COMMISSION OF THE EUROPEAN COMMUNITIES

DIRECTORATE-GENERAL FOR AGRICULTURE

EUROPEAN COMMUNITY FOREST HEALTH REPORT 1989

Executive report

DOCUMENT

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Background

This report gives the results of national forest health reports and the European Community's forest damage survey of 1989. The aim of the report is to give an updated overview of the state of forest health in the European Community. This report is a follow-up of the Forest Health Report 1987-1988.

The report is a result of the application of three years of Council Regulation (EEC) no. 3528/86 of 17 November 1986 on protection of the Community's forests against atmospheric pollution. Member States set up a Communitywide forest damage inventory system and have forwarded annual forest health reports to the Commission since 1987.

Under the same Regulation the Commission has granted financial aid to Community Member States for the completion of pilot projects and experiments to improve knowledge on air pollution in forests and its effects, to improve methods of observing and measuring damage to forests and to devise methods of maintaining and restoring damaged forests.

To ensure a common methodology, details of the methods to be used in the forest damage survey and the presentation of the results of the national inventories were laid down by Commission Regulation (EEC) No. 1696/87 of June 10, 1987 and No. 2995/89 of October 5, 1989. The methodology is based on guidelines for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests, as adopted by the parties of the Convention on Long Range Transboundary Air Pollution participating in the International Cooperative Programme for Assessment and Monitoring of Air Pollution Effects on Forests.

The Community's forest damage inventory is the first large scale transboundary inventory of its kind to be carried out in accordance with a common method, involving a unified sampling system and centralized data treatment. By 1989, it enabled comparable data to be collected in respect of over 45,000 sample trees throughout the Community.

The appearance of widespread decline of forest vitality, generally attributed to atmospheric pollution in many regions of the Community since the beginning of the 1980's, as well as the rapid spread of forest damage, were at the origin of the Community's action for the protection of forests against atmospheric pollution.

Summary

In 1989 the installation of the Community inventory network on forest health was completed in most Member States. The results of the inventory indicate that **a considerable part of the forests in the EC Member States are damaged.** Although the overall situation does not show clear changes in vitality, **certain species show a pronounced deterioration,** while the situation of the forest vitality varies widely. To reduce the variability of the vitality of the forest, an **increased effort** with respect to the analysis of the **influence of the ecological factors on the forest vitality** will be needed.

In the 1891 plots of the 1989 inventory, **a total of 9.9% of the trees showed a clear indication of needle- or leaf loss** (defoliation more than 25%). Trees showing more than 10% **discolouration** represented **16.0% of the tree sample**.

Between 1988 and 1989, **no clear changes in the percentage of damaged trees occurred** over the entire Community.

When regarding **defoliation** by species group, ***Eucalyptus* sp.** and ***Quercus ilex*** showed the **lowest percentages of damaged trees. Most damage** was found for ***Abies* sp.** and ***Picea* sp.**, suggesting a relatively poorer health condition of these species groups.

Of all the broadleaves, **most discolouration** was found for ***Quercus suber*.** ***Quercus ilex* showed the least discolouration.** The conifers did not show a great variation in discolouration. *Abies* sp. and *Pinus* sp. showed relatively low percentages of not-discoloured trees.

In the results of the 1989 inventory, **no significant relationships were found between the degree of defoliation or discolouration and the properties of the recorded parameters describing site conditions** (altitude, aspect or exposition, water availability and humus type).
However, it was found that **a relationship may exist between defoliation and mean stand age**. Younger stands appear to be more foliated than older stands.

Between 1988 and 1989, the **overall vitality of *Quercus suber* deteriorated considerably. The vitality of *Castanea sativa* only slightly worsened**.

No clear changes in vitality were found over the first three years of the inventory for the **majority of the species.**
A strong deteriorating trend in defoliation was found for *Picea sitchensis*. This is for a large part due to extensive **insect damage** in plots in the United Kingdom.

1 Introduction

1.1 Completion

The installation of the Community network which started in 1987 has almost been completed. In 1989, only Sardinia and Sicily remained unsurveyed. Now that the network has been nearly completed in most Member States, representative data can be obtained on the state of health of the forests. The inventory in 1989 comprised observations on 45772 sample trees from a total of 1891 plots.

1.2 Inventory method

The network of observation points used in the inventory comprises a 16 x 16 km. grid, and covers the entire forest area (537,000 km^2) of the Community. At each grid intersection point falling in a forest, a sample of 20 to 30 trees is selected for assessment according to a stringently defined procedure, as laid down in Commission Regulations No. 1696/87 and No. 2995/89.
Defoliation and discolouration of trees are the basic indices of vitality. They are estimated in comparison with a reference tree, being a healthy tree in the vicinity or a photograph of a tree with full foliage and not-discoloured, suitable for the region of investigation.

In addition to the vitality of sample trees, data are collected on the following parameters, describing general site- and stand characteristics of each sample plots: altitude, aspect (exposition), availability of water to principal species, humus type, mean age of dominant storey and observations of easily identifiable damages.

1.3 Presentation of the inventory results

The damage results are presented in terms of the percentage of the tree sample falling into each of the following defoliation and discolouration classes:

Class	Degree of defoliation/ discolouration	Percentage of needle/leaf loss or discolouration
0	not or negligable	0-10%
1	slight	11-25%
2	moderate	26-60%
3	severe	>60%
4	dead	

In this report, trees in **defoliation classes 0 and 1** will be referred to as **'not damaged'**, even though some slight defoliation may have occurred. Defoliation class 1 (slight defoliation) is sometimes considered as a warning class. Trees classified in **defoliation classes 2, 3 or 4** will be considered as **'damaged trees'**. The total percentage of sample trees classified in the defoliation classes 2, 3 and 4 gives an indication of the presence of clearly visible defoliation. The loss of more than 25% of foliage, in relation to the reference tree, is a clear indication of a loss of health.
In this report, a **sample plot** will be considered **'damaged'** if the weighted average defoliation class of the sample trees in this plot is more than 25%. If, on the other hand, the weighted average of a plot is 25% or less, the sample plot will be considered as **'not damaged'**.

2 1989 inventory results

2.1 General results

In 1989 a total of 45572 trees were sampled in 1981 plots. An overview of the total percentages of defoliation and discolouration for all broadleaves and conifers in the Community is given in Table 1. Regarding all the Member States, conifers show a slightly lower percentage of trees in defoliation classes 0 + 1 (0 - 25% defoliation). As for discolouration, the percentages are similar for broadleaves and conifers.

TABLE 1: Total percentages of defoliation and discolouration for all broadleaves, conifers and total sample trees in the EC.

	Defoliation						
Species type	0-10%	11-25%	**0-25%**	26-60%	>60%	dead	No. trees
Broadleaves	69.2	22.4	**91.6**	7.4	0.7	0.3	24737
Conifers	62.3	25.8	**88.1**	10.2	1.2	0.4	20835
All species	66.1	24.0	**90.1**	8.7	0.9	0.3	45572

	Discolouration				
Species type	0-10%	11-25%	26-60	>60%	No. trees
Broadleaves	83.7	12.6	2.9	0.7	24737
Conifers	84.2	12.8	2.2	0.7	20835
All species	84.0	12.7	2.6	0.7	45572

In the 1891 plots of the 1989 inventory, the **total percentage of damaged trees amounted to 9.9%** (Figure 1). Trees showing more than 10% discolouration represented 16.0% of the tree sample.
In 1988 the percentage of damaged trees was 10.2%. This percentage was derived from 1526 plots and 37607 trees, which makes the total percentages of 1988 and 1989 non-comparable.

In order to compare the results of the 1988 and 1989 inventory, a subsample was defined including trees that are common to both inventories: the Common Sample Trees (CST's). This subsample consists of 35478 trees, representing 95% of the total tree sample of 1988 and 78% of the total tree sample of 1989.
Within the subsample of Common Sample Trees, **no clear changes in the percentage of damaged trees occurred** (in 1988 and 1989 respectively 10.0% and 10.8% of the CST's were damaged).

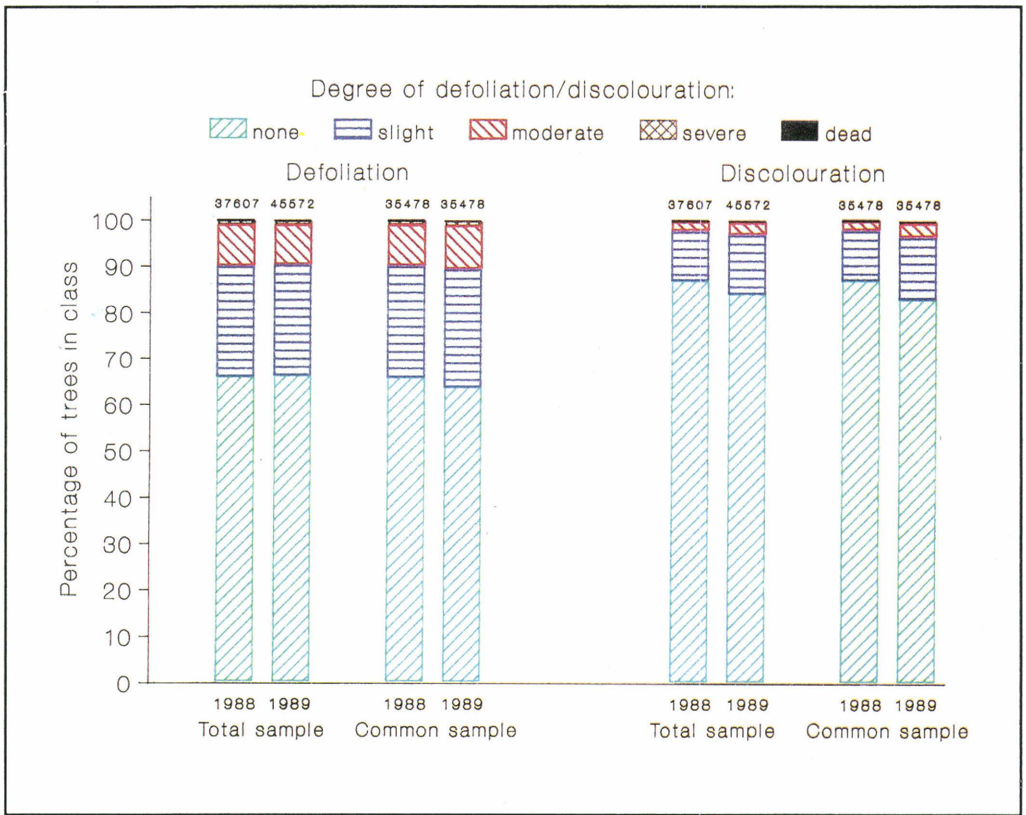

Figure 1: Total percentages of trees in the different defoliation and discolouration classes for the total tree samples and common sample trees of the 1988 and 1989 forest health inventories.

In the entire Community **9.7% of the plots were damaged**. In the Figures 2, 3 and 4, overviews are given of the degrees of tree damage, plot defoliation and plot discolouration in the entire Community. The direct comparison between countries and regions is not fully justified due to differences in the choice of reference trees.

The **most damaged plots** were found in Scotland, the southern parts of the Federal Republic of Germany and France, and the northwestern part of Italy (Figure 2). Also Greece showed a relatively large number of damaged plots.
Plot defoliation was relatively **high** in Scotland and the southern part of the Federal Republic of Germany.
Plot discolouration was relatively **high** in Portugal, Greece, and the southern part of France (Figure 4).

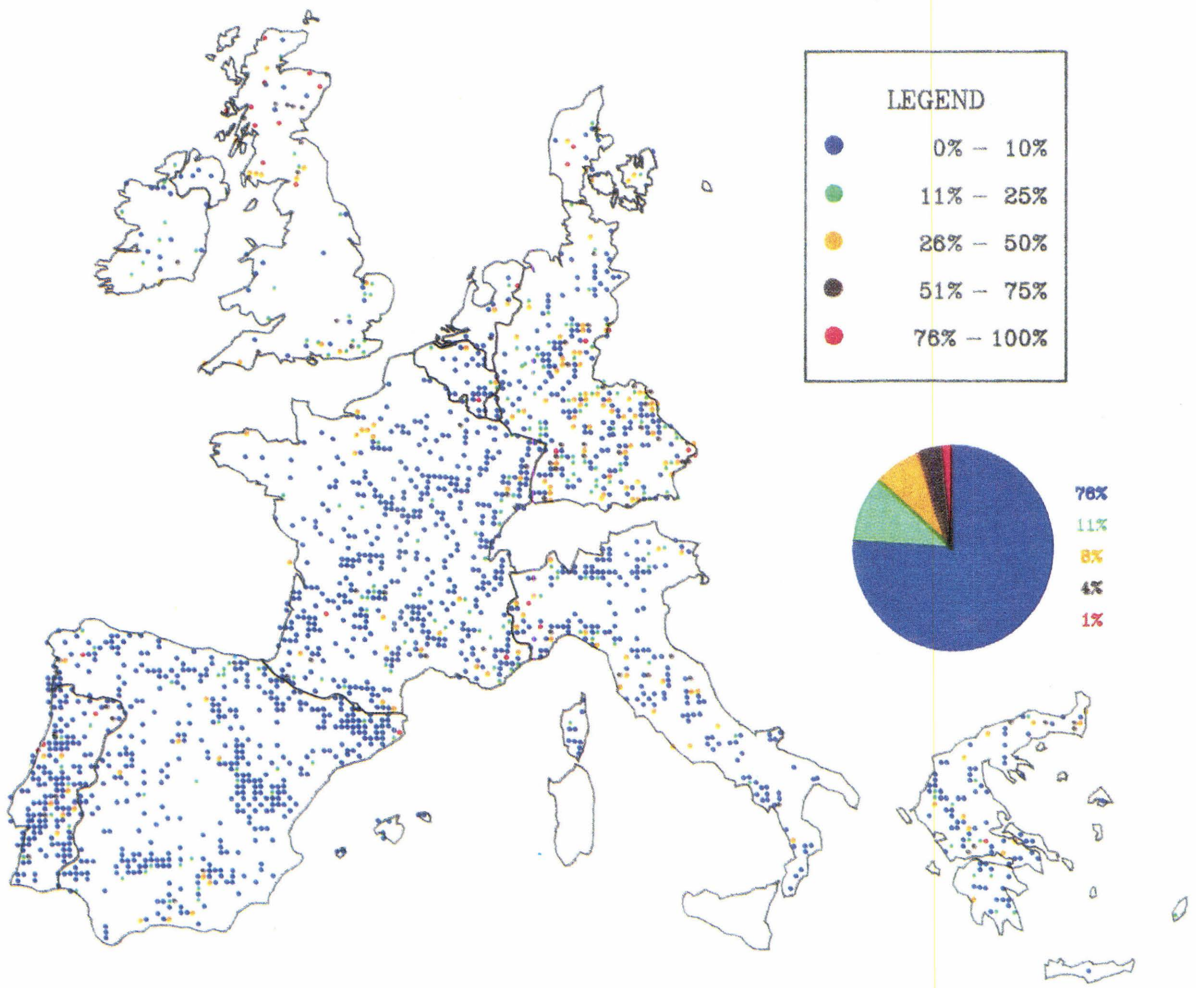

Figure 2: Percentages of trees damaged over the Community in 1989.

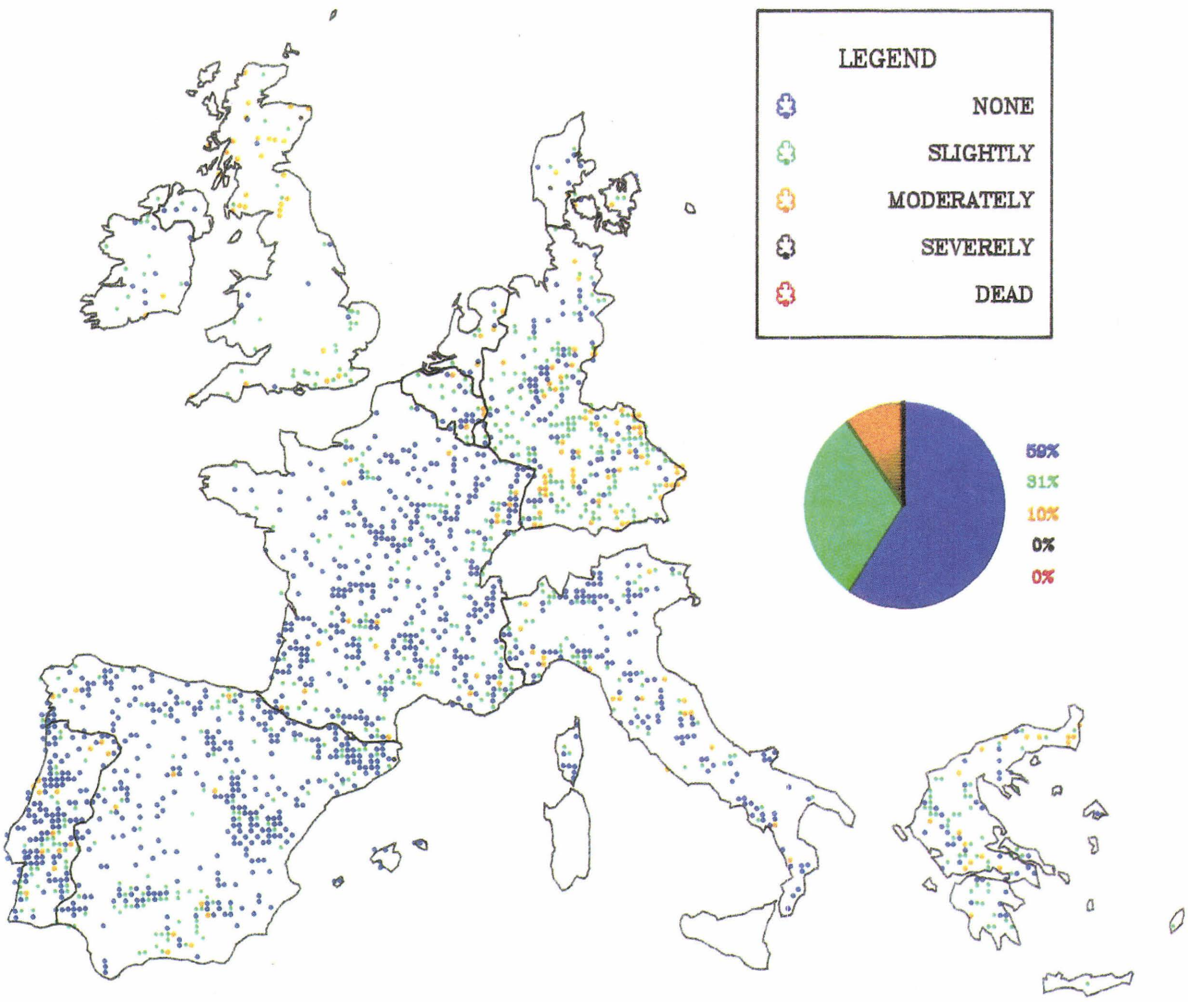

Figure 3: Plot defoliation for the Community in 1989.

2.2 Vitality by species group

In the 1989 inventory a total of 106 species was identified in the sample plots. The 10 most common species represented over 60% of all observed trees. The total proportion of broadleaves and conifers was 54.3% and 45.7% respectively.

Regarding the total tree sample, conifers show a slightly higher percentage of **damaged** trees than broadleaves. The degrees of **discolouration** are similar for broadleaves and conifers.

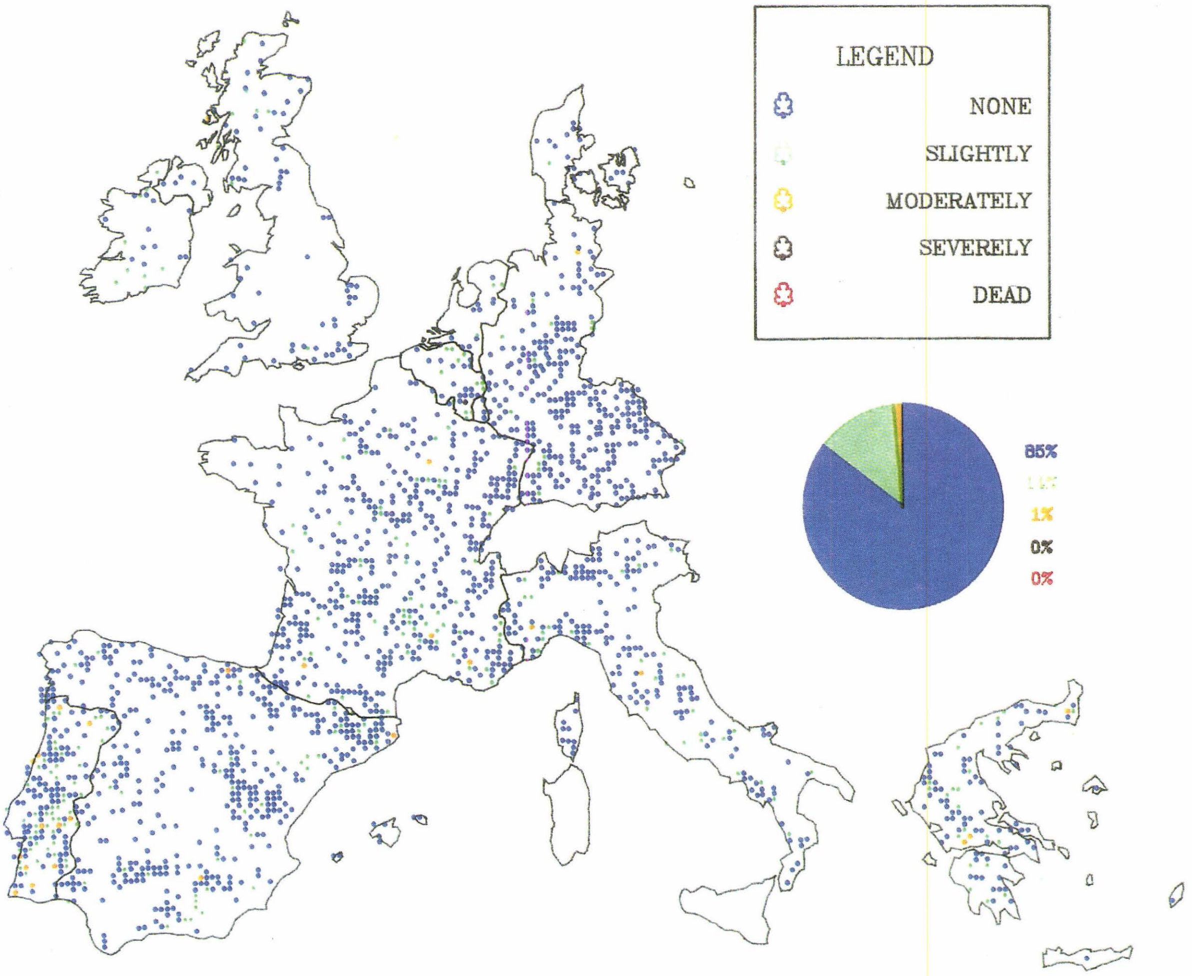

Figure 4: Plot discolouration for the Community in 1989.

When regarding **defoliation** by species group, ***Eucalyptus* sp.** and ***Quercus ilex*** show the **lowest percentages of damaged trees** (respectively 1.6% and 3.5%). **Most damage** was found for ***Abies* sp.** and ***Picea* sp.** (respectively 17.3% and 20.0%), suggesting a relatively poorer health condition of these species groups.

Of all the broadleaves, **most discolouration** was found for ***Quercus suber*** (only 54.2% of the trees were not-discoloured). ***Quercus ilex* showed the least discolouration** (93.0% of the trees were not-discoloured). The conifers did not show such a great variation in discolouration. *Abies* sp. and *Pinus* sp. showed relatively low percentages of not-discoloured trees (respectively 76.6% and 81.8%).

2.3 Vitality with respect to stand characteristics

In the results of the 1989 inventory **no significant relationships were found between the degree of defoliation or discolouration and the properties of the recorded parameters describing site conditions** (altitude, exposition or aspect, water availability and humus type).

However, it was found that **a relationship may exist between defoliation and mean stand age**. Younger stands appeared to be more foliated than older stands. This became apparent in differences in the percentages of not- and slightly defoliated trees. Older stands had a lower percentage of not-defoliated trees and a higher percentage of slightly defoliated trees as compared to younger stands. The relationships were strongest for conifers as compared to broadleaves.

Especially *Picea abies* showed relatively high correlations for the percentages of not- and slightly defoliated trees with mean age throughout the Community (Figure 5). These relationships suggest that tree vitality may worsen with increasing stand age. However, the percentage of **the total of not- and slightly defoliated trees** did **not** show strong correlations with mean age. Also, no relationships were found with respect to discolouration.

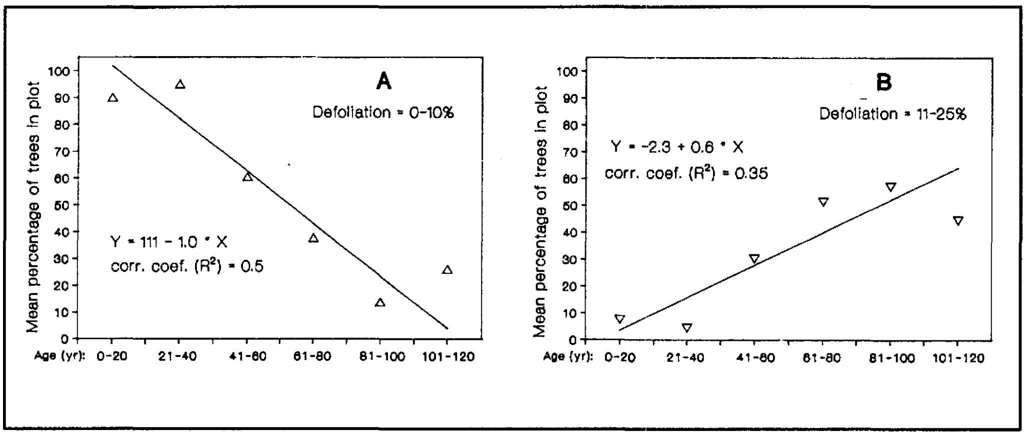

Figure 5: The relationship between mean stand age and the percentage of not-defoliated (**A**) and slightly defoliated (**B**) trees for *Picea abies*. The individual points are the averages of the percentages per plot in the mean age class. The lines show the trends in the percentages of trees per plot with mean age.

2.4 Vitality by easily identifiable damage

Of the total tree sample, 38.8% of the trees showed one or more identifiable causes of damage. The most commonly observed type of damage was caused by **insects.**

All types of damage that were identified had **some negative influence** on foliation and colouration of the trees. However, when regarding all types of damage together, the percentage of damaged trees was only slightly (4.0%) higher as compared to trees that did not show signs of identifiable damage. The difference with respect to the percentages of not-discoloured trees was considerably higher: 17.4%.

As for defoliation, the largest effect on the percentage of damaged trees was observed for trees affected by **local or regional pollution**. Also, trees affected by **game and grazing, fire** and **abiotic agents** (snow, storm, frost, etc.) showed high degrees of defoliation. However, the total observations for pollution, fire, game and grazing were very small, so no conclusion can be drawn from these figures.

As regards to **discolouration**, the most pronounced negative effect was observed for trees affected by **abiotic agents**. Only 57.1% of the trees showing this type of damage were not discoloured.

3 Comparison of 1988 and 1989 results

3.1 Changes over the entire Community

Comparisons between forest vitality of 1988 and 1989 must be based on trees that were common to both inventories. The percentages of trees in the different defoliation and discolouration classes for the **total tree sample** in 1988 and 1989, and the percentages for the trees common to the 1988 and 1989 inventory (**CST's**) are shown in Figure 1. When comparing the CST's, in 1989 the overall percentage of damaged trees was only slightly higher than in 1988. A slight increase (by 4.1%) in the total percentage of discoloured trees was found in the period 1988-1989.

The positive difference of 0.9% in the percentage of damaged trees between the total tree sample and the common sample trees of the 1989 inventory shows that with the extension of the grid network in 1989, relatively vital trees were included in the total sample.

Most worsening in plot defoliation occurred in Scotland, Ireland, Portugal and parts of Italy, where a relatively high number of plots changed from undamaged to damaged in the period 1988-1989. A general improvement in plot defoliation was found in Spain and parts of Greece (Figure 6).

Regarding the entire subsample of CST's in the Community, no clear overall changes in vitality occurred in the period 1988-1989.

3.2 Changes by species group

Although only minor overall differences exist in defoliation and discolouration between the CST's in 1988 and 1989, some species groups showed considerable changes over this one year interval.

As to **defoliation**, *Quercus ilex* and *Fagus* sp. showed a slight improvement, with a decrease in the percentages of damaged trees by respectively 3.0% and 3.5%. *Picea* sp. and *Quercus suber* showed a worsening in defoliation, with an increase by respectively 4.2% and 8.9% of damaged trees.

As to **discolouration**, most species groups remained unchanged over the period 1988-1989. **Considerable worsening in discolouration** occurred for ***Castanea sativa*** and ***Eucalyptus* sp.**, which species showed a decrease in the total percentage of not-discoloured trees by respectively 8.1% and 17.6%. A **pronounced change in discolouration** occurred for ***Quercus suber***. The total percentage of not-discoloured trees decreased from 87.8% in 1988 to 52.3% in 1989, which means a decrease by 35.5%.

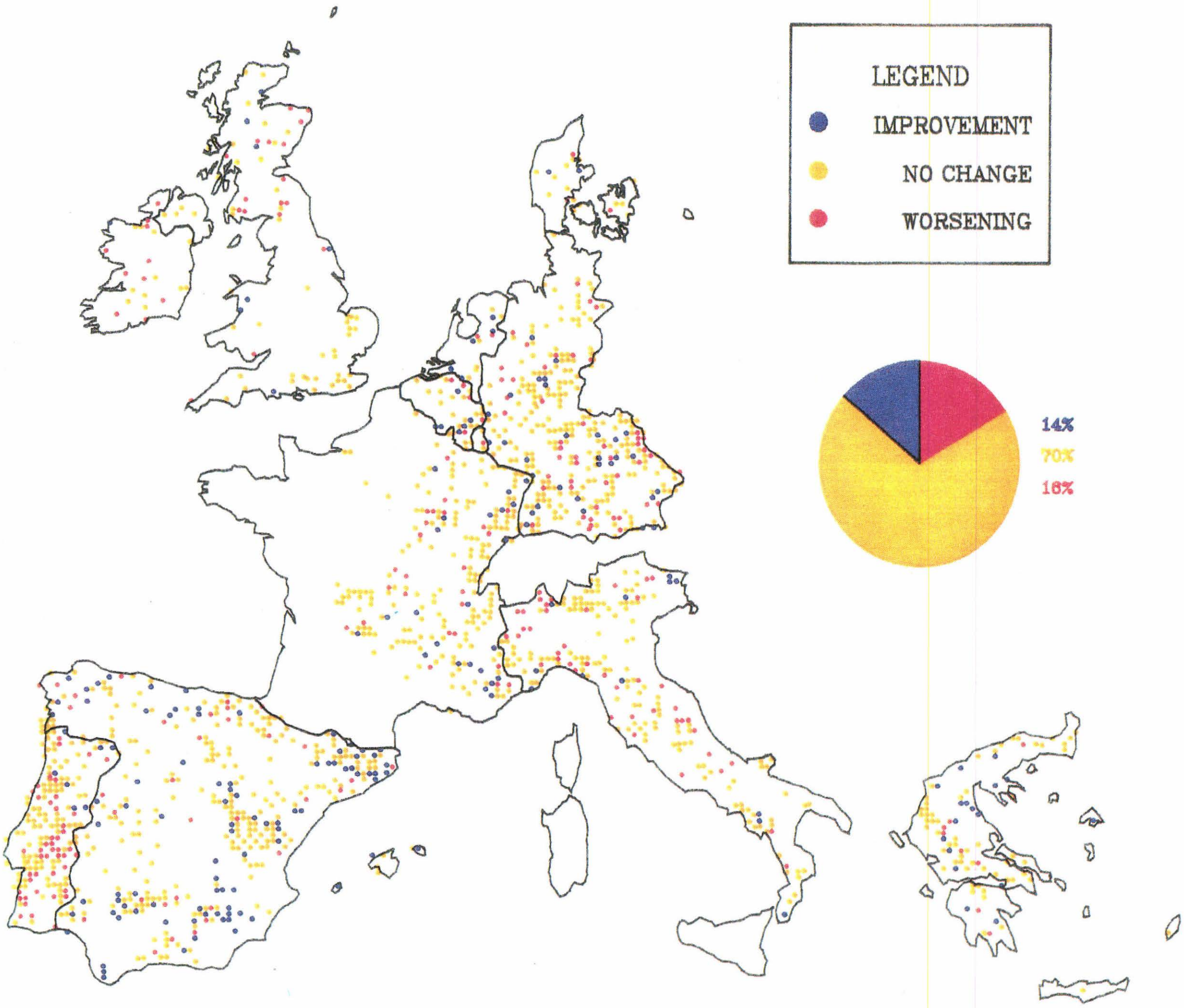

Figure 6: Changes in plot defoliation over the Community in the period 1988-1989.

When defining tree vitality as a combination of defoliation and discolouration, the **overall vitality of *Quercus suber* deteriorated considerably** in the period 1988-1989. **Vitality of *Castanea sativa* only worsened slightly**. For most other species groups, changes in both defoliation and discolouration were very small. Some species groups only showed changes in either defoliation or discolouration (*Quercus ilex*, *Picea* sp.) so no definite statement can be made regarding changes in vitality for these species groups.

4 Trends in tree vitality 1987-1988-1989

By 1989 the Community's forest damage inventory was carried out for three successive years. In order to investigate the possible trends in vitality over these first three years of the inventory, a separate **subsample** was defined containing **plots that were common to the 1987, 1988 and 1989 inventories**. Within this subsample, the changes in vitality were examined for the most common tree species to enable the establishment of possible trends in the health condition of the species.
Because of the **incomplete surveys** of 1987 and 1988, the trees in the sub-sample only represented a part of the total tree sample of the Community network. Therefore slight changes in vitality that were observed for some species could in many cases not be regarded as conclusive because of the low number of plots. Future surveys of the completed network will greatly improve this situation.

For the **majority of the species** included in the investigation, **no clear changes in vitality** were found over the first three years of the inventory (Table 2). In many cases the **percentages of trees in the different defoliation classes fluctuated considerably**. These fluctuations may reflect temporal changes in growing conditions such as extreme weather types (i.e. the hot summer of 1989). As to discolouration, variation was considerably smaller and annual changes rarely exceeded 10%.

TABLE 2: Changes in defoliation and discolouration for trees common to the 1988 and 1989 sample (CST's), by species group.

Species group	Defoliation 0-10%		Defoliation 11-25%		Defoliation 0-25%		Discolouration 0-10%	
	1988	1989	1988	1989	1988	1989	1988	1989
Castanea sativa	76.4	66.7	13.7	23.3	90.1	90.0	83.3	75.2
Eucalyptus sp.	95.8	95.5	3.9	3.1	99.7	98.6	99.5	81.9
Fagus sp.	60.0	60.3	26.3	29.5	86.3	89.8	87.2	88.8
Quercus sp. (deciduous)	64.0	63.0	22.9	25.2	86.9	88.2	86.7	86.2
Quercus ilex	62.0	70.6	31.3	25.7	93.3	96.3	91.5	93.1
Quercus suber	89.7	62.5	8.7	27.0	98.4	89.5	87.8	52.3
Other broadleaves	77.8	66.9	16.7	23.7	94.5	90.6	90.1	78.1
Total broadleaves	70.8	66.2	20.9	24.7	91.7	90.9	88.8	82.0
Abies sp.	53.0	55.5	26.4	26.6	79.4	82.1	75.1	77.2
Larix sp.	64.7	66.1	27.5	23.6	92.2	89.7	90.4	88.5
Picea sp.	50.0	45.8	33.9	33.9	83.9	79.7	88.9	89.4
Pinus sp.	66.5	68.1	24.9	23.5	91.4	91.6	83.2	80.4
Other conifers	68.6	74.2	20.6	16.9	89.2	91.1	92.9	88.6
Total conifers	60.9	61.0	27.6	26.4	88.5	87.4	85.0	83.5
Total species	65.8	63.6	24.2	25.6	90.0	89.2	86.9	82.2

A slightly improving trend in vitality was observed for *Pinus halepensis* and *Pinus pinaster*.

A strong deteriorating trend in defoliation was found for *Picea sitchensis* (Figure 7). This species showed a rapid increase in the percentage of damaged trees. The percentage of not-discoloured trees slightly increased. The strong deterioration in foliation is for a large part due to to extensive **insect damage** in plots in the United Kingdom. In the national health report of this country, strong attacks have been reported by the Green spruce aphid (*Elatobium abietinum*).

An **improvement of vitality was suggested for *Quercus ilex***. However, the number of trees in the plots of the subsample gradually increased in the period 1988-1989, so this improvement may be caused by the inclusion of relatively healthy trees in the plots.

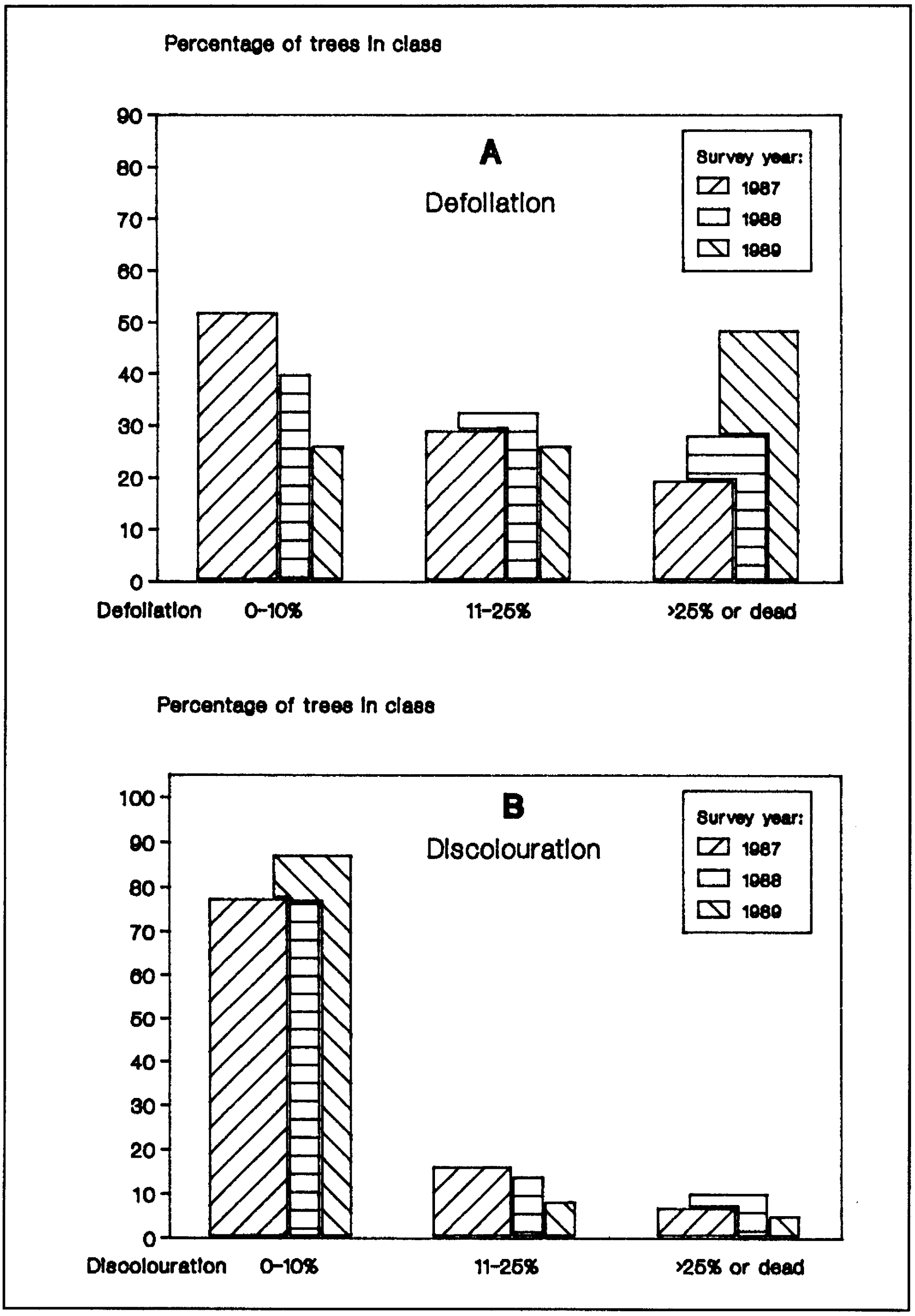

Figure 7: Changes in defoliation (A) and discolouration (B) of *Picea sitchensis* over the period 1987-1989.

5 Extended evaluation

5.1 Soil properties

No clear relationships were found between forest health and the recorded parameters describing soil properties (water availability to principal tree species and humus type).

Yet, the character of soil properties, such as parent material, soil fertility, etc. is known to play a significant role in forest vitality. Soil types can be used to characterize a number of soil properties.
It was investigated whether relationships exist between defoliation and the general soil type. The general soil types were determined per plot in the Federal Republic of Germany, Belgium and the Netherlands, using the Soil Map of the European Communities. Four general **soil units** were used in the investigation: luvisols, cambisols, podzols and histosols.
The soil units which have been distinguished all include a wide range of soil properties, such as different nutrient availability, soil humidity, basidity, etc. Consequently, the variation within each soil unit is very high. This probably accounts for the fact that **no clear relationships were found between defoliation and soil unit**.

To enable a more complete evaluation of forest vitality it is therefore recommended that **additional and more detailed information regarding soil properties be recorded for each sample plot in the inventory.**

5.2 Air pollution

Air pollution is generally assumed to play an important role in the decline of forests. The impact of air pollution on forest ecosystems also depends on the properties of a large number of site- and stand parameters. Unfortunately no specific information regarding air pollutants or additional site- and stand parameters is recorded in the inventory at this moment. This makes it impossible to directly assess any relationship between defoliation or discolouration and levels of air pollution in the Community.

A tentative investigation was carried out to evaluate the effects or influences of air pollution on forest vitality. For this evaluation the data were used of the **1988** inventory from the **Federal Republic of Germany**, **Belgium** and the **Netherlands**. The **general distribution maps** for the mean concentrations of a number of air pollutants were used to obtain information on the levels of air pollution in the plots. The air pollutants included in this investigation were: sulpher dioxide (SO_2), sulphate (SO_4), nitrate (NO_3) and acidity of precipitation (pH).

Per plot, the percentages were calculated of trees in the different defoliation classes for the five most common species (*Picea abies*, *Fagus sylvatica*, *Pinus sylvestris*, *Quercus petraea* and *Quercus robur*). For all five species, **no relationships** were found between defoliation and the mean levels of the different air pollutants and precipitation pH.

The information on levels of air pollution that was used here was too general; actual immissions of air pollutants can show a large variation over short distances, can vary with altitude, are dependent on the forest structure, etc.

To enable a more complete evaluation of the relationship between forest vitality, forest ecosystem and air pollution it is essential that **data be collected on the levels of a number of different air pollutants in or nearby the sample plots**.

6 Possible causes of observed damage as reported in the national forest health surveys

6.1 Introduction

The National forest health survey is in many cases executed with a denser grid than the 16 x 16 km of the EC-network.
Grids range from 0.3 x 0.3 km. (some parts of Federal Republic of Germany), 1 x 1 km. (Netherlands), 2 x 2 km. (Luxemburg), up to 16 x 16 km. Due to the different grids used in the National surveys, differences may occur when results are compared with results of the 16 x 16 km. EC-grid (Table 3).
National inventory reports from the EC Member States have been received.
In the National reports a chapter is included in which information is presented on the possible causes of observed damage on regional level. The most important possible causes mentioned are: the weather, insects, fungi, forest fires, and air pollution.

TABLE 3: Summary of National Forest Damage Inventories 1989

Defoliation in the EC Member States

Country	Forest Area (1000 ha)	Defoliation (0 - 10%)	(11 - 25%)	(0 - 25%)	(26 - 60%)	(> 60%)	(Dead)
BELGIE ')	617	44.2/57.2	44.2/26.3	88.4/83.5	10.0/13.8	1.5/2.6	0.1/0.1
DANMARK	460	54.0	21.0	75.0	20.0	5.0	1.0
DEUTSCHLAND	7388	47.0	37.4	84.4	14.6	0.8	0.2
ELLAS	2512	45.4	42.5	87.9	10.6	1.2	0.2
ESPANA	11921	78.0	18.7	96.7	2.8	0.5	0.0
FRANCE	13845	78.4	15.5	93.9	5.4	0.6	0.1
IRELAND	261	47.2	39.6	86.8	12.6	0.6	0.0
ITALIA	8675	75.8	15.1	90.9	7.9	0.6	0.6
LUXEMBOURG	84	60.9	29.0	89.9	7.8	1.8	0.5
NEDERLAND	330	52.6	31.3	83.9	13.7	1.8	0.8
PORTUGAL	3060	75.2	15.8	91.0	6.5	0.2	2.3
UNITED KINGDOM	2112	41.0	31.0	72.0	22.0	6.0	0.0

') Flanders/Wallon region

6.2 Weather in 1988/1989

The weather over the period winter 1988 - summer 1989 was in many places dry, and relatively warm (e.g. Belgium, Federal Republic of Germany, France, Netherlands, and Portugal). An exception is Spain, which reported exceptional rainfall over 1988/89. On one hand, this high rainfall lead to an improvement of the vitality, but on the other hand to severe attacks of fungi in some regions.
The dry and relative warm weather (mild winter, warm summer) lead in many areas to extra forest fires (Mediterranean area), to an increase in defoliation and an accelerated discolouration through early-ageing of the leaves (Belgium, Federal Republic of Germany, and Netherlands)

6.3 Insects

Insects have been recorded in most countries. Severe attacks have been recorded in Belgium, Denmark, Federal Republic of Germany (N), Greece, Ireland, Luxemburg, The Netherlands, Portugal, and the United Kingdom. In relation to 1988, improvements have been recorded in Belgium (*Fagus*), Luxemburg (*Fagus*, *Quercus*), The Netherlands (most conifers), while increased attacks have been recorded in The Netherlands (*Picea sitchensis* and most broadleaves), Ireland and the United Kingdom (*Picea sitchensis*).

6.4 Fungi

Attacks of fungi have been recorded in Spain (NW and SW regions, caused by the exceptional high rainfall), Greece, Netherlands (attacks are decreasing as a result of the mild winter and dry periods during the time of infection) and Portugal (*Quercus*, *Eucalyptus*).

6.5 Forest fires

Severe damage caused by forest fires has been reported by Greece, France, and Portugal. Also, it was an important problem in Spain.

6.6 Air pollution

Air pollution as a possible cause of damage has been reported in Denmark (NW Jutland), Federal Republic of Germany (higher elevations), France, Italy and The Netherlands.

6.7 Fructification

Although fructification is not considered to be a cause of damage, excessive fructification could result in a decreased foliation. Excessive fructification has been recorded in Denmark, the Federal Republic of Germany (*Fagus*), and the Netherlands (*Quercus*, *Betula*, *Fagus* and to some extend *Pinus*).

6.8 Other possible causes of observed damage

Greece reported damage caused by overgrazing (especially in the maquis area).
An undetermined dieback of single trees has been reported in Belgium (*Quercus*), Federal Republic of Germany (*Quercus*) and Greece (*Abies*)

7 Conclusions and Recommendations

Observations in 1989 showed that **9.9%** of the trees were **damaged** (defoliation more than 25%). The overall figures for the defoliation in 1987 and 1988 were respectively 14.3% and 10.2%.
In 1989 a **discolouration of more than 10%** was observed for **16.0%** of the trees. For 1987 and 1988 these figures (from smaller samples) were respectively 13.5% and 13.2%.

Conifers were slightly more damaged than **broadleaves**. In 1989, a defoliation of more than 25% was found for 11.8% of the conifers and 8.4% of the broadleaves. Of the more common species found in the EC, the coniferous species ***Abies*** sp. and ***Picea*** sp. show the **most defoliation** with respectively 17.3% and 20.0 % of the trees damaged. The broadleaves ***Eucalyptus*** sp. and ***Quercus ilex*** sow the **lowest** degree of defoliation, with respectively only 1.6% and 3.5% of the trees damaged.
Discolouration is approximately the same for broadleaves (16.3%) as for conifers (15.8%). The percentage of trees with a discolouration of more than 10 % was **highest** for ***Quercus suber*** (45.8%). For ***Quercus ilex***, this percentage was **lowest** (7.0%). Among the conifers, *Abies* sp. and *Pinus* sp. showed relative high percentages of discoloured trees with respectively 23.4% and 18.2 %.

Within the subsample of Common Sample Trees, **no clear changes in the percentage of damaged trees occurred**. The total percentage of damaged trees increased with only 0.8% in the period 1988 - 1989.
For **most tree species no clear changes** in vitality were observed.
For two tree species a pronounced deterioration in vitality was observed over the period 1987-1989. The **increase in defoliation for *Picea sitchensis*** is greatly due to attacks by the green spruce aphid (*Elatobium abietinum*). For the decrease in vitality for ***Quercus suber*** no cause of damage has been reported.

There is a major problem in **separating** changes in crown density or colouration **attributable to pollution from those caused by to other factors**. However, research has indicated that air pollution in many cases plays a significant role in forest decline. In many cases the existence and extent of forest damage cannot be explained without considering an influence of air pollution.

The relationships between forest vitality and air pollution can not be established without accurate information on levels of air pollutants that accounts for regional or local variation.
The parameters recorded in the inventory do not provide a complete and extensive description of site conditions. For example soil properties are not adequately characterized in order to establish relationships between soil conditions and forest vitality.
It is therefore recommended that **accurate data be collected on the levels of a number of pollutants**, in combination with **detailed information** on a number of site- and stand parameters, in order to be able to investigate the possible relationships between forest vitality and immissions of air pollutants in the forest.

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