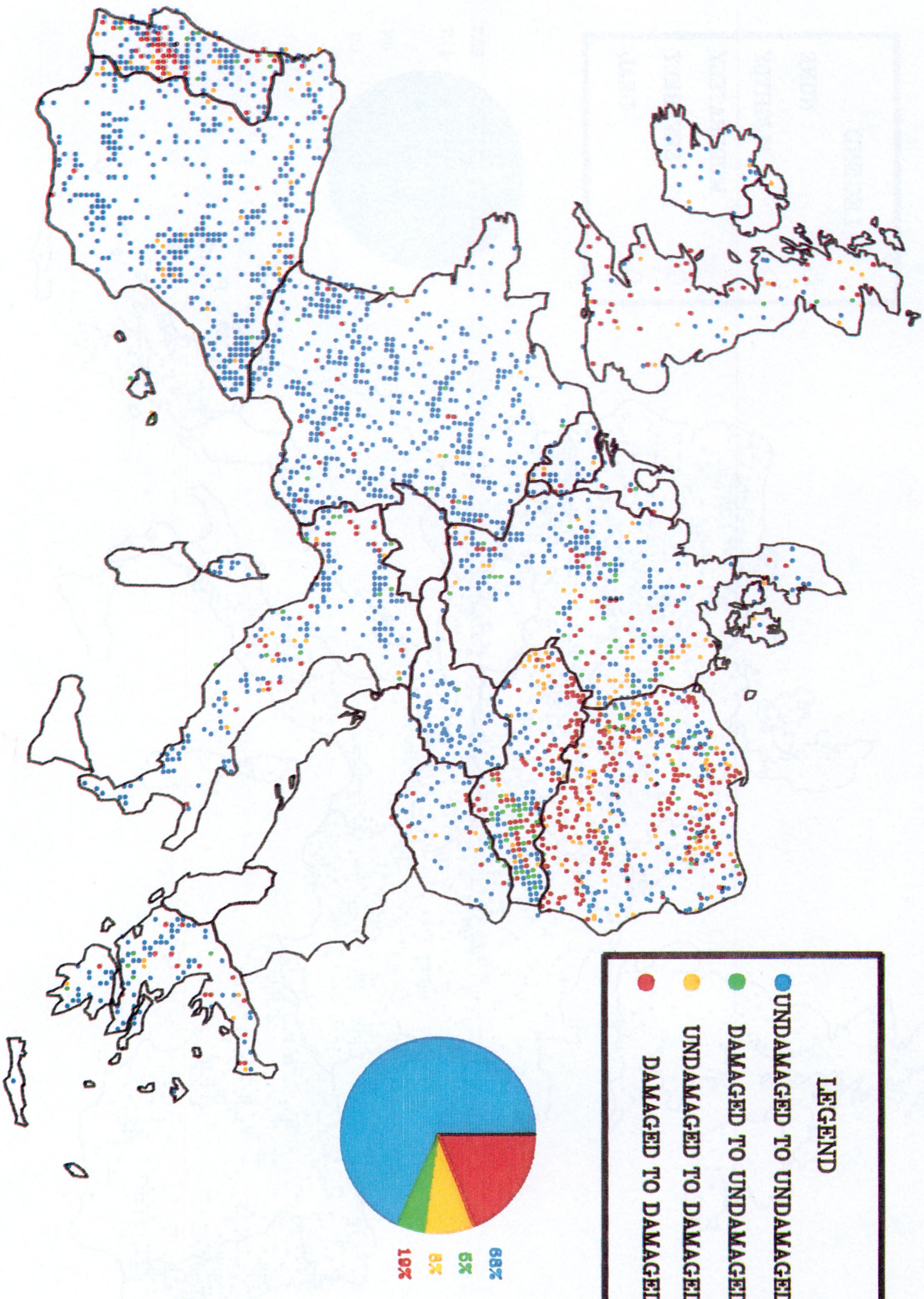
Annex 1-7

Plot discolouration (1991)



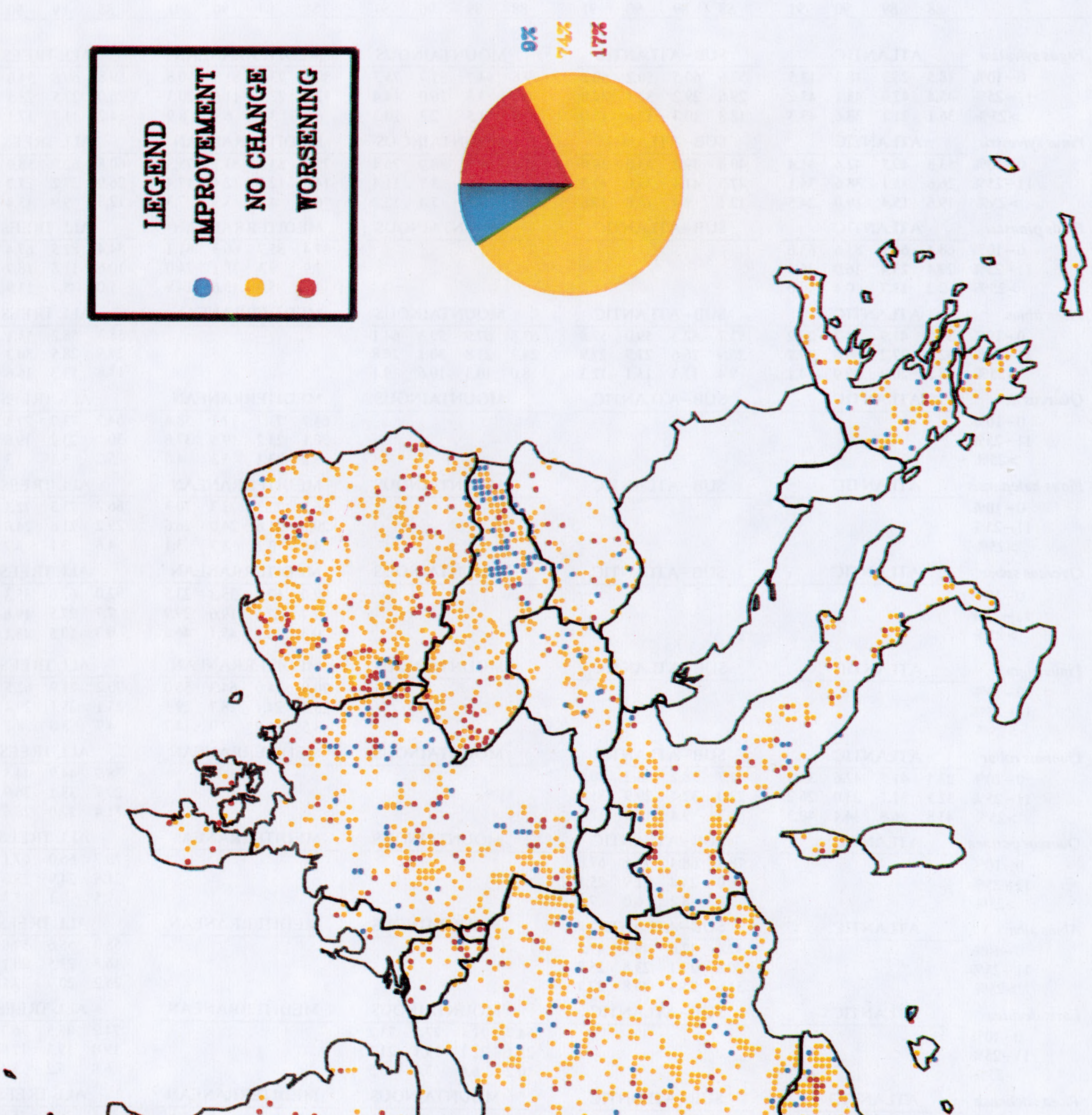
Annex 1-8

Changes in plot defoliation classes (1991)



Annex 1-9

Changes in plot defoliation (1991)



Annex 1-10

Defoliation of most common species (1988-1991)

Survey years / Climatic region

Species/class	88	89	90	91	88	89	90	91	88	89	90	91	88	89	90	91	88	89	90	91
Fagus sylvatica	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%	18.5	26.9	18.3	13.5	57.6	60.5	50.2	50.2	99.6	94.7	81.7	75.3	80.9	73.6	81.5	70.8	59.8	60.8	54.0	50.5
11-25%	45.4	42.0	43.1	43.2	29.6	29.2	32.4	34.8	0.4	3.8	16.0	14.4	12.8	22.7	11.6	20.3	26.0	27.5	28.5	31.3
>25%	36.1	31.1	38.6	43.3	12.8	10.3	17.4	15.0	0.0	1.5	2.3	10.3	6.3	3.7	6.9	8.9	14.2	11.7	17.5	18.2
Pin us sylvestris	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%	53.8	49.5	42.4	41.4	40.6	49.2	43.0	39.9	81.6	89.3	88.9	76.4	79.2	83.3	83.7	75.3	60.8	62.9	58.9	54.1
11-25%	26.6	35.1	38.6	34.1	47.3	41.4	39.0	42.5	16.6	5.9	3.7	11.4	1478	12.5	12.4	17.4	26.9	27.2	27.7	29.0
>25%	19.6	15.4	19.0	24.5	12.1	9.4	18.0	17.6	1.8	4.8	7.4	12.2	6.0	4.2	3.9	7.3	12.3	9.9	13.4	16.9
Pin us pinaster	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%	68.4	64.9	83.6	63.6									87.4	85.7	66.3	61.1	84.4	82.5	67.4	60.7
11-25%	29.4	23.4	16.0	26.4									7.9	9.3	18.1	24.0	10.6	11.8	18.7	25.0
>25%	2.2	11.7	0.4	10.0									4.7	5.0	15.6	14.9	5.0	5.7	13.9	14.3
Pice a abies	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%	39.2	41.9	34.2	26.2	63.7	62.3	59.0	59.8	67.8	67.9	59.3	64.1					58.3	58.2	53.1	52.2
11-25%	32.6	37.2	36.8	39.7	26.9	26.6	27.9	27.9	24.2	21.8	30.1	26.8					27.9	28.5	30.3	30.6
>25%	28.2	20.9	29.0	34.1	9.4	11.1	13.1	12.3	8.0	10.3	10.6	9.1					13.8	13.3	16.6	17.2
Quercus Hex	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%													64.7	73.7	77.1	58.4	64.7	73.7	77.1	58.4
11-25%													30.1	23.2	19.6	37.6	30.1	23.2	19.6	37.6
>25%													5.2	3.1	3.3	4.0	5.2	3.1	3.3	4.0
Pin us balepensis	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%													66.2	75.3	72.3	70.3	66.2	75.3	72.3	70.3
11-25%													29.2	21.6	24.0	26.6	29.2	21.6	24.0	26.6
>25%													4.6	3.1	3.7	3.1	4.6	3.1	3.7	3.1
Quercus suber	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%													92.0	62.0	35.3	23.5	92.0	62.0	35.3	23.5
11-25%													7.7	27.5	19.6	29.9	7.7	27.5	19.6	29.9
>25%													0.3	10.5	45.1	46.6	0.3	10.5	45.1	46.6
Pin us nigra	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%													70.8	74.0	64.3	56.0	70.2	71.9	62.5	54.2
11-25%													25.7	24.1	28.7	29.3	25.1	25.1	29.4	30.1
>25%													3.5	1.9	7.0	14.7	4.7	3.0	8.1	15.7
Quercus robur	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%	23.5	41.5	42.6	33.5	71.7	58.2	58.2	50.6									38.9	44.9	44.5	36.5
11-25%	32.7	31.7	23.0	26.2	22.0	32.4	29.9	31.8									29.7	33.1	26.9	29.4
>25%	43.8	26.8	34.4	40.3	6.3	9.4	11.9	17.6									31.4	22.0	28.6	34.1
Quercus petraea	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0- 10%					78.4	68.4	72.1	67.8									70.7	66.0	67.1	62.1
11-25%					18.0	23.4	21.9	25.1									21.8	24.9	25.6	26.9
>25%					3.6	8.2	6.0	7.1									7.5	9.1	7.3	11.0
Abies alba	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%					47.6	47.6	49.4	47.3									58.0	55.6	57.8	55.9
11-25%					20.8	27.1	23.8	25.0									16.8	23.5	20.1	21.3
>25%					31.6	25.3	26.8	27.7									25.2	20.9	22.1	22.8
Larix decidua	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%									64.7	71.1	77.1	73.2					74.2	75.5	76.7	77.4
11-25%									25.1	22.1	19.1	21.3					19.0	19.3	17.9	18.8
>25%									10.2	6.8	3.8	5.5					6.8	5.2	5.4	3.8
Picea sitchensis	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%	33.1	30.7	35.8	28.5													33.1	30.7	35.8	28.5
11-25%	34.2	36.5	34.7	35.6													34.2	36.5	34.7	35.6
>25%	32.7	32.8	29.5	35.9													32.7	32.8	29.5	35.9

Annex 1-11

Discolouration of most common species (1988-1991)

Species/class	Survey years / Climatic region																			
	'88	89	90	91	88	89	90	91	88	89	90	91	88	*89	90	91	88	89	90	91
Fagus sylvatica	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%	82.0	90.1	94.8	91.9	89.3	93.8	93.3	93.8	100.0	89.0	77.6	84.1	89.7	84.4	87.2	91.5	90.0	90.9	90.3	92.0
11-25%	12.2	2.3	5.2	5.8	9.6	5.3	5.4	5.6	0.0	11.0	21.3	14.4	9.1	13.4	10.8	6.9	8.6	7.5	8.4	6.9
>25%	5.8	7.6	0.0	2.3	1.1	0.9	1.3	0.6	0.0	0.0	1.1	1.5	1.2	2.2	2.0	1.6	1.4	1.6	1.3	1.1
Pin us sylvestris	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%	95.7	79.5	83.2	92.3	77.2	75.6	75.4	75.6	88.2	86.0	89.3	86.0	89.5	91.5	97.3	91.0	88.3	83.0	86.3	87.0
11-25%	3.7	16.7	15.1	3.7	18.5	20.5	18.2	18.9	11.1	10.7	3.0	7.0	9.6	8.1	2.0	5.4	10.1	14.3	10.4	8.4
>25%	0.6	3.8	1.7	4.0	4.3	3.9	6.4	5.5	0.7	3.3	7.7	7.0	0.9	0.4	0.7	3.6	1.6	2.7	3.3	4.6
Pinus pinaster	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%	98.3	87.9	100.0	91.3									89.3	75.9	68.5	71.9	89.3	76.3	71.2	73.2
11-25%	1.7	12.1	0.0	0.9									10.2	19.7	24.2	22.5	10.1	19.8	22.4	21.0
>25%	0.0	0.0	0.0	7.8									0.5	4.4	7.3	5.6	0.6	3.9	6.4	5.8
Picea abies	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%	98.3	88.4	92.9	90.9	86.2	86.9	94.1	88.3	85.8	90.3.	87.4	88.2					87.4	87.7	92.8	88.6
11-25%	1.7	11.2	4.6	5.0	10.7	9.3	3.4	8.8	11.8	8.8	9.7	9.1					9.9	9.4	4.6	8.4
>25%	0.0	0.4	2.5	4.1	3.1	3.8	2.5	2.9	2.4	0.9	2.9	2.7					2.7	2.9	2.6	3.0
Quercus Hex	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%													92.8	94.4	99.2	98.5	92.8	94.4	99.2	98.5
11-25%													7.1	5.6	0.7	1.5	7.1	5.6	0.7	1.5
>25%													0.1	0.0	0.1	0.0	0.1	0.0	0.1	0.0
Pinus haiepensis	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%													70.7	78.6	87.3	91.7	70.7	78.6	87.3	91.7
11-25%													28.0	18.9	12.0	7.6	28.0	18.9	12.0	7.6
>25%													1.3	2.5	0.7	0.7	1.3	2.5	0.7	0.7
Quercus suber	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%													87.9	49.3	47.8	553	87.9	49.3	47.8	55.3
11-25%													12.0	35.1	353	353	12.0	35.1	353	35.3
>25%													0.1	15.6	16.9	9.4	0.1	15.6	16.9	9.4
Pinus nigra	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%													81.1	83.8	88.5	93.2	79.2	82.0	85.1	92.1
11-25%													18.4	15.8	11.1	6.3	19.5	17.4	14.3	7.5
>25%													0.5	0.4	0.4	0.5	1.3	0.6	0.6	0.4
Quercus robur	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%	89.6	89.0	89.5	94.8	90.9	87.1	91.2	81.1									87.2	87.0	89.1	88.1
11-25%	8.9	10.1	8.0	4.6	7.2	11.3	7.2	15.4									8.8	11.3	8.9	9.9
>25%	1.5	0.9	2.5	0.6	1.9	1.6	1.6	3.5									4.0	1.7	2.0	2.0
Quercus petraea	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%					94.2	89.7	91.0	93.6									90.7	87.9	88.9	91.4
11-25%					3.0	9.2	7.5	6.0									6.0	9.5	9.1	7.1
>25%					2.8	1.1	1.5	0.4									3.3	2.6	2.0	1.5
Abies alba	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%					78.6	84.3	88.6	82.5									83.0	87.6	90.7	84.9
11-25%					19.0	13.9	7.5	13.9									15.1	11.0	6.2	12.2
>25%					2.4	1.8	3.9	3.6									1.9	1.4	3.1	2.9
La rix decidua	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%									82.5	84.7	91.1	91.1					88.1	87.5	93.4	92.4
11-25%									16.6	14.9	8.5	8.9					11.4	12.2	6.3	6.5
>25%									0.9	0.4	0.4	0.0					0.5	0.3	0.3	1.1
Picea sitchensis	ATLANTIC				SUB-ATLANTIC				MOUNTAINOUS				MEDITERRANEAN				ALL TREES			
0-10%	81.5	66.7	77.1	79.5													81.5	66.7	77.1	79.5
11-25%	18.5	28.5	19.3	17.3													18.5	28.5	19.3	17.3
>25%	0.0	4.8	3.6	3.2													0.0	4.8	3.6	3.2

Annex II

National surveys

Annex II-1
Forests and surveys in European countries (1991)

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	2022	935	3857	8.7 x 8.7	223	6890
Belgium	3057	602	302	300	602	8²/ 16*	07	2311
Bulgaria	111ÔÔ	3314	1172	2142	3314	162/8*	116	4724
Byelorussia	107(50	6002	4124	1878		16 x 16		
Croatia	5654	1779	404	1295	no survey in 1991			
Czechoslovakia	12789	4401	2801	1600	4491	16 x 16	218	14369
Denmark	4300	466	308	158	466	7x7	70	1626
Estonia	4510	ÏSÏT	1135	680	1135	16 x 16	80	1908
Finland	30464	2005$	18484	1575	18484	varying	450	3896
France	54019	1444Ö	4840	0600	1310Ö	16²/16xl	513	1Ô255
Germany	35562	9828	6027	2901	9828	4x4	7794	210876
Greece a)	13204	2034	054	108Û	2034	16 x 16	83	1060
Hungary	0300	168'4	264	142Ô	1684	4x4	1027	20858
Ireland	6880	380	334	46	261	l6x 16	22	462
Italy	.........3ÜT25"	8675	1735	6940	7154	16 x 16	221	5818
Latvia	6450	1664	1142	522		8x8		
Lithuania	6520	- -rtèi*	>=*- 1073^	. 750	1821	4x4	552	22836
Liechtenstein	16	—— 8	r'~6	2	8	varying	16	480
Luxembourg •	.......-..."W	88	31	— 57	«8	4x4 ^	... 48	1151
Netherlands •	4147	3ii	2Ô8	103	281	lxl	- -1364	341ÔÔ
Norway	30686	P.-; P3T	77ÔÔ	735	7700	0x0	700	8147
Poland	31270	8654	~~*sm'*	1750	' 8654	7,75x7,75	1403	29862
Portugal	8800	3372	1340	2Ô32	306Ô	16 x 16	153	4588
Romania	.... *"ITTW*	6244	1929	4315	6244	2x2/2x4	0333	243473
Russian Federation	80330	31592	25518	6Ô74	31592	varying	229	5472
Slovenia ••	¿008	1071	5ÔÔ	571	1071	4x4	.3 30	13176
Spain	50471	11792	5637	6155	11792	16 x 16	437	10554
Sweden	40800	23700	194ÔÔ	4300	19900	varying	8200	11733
Switzerland	4129	1186	818	368	1186	4x4	686	8244
Turkey	77945	2Ô100	0426	10773	no survey in 1991			
Ukraine	60370	6151	2931	3220		16 x 16		
United Kingdom	24100	220Ô	155Ô	650	2200	random	369	8843
Yugoslavia • b)	25600	61ÔÔ	900	5200	61ÔÖ	16 x 16	190	4547
TÔTÀL	728670	214016	133800	80136	168109	varying	35723	702150

•) defoliation and discolouration combined; • •) combined assessment method
a) excluding maquis b) former Yugoslavia excluding Croatia and Slovenia

Annex II-2

Defoliation of all species by classes and aggregates (1991)

Participating countries	Area surveyed 1000 ha	"NoToT sample trees	... ... 15 " none	...... 1 slight	2 moderate	3+4 severe and dead	2+3+4
Austria	3339	6890	54,6	37,9	7,1	0,4	[illegible]
Belgium	602	2311	43,4	38,7	16,0	1,9	17,9
Bulgaria	3314	4724	44,7	33,5	17,9	3,9	21,8
Byelorussia							
Croatia							
Czechoslovakia	4491	14369	24,1	34,6	35,4	5,9	41,3
Denmark	466	1626	41,5	28,6	24,4	5,5	29,9
Estonia	1135	1008			onl'y conifers assessed		
Finland	18484	3896	64,5	19,5	15,1	0,9	16,0
France	131Ö0	10255	76,4	16,5	5.9	1,2	7,1
Germany	9828	219876	35,8	39,0	23,0	2,2	25,2
Greece	2034	i960	51,8	3l,3	13,1	3,8	16,9
Hungary	1684	2Ô858	48,3	32,1	15,9	3,7	19,6
Ireland	261	462			onl'y conifers assessed		
Italy	7154	5818	58,4	25,2	13,7	2,7	16,4
Latvia							
Lithuania	1823	22836	24,6	5i3	22,1	1,8	23,9
Liechtenstein	8	480	32,0	49,0	17,0	2,0	19,0
Luxembourg •	88	ll5l	55,8	23,4	18,0	2,8	20,8
NeÉerlands •	281	341ÖÔ	52,5	30,3	14,3	2,9	17,2
Norway	77Ô0	8l47	49,4	30,9	l6,l	3,6	19,7
Poland	8654	29862	9,2	45,8	42,5	2,5	45,0
Portugal	3060	4588	474	22,9	24,8	4,8	29,6
Romania	6244	243473	61,6	28,7	8,4	1,3	9,7
Russian Federation	31592	5472			onl'y conifers assessed		
Slovenia ••	1071	13176	62,9	21,2	9,4	6,5	15,9
Spain	11792	1Ò554	64,3	28,4	5,2	2,1	7,3
Sweden	19900	11733	54,7	33,3	104	1,5	12,0
Switzerland	1186	8244	32,0	49,0	17,0	2,0	19,0
Turkey							
Ukraine							
United Kingdom	2200	8843	6,0	37,3	53,9	2,8	56,7
Yugoslavia • a)	6100	4547	74,5	15,7	6,4	3,4	9,8

•) defoliation and discolouration

••) combined assessment method

a)former Yugoslavia excluding Croatia and Slovenia

Annex II-3

Defoliation of conifers by classes and aggregates (1991)

Participating countries	Coniferous forest (1000 ha)	No. of sample trees	...." IT ^ none	..... i.......... slight	.... ' 2 moderate	3+4 " severe and dead	2+3+4
Austria	2022	6043	56,8	36,2	6,7	0,3	7,0
Belgium	3[illegible]	1043	31,1	45,5	21,3	2,1	23,4
Bulgaria	1172	2729	34,0	39,5	22,9	3,6	26,5
Byelorussia	4124						
Croatia	494						
Czechoslovakia	2891	11316	19,9	34,1	39,9	6,1	46,0
Denmark	3[illegible]	1035	50,1	18,5	22,8	8,6	31,4
Estonia	1135	1908	35,0	37,0	27,0	1,0	28,0
Finland	18484	3381	63,4	19,4	16,2	1,0	17,2
France	484Ô	3454	78,9	14,4	5,8	0,9	6,7
Germany	6927	154969	37,3	37,9	22,5	2,3	24,8
Greece	954	1062	65,7	27,1	5,3	1,9	7,2
Hungary	264	3403	53,5	28,7	14,9	2,9	17,8
Ireland	333	462	53,8	31,2	14,2	0,8	15,0
Italy	1735	1272	62,9	23,3	10^	3,3	13,8
Latvia	1142						
Lithuania	1073	15882	18,3	53,9	26,2	1,6	27,8
Liechtenstein	6	42Ô	31,0	48,0	19,0	2,0	21,0
Luxembourg •	31	405	86,7/21,3	8,9/46.8	3,8/31,9	0,6/0,0	4,4/31,9
Netherlands	208	22125	48,7	29,9	18,5	2,9	21,4
Norway	*im*	7166	51,7	29,3	15,3	3,7	*m*
Poland	6895	25261	7,4	45,7	44,2	2,7	46,9
Portugal	1340	1728	57,4	24,8	14,3	3,5	17,8
Romania	1929	52195	63,5	29,6	6,1	03	6,9
Russian Federation	25518	3765	32,8	41,2	233	2,5	26,0
Slovenia	500	5255	29,5	39,2	18,1	13,2	31,3
Spain	5637	5270	67,8	24,9	5,1	2,2	7,3
Sweden	194Ö0	7374	53,3	34,4	10,8	1,5	123
Switzerland	818	5265	31,0	48,0	19,0	2,0	21,0
Turkey	9426						
Ukraine	2931						
United Kingdom	155Ô	5539	6,5	42,0	48,6	2,9	51,5
Yugoslavia a)	900	806	62,5	21,6	10,3	5,6	15,9

•) trees under/over 60 years

a)former Yugoslavia excluding Croatia and Slovenia

Annex II-4
Defoliation of broadleaves by classes and aggregates (1991)

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	847	39,2	49,7	9,9	1,2	11,1
Belgium	300	1268	53,5	33,0	11,7	1,8	13,5
Bulgaria	2142	1995	59,3	25,4	11,0	4,3	15,3
Byelorussia	1878						
Croatia	1295						
Czechoslovakia	1600	3053	39,6	36,7	18,5	5,2	23,7
Denmark	158	591	26,4	46,3	27,1	0,2	27,3
Estonia	680						
Finland	1575	492	72,2	20,1	7,5	0,2	7,7
France	9600	6801	75,1	17,5	6,0	1,4	7,4
Germany	2901	64907	33,2	40,3	24,4	2,1	26,5
Greece	1080	898	35,3	36,2	22,4	6,1	28,5
Hungary	1420	17455	47,2	32,9	16,1	3,8	19,9
Ireland	46						
Italy	6940	4546	57,2	25,7	14,6	2,5	17,1
Latvia	522						
Lithuania	750	6954	39,2	45,9	12,7	2,2	14,9
Liechtenstein	2	60	35,0	52,0	12,0	1,0	13,0
Luxembourg	57	746	36,5	29,6	28,8	5,1	33,9
Netherlands	103	11975	59,5	31,1	6,6	2,8	9,4
Norway •	735	981	32,5	42,4	21,5	3,6	25,1
Poland	1759	4601	18,7	46,5	33,1	1,7	34,8
Portugal	2032	2860	41,6	21,8	31,1	5,5	36,6
Romania	4315	191278	61,2	28,4	9,0	1,4	10,4
Russian Federation	6074						
Slovenia	571	7921	85,1	9,1	3,6	2,2	5,8
Spain	6155	5284	60,8	31,8	5,2	2,2	7,4
Sweden	4300	258	67,9	23,0	7,3	1,8	9,1
Switzerland	368	2979	35,0	52,0	12,0	1,0	13,0
Turkey	10773						
Ukraine	3220						
United Kingdom	650	3304	5,0	29,4	62,9	2,7	65,6
Yugoslavia a)	5200	3741	77,3	14,5	5,4	2,8	8,2

•) special study on birch

a) former Yugoslavia excluding Croatia and Slovenia

Annex D-5
Changes in defoliation of conifers and broadleaves (1986-1991)

Country	conifers							broadleaves						
	defoliation classes 2-4						% change	defoliation classes 2-4						% change
	1986	1987	1988	1989	1990	1991	1990/91	1986	1987	1988	1989	1990	1991	1990/91
Austria	·	_	12.0	10,1	8,3	7,0	-1.3	-	-	16,6	15,7	14,9	11,1	-3,8
Belgium	·	4,7	10.8	15,0	10.7	23,4	12,7	_	16,0	10,0	8,1	5,2	13.5	8.3
Bulgaria	4,7	3.8	7,6	32.9	37,4	26,5	-10,9	4,0	3,1	8,8	16,2	17,3	15,3	-2,0
Byelorussia	-	·	-	76.0	57,0			-	-	-	33,4	45,0		
Croatia														
Czechoslovakia	16,4	15,6	27.0	32,0	50,3	46,0	-4,3	·	_	29,1	37,0	33,9	23,7	-10,2
Denmark	_	24,0	21,0	24.0	18,8	31,4	12,6	-	20,0	14,0	30,0	25,4	27,3	1.9
Estonia	·	-	9,0	28,5	20.0	28,0	8,0		only conifers assessed					
Finland	_	13.5	17.0	18,7	18.0	17,2	-1,6	-	4,7	7,9	12.6	11,6	7,7	-3,9
France •	12,5	12.0	9,1	7.2	6.6	6,7	-0,1	4,8	6,5	5,3	4,8	7,7	7,4	-0,3
Germany a)	19.5	15.9	14.0	13,2	15.0	24,8	9,8	16,8	19,2	16,5	20,4	23,8	26,5	2,7
Greece	·	·	7.7	6,7	10.0	7,2	-2,8	-	-	28,5	18,4	26,5	28,5	2,0
Hungary	-	_	9,4	13,3	23,3	17,8	-5.5	·	·	7,0	12,5	21,5	19,9	-1.6
Ireland	· -	_	4.8	13,2	5,4	15,0	9,6		only conifers assessed					
Italy	_	·	·	-	-	13,8		-	3,6	2,9	9.5	16,7	17,1	0,4
Latvia	·	_	_	_	43.0			·	-	-	-	27,0		
Lithuania	·	14,8	3,0	24,0	22,9	27,8	4,9	-	-	1,0	16.0	15.8	14,9	-0,9
Liechtenstein	22.0	27.0	23.0	12,4				10,0	7,0	5,0	9,0			
Luxembourg	4,2	3,8	11.1	9.5				5,6	10,1	12,3	13.9	-	33.9	
Netherlands	28,9	18.7	14.5	17.7	21,4	21,4	0,0	13.2	26.5	25,4	13.1	11.5		
Norway	-	_	20.8	14,8	17,1	19,0	1.9	·	-	-	-	18.2	25.1	6,9
Poland	-	_	24.2	34.5	40,7	46.9	6,2	-	-	7,1	17.7	25.6	34.8	9,2
Portugal	_	_	1.7	9.8	25,7	19.8	-5.9	-	_	0,8	8,6	34,1	36.6	2,5
Romania	_	_	_	-	·	6,9		·	-	-	-	-	10.4	
Russian Federation	·	·	_	• -	-	4.2			only conifers assessed					
Slovenia					34,6	31.3	-3,3					4,4	5,8	1.4
Spain	18.2	10.7	7.3	3,5	3,1	7,3	4.2	13,7	13,7	6,8	3,2	4.4	7.4	3,0
Sweden	11.1	5.6	12.3	12.9	16,1	12.3	-3,8	-	-	5,2	-	22.1	9,1	-13,0
Switzerland	16.0	14.0	15,0	14.0	19,0	21.0	2.0	8,0	15.0	7,0	6.0	12.0	13.0	1.0
Tutkey														
Ukraine	-	-	_	1.4	3,0			-	-	-	1,4	2.7		
United Kingdom	-	23.0	27.0	34.0	45,0	51,5	6.5	-	20.0	20,0	21.0	28.8	65.6	36,8
Yugoslavia b)	23.0	16,1	17,5	39.1	34.6	15.9	-18.7	-	7,3	9,0	8,2	4.4	8.2	M

•) 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 II-6

10%-defoliation classes

Austria 1991

10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0- 10%	54,6	56,7	39,2
>10-20%	31,0	29,7	40,4
>20 - 30%	10,3	9,9	13,9
>30- 40%	2,5	2,5	2,9
>40- 50%	0,9	0,8	2,3
>50- 60%	0,2	0,1	0,2
>60- 70%	0,2	0,1	0,7
>70- 80%	0,1	0,1	0,0
>80 - 90%	0,1	0,1	0,1
>90 -100%	0,1	0,0	0,3
total:	100,0	100,0	100,0
mean defoliation:	11,7	11,3	14,5

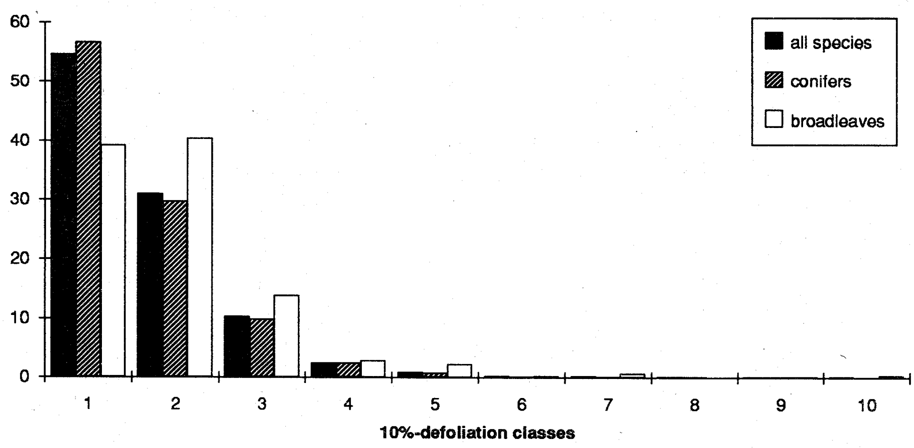
Belgium-Flanders 1991

10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0-10%	32,2	27,8	37,7
>10- 20%	41,9	47,5	35,0
>20- 30%	20,1	19,4	21,1
>30 - 40%	3,6	3,4	3,8
>40- 50%	1,5	1,4	1,6
>50- 60%	0,5	0,5	0,4
>60- 70%	0,0	0,0	0,0
>70- 80%	0,0	0,0	0,0
>80- 90%	0,2	0,0	0,4
>90 -100%	0,0	0,0	0,0
total:	100,0	100,0	100,0
mean defoliation:	15,3	15,5	15,0

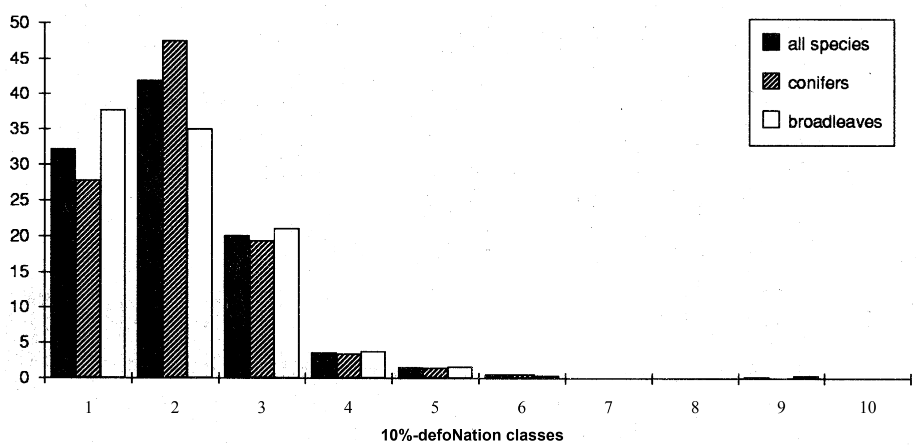
Czechoslovakia 1991

10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0- 10%	24,1	19,9	39,6
>10- 20%	24,7	23,4	29,6
>20- 30%	19,9	21,5	14,1
>30 - 40%	13,7	15,4	7,5
>40- 50%	6,9	8,2	2,3
>50 - 60%	4,8	5,7	1,7
>60- 70%	2,9	3,2	1,5
>70 - 80%	1,8	1,8	1,6
>80- 90%	0,6	0,5	0,7
>90 -100%	0,6	0,4	1,4
total:	100,0	100,0	100,0
mean defoliation:	24,7	26,3	18,6

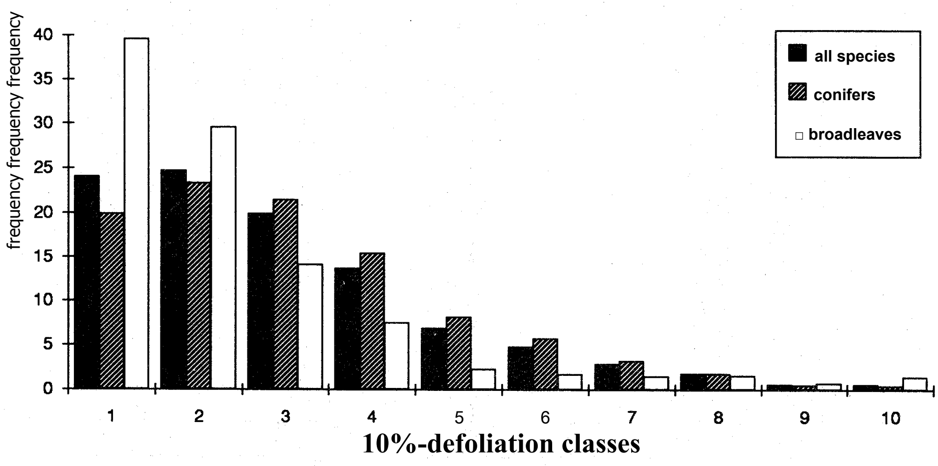
Austria 1991



Belgium-Flanders 1991



Czechoslovakia 1991



Estonia 1991

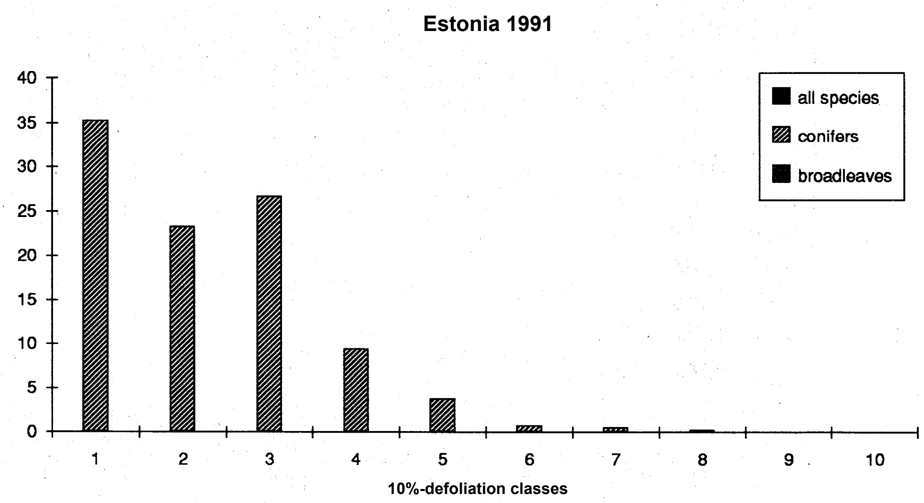
10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0- 10%		35,3	
>10- 20%		23,3	
>20 - 30%		26,7	
>30 - 40%		9,5	
>40- 50%		3,8	
>50- 60%		0,7	
>60- 70%		0,5	
>70- 80%		0,2	
>80- 90%		0,0	
>90 -100%		0,0	
total:	0,0	100,0	0,0
mean defoliation:	0,0	17,8	0,0

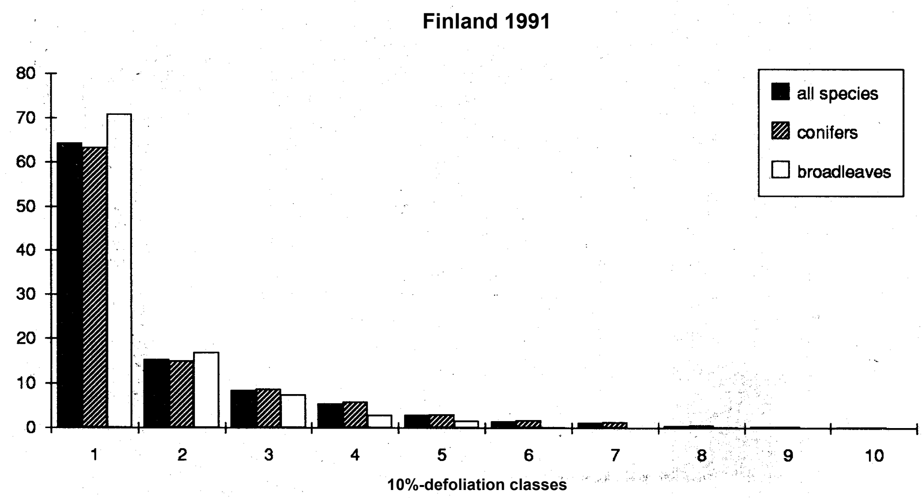
Finland 1991

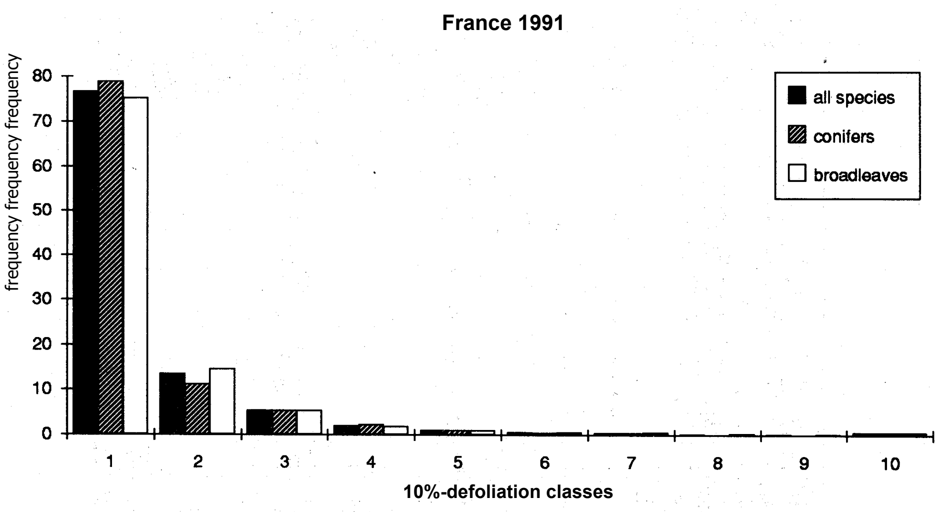
10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0 - 10%	64,3	63,3	70,8
>10 - 20%	15,3	15,0	16,9
>20 - 30%	8,5	8,7	7,5
>30 - 40%	5,5	5,9	2,8
>40- 50%	2,9	3,0	1,6
>50- 60%	1,5	1,7	0,2
>60- 70%	1,1	1,3	0,0
>70- 80%	0,5	0,6	0,2
>80- 90%	0,3	0,3	0,0
>90 -100%	0,1	0,2	0,0
total:	100,0	100,0	100,0
mean defoliation:	13,1	13,7	9,9

France 1991

10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0 - 10%	76,6	78,9	75,3
>10- 20%	13,5	11,2	14,6
>20 - 30%	5,4	5,4	5,4
>30- 40%	1,9	2,2	1,8
>40- 50%	1,0	1,0	1,0
>50- 60%	0,5	0,4	0,6
>60- 70%	0,4	0,4	0,5
>70 - 80%	0,1	0,0	0,2
>80- 90%	0,1	0,0	0,1
>90 -100%	0,5	0,5	0,5
total:	100,0	100,0	100,0
mean defoliation:	9,5	9,2	9,8


Estonia 1991
40
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes
all species
conifers
broadleaves


Finland 1991
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes
all species
conifers
broadleaves


France 1991
frequency frequency frequency
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes
all species
conifers
broadleaves

Greece 1991

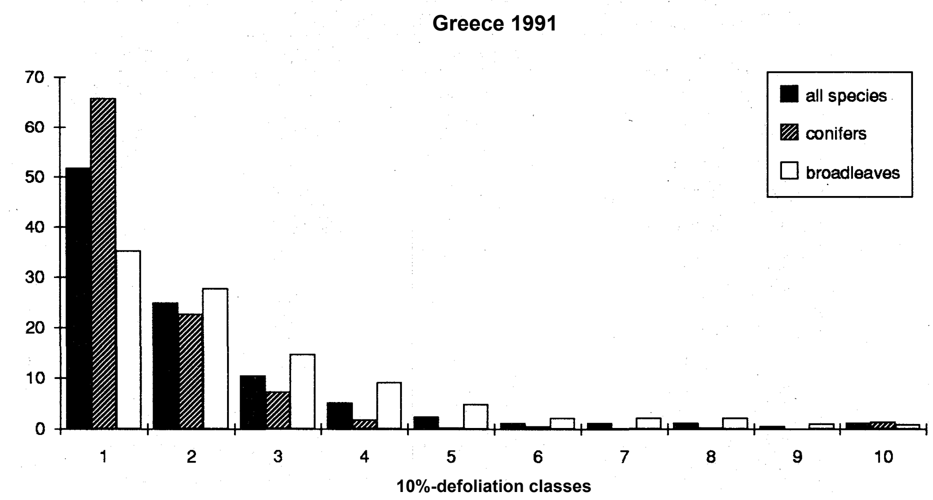
10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0- 10%	51,8	65,7	35,3
>10- 20%	24,9	22,6	27,7
>20 - 30%	10,6	7,3	14,7
>30- 40%	5,1	1,7	9,2
>40 - 50%	2,4	0,3	4,9
>50 - 60%	1,2	0,5	2,1
>60 - 70%	1,1	0,2	2,1
>70 - 80%	1,2	0,3	2,1
>80 - 90%	0,5	0,0	1,0
>90 -100%	1,2	1,4	0,9
total:	100,0	100,0	100,0
mean defoliation:	15,7	11,2	20,8

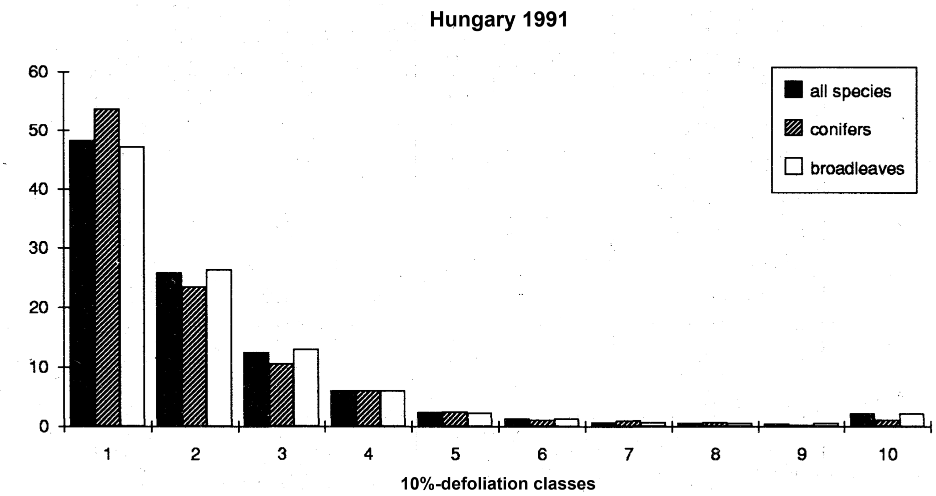
Hungary 1991

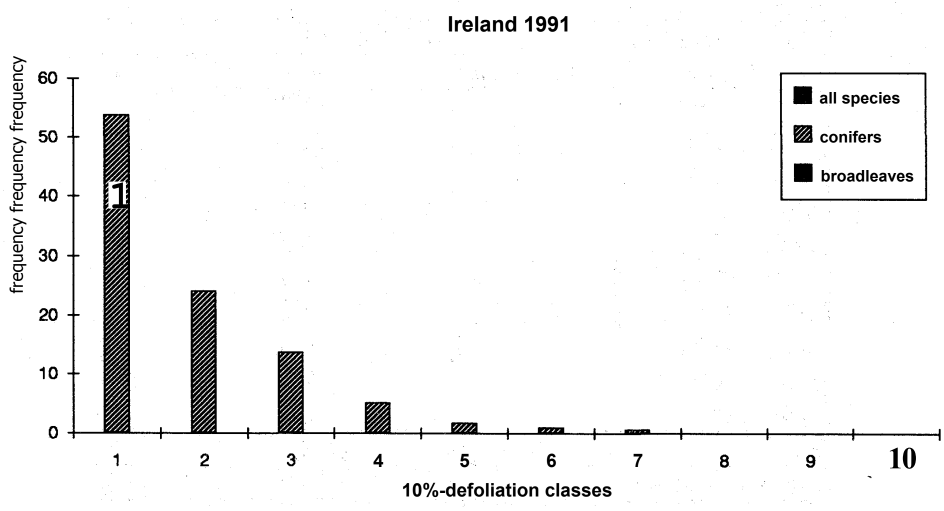
10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0- 10%	48,3	53,6	47,2
>10 - 20%	25,8	23,4	26,4
>20 - 30%	12,5	10,5	13
>30- 40%	6	6	6
>40- 50%	2,4	2,5	2,3
>50 - 60%	1,3	1,1	1,3
>60 - 70%	0,7	1	0,6
>70- 80%	0,5	0,6	0,5
>80 - 90%	0,4	0,2	0,5
>90 -100%	2,1	1,1	2,2
total:	100,0	100,0	100,0
mean defoliation:	16,5	15,0	16,7

Ireland 1991

10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0- 10%		53,7	
>10- 20%		24,1	
>20- 30%		13,7	
>30 - 40%		5,2	
>40- 50%		1,7	
>50- 60%		1,0	
>60- 70%		0,6	
>70 - 80%		0,0	
>80- 90%		0,0	
>90-100%		0,0	
total:			0,0 100,0 0,0
mean defoliation:			0,0 13,3 0,0


Greece 1991
70
60
50
40
30
20
10
0
all species
conifers
broadleaves
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes


Hungary 1991
60
50
40
30
20
10
0
all species
conifers
broadleaves
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes


Ireland 1991
frequency frequency frequency
60
50
40
30
20
10
0
all species
conifers
broadleaves
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes

Lithuania 1991

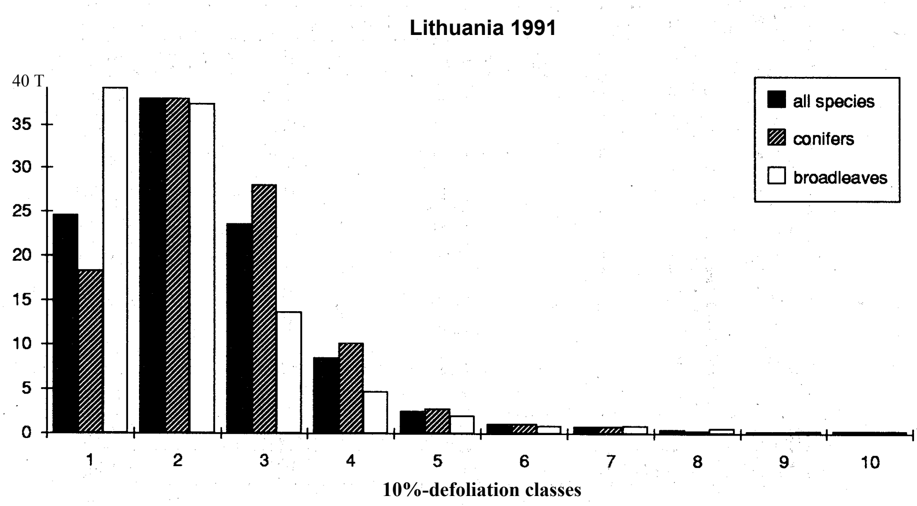
10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0- 10%	24,6	18,3	39,2
>10- 20%	38,0	38,0	37,4
>20- 30%	23,6	28,0	13,7
>30- 40%	8,5	10,2	4,7
>40- 50%	2,5	2,8	2,0
>50- 60%	1,1	1,1	0,9
>60- 70%	0,8	0,8	0,9
>70- 80%	0,4	0,3	0,6
>80 - 90%	0,2	0,2	0,3
>90 -100%	0,3	0,3	0,3
total:	100,0	100,0	100,0
mean defoliation:	18,8	20,3	15,6

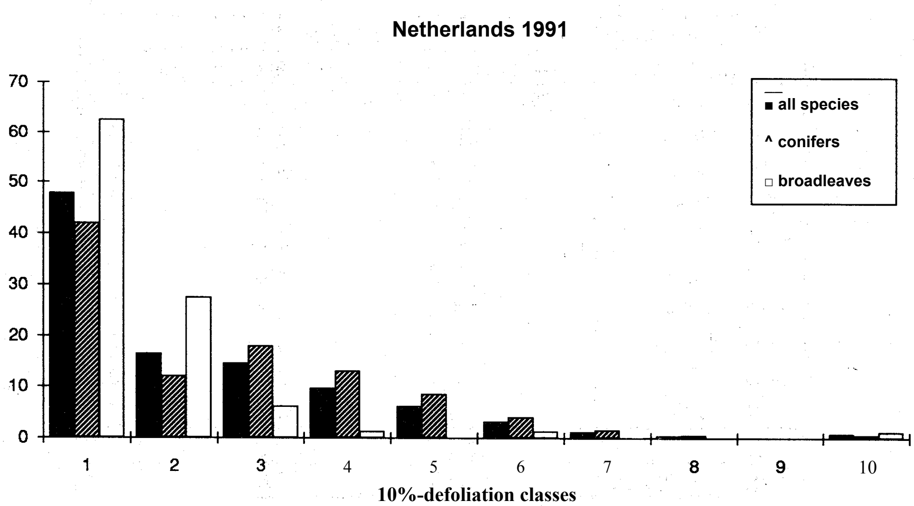
Netherlands 1991

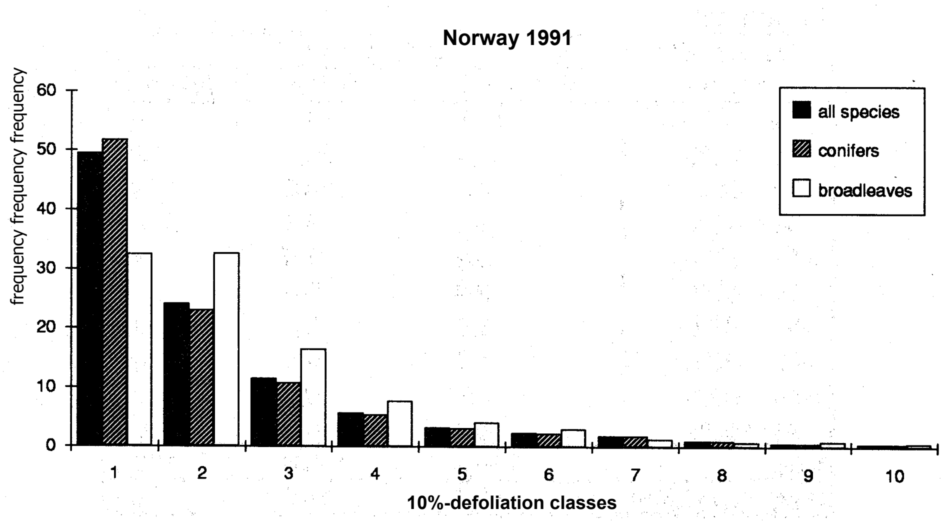
10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0 - 10%	47,9	42,0	62,5
>10- 20%	16,4	12,0	27,5
>20 - 30%	14,6	18,0	6,2
>30 - 40%	9,6	13,0	1,3
>40- 50%	6,1	8,5	0,0
>50- 60%	3,2	4,0	1,3
>60 - 70%	1,1	1,5	0,0
>70 - 80%	0,4	0,5	0,0
>80- 90%	0,0	0,0	0,0
>90-100%	0,7	0,5	1,2
total:	100,0	100,0	100,0
mean defoliation:	18,1	20,8	11,1

Norway 1991

10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0- 10%	49,4	51,7	32,5
>10- 20%	24,1	23,0	32,6
>20- 30%	11,5	10,8	16,5
>30- 40%	5,7	5,4	7,8
>40 - 50%	3,2	3,1	4,1
>50- 60%	2,4	2,3	3,0
>60- 70%	1,8	1,8	1,3
>70 - 80%	1,0	1,0	0,8
>80 - 90%	0,5	0,5	0,9
>90 -100%	0,4	0,4	0,5
total:	100,0	100,0	100,0
mean defoliation:	16,4	16,0	19,6


Lithuania 1991
40
35
30
25
20
15
10
5
0
all species
conifers
broadleaves
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes


Netherlands 1991
70
60
50
40
30
20
10
0
all species
conifers
broadleaves
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes


Norway 1991
frequency frequency frequency
60
50
40
30
20
10
0
all species
conifers
broadleaves
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes

Poland 1991

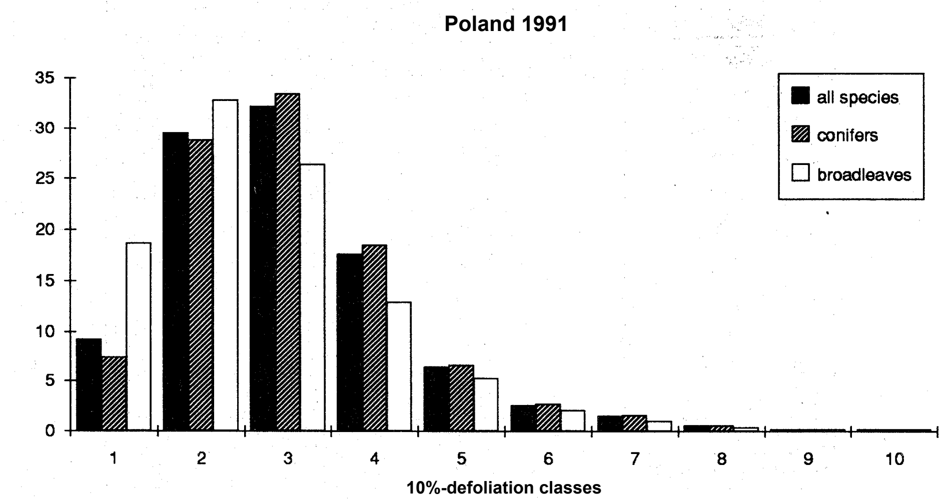
10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0- 10%	9,2	7,4	18,7
>10- 20%	29,5	28,8	32,8
>20- 30%	32,2	33,4	26,4
>30 - 40%	17,6	18,5	12,9
>40- 50%	6,4	6,6	5,3
>50- 60%	2,6	2,7	2,1
>60- 70%	1,5	1,6	1
>70 - 80%	0,6	0,6	0,4
>80 - 90%	0,2	0,2	0,2
>90 -100%	0,2	0,2	0,2
total:	100,0	100,0	100,0
mean defoliation:	25,2	25,8	21,8

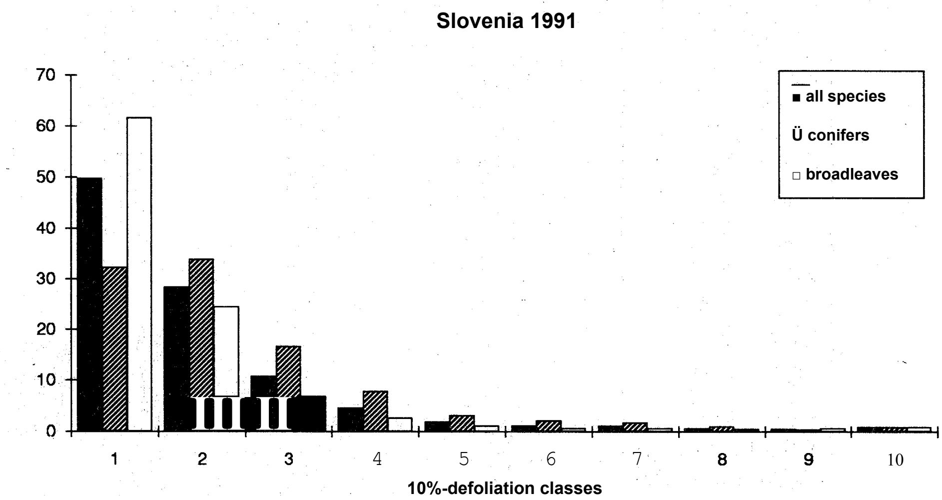
Slovenia 1991

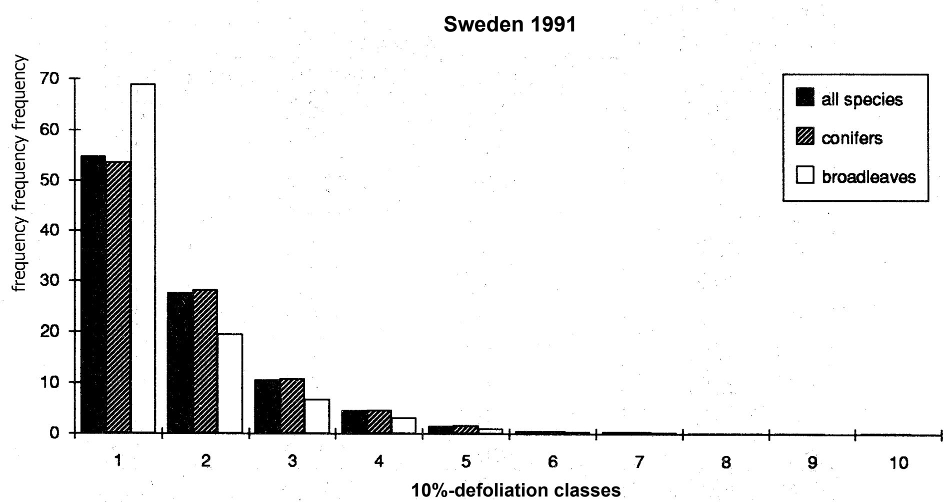
10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0- 10%	49,8	32,3	61,6
>10- 20%	28,4	33,9	24,5
>20- 30%	10,8	16,6	6,9
>30- 40%	4,7	7,9	2,6
>40- 50%	1,9	3,1	1,1
>50- 60%	1,2	2,1	0,7
>60- 70%	1,1	1,8	0,6
>70 - 80%	0,7	1	0,5
>80- 90%	0,5	0,4	0,6
>90-100%	0,9	0,9	0,9
total:	100,0	100,0	100,0
mean defoliation:	15,1	19,3	12,4

Sweden 1991

10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0-10%	54,7	53,6	68,8
>10- 20%	27,5	28,1	19,5
>20 - 30%	10,5	10,8	6,7
>30- 40%	4,5	4,6	3,2
>40- 50%	1,5	1,6	1,0
>50- 60%	0,5	0,5	0,4
>60- 70%	0,4	0,4	0,3
>70- 80%	0,2	0,2	0,1
>80- 90%	0,1	0,1	0,0
>90-100%	0,1	0,1	0,0
total:	100,0	100,0	100,0
mean defoliation:	12,6	12,8	10,1


Poland 1991
35
30
25
20
15
10
5
0
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes
all species
conifers
broadleaves


Slovenia 1991
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes
all species
Ü conifers
broadleaves

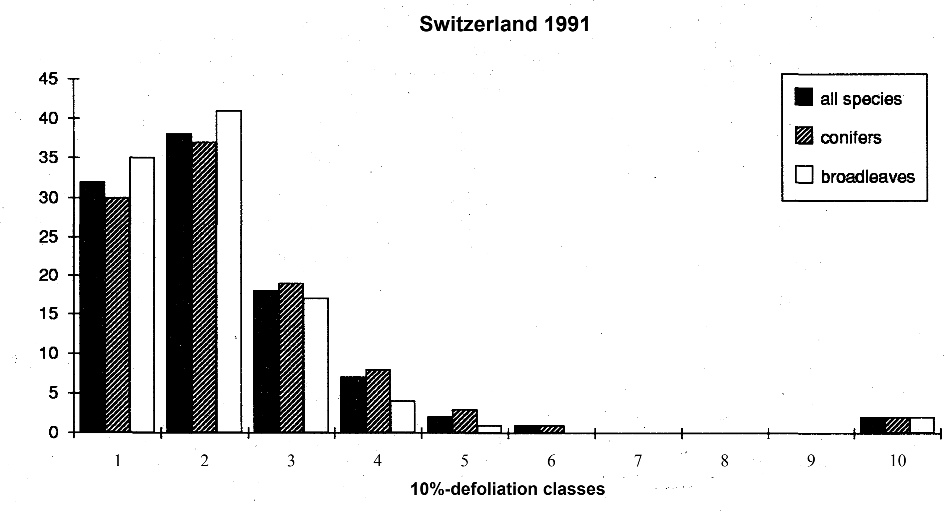

Sweden 1991
frequency frequency frequency
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes
all species
conifers
broadleaves

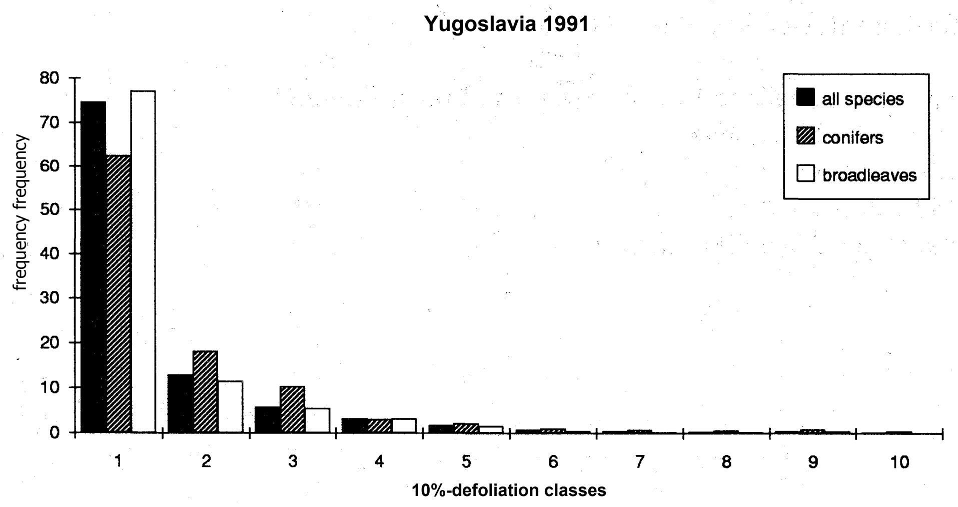
Switzerland 1991

10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0- 10%	32,0	30,0	35,0
>10-20%	38,0	37,0	41,0
>20- 30%	18,0	19,0	17,0
>30- 40%	7,0	8,0	4,0
>40 - 50%	2,0	3,0	1,0
>50- 60%	1,0	1,0	0,0
>60- 70%	0,0	0,0	0,0
>70 - 80%	0,0	0,0	0,0
>80 - 90%	0,0	0,0	0,0
>90 -100%	2,0	2,0	2,0
total:	100,0	100,0	100,0
mean defoliation:	17,6	18,4	15,9

Yugoslavia 1991

10%-defoliation classes	defoliation-% all species	conifers	broadleaves
0- 10%	74,5	62,5	77,1
>10- 20%	12,8	18,2	11,5
>20 - 30%	5,7	10,3	5,5
>30 - 40%	3,1	3,0	3,1
>40- 50%	1,8	2,2	1,6
>50- 60%	0,7	1,1	0,4
>60- 70%	0,5	0,8	0,2
>70 - 80%	0,3	0,6	0,2
>80 - 90%	0,5	0,9	0,4
>90 -100%	0,1	0,4	0,0
total:	100,0	100,0	100,0
mean defoliation:	10,4	13,2	9,6


Switzerland 1991
45
40
35
30
25
20
15
10
5
0
all species
conifers
broadleaves
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes


Yugoslavia 1991
frequency frequency
80
70
60
50
40
30
20
10
0
all species
conifers
broadleaves
1
2
3
4
5
6
7
8
9
10
10%-defoliation classes

For further information please contact:

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