CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION

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

United Nations
Economic Commission
for Europe

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Forest Condition
in Europe

1992 Executive Report

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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). Both have been prepared and published separately since 1987 by these two institutions.

The former Forest Damage Reports of UN/ECE described 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. The objectives of the ICP Forests are the assessment, monitoring and documentation of the extent and development of recent forest damage in Europe. For this purpose harmonized survey methods have been worked out and laid down in the Manual of Methodologies and Criteria for Harmonized Sampling, Assessment, Monitoring, and Analysis of the Effects of Air Pollution on Forests. Plot density differs from country to country. Plot data are converted into mean values related to the specific member state.

The former Forest Health Reports of the Commission of the European Communities were based on the Council Regulation (EEC) 3528/86 of November 1986 on the Protection of the Community's Forests against atmospheric pollution. Since 1987 the member states of the European Community (EC) have been surveying forest damage on sample plots of a uniform large-scale transnational grid (16x16 km), and have submitted data and reports to CEC for evaluation. The methods for this **transnational survey** are based on the guidelines of the ICP-Forests Manual as laid down under Commission Regulation (EEC) 1696/87 of June 1987.

The 6th Meeting of the Programme Task Force of ICP Forests and the European Community in 1990 decided to invite all UN/ECE member states to participate in the transnational survey formerly only carried out by EC countries, that the data of both the national assessments of UN/ECE and 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.

Based on the results of both the national assessments and the transnational survey, the present report is the first common report of EC and UN/ECE describing the condition of forests in Europe.

SUMMARY

The main objective of the present report is a condensed description of the condition of forests in Europe, as it has been assessed by transnational and national surveys of EC and UN/ECE. The report presents survey results from 28 European countries, referring to about 36 000 sample plots with about 700 000 sample trees. Of 214 million hectares of forests in Europe around 168 million hectares have been covered by the surveys (6 million more than in 1990). The results of the 1991 survey indicate that a significant proportion of forests in Europe shows signs of defoliation and/or discolouration.

The **transnational survey** results of 1991 revealed that 22.2% of the total tree sample (around 83 000 trees) had a **defoliation** of more than 25% and are thus classified as damaged. The respective value in 1990 was 20.8% which represents an increase by 1.4 percent points within a year.

In 1991 the share of trees with a discolouration of more than 10% was 10.6% of the total tree sample, which is a decrease by 3.2 percent points as compared with the previous year (13.8%).

As regards the two main **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 subsample of common trees of 1988 to 1991, greatest deterioration occurred in *Quercus suber,* followed by *Pinus nigra* and *Pinus pinaster.* A slight deterioration was observed in *Fagus sylvatica, Pinus sylvestris* and *Picea abies.* No notable changes occurred in *Quercus robur* and *Quercus petraea* neither in *Pinus halepensis, Picea sitchensis* nor *Abies alba.* The defoliation of *Larix decidua* even decreased slightly. Notable fluctuations and differences in discolouration have been observed over the years but without showing a clear trend.

In the **national surveys** a loss of needles/leaves has been observed to different extent in all of the participating countries. 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. Although particular attention is being paid to the effects of air pollution, very little direct impact from known pollution sources has been reported. Nevertheless, some countries regard air pollution as the essential factor causing forest damage in their countries. The majority of the remaining countries considers air pollution as a factor leading to the weakening of forest ecosystems because of impaired nutrient uptake, increased soil acidification and reduced base elements.

The great spatial and temporal variability observed calls for continued monitoring of defoliation and discolouration and additional assessment of various ecological data which may contribute to a better understanding of cause-effect relationship. In the years to come the already existing close cooperation between UN/ECE and the European Community will be intensified. In addition to the assessment of vitality of sample trees (defoliation and discolouration), first steps will be taken towards an integrated monitoring system by including information on the chemical soil properties and element contents in the needles.

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)

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

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.

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 atmosperic 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. Sub-manuals on soil surveys and on increment analyses have been drafted.

2.   METHODS

2.1   Transnational survey

The network of the transnational survey is a 16x16 km grid which covers nearly the entire forest area of Northern, Western, Central, Southern and Southeastern Europe. This grid network was created in Gauss-Krüger projection, and has been surveyed only by ECE-member states until 1989. By implementing the decison of the 7th Task Force Meeting the grid 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 now participating. The present report is based on a dataset of 3 846 plots comprising about 83 000 sample trees.

2.2   National surveys

The national surveys are also carried out by systematic sampling methods, but on national grids of different densities ranging from 1x1 km to 16x16 km. In 1991 28 countries participating in the ICP Forests conducted national surveys. On about 36 000 plots the vitality of more than 700 000 trees has been assessed. The results give specific information about the distribution and severity of forest damage in each country. However, caution is advisable when comparing the national results with those of the transnational survey because of differences in the sample point densities, in species composition, site conditions and climate.

2.3   Selection of sample trees

Within both the national and transnational surveys, at each sampling point falling in a forest area, sample trees are selected according to a stringently defined procedure. The sampling includes trees of all species having a minimum height of 60 cm. Only predominant, dominant, and co-dominant trees without significant mechanical damage qualify as sample trees. Trees removed within management operations or blown over by wind must be replaced by newly selected trees.

2.4   Assessment parameters and presentation of data

On each sample plot the sample trees are assessed with respect to defoliation and discolouration according to the instructions of the ICP-Forests Manual and EC Regulations. The survey results are expressed in terms of the percentage of the tree sample falling into the defoliation of discolouration classes (table 2.4-1).

Class	needle/leaf loss or discolouration	degree of defoliation/discolouration
0	up to 10 %	none
1	> 10 - 25 %	slight
2	> 25 - 60 %	moderate
3	> 60 %	severe
4	100 %	dead tree

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

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 surveyed may be used. In this report a sample point is referred to as "**damaged**" if the mean defoliation of its trees falls into class 2 or higher. Otherwise the sample point will be considered as "**undamaged**", even though some light defoliation may have occurred.

3.   RESULTS OF THE 1991 SURVEYS

3.1   Transnational survey results

3.1.1   General results

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 seem healthier than the conifers in terms of defoliation. This difference is less pronounced in the EC countries (Table 3.1.1-1).

	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	1.9	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 3.1.1-1: Percentages of defoliation for broadleaves, conifers and all species

10.6% of the total transnational tree sample showed a **discolouration** of more than 10%. In terms of discolouration, however, conifers appear slightly more vital than the broadleaves. Again, this difference is less pronounced in EC countries (Table 3.1.1-2).

	Species type	Discolouration						No. trees
		0-10%	>10-25%	>25-60%	>60%	dead	>25%	
EC	Broadleaves	84.9	11.6	2.2	0.8	0.5	3.5	25295
	Conifers	86.9	10.1	1.8	0.4	0.8	3.0	22719
	All species	85.9	10.9	2.0	0.6	0.6	3.2	48014
Total Europe	Broadleaves	85.4	11.2	2.1	0.7	0.6	3.4	30532
	Conifers	91.6	6.5	1.2	0.2	0.5	1.9	52602
	All species	89.4	8.2	1.5	0.4	0.5	2.4	83134

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

The figures 3.1.1-1, 3.1.1-2 and 3.1.1-3 give overviews of the percentage of trees damaged, plot defoliation and plot discolouration in the entire survey area.

Figure 3.1.1-1: Percentages of trees damaged (1991)

The percentage of trees damaged (defoliation more than 25%) was highest in certain highland areas of Central Europe.

Figure 3.1.1-2: Plot defoliation (1991)

Plot defoliation was highest in certain highland regions in Central Europe

LEGEND

NONE
SLIGHTLY
MODERATELY
SEVERELY
DEAD

88%
11%
1%
0%
0%

Figure 3.1.1-3: Plot discolouration (1991)

The overwhelming majority of all plots showed no or slight discolouration

3.1.2 Vitality by species groups

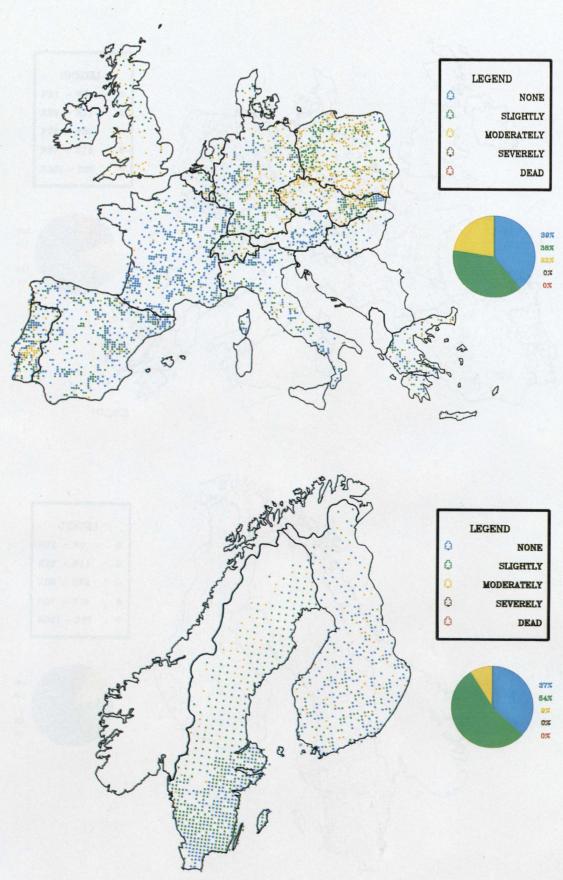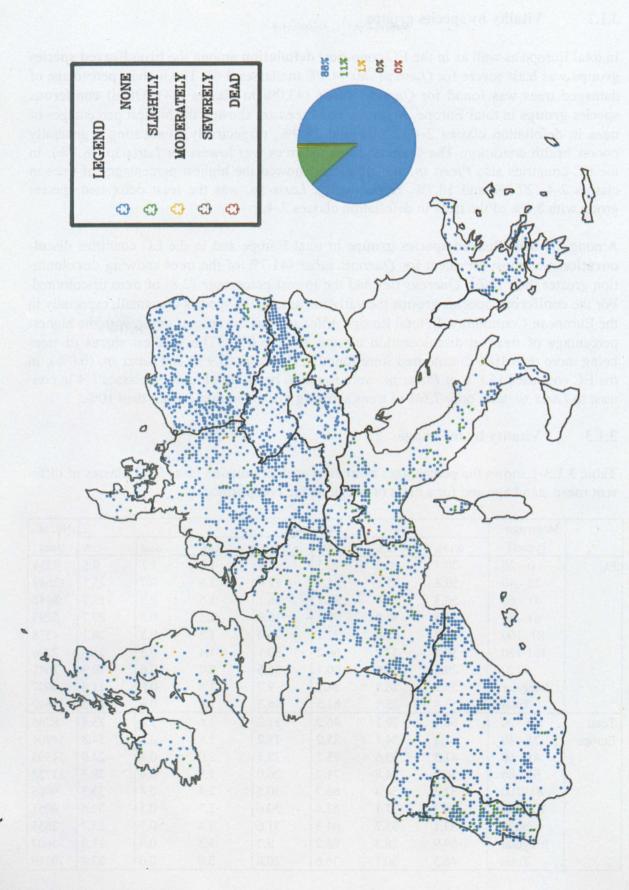In total Europe as well as in the EC countries, **defoliation** among the **broadleaved species groups** was least severe for *Quercus ilex* (4.4% in classes 2-4). The highest percentage of damaged trees was found for *Quercus suber* (43.0% in classes 2-4). Of all **coniferous species groups** in total Europe, *Abies sp.* and *Picea sp.* showed the highest percentages of trees in defoliation classes 2-4 (27.5% and 26.9%, respectively), indicating 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.

Among the **broadleaved species groups** in total Europe and in the EC countries **discolouration** was most prevalent for *Quercus suber* (41.7% of the trees showing discolouration greater than 10%). *Quercus ilex* had the lowest percentage (2.8) of trees discoloured. For the **coniferous species groups** the variation among the species was small, especially in the European Community. In total Europe *Abies sp.* was the species group with the highest percentage of trees in discolouration classes 1-4 (15.0%). The smallest shares of trees being more than 10% discoloured were found in *Picea sp.* (5.9%) and *Larix sp.* (6.0%). In the EC countries 15.0% of *Pinus sp.* were found to be in discolouration classes 1-4 in contrast to *Larix sp.* with only 7.6% of trees showing discolouration greater than 10%.

3.1.3 Vitality by mean age

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

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

The percentage of trees with defoliation of 10% declines gradually with increasing mean age. Accordingly, an opposite trend can be observed for the percentages of trees with defoliations of >10 - 25% and >25 - 60%. This confirms the well known strong positive correlation between age and defoliation of the trees investigated.

As in previous years, the analysis of discolouration and tree age did not lead to conclusive results.

3.1.4 Vitality by easily identifiable damage

Easily identifiable damage, i.e. damage caused by known and apparent agents has been divided into the following 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, etc.)
- fire
- known local or regional pollution
- other types of damage.

Table 3.1.4-1 presents the percentage of the total tree and plot sample affected by these damage categories.

Damage type	Defoliation % in classes 2,3+4		Discolouration %in classes1,2,3+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 3.1.4-1: Percentages of trees with defoliation >25% and discolouration >10% by identified damage types

Only the presence, but not the **intensity** of such damage types was recorded. Of the available data set for total Europe, one or more identifiable causes of damage was reported for 29.2% of the trees. As in the 1990 survey, the most frequently observed type of damage was caused by insects (11.3%). Damage attributed to **action of man, fungi** and **abiotic agents** was recorded less frequently, representing respectively 5.0%, 4.9% and 4.7% of the

total tree sample. The share of damage attributable to known pollution sources was with 0.1% of the trees without any importance. As expected, most of the damage types identified have some negative influence on foliage and colouration of the trees. 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.

Because of the heterogenity of the sample investigated, the possibility of more than one type of damage being present on a single tree and complicated relationship between known damage agents and air pollution effects, great care should be taken to avoid misinterpretation of easily identifiable damage as having influence on the needle/leaf losses observed.
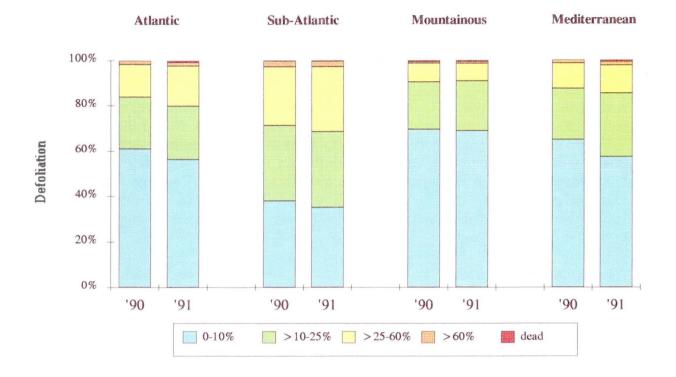
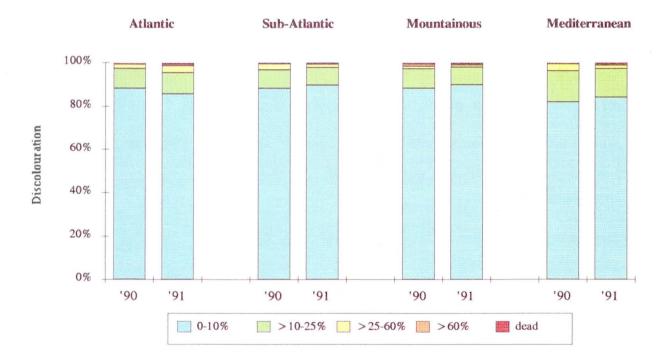### 3.1.5 Changes in defoliation and discolouration from 1990 - 1991

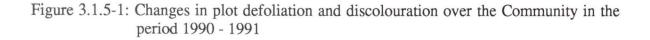### 3.1.5.1 Changes over the entire Community

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.

The percentages of trees in the different defoliation classes for the **total tree sample** and the **CSTs** of 1990 and 1991 are shown in Figure 3.1.5-1.

The percentage of undamaged trees increased by 4.6 percent points within the **total tree sample**, and by 4.4 percent points among the **CSTs**. On 74% of the total number of plots the defoliation between 1990 and 1991 remained unchanged whereas the total of plots showing a worsening vitality surpassed by 8% that of plots with improved vitality. This indicates a slight deterioration between 1990 and 1991.

Figure 3.1.5-1: Changes in plot defoliation and discolouration over the Community in the period 1990 - 1991

3.1.5.2   Changes by species groups

Nearly all species groups confirm the overall increase of defoliation between 1990 and 1991. 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 eminent change was the increase of the percentage of *Eucalyptus sp.* trees with a defoliation greater than 25% from 1.9% in 1990 to 7.5% in 1991. As the number of Eucalyptus 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* recorded in 1990 did not continue in 1991, but remained on a high level with 42.8% of trees in classes 2, 3 and 4.

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%. The vitality of *Picea sp.* has slightly deteriorated, whereas that of *Abies sp.* has slightly improved. A considerable improvement can be observed in *Larix sp.* with a decrease of trees in classes 2-4 from 12.0% to 7.2%. The other conifers show a marked 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.

3.1.6   Changes in defoliation and discolouration since 1988

Similar to the Common Sample Trees (CSTs) of 1990 and 1991 a separate subsample of trees common to the years 1988 - 1991 was created in order to study the trends in vitality over a longer period. Table 3.1.6-1 shows the changes in defoliation according to the main species groups.

	Defoliation											
	0 - 10%				11 - 25%				> 25%			
year:	'88	'89	'90	'91	'88	'89	'90	'91	'88	'89	'90	'91
Fagus sylvatica	59.8	60.8	54.0	50.5	26.0	27.5	28.5	31.3	14.2	11.7	17.5	18.2
Pinus sylvestris	60.8	62.9	58.9	54.1	26.9	27.2	27.7	29.0	12.3	9.9	13.4	16.9
Pinus pinaster	84.4	82.5	67.4	60.7	10.6	11.8	18.7	25.0	5.0	5.7	13.9	14.3
Picea abies	58.3	58.2	53.1	52.2	27.9	28.5	30.3	30.6	13.8	13.3	16.6	17.2
Quercus ilex	64.7	73.7	77.1	58.4	30.1	23.2	19.6	37.6	5.2	3.1	3.3	4.0
Pinus halepensis	66.2	75.3	72.3	70.3	29.2	21.6	24.0	26.6	4.6	3.1	3.7	3.1
Quercus suber	92.0	62.0	35.3	23.5	7.7	27.5	19.6	29.9	0.3	10.5	45.1	46.6
Pinus nigra	70.2	71.9	62.5	54.2	25.1	25.1	29.4	30.1	4.7	3.0	8.1	15.7
Quercus robur	38.9	44.9	44.5	36.5	29.7	33.1	26.9	29.4	31.4	22.0	28.6	34.1
Quercus petraea	70.7	66.0	67.1	62.1	21.8	24.9	25.6	26.9	7.5	9.1	7.3	11.0
Abies alba	58.0	55.6	57.8	55.9	16.8	23.5	20.1	21.3	25.2	20.9	22.1	22.8
Larix decidua	74.2	75.5	76.7	77.4	19.0	19.3	17.9	18.8	6.8	5.2	5.4	3.8
Picea sitchensis	33.1	30.7	35.8	28.5	34.2	36.5	34.7	35.6	32.7	32.8	29.5	35.9

Table 3.1.6-1: Changes in defoliation for trees common to 1988 - 1991 surveys

For most of the species included in the investigation, changes in vitality were found over the four years of the survey. The health of *Fagus sylvatica* has constantly declined over the entire Community since 1988 reaching now 18.2% of the CSTs with defoliation greater than 25%. For *Pinus sylvestris* the slight downward trend which started in 1989 continued with 16.9% of notably defoliated CSTs damaged in 1991. The defoliation of *Picea abies* increased slightly with 17.2% of the CSTs having a defoliation greater than 25% in 1991. A pronounced deterioration could be observed for *Pinus nigra* as well as for *Quercus robur* and *Picea sitchensis*.

3.2   National survey results

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

The majority of highly 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. Some Mediterranean countries reported forest destruction mainly caused by fires (almost 420 000 ha in Greece and Spain) and degradation caused by drought. The overall tendency in 1991 has been a deterioration in the majority of countries. Table 3.2-1 describes the changes of defoliation that were observed between 1990 and 1991 in classes 2 to 4 (more than 25% of needles/leaves lost). Changes are qualified as unimportant if equal to or less than 5 percent points, moderate between >10 and 20 percent points, substantial if exceeding 20 percent points from one year to the next one.

	number of countries					
	no or un-important 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 3.2-1: Numbers of countries showing increase, decrease or no change in defoliation by species groups

In 18 countries having reported in 1990 and 1991, defoliation (>25% needle loss) in *Picea sp.* stands over 60 years of age increases/decreases were unimportant in 7 and 2 countries, respectively; slight increases/decreases of defoliation occurred in 3 and 2 countries, respectively, while in one country a moderate increase, in 3 countries substantial decreases of defoliation were observed.

For *Pinus sp.* unimportant increases of defoliation (>25% needle loss) in stands over 60 years old were reported from 9 countries, slight increases/decreases occurred in 4 and 6 countries, respectively. Only in one country a substantial decrease was observed.

In the 9 countries that reported for *Abies alba*, increases/decreases of defoliation were unimportant in 3 and 4 countries, respectively; a substantial decrease, no change and a moderate increase of defoliation was observed in one country, each.

16 countries reported results for *Fagus sylvatica* in 1990 and 1991. Increases/decreases of defoliation were unimportant in 8 and 3 countries, respectively. Slight increases/decreases occurred in 2 and 3 countries, respectively.

For *Quercus robur* comparable data have been received from 15 countries. Increases/ decreases were unimportant in 9 and one countries, respectively. Slight increases/ decreases were observed in one and 2 countries, respectively, a moderate increase and decrease was reported from one country, respectively.

4. CONCLUSIONS AND RECOMMENDATIONS

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 83 000 trees 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.

Forest damage, expressed as a loss of needles or leaves and discolouration, 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 heavier defoliated than younger stands and forests at lower elevations. Several thousand hectares of forests on mountain tops and in industrial areas of Czechoslovakia and Poland are almost completely destroyed.

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 concentration and the deposition of certain pollutants in many areas exceed the levels at which disturbance to forest ecosystems would be expected. Sulphur dioxide, ammonia nitrogen oxide (as a precursor of ozone and acid deposition) and others may all be important in particular areas. Reducing the air pollution load is therefore the prerequisite for enhancing the ability of the forest ecosystems to recover and to regain the resistence lost. 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. Apart from adverse weather conditions and air pollution the importance of biotic damage agents such as insects and fungi for the observed defoliation and discolouration has been stressed in country reports. Nevertheless, the majority of the countries considers air pollution as a main factor leading to the weakening of forest ecosystems.

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 spatial and temporal variation can only be scrutinized by means of time series of observations detached from the constraints of national borders. Not the forest condition in a particular year but a time series of many consecutive years 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 survey not all parameters assessed by most of the participating countries have been evaluated, because their evaluation in previous years has not led to conclusive results. Considering the importance of time series, however, the assessment of parameters should be continued and even started to be conducted by those countries which have not yet already done so. For future in-depth analyses the complete data set will be needed.

The parameters presently recorded in the survey do not provide a complete and extensive description of site conditions. The collection of more detailed infomation 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.

The overall situation of forests in Europe indicates a clear need for continued monitoring. An advanced monitoring system 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 which are monitoring air pollution and its effects.

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 as well as the sampling and analysis of needles and leaves and deposition measurements are presently being prepared.

Latin	English	German	French	Spanish	Italian	Dutch
Fagus sylvatica	Common beech	Rotbuche	Hêtre commun	Haya	Faggio	Gewone buk
Pinus sylvestris	Scots pine	Gemeine Kiefer	Pin sylvestre	Pino silvestre	Pino commune	Pijnboom
Pinus pinaster	Maritime pine	Seestrandkiefer	Pin maritime	Pino negral	Pino marittimo	Zeepijn
Picea abies	Norway spruce	Fichte	Epicéa	Abeto falso	Picea comune	Gewone spar
Quercus ilex	Holm oak	Grüneiche	Chêne vert	Carrasca	Leccio	Altijdgro ene eik
Pinus halepensis	Aleppo pine	Aleppokiefer	Pin d'Alep	Pincarrasco	Pino d'Aleppo	Aleppo pijn
Quercus suber	Cork oak	Korkeiche	Chêne liège	Alcornoque	Sughera	Kurkeik
Pinus nigra	Corsican black pine	Schwarzkiefer	Pin noir	Pino laricino	Pino nero	Zwarte pijn
Quercus robur	European oak	Stieleiche	Chêne péndonculé	Quejigo	Farnia	Zomereik
Quercus petraea	Sessile oak	Traubeneiche	Chêne rouvre	Roble de invierno	Rovere	Wintereik
Abies alba	Silver fir	Weißtanne	Sapin pectiné	Abeto común	Abete bianco	Zilverden
Larix decidua	European larch	Europäische Lärche	Mélèze d'Europe	Alerce europeo	Larice europeo	Europese lariks
Picea sitchensis	Sitka spruce	Sitkafichte	Épicéa de Sitka	Picea de Sitka	Picea di Sitka	Sitka spar

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