COMMISSION OF THE EUROPEAN COMMUNITIES

DIRECTORATE-GENERAL FOR AGRICULTURE

EUROPEAN COMMUNITY FOREST HEALTH REPORT 1989

Technical report

DOCUMENT

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Background

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

The report is a result of the application for 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 have set up a Community wide forest damage inventory and forwarded annual forest health reports to the Commission since 1987.

Under the same Regulation the commission has granted Community financial aid for the completion of pilot projects and experiments to improve knowledge of 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.

For the purpose of making the forest damage survey and national reports, a common methodology was used as laid down by Commission Regulation (EEC) No 1696/87 of 10 June 1987. This 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 to 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 forest decline, 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

The **forest damage inventory** programme started in 1987 with 1216 plots and 26390 sample trees. By 1989, the network had been enlarged to 1891 plots and 45572 trees, covering most of the total forest area of the European Community (EC) Member States (approximately 500 000 km2) by a 16x16 km. grid.

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 respectivily 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*** show 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 %.

With regard to the **climatic zones**, in 1989 the percentage of damaged trees was slightly higher in the Atlantic and Sub-atlantic regions (respectively 13.0% and 12.9%) as compared to the Mediterranean (7.0%) and Mountainous region (6.0%).
The highest percentages for discolouration were found in the Mediterranean region (20.6%). Especially *Castanea sativa*, *Quercus suber* and *Abies* sp. show high discolouration figures with respectively 38.6% 45.8% and 38.0% of the trees showing discolouration. Total percentages of trees showing discolouration in the Atalantic, Sub-atlantic and Mountainous region were respectively 14.1%, 10.3%, and 14%.

Easily identifiable damage due to known causes has been observed for 38.8% of the trees. For 10.9% of the trees more than one type of damage was identified. **Insects** were the most commonly identified damage type (19.1%), known pollution was the least with 0.2%. A defoliation of more than 25% was slightly more observed for trees for which a damage type was identified (12.4%) than in trees were no identifiable damage was apparent (8.4%). The percentage of trees with a discolouration of more than 10% was clearly higher in trees where damage types have been identified (26.7% versus 9.3%). The most discolouration was observed in trees where damage from **abiotic agents** (wind,snow, frost, etc.) was identified (42.9% of the tree more than 10% discoloured).

For the comparison of the results of the 1988 and 1989 inventory, a subsample was defined containing all trees that were **common to both inventories**. This subsample consisted of 35478 Common Sample Trees (CST's). When regarding the entire subsample, an increase in damaged trees of only 0.8 % was observed, indicating that **no clear changes in forest vitality** occurred in the period 1988-1989.

The CST's in the Atlantic region showed a slight increase in defoliation. A slight increase in discolouration was observed with CST's found in the Mediterranean region.
The overall vitality of ***Quercus suber*** **deteriorated considerably** in the period 1988-1989. The vitality of ***Castanea sativa*** also showed a **slight deterioration**. Other species groups did not showed clear changes in vitality. ***Eucalyptus* sp.** did however show a sharp **increase in discolouration** of the CST's.

From a study on the 12 most common species executed on a subsample of plots common in 1987, 1988, and 1989, it appears that for most species **no improving or deteriorating trends** in the vitality of the sampled trees could be determined when regarding the entire Community.
Only for the species *Quercus ilex and the Picea sitchensis a clear trend was found.* ***Quercus ilex*** seems to be **improving**, while ***Picea sitchensis*** shows a **pronounced deteriorating trend**.

In an extended evaluation of a selection of the available inventory data, correlations have been investigated between defoliation with respect to site parameters (i.e. water availability, humus type, altitude and exposition), stand parameters (i.e. mean age and species) and two added parameters (soil unit and levels of air pollution). No clear relationships could be determined between defoliation and most parameter. However, there seems to exist a relationship between defoliation and mean stand age.

In a more detailed evaluation it appeared that the total percentage of **not-defoliated** trees clearly decreases with increasing age, while at the same time an increase is found in the percentage of **slightly defoliated** trees.
No clear relationships between age and discolouration have been found.

1 INTRODUCTION

1.1 Legislative Basis

On November 17, 1986 the Council of Ministers of the EC adopted Regulation (EEC) No. 3528/86 on the protection of the Community's forests against atmospheric pollution, which took effect from January 1st, 1987 (1). Within the Regulation, a Community scheme is provided for establishing a periodic Community inventory of damage to forests and the drawing up by the Member States of a periodic forest health report. It also provides for the development of pilot projects and field experiments in order to improve the understanding of atmospheric pollution in forests and its effects, to improve methods of observing and measuring damage and to establish methods for the restoration of damaged forests.
In Council Regulation (EEC) No. 1613/89 an amendment was adopted in which the provision for pilot projects to maintain damaged forests was included. Also a programme was introduced for the synoptic processing of information on knowledge of atmospheric pollution in woodlands and its effects (2).

With respect to the Community inventory, the scheme in the above Regulation provides for:

- Establishing, on the basis of a common method, a periodic inventory of damage caused to forests in particular by atmospheric pollution;

- Establishing or extending, in a coordinated and harmonious way, the network of observation points required to conduct this inventory.

The Community provides financing of up to 50% of the costs.
Following the inventory, each Member State forwards to the Commission the data gathered at the observation points of the network.

In addition, in accordance with Article 3 of the above Regulation, each Member State draws up and forwards to the Commission a periodic forest health report based in particular on the inventory data referred to in Article 2.

In accordance with the opinion of the Committee on Forest Protection, established by the same Regulation (no. 3528/86), the detailed rules of implementation of the inventory, and in particular the common methodology and format of presentation of the national forest health reports have been adopted and are laid out in Commission Regulation (EEC) no. 1696/87 of June 10, 1987 (3). This common method takes account of the recommendations of the ECE manual (United Nations Economic Commission for Europe, Convention on Long-Range Transboundary Air Pollution - International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests).

(1) OJ no. L 326, 11.21.1986, p. 2
(2) OJ no. L 165, 06.15.1989, p. 8
(3) OJ no. L 161, 06.22.1987, p. 1

1.2 Inventory method

The common method for establishing a periodic inventory of damage caused to forests is described in Annex 1 of Commission Regulation (EEC) no. 1696/87 of June 10, 1987, and in the Council Regulation (EEC) No. 1613/89. They lay down certain detailed rules for the implementation of Council Regulation (EEC) no. 3528/86. They apply to both the Community Inventory of forest damage and to the more dense grid networks that might be used by the Member States to draw up their forest health reports to be forwarded to the Commission.

The common inventory methodology requires that a network of observation points should be established following a systematic grid covering the entire forest area of the Community. For the community inventory, a 16 x 16 km. grid is used for which the latitude and longitude coordinates of each point have been provided by the Commission to each Member State. Member States are however encouraged to collect additional information from denser networks using the common methodology, in order to obtain representative data at national or regional level to be included in their annual reports as foreseen by Council Regulation (EEC) no. 3528/86.

At each grid intersection point falling in a forest, a sample of 20-30 trees is selected for assessment according to a stringently defined, objective and unbiased statistical procedure. The sample includes all tree species provided the sample trees have a minimum height of 60 cm. Only predominant, dominant and co-dominant trees, according to the system of Kraft, qualify as sample trees.

In each observation plot the tree sample is assessed with respect to defoliation and discolouration following the European classification. In the 1987 and 1988 forest damage inventory, defoliation was estimated in five classes:

Class	Degree of defoliation	Percentage of needle/leaf loss
0	not defoliated	0-10%
1	slightly defoliated	11-25%
2	moderately defoliated	26-60%
3	severely defoliated	>60%
4	dead	

In the 1989 inventory, defoliation was estimated in 5% increment classes, with class 0 = 0% defoliation, class 5 = 1-5% defoliation, class 10 = 6-10% defoliation, etc.

Defoliation is estimated in comparison with a tree with full foliage, the reference being a healthy tree in the vicinity or a photograph of a tree with full foliage, suitable for the region of investigation.
Discolouration is estimated in four classes:

Class	Degree of discolouration	Percentage of discolouration
0	negligably discoloured	0-10%
1	slightly discoloured	11-25%
2	moderately discoloured	26-60%
3	severely discoloured	>60%

Defoliation of trees or crown density is the basic index used in all surveys of forest health carried out throughout Europe in the framework of the Convention on long-range transboundary air pollution. It is influenced by a number of factors, of which pollution is one. The same holds for discolouration of foliage, another index used for evaluating the vitality of trees. Consequently, there is a major problem in separating any changes in crown density or colouration attributable to pollution from those attributable 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 the influence of air pollution.

In addition, for each sample plot data are collected on the following parameters and classified into common categories laid down in Regulation no. 1696/87: country, actual latitude and longitude coordinates, observation plot number, altitude, aspect, availability of water to principal species, humus type, mean age of dominant storey, date of observation, tree number, tree species and observations of easily identifiable damages. For the Community network these data are collected on common census forms (see Annex V) which are forwarded to the Commission.

2 1987, 1988 and 1989 Community inventory of damage caused to forests

2.1 Completion

The aim of the Community scheme, provided for under Article 2 of Council Regulation (EEC) no. 3528/86, is to establish a periodic inventory of the health status of forests in the Member States of the EC by collecting representative and comparable data on the extent and intensity of forest damage and to monitor its development.

The installation of the Community network of observation plots started in 1987 and the first observations of forest damage were carried out during the summer of that year. In 1987 the Commission received information from 1,216 Community observation plots and for 26,390 sample trees, in 1988 from 1526 plots and 37,607 trees, and in 1989 from 1891 plots and 45572 trees.

In the 1987 Community inventory, only a little over half of the grid network was established. In 1988, the network was considerably extended and was almost completed in 1989, with the inclusion of additional parts of France in the inventory. Only Sardinia and Sicily remained unsurveyed. Therefore the results of 1987 and 1988 may not be considered entirely representative for the Community's forests as a whole. With the completion of the network for almost all the Member States, the inventory results for 1989 can give representative data on the state of health of the forests in the Community. Table 1 gives the numbers of sample trees and plots by Member State for 1989.

TABLE 1: Number of plots and sample trees in 1987, 1988 and 1989.

Country	Plots			Sample trees		
	1987	1988	1989	1987	1988	1989
France	75	228	509	1806	4465	10192
Belgium	11	33	33	264	792	791
Netherlands	14	14	14	280	280	278
F. R. Germany	300	299	298	8062	7919	7883
Italy	189	208	206	5059	5536	5695
United Kingdom	75	75	76	1803	1791	1811
Ireland	22	22	22	535	461	462
Denmark	20	19	19	480	456	456
Greece	0	84	104	0	1979	2463
Portugal	108	154	152	2274	4621	4569
Spain	398	386	454	5730	9211	10876
Luxemburg	4	4	4	96	96	96
EC	1216	1526	1891	26389	37607	45572
Common Sample Trees				--	19651	35478

2.2 Input and screening of data

As stated in the rules of the Council Regulation detailing the inventory of forest damage in the European Communities, the forms with data of the forest damage inventory shall be forwarded to the Commission by December 15th of the year the inventory takes place.

Upon arrival at the Commission the information on the forms is screened. Incomplete and obviously faulty data are not accepted for further evaluation. Forms on which a single and less vital parameter is missing are accepted for evaluation, but will be excluded from the detail evaluation concerning the missing parameter. This is the reason why in a number of detail evaluations the totals do not always correspond to the grand total of 45572 trees.
After the first year (1987), in which a relatively large number of data were excluded, almost no data had to be rejected.
When the input of the data has been completed, a check is made with the data of former years. Trees common in both 1988 and 1989 are accepted for the evaluation with regard to Common Sample Trees (CST's)

2.3 Main characteristics of sample trees

Within the tree sample assessed in 1989, the following 10 species, mentioned in descending order of presence occur most frequently: *Picea abies* (10.3%), *Pinus sylvestris* (9.2%), *Fagus sylvatica* (8.4%), *Pinus pinaster* (8.0%), *Quercus ilex* (6.8%), *Quercus robur* (4.8%), *Quercus petraea* (4.1%), *Pinus halepensis* (4.0%), *Quercus pubescens* (3.2%) and *Quercus suber* (3.2%).
The total proportion of broadleaves and conifers was 49.7% and 50.3% respectively for the 1988 survey, and 54.3% and 45.7% respectively for the 1989 survey.

In 1989 the great majority (84.5%) of the sampled trees was situated in plots which had been classified in the **water availability class** 'sufficient', 13.8% in 'insufficient' and 1.7% in 'excessive'.
As far as **humus type** is concerned, 39.3% of the trees were on mull humus, 38.7% on moder, 13.4% on mor and only 0.3% and 1.2% respectively on anmor and peat. For 7% of all sample trees, the humus type was not defined.
As to **altitude**, 55.2% of the total sampled trees was situated at less than 500 m., 28.6% between 500 and 1000 m. and 16.3% above 1000 m.
As to **exposition or aspect**, the plots were generally fairly equally distributed among the classes except for class 9 (flat) which represents almost a quarter of the sampled trees. A slightly higher proportion of the samples trees was found in north-facing plots.
As regards to **mean age** classes, 61.1% of sample trees were located in less than 60 years old stands and 28.9% in stands of 60 years of age or more. A total of 10.1% of the trees was observed in stands with an irregular age distribution. Most age classes were fairly equally distributed over the altitude classes. Irregular aged stands were somewhat more common at higher altitudes.
As for **climatic zone**, 21.2% of the sampled trees were found in the Atlantic zone, 29.6% in the Sub-atlantic zone, 4.9% in the Mountainous zone. Most sample-trees (44.4%) were found in the Mediterranean zone.

2.4 Presentation and definitions

The damage results are presented in terms of the percentage of the tree sample falling into each defoliation class.
The question can be raised whether a qualitative distinction can be made between the first two defoliation classes. It can often be debated whether a tree in defoliation class 1 may truely be described as 'damaged'. It was demonstrated that over a two years time interval, individual trees may shift from defoliation class 0 to defoliation class 1 and vice versa (Annex VI). This shift may be due to changes in the health conditions of the trees, but may also reflect the natural variation in crown density.
However, before initially healthy trees reach higher defoliation classes, they must pass the state of defoliation class 1 at a certain phase of development. This class may therefore be interpreted as a 'warning class'. In the report, trees in **defoliation classes 0 and 1** will be referred to as **'not damaged'**, even though some defoliation has occurred.

Defoliation classes 2, 3 and 4 represent considerable defoliation (crown density less than 75% of what would be considered as normal). The total percentage of sample trees classified in those three defoliation classes gives a reliable indication of the presence of significant damage. Hereafter, trees classified in **defoliation classes 2, 3 or 4** will per definition be considered as **'damaged trees'**. A **sample plot** will in this report be considered as **'damaged'** if the weighted average defoliation class of the sample trees of this plot is 2, 3 or 4. If, on the other hand, the weighted average of a plot is 0 or 1, the sample plot will be considered as **'not damaged'**.

Whenever time trends in defoliation are presented, the percentages of trees in defoliation class 0 and 1 **per plot** will be considered for individual tree species. This can give an indication of the variation in defoliation of trees between plots. Additionally, when time trends are presented with respect to some environmental variables, only plots will be included that contain at least **10** individuals of the tree species concerned. This way, only stands are included in which the species represents a major stand component, and so the possible influence of competition from other species is diminished. Furthermore, **extreme values** for percentages of trees in the defoliation classes, due to the presence of only a few individuals of the species, will be avoided.

2.5 Comparability of 1987, 1988 and 1989 results

As the number of sample trees was largely increased in 1989 as compared to 1988 and 1987 (respectively 45572, 37607 and 26390 sample trees), the global results of these three years are not fully comparable. The increase in the number of sample trees is mainly due to the extension of the inventory grid in Spain, Portugal and Greece in period 1987-1988, and the further extension of the grid in France in the period 1988-1989.

In order to allow certain comparisons be made between results of subsequent years, a subsample has been defined which consists of those sample trees that have been observed over the **entire time interval**. The subsample for the period 1988-1989 contains 35478 trees, and will be referred to as **Common Sample Trees** 1988/1989 (CST's). The comparisons between the 1988 and 1989 observations given hereafter are based on this subsample.

Separate comparisons have been made for the observations on some of the most common tree species in the Community. For these species, a separate sub-sample has been defined for sample trees observed over the entire period of the survey (1987-1989). These comparisons enable the establishment of possible trends in the health condition of the species considered over the full time interval of the forest health inventory.

3 1989 Inventory results

3.1 Inventory results for the entire Community

Table 2 shows the total percentages of defoliation and discolouration for all broadleaves and conifers in the Community. 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 2: 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 1989 survey, a total of 106 species was identified in the sample plots. The number of observed trees per species was generally low. Only 13 species had a presence of over 2%. The 10 most common species represented over 60% of all observed trees (Table 3, Annex I-1).

When regarding **defoliation** by species group, of all the broadleaves *Eucalyptus* sp. and *Quercus ilex* show the highest percentages of not- to slightly defoliated trees (respectively 98.4% and 96.5%). The percentages of not- to slightly defoliated trees for the other broadleaved species groups are all within the average range for total broadleaves (Annex I-3).
As to coniferous species groups, *Abies* sp. and *Picea* sp. show the lowest percentages of not- to slightly defoliated trees (respectively 82.7% and 80.0%), suggesting a relatively poorer health condition. Other species groups showed more or less average percentages of not- to slightly defoliated trees (Annex I-3).

TABLE 3: Presence of most frequent species in the inventory.

Species	Trees			Plots	
	No	%	(% cum.)	No	%
Picea abies	4705	10.3	10.3	287	6.8
Pinus sylvestris	4188	9.2	19.5	316	7.5
Fagus sylvatica	3831	8.4	27.9	352	8.3
Pinus pinaster	3645	8.0	35.9	188	4.5
Quercus ilex	3084	6.8	42.7	201	4.8
Quercus robur	2204	4.8	47.5	260	6.2
Quercus petraea	1849	4.1	51.6	209	5.0
Pinus halepensis	1804	4.0	55.6	105	2.5
Quercus pubescens	1501	3.3	58.9	138	3.3
Quercus suber	1470	3.2	62.1	91	2.2
Pinus nigra	1464	3.2	65.3	103	2.4
Castanea sativa	1315	2.9	68.2	133	3.2
Eucalyptus sp.	1052	2.3	70.5	62	1.5

Of all the broadleaves, most **discolouration** was found for *Quercus suber* (only 54.2% of the trees not-discoloured). *Quercus ilex* showed least discolouration, with 93.0% of not-discoloured trees (Annex I-4). 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%) (Annex I-4).
The total percentages of trees in the discolouration classes 0+1 were approximately the same for all species groups.
Annexes I-5, I-6 and I-7 show maps of the distribution of the percentages of damaged trees, plot defoliation and plot discolouration over the Community.

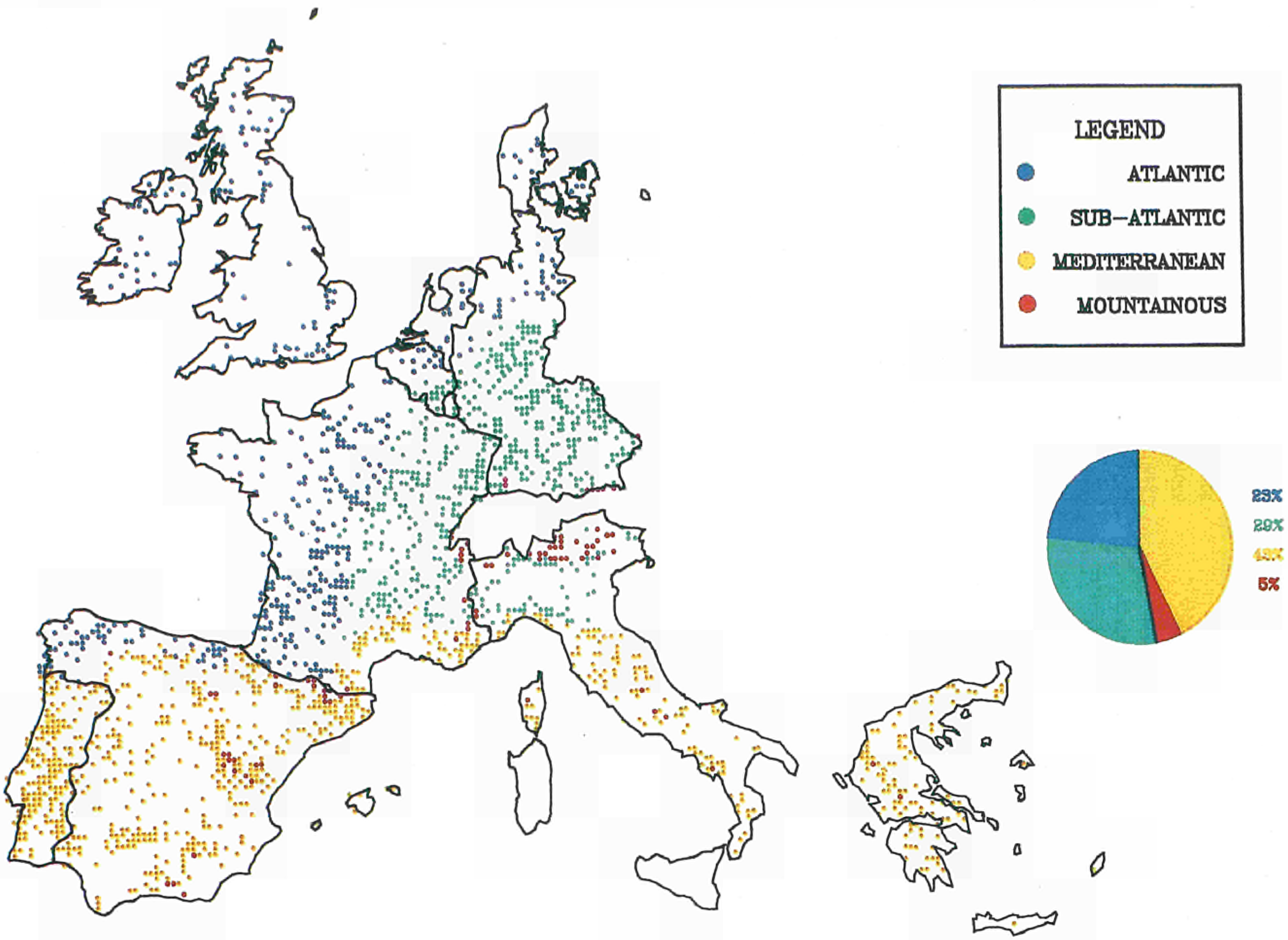
3.2 Defoliation and discolouration by climatic region

To each sample plot a climate type has been attributed. This climate type has been assigned in function of the geographical location of the plot. In this attempt to define climatic regions, simplicity has been striven after in order to avoid excessive splitting of the data set.
Four large climatic regions are distinguished (Figure 1):

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

The **Atlantic** region comprises a broad belt along the Atlantic coast. It starts at the northern border of Portugal, runs across 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 1989, 23.4% of all the sample plots were located within the Atlantic region.

CLIMATIC REGIONS ACROSS THE COMMUNITY



Source: 1989 Community Inventory of Forest Damage

Figure 1:
Climatic regions across the Community

The **Sub-atlantic** region comprises Luxemburg, the greater part of the Federal Republic of Germany, and parts of Belgium, France and Italy.
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 1989, 29.4% of all the sample plots 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 1989, 41.7% of all the sample plots 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 southern part of the Community (up to the latitude running along the southern edge of the Alps and through Lyon) plots situated at more than 1500 m. above sea level have been considered mountainous. North of this latitude, plots situated at more than 1000 m. above sea level have been considered mountainous. In 1989, 4.6% of the sample plots were assigned to this region.

TABLE 4: Total percentages of defoliation for all broadleaves, conifers and total sample trees by climatic region.

Climatic region	Defoliation						
	0-10%	11-25%	0-25%	26-60%	>60%	dead	No. trees
Atlantic							
Broadleaves	74.7	16.9	91.6	7.5	0.7	0.2	5149
Conifers	52.8	25.9	78.7	14.2	3.7	0.4	4489
All species	65.9	21.1	87.0	10.6	2.1	0.3	9638
Sub-atlantic							
Broadleaves	65.9	24.5	90.4	8.8	0.7	0.2	6700
Conifers	48.1	35.8	83.9	15.2	0.8	0.2	6805
All species	56.9	30.2	87.1	12.0	0.8	0.2	13505
Mediterranean							
Broadleaves	68.0	24.2	92.2	6.8	0.7	0.4	12347
Conifers	76.6	17.9	94.5	4.5	0.3	0.7	7865
All species	71.3	21.7	93.0	5.9	0.5	0.5	20212
Mountainous							
Broadleaves	87.4	10.2	97.6	2.2	0.2	---	541
Conifers	70.7	22.1	92.8	6.5	0.4	0.3	1676
All species	74.8	19.2	94.0	5.5	0.4	0.2	2217
EC							
Broadleaves	69.2	22.4	91.6	7.4	0.7	0.3	24737
Conifers	62.4	25.8	88.2	10.2	1.2	0.4	20835
All species	66.1	24.0	90.1	8.7	0.9	0.3	45572

Table 4 shows the percentages of trees in the different defoliation classes by climatic region, as is observed for broadleaves, conifers and the total number of sampled trees. As for the total sample, most defoliation is observed in the Atlantic and Sub-atlantic regions.

Except for the Mediterranean region, coniferous species show more defoliation than broadleaved species. Especially in the **Atlantic** region, the combination of the high presence (1185 trees) and relatively high defoliation (31.6% in classes 2+3+4) of *Picea* sp. has a negative influence on the total percentages for all sampled trees and the conifers for this region (Annex I-3).

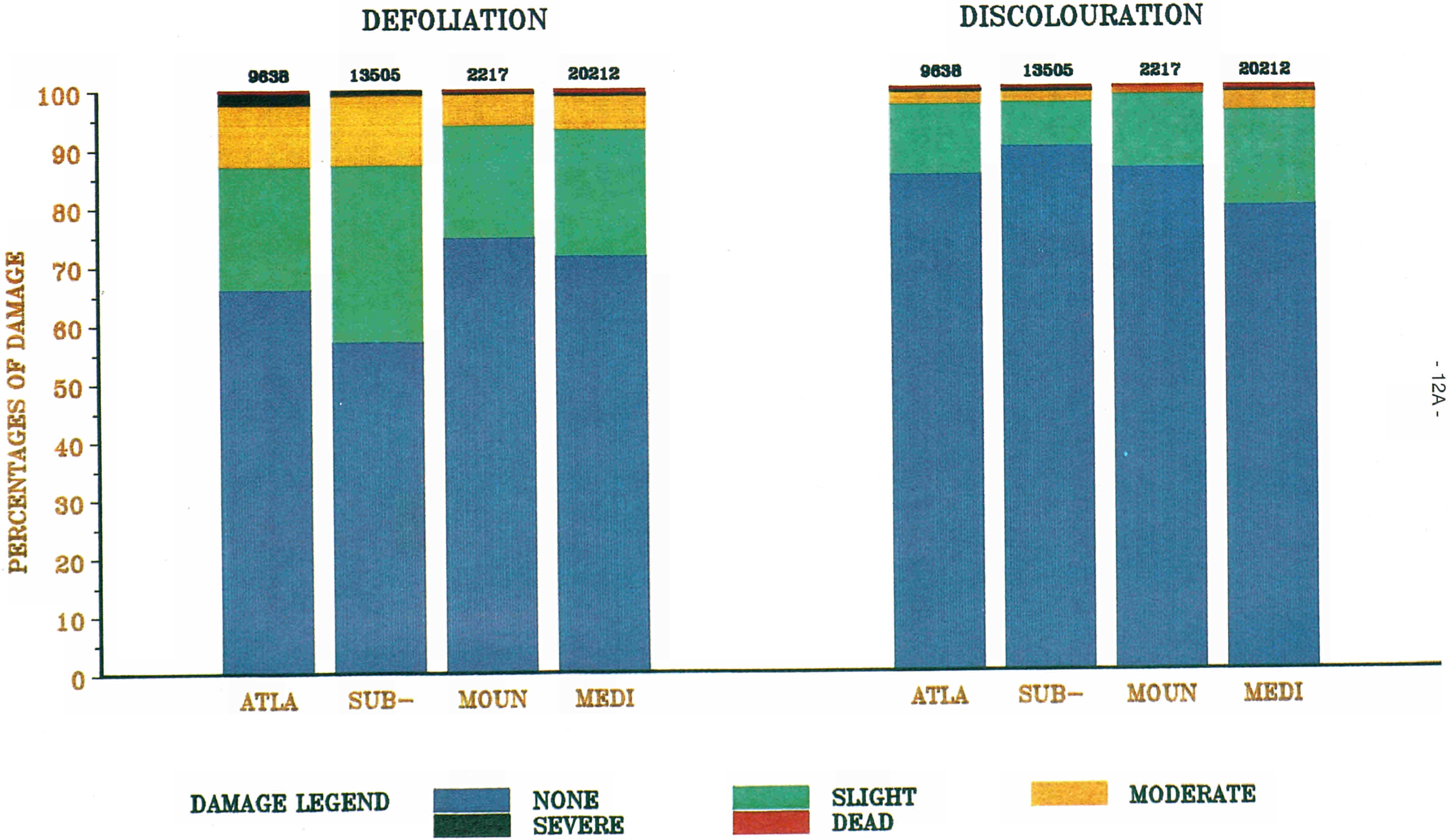
In the **Sub-atlantic** region, the score for the coniferous species is mainly lowered due to high defoliation of *Abies* sp. (27.4% in classes 2+3+4) and the combination of relatively high defoliation and high presence of *Picea* sp. (17.8% in classes 2+3+4, No. of trees = 3787).

In the **Mountainous** region, the total perecentage of damaged trees for conifers is largely influenced by the relatively high defoliation of *Picea* sp. (11.8% in classes 2+3+4)

TABLE 5: Total percentages of discolouration for all broadleaves, conifers and total sample trees by climatic region.

Climatic region	Discolouration					No. trees
	0-10%	11-25%	26-60%	>60	dead	
Atlantic						
Broadleaves	87.2	10.5	1.6	0.6	0.2	5149
Conifers	82.3	14.0	3.1	0.3	0.4	4489
All species	84.9	12.1	2.3	0.4	0.3	9638
Sub-atlantic						
Broadleaves	89.6	7.5	2.3	0.5	0.2	6700
Conifers	89.8	8.0	1.6	0.5	0.2	6805
All species	89.7	7.7	2.0	0.5	0.2	13505
Mediterranean						
Broadleaves	78.7	16.5	3.9	0.4	0.4	12347
Conifers	80.6	15.9	2.5	0.3	0.7	7865
All species	79.4	16.3	3.4	0.4	0.5	20212
Mountainous						
Broadleaves	92.2	7.4	0.4	---	---	541
Conifers	84.0	14.2	1.4	0.1	0.3	1676
All species	86.0	12.5	1.2	0.0	0.2	2217
EC						
Broadleaves	83.7	12.6	2.9	0.5	0.3	24737
Conifers	84.2	12.8	2.3	0.3	0.4	20835
All species	84.0	12.7	2.6	0.4	0.3	45572

DAMAGE COMPARISONS BY CLIMATIC ZONES



Source: 1989 Community Inventory For Forest Damage

Table 5 shows the **discolouration** for broadleaves, conifers and total sample trees by climatic region. The percentage of trees that show some discolouration (classes 1+2+3+4) is highest in the **Mediterranean** region. Especially *Castanea sativa*, *Quercus suber* and *Abies* sp. show high proportions of discoloured trees in this region. Only 61.4%, 54.2% and 62.0% respectively of the trees show no discolouration (Annex I-4).
In the **Sub-atlantic** region, broadleaves and conifers show similar discolouration. Overall, this region shows the smallest proportion of discoloured trees. In the **Atlantic** and **Mountainous** regions, most discolouration is found with coniferous species, largely due to the high discolouration of *Pinus* sp. (only 81.0% and 78.6% not discoloured in respectively the Atlantic and Mountainous regions).

3.3 Defoliation and discolouration by altitude

Altitude was determined for each sample plot, using 50 m. increment classes. In general, the lower altitude classes are represented most in the total sample, and the number of plots gradually declines with increasing altitude. Trees in plots at altitudes of 0-250 m. represent almost one third of the total sample (see Table 6).

TABLE 6: Defoliation and discolouration by altitude and by climatic region. Numbers in italics represent less than 250 trees (= approximately 10 plots).

Defoliation (% of trees in classes 0+1)	Region				Entire EC	
Altitude (m)	Atl.	Sub-atl.	Medit.	Moun.	%	trees
0 - 250	86.3	89.0	91.1	---	88.2	13468
251 - 500	84.7	87.9	92.3	---	89.2	11594
501 - 750	93.1	83.8	92.8	---	88.9	7655
751 - 1000	95.2	85.0	94.7	---	92.4	5329
1001 - 1250	*100*	90.3	94.4	91.6	93.4	3928
1251 - 1500	*100*	97.0	95.0	*84.1*	94.2	2047
>1500	---	---	---	96.4	96.4	1411
Total	87.0	87.4	93.3	93.9	90.0	45432

Discolouration (% of trees in class 0)	Region				Entire EC	
Altitude (m)	Atl.	Sub-atl.	Medit.	Moun.	%	trees
0 - 250	84.9	88.3	65.2	---	79.3	13468
251 - 500	82.5	92.2	79.4	---	86.3	11594
501 - 750	89.4	89.6	82.1	---	86.0	7655
751 - 1000	90.0	87.4	89.0	---	88.5	5329
1001 - 1250	*5.0*	84.7	82.1	88.7	83.0	3928
1251 - 1500	*90.9*	74.0	83.0	*94.4*	83.3	2047
>1500	---	---	---	83.3	83.3	1411
Total	84.9	89.7	79.3	85.9	83.9	45432

Table 6 shows the total percentages of **not- to slightly defoliated** trees in the different altitude ranges, and separated by climatic region. For the entire Community as well as for the different climatic regions, only very slight differences occur in defoliation between altitude classes. No clear trends become apparent in defoliation in relation to altitude (Annex I-8).

In Table 6, the total percentages are given of **not-discoloured** trees by altitude and climatic region. For the entire Community, most discolouration is found at lower altitudes (only 78.7% not discoloured trees at 0-250 m.). No clear trends are found for discolouration in relation to altitude.

In the **Atlantic** and **Sub-atlantic** regions, also no clear trends are apparent for discolouration in relation to altitude. Only slight differences in discolouration occur (the 5% for not-discoloured trees at 1001-1250 m. in the Atlantic region includes only one plot, and is therefore not representative).
In the **Mediterranean** region, there appears to be a trend in decreasing discolouration with increasing altitude for the first 1000 m. In the lowest 250 m., only 65.1% of the trees are not discoloured. Climbing to an altitude of 1000 m., the proportion of not-discoloured trees gradually rises to 89.1%. This possible relationship may be caused by several factors, for instance the more favorable site conditions such as temperature and humidity at higher altitudes.

However, the trend shown here was not found in the results of the 1988 inventory. Investigation of the CST's (Common Sample Trees 1988-1989) suggests that this increase in discolouration may be largely due to the dramatic increase in discolouration of *Quercus suber* in the period 1988-1989 (see Table 13). This species is commonly found at lower altitudes in the Mediterranean region. Therefore, the observed trend of increased discolouration at lower altitudes probably only reflects the distribution over the altitude classes of *Quercus suber*.

3.4 Defoliation and discolouration by exposition (aspect)

The exposition or aspect is determined by the orientation of the sample plot towards a certain compass direction (facing north, southwest, etc.). No differences in defoliation or discolouration are observed between sample trees in plots with different aspect (Table 7, Annex I-9).

TABLE 7: Defoliation and discolouration by aspect.

Aspect	Defoliation (% class 0+1)	Discolouration (% class 0)	Sampled trees No	Sampled trees %
N	91.8	87.0	5705	12.3
NE	90.4	84.3	4800	10.4
E	91.0	80.4	3708	8.1
SE	89.0	81.9	3802	8.4
S	91.6	81.6	4560	10.0
SW	91.0	84.8	3735	8.2
W	87.0	81.3	3942	8.6
NW	90.3	83.6	4872	10.6
Flat	89.0	85.9	10283	23.4
Total	90.0	83.9	45407	100

The combined effect of altitude and exposition on defoliation was investigated, but no clear trends became apparent. However, it can be expected that exposition may have a possible influence on the growing conditions for trees, since at a certain altitude, site conditions are dependent on exposition.

3.5 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. Table 8 shows that most defoliation and discolouration occurs in plots with **excessive** water availability. The lowest degree of defoliation and discolouration was observed in plots with **sufficient** water available.

TABLE 8: Defoliation and discoloration by water availability.

Water availability	Defoliation 0-10%	Defoliation 11-25%	Defoliation 0-25%	Discoloration 0-10%	Sampled trees No.	Sampled trees %
Insufficient	58.4	29.5	87.8	82.4	6255	14.3
Sufficient	67.5	23.1	90.6	84.3	38352	83.9
Excessive	56.9	23.4	80.4	77.7	785	1.8
Total	66.0	24.0	90.0	83.9	45392	100.0

Regarding the defoliation classes 0 and 1, the major differences between water availability classes occur in defoliation class 0 (0-10% defoliation), with 56.9% and 67.5% of trees in defoliation class 0 in plots with respectively excessive and sufficient water availability (Table 8, Annex I-10).

3.6 Defoliation and discolouration by humus type

An overview of defoliation and discolouration by humus type is presented in Table 9 (see also Annex I-11). Only humus types **mull, moder** and **mor** are well represented in the total sample. There are only very slight differences in defoliation and discolouration between these three humus types. Percentages of trees in defoliaton classes 0+1 and discolouration class 0 in plots with anmor or peat are deviating from the percentages for trees in plots of other humus types (Table 9).

Defoliation and discolouration of trees in plots with **anmor** is much **lower** than in plots with other humus types. The tree sample however is extremely small (only 0.3% of the total sample), so no conclusions should be drawn from these figures.
In plots with **peat**, defoliation and discolouration was found to be much **higher** than in plots with other humus types. This may indicate that tree health is negatively influenced by peat. However, as the tree sample in this humus type is very small (1.2% of the total sample), no conclusions can be drawn from these figures either.

TABLE 9: Defoliation and discolouration by humus type.

Humus type	Defoliation (% in 0+1)	Discolouration (% in 0)	Sampled trees No.	Sampled trees %
Mull	92.1	81.4	17796	39.3
Moder	90.6	85.4	17566	38.7
Mor	87.8	85.8	6062	13.4
Anmor	99.4	97.4	154	0.3
Peat	76.2	64.1	551	1.2
Other	82.1	89.0	3215	7.1
Total	90.0	83.9	45344	100

3.7 Defoliation and discolouration by mean age

Table 10 shows the defoliation and discolouration by mean age for all species. Percentages of not- to slightly defoliated trees show a gradual decline with increasing mean age. However, when the defoliation classes 0 and 1 are considered separately, a relatively strong relationship between defoliation and mean stand age becomes apparent; percentages of not-defoliated trees show a rapid decrease with increasing age, whereas an opposite trend is observed for the percentages of slightly defoliated trees. Trends are strongest for conifers as compared to broadleaves (Annexes 1-12 and I-13).

Percentages of trees in the different **discolouration** classes do not show any trend with increasing age. The total percentage of not- to slightly defoliated trees, and the total percentage of not-discoloured trees was highest for irregular stands (Table 10).

TABLE 10: Defoliation and discolouration by mean age.

Mean age (yr.)	Defoliation 0-10	Defoliation 11-25	Defoliation 0-25%	Discolouration 0-10%	Discolouration 11-25	Discolouration 0-25%	Sampled trees No	Sampled trees %
0 - 20	78.8	13.6	92.4	83.9	12.5	96.4	7339	16.2
21 - 40	73.5	18.3	91.8	83.6	13.5	97.0	12549	27.6
41 - 60	64.0	27.1	91.1	84.5	12.2	96.7	7854	17.3
61 - 80	58.8	32.5	91.3	82.6	13.6	96.2	4813	10.6
81 - 100	51.7	33.6	85.2	82.9	13.5	96.4	4008	8.8
101 - 120	43.6	38.5	82.1	82.5	13.2	95.7	1927	4.2
>120	35.8	38.1	73.9	80.9	13.2	94.1	2355	5.2
Irregular	73.8	20.3	94.1	88.2	9.9	98.1	4577	10.1
Total	66.1	24.0	90.0	83.9	12.7	96.6	45422	100

When considering the percentages of trees in the **defoliation** classes 0 and 1 by individual species, these percentages show low correlations with mean age for most of the commonly encountered species in the Community. Only *Picea abies* showed a relatively high correlation for trees in defoliation class 0 with mean age (Fig 2) throughout the Community. The low correlations for other species are due to the extremely high variation in the data set. When accounting for the properties of environmental variables (such as humus, water, etc), correlations may be largely improved.
See section 6.2.5 for more details and a discussion on this subject.

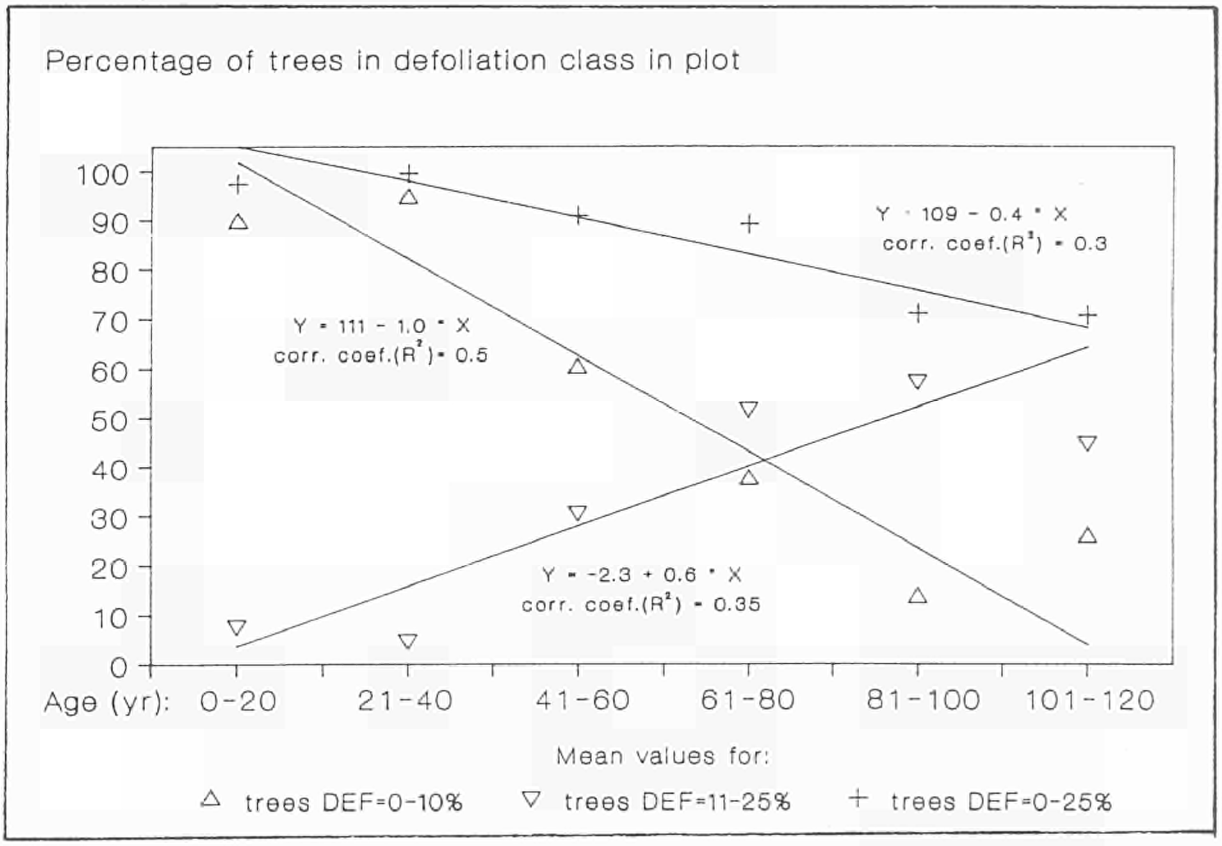


Figure 2: Correlations between mean stand age and the percentage of not-defoliated, slightly defoliated and not-to slightly defoliated trees for Picea abies in plots that contained at least 10 individuals of this species. Plots located throughout the Community.

3.8 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 sylvicultural 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 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.

TABLE 11: Defoliation and discolouration by identifiable damage type.

Damage type	Defoliation (% in 0+1)	Discolouration (% in 0)	Observations (% total sample)	
			trees	plots
Game / Grazing	82.0	73.4	1.5	3.1
Insects	88.2	78.3	19.1	39.8
Fungi	88.9	75.5	7.0	21.8
Abiotic agents	82.6	57.1	6.5	21.4
Action of man	89.5	65.9	5.8	14.8
Fire	84.7	64.1	1.5	3.1
Known pollution	71.9	67.4	0.2	0.5
Other	89.5	81.8	10.7	25.1
Any ident. damage	87.6	73.3	38.8	70.0
No ident. damage	91.6	90.7	61.2	30.0
Multiple damage	88.0	74.9	10.9	27.7
Total in EC	90.0	83.9	N=45572	N=1891

Of the total tree sample, 38.8% of the trees showed one or more identifiable causes of damage (Table 11, Annex I-14). These trees are observed in 70.0% of the plots. The most commonly observed type of damage is caused by **insects** (19.1% of the trees, 39.8% of the plots). Damage attributed to **fungi, abiotic agents** and **action of man** is observed less frequently, representing respectively 7.0%, 6.5% and 5.8% of the total tree sample. Identifiable damage that could not be assigned to any category is observed for 10.7% of the trees, and in 25.1% of the plots. Of the total sample, 10.9% of the trees suffered damage from more than one factor (Table 11).

All types of damage that are identified have some negative influence on foliation and colouration of the trees. However, the effect is small for most types of damage. When regarding all types of damage together, the percentage of not- to slightly defoliated trees is only 4.0% lower as compared to trees with no damage identified (Table 11). The difference for the percentages of not-discoloured trees is considerably higher: 17.4%.

As for defoliation, the largest negative effect on the percentage of not- to slightly defoliated trees is observed for trees affected by **local or regional pollution**. Also, trees affected by **game and grazing, fire** and **abiotic agents** show high degrees of defoliation. However, except for the latter damage type, the total observations are very small, so no conclusion can be drawn from these figures.

As regards to **discolouration**, the most pronounced negative effect is observed for trees affected by **abiotic agents**. Only 57.1% of the trees showing this type of damage were not discoloured (Table 11).

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 not be accounted for. Regarding defoliation, the identification of damage types does not influence the total percentage of not- to slightly defoliated trees to a large extent. However, identification of damage types does considerably reduce the percentage of not-discoloured trees (Table 11).

4 Comparison of 1988 and 1989 results

Comparison of the total tree samples of 1988 and 1989 may produce biased results since the 1989 survey includes an increased number of observations due to the further extension of the Community network. Furthermore, some of the plots surveyed in 1988 have not been resurveyed in 1989. In order to be able to compare the results of the 1988 and 1989 inventory, a subsample is defined containing all trees that are common to both inventories: the **Common Sample Trees (CST's)**. This Common sample consists of 35478 trees, representing 95% of the total tree sample of 1988 and 78% of the total tree sample of 1989 (see Table 12 and Annex II-6)

4.1 Comparison 1988-1989 for the entire Community

The Table 12 shows 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**).

TABLE 12 Changes in defoliation and discolouration over 1988–1989 for total sampled trees and common sampled trees.

DEFOLIATION

Defoliation classes	Total tree sample 1988	Total tree sample 1989	Common Sample Trees 1988	Common Sample Trees 1989
0 - 10%	65.8	66.1	65.7	63.6
11 - 25%	24.0	24.0	24.2	25.6
26 - 60%	9.0	8.7	8.9	9.4
>60%	1.0	0.9	1.0	1.0
dead	0.2	0.3	0.1	0.4
No. of trees	37607	45572	35478	35478

DISCOLOURATION

Discolouration classes	Total tree sample 1988	Total tree sample 1989	Common Sample Trees 1988	Common Sample Trees 1989
0 - 10%	86.8	84.0	86.9	82.8
11 - 25%	10.7	12.7	10.8	13.4
26 - 60%	2.0	2.6	2.0	3.0
>60%	0.3	0.4	0.3	0.4
dead	0.2	0.3	0.1	0.4
No. of trees	37607	45572	35478	35478

In 1989, the total tree sample was enlarged by 21% (Table 12). The difference between the total sampled trees and the common sample trees of the 1989 sample (Table 12) was +2.5% for trees in **defoliation** class 0, and -1.6% for trees in defoliation class 1. This difference shows that the extension of the grid network has caused an overall increase of the total percentage of not-damaged trees. When comparing the CST's, the overall percentage of damaged trees very slightly decreased over the period 1988-1989. This implies that for the total tree sample the slight increase of the percentage of trees in defoliation classes 0+1 in the entire Community was due to the extension of the grid network, and thus the inclusion of relatively healthy trees.
Maps showing the changes in defoliation are included in Annex II-5. A worsening in plot defoliation was notably found in Scotland, the southern part of the Federal Republic of Germany, Portugal and parts of Italy.

The percentage of not-**discoloured** trees in the total tree sample of 1989 is slightly higher than in the Common Sample; 82.8% of the CST's in 1989 show no discolouration, whereas this percentage is 84.0% for the total tree sample (Table 12). This implies that the extension of the grid has caused a relative increase of the percentage of not-discoloured trees. When comparing CST's, a slight increase of discolouration by 4.1% was found in the period 1988-1989 (Table 12).

Regarding the entire subsample of CST's in the Community, no clear overall changes in **vitality** have occurred in the period 1988-1989 (Table 12).

4.2 Comparison of CST's by climatic region

As to **defoliation**, only minor differences are present between the percentages of not- to slightly defoliated trees for the CST's in the different regions in 1988 and 1989 (Figure 3).
The CST's in the Atlantic region show a slight decrease in the percentage of not- to slightly defoliated trees; 86.4% in 1988, 81.9% in 1989 (Annex II-1). No differences become apparent in the other regions (Figure 3).

As to **discolouration**, slight differences occur between the CST's in 1988 and 1989. The CST's in the Mediterranean region show the largest differences in discolouration; the percentage of not-discoloured trees decreased from 85.2% in 1988 to 77.6% in 1989 (Annex II-1, Figure 3).

The CST's in the Atlantic and Sub-atlantic regions only show a slight increase, the CST's in the Mountainous region show a slight decrease in the percentages of discoloured trees (Figure 3).

4.3 Comparison of CST's by species group

Although only minor overall differences exist in defoliation and discolouration between the CST's in 1988 and 1989, some species groups show considerable changes over this one year interval (Table 13, Annex II-2 and II-3).

As to **defoliation**, *Quercus ilex* shows a general improvement, with percentages of not-defoliated trees increasing from 62.0% in 1988, to 70.6% in 1989. *Castanea sativa* and *Picea* sp. show a decrease in foliation, with respectively 76.4% and 50.0% of not-defoliated trees in 1988, decreasing to respectively 66.7% and 45.8% in 1989.

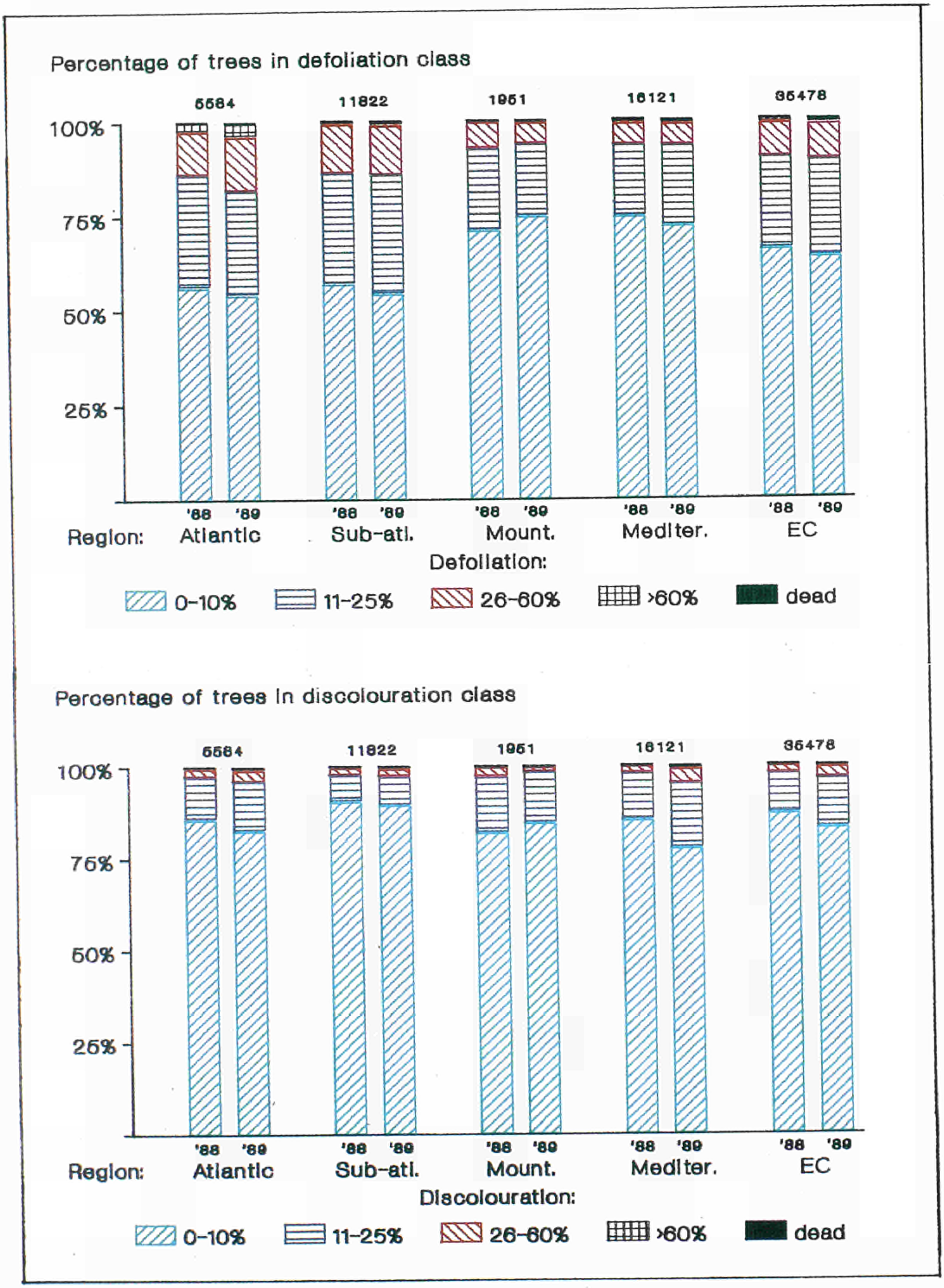


Figure 3: **Changes in defoliation and discolouration for trees common to the 1988 and 1989 sample**

TABLE 13: Changes in defoliation and discolouration for trees common to the 1988 and 1989 sample (CST's), by species group.

Species group	Defoliation						Discolouration	
	0-10%		11-25%		0-25%		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

However, considering the percentages of not- to slightly defoliated trees, the amount of defoliation for *Castanea sativa* remained **constant**, *Quercus ilex* improved by only 3.0% while *Picea* sp. shows a **decrease** by 4.2% in the period 1988-1989 (Table 13).

The largest change in **defoliation** is found for *Quercus suber*. The total percentage of not-defoliated trees decreased by 27.2% in the period 1988-1989. The percentage of not- to slightly defoliated trees decreased from 98.7% in 1988 to 89.7% in 1989 (Table 13).

Both **total broadleaves** and **conifers** only show **minor changes** in the percentages of not- to slightly defoliated trees. The total percentages of CST's in these classes decreased by 0.8% and 0.9% for respectively broadleaves and conifers (Table 13).

As to **discolouration**, most species groups remained unchanged over the period 1988-1989. **Considerable changes** occurred for *Castanea sativa* and *Eucalyptus* sp.. For these species groups, the percentages of not-discoloured trees decreased by respectively 8.1% and 17.6% (Table 13).
As was also the case with respect to defoliation, a **pronounced change** in discolouration occured for *Quercus suber*. The total percentage of not-discoloured trees decreased from 87.8% in 1988 to 52.3% in 1989; a change of 35.5%.

For **total broadleaves** and **total conifers**, the percentages of not-discoloured trees decreased by respectively 6.8% and 1.5% in the period 1988-1989 (Table 13).

When defining tree vitality as a combination of defoliation and discolouration, the **overall vitality** of *Quercus suber* decreased considerably in the period 1988-1989. Approximately 80% of the sampled *Quercus suber* is located in Portugal. In 1989 the Portugese government started a 3 year study on the damage caused to woodlands (*Q. suber*) by air pollution in the southern region of Portugal. This study is co-financed under Article 4 of Council Regulation (EEC) no. 3528/86 (see background).

Vitality of *Castanea sativa* only slightly decreased. For most other species groups, changes in both defoliation and discolouration were very small. Some species groups only show 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.

Comparing **broadleaves** with **conifers**, broadleaves show a slightly higher decrease in vitality, because of a relatively greater change in both defoliation and discolouration in the period 1988-1989.

4.4 The relationship between defoliation and discolouration

It was investigated whether an indication of discolouration in a certain year would have an effect on the degree of defoliation in the following year. This possible effect was evaluated for the Common Sample Trees for 1987-1988 (19637 trees) and for 1988-1989 (35478 trees).

No clear relationships between defoliation and discolouration were found (Table 13A). From the data it shows that the improvement in defoliation is highest with slightly- to severely discoloured trees, while the not-discoloured trees show a relatively increased worsening in defoliation. The patterns for 1987-1988 and 1988-1989 are similar (Table 14).

TABLE 14: Changes in defoliation of trees as a result of the discolouration of the tree in the year before.

Discolouration 1987	Change in defoliation Improvement	No Change	1987 - 1988 Worsening	Total	Net Change
None	2101	12207	2514	16822	-413
Slight	697	1124	270	2091	427
Moderate	257	292	86	635	171
Severe	30	37	12	79	18
Dead	5	5	0	10	5
Total	3090	13665	2882	19637	208

Discolouration 1988	Change in defoliation Improvement	No Change	1988 - 1989 Worsening	Total	Net Chamge
None	3388	22497	4938	30823	-1550
Slight	1270	2028	533	3831	737
Moderate	270	335	90	695	180
Severe	29	41	19	89	10
Dead	5	35	0	40	5
Total	4962	24936	5580	35478	-618

5 Comparison of 1987, 1988 and 1989 results

In order to investigate the changes in vitality over the first three years of the inventory, a separate subsample was defined containing plots that are common to the 1987, 1988 and 1989 inventories. Within this subsample, the changes in vitality were examined for the individual species. Whenever appropriate, these changes were examined by climatic region.
A further selection of the data was made regarding the number of individuals of a certain species in a plot. Only trees of a certain species were considered that were found in plots containing at least 10 individuals of this species. This way, possible sources of variation due to competition with other tree species were lessened by only including plots in which a species represented a major component of the stand. The number of 10 individual trees of a single species per plot was chosen arbitrarily.

5.1 Investigated species

The 12 most common species in the subsample were investigated regarding changes in defoliation and discolouration over the period 1987, 1988 and 1989. The investigation was carried out for the entire Community, as well as for the separate climatic regions. The changes by climatic region were only considered when the number of plots containing a certain species in a region was 10 or more.
The order of presence of the individual species was somewhat different from the inventory of 1989, since the 1987 and 1988 inventories lacked a great number of plots in especially the Mediterranean region. Therefore, *Quercus suber* could not be investigated. A list of the investigated species is given in Table 15.

TABLE 15: Investigated species from plots common to the 1987, 1988 and 1989 inventory. Total number of plots comprising at least 10 individuals of a species, total number of trees in 1989, and change in no. of trees relative to 1987 (see text).

	Plots					Trees		
Species	Atl.	Sub-atl.	Medit.	Moun.	EC	1987	1989	change '87-'89
Picea abies	11	129	--	23	163	3523	3527	+ 0.1%
Pinus sylvestris	42	50	14	7	113	2423	2405	- 0.3%
Fagus sylvatica	13	59	13	8	93	1841	1842	+ 0.1%
Quercus ilex	1	--	56	--	57	1051	1238	+17.8%
Pinus halepensis	--	--	34	--	34	719	771	+ 7.2%
Pinus nigra	2	1	23	3	29	572	589	+ 3.0%
Pinus pinaster	10	--	17	1	28	585	593	+ 1.4%
Castanea sativa	3	10	14	--	27	513	514	+ 0.2%
Picea sitchensis	25	--	--	--	25	522	529	+ 1.3%
Quercus robur	16	9	--	--	25	439	462	+ 5.2%
Quercus pubescens	--	4	17	1	22	453	470	+ 3.8%
Quercus petraea	--	16	1	--	17	299	295	- 1.3%

The selection of trees common to the 1987, 1988 and 1989 inventories was based on the plots present throughout this period (referred to as Common Plots). During this period the number of trees of a species in a plot has changed in a number of cases, due to replacement of thinned, dead or otherwise excluded trees from the plot. Therefore, the subsamples do not strictly cover identical individuals. However, changes in the number of individuals per species between 1987 and 1989 generally did not exceed 5%, except for *Quercus ilex* (17.8%), *Pinus halepensis* (7.2%) and *Quercus robur* (5.2%) (Table 15). Changes in defoliation and discolouration were examined using the percentages of trees in classes 0 (0-10% def./disc.), 1 (11-25% def./disc.) and 2-4 (>25% def./disc. or dead). The percentages of trees in the different classes were calculated over all individuals included in the subsample.

5.2 Presentation of the results

The results are presented by species. For each species, a small table is presented showing the general range in the percentages of healthy and damaged trees -including the observed trends- for all plots over the three years in the entire subsample, as well as by climatic region. The percentages of trees in the different defoliation and discolouration classes for the years 1987, 1988 and 1989 are presented by means of figures. Numerical information on percentages for defoliation and discolouration is presented in respectively Annex III-1 and Annex III-2.

5.3 Changes by species over 1987-1989

5.3.1 Picea abies

Defoliation		Healthy trees (def. 0-10%)		Damaged trees (def. >25%)	
Picea abies	**plots**	**range**	**trend**	**range**	**trend**
Total sample	163	45%	constant	20%	constant
- Atlantic	11	60-65%	sl. increase	7-15%	decrease
- Sub-atlantic	129	40%	constant	20%	constant
- Mountainous	23	50-60%	sl. decrease	15%	constant

Picea abies was represented most frequently in the Sub-atlantic zone. In this region the total percentages of damaged as well as healthy trees has remained fairly constant in the period 1987-1989 (Figure 4). Compared with the Sub-atlantic region, the percentages of healthy trees were higher in the Mountainous and Atlantic region. The total percentages of damaged trees in the Mountainous zone remained practically unchanged.
In the Atlantic region, trees seem to slightly improve. However, the number of plots in this region is small (11), so no conclusions can be drawn from this trend.

Discolouration		Not-discoloured (disc. 0-10%)		Slightly discoloured (disc. 11-25%)	
Picea abies	**plots**	**range**	**trend**	**range**	**trend**
Total sample	163	95%	constant	5%	constant
- Atlantic	11	97%	constant	3%	constant
- Sub-atlantic	129	95%	constant	4%	constant
- Mountainous	23	80-90%	increase	8-15%	fluctuating

The percentage of not-discoloured trees for the entire subsample has remained constant over the last three years (Figure 5). This percentage also remained constant in the Atlantic and Sub-atlantic regions.
The percentage of not-discoloured trees in the Mountainous region shows a gradual increase in the period 1987-1989. In the other discolouration classes percentages show a large fluctuation.

The overall vitality of *Picea abies* in the Common Plots has not changed over the period 1987-1989.

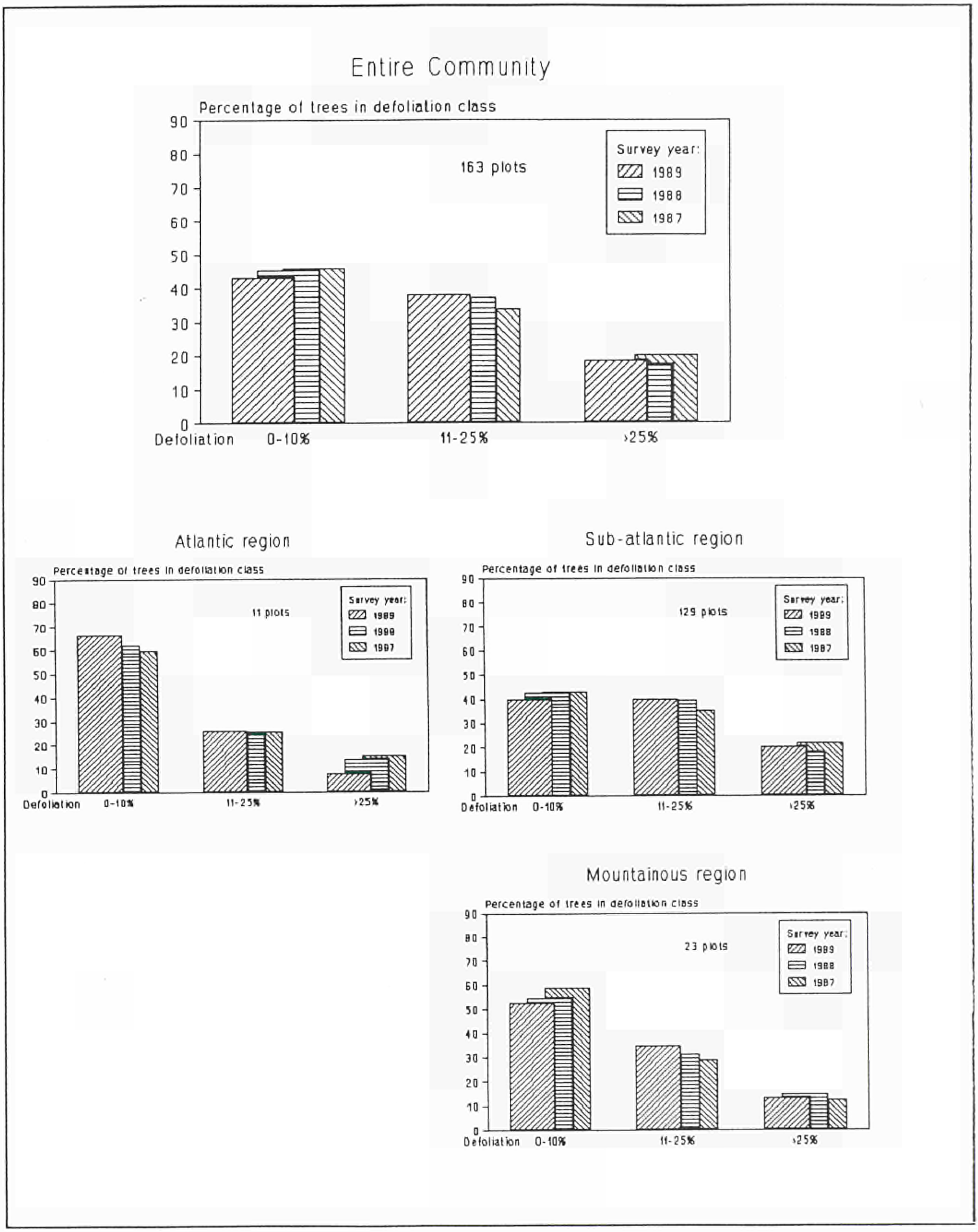


Figure 4: Changes in defoliation for *Picea abies* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

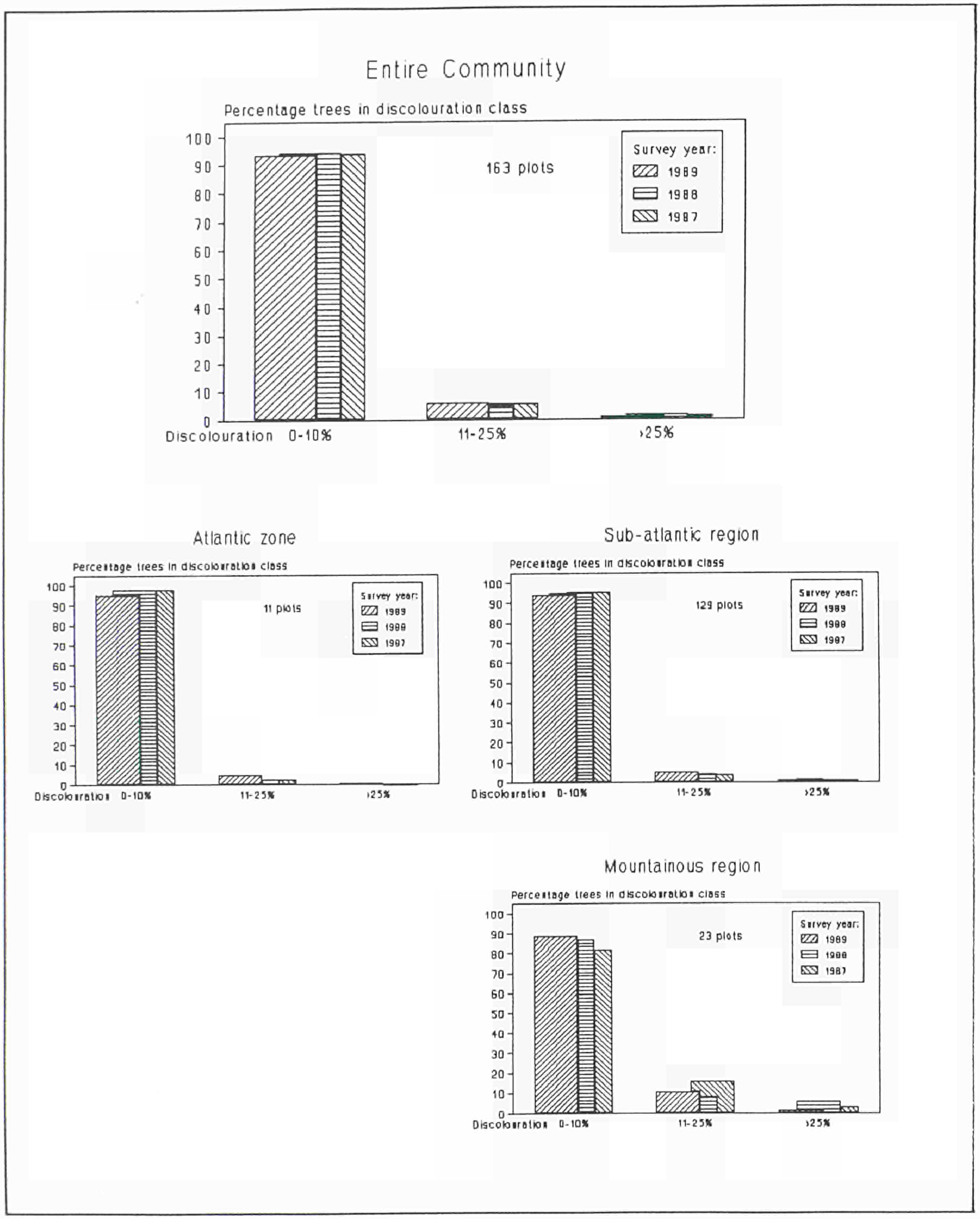


Figure 5: Changes in discolouration for *Picea abies* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

5.3.2 *Pinus sylvestris*

Defoliation		Healthy trees (def. 0-10%)		Damaged trees (def. >25%)	
Pinus sylvestris	plots	range	trend	range	trend
Total sample	113	55%	sl. decrease	10%	constant
- Atlantic	42	55-70%	decrease	10%	constant
- Sub-atlantic	50	35%	constant	15%	constant
- Mediterranean	14	60-85%	fluctuating	2-8%	fluctuating

For the entire Community, no clear changes have occurred in the total percentages of damaged trees. The percentages of healthy trees only slightly decreased (Figure 6).
In the Atlantic and Sub-atlantic regions, the percentages of damaged trees remained unchanged. In the Sub-atlantic region, also the percentages of healthy trees show no distinct trend. In the Atlantic region however, the fraction of healthy trees shows a gradual decrease, which is accompanied by an increase in total percentages of slightly defoliated trees.
In the Mediterranean region the percentages of healthy trees are remarkably high. Within this region *Pinus sylvestris* shows large fluctuations in defoliation. Number of plots are relatively low for this region (14), so the patterns found must be regarded with some restraint.

Discolouration		Not-discoloured (disc. 0-10%)		Slightly discoloured (disc. 11-25%)	
Pinus sylvestris	plots	range	trend	range	trend
Total sample	113	90%	constant	8%	constant
- Atlantic	42	80-90%	fluctuating	6-17%	fluctuating
- Sub-atlantic	50	98%	constant	3%	constant
- Mediterranean	14	75-95%	fluctuating	3-20%	fluctuating

For *Pinus sylvestris*, no trends are visible in the percentages of trees in The different discolouration classes (Figure 7). In the Atlantic and Mediterranean regions the percentages of not- and slightly discoloured trees show large fluctuations. In the Sub-atlantic region, overall discolouration has remained unchanged over the period 1987-1989.

Overall, no trends have become apparent in the defoliation and discolouration of *Pinus sylvestris* between 1987 and 1989. The overall vitality has not changed.

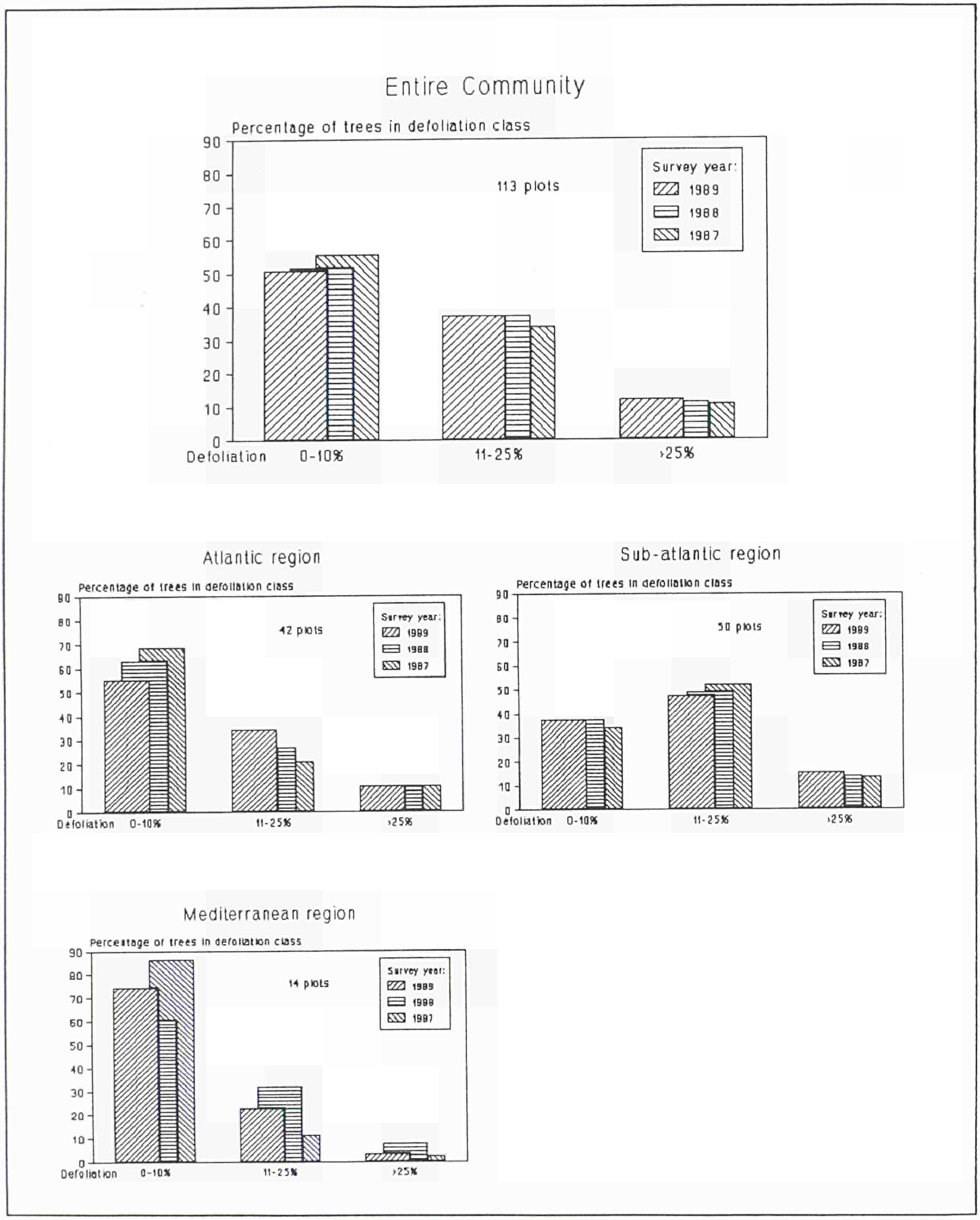


Figure 6: Changes in defoliation for *Pinus sylvestris* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

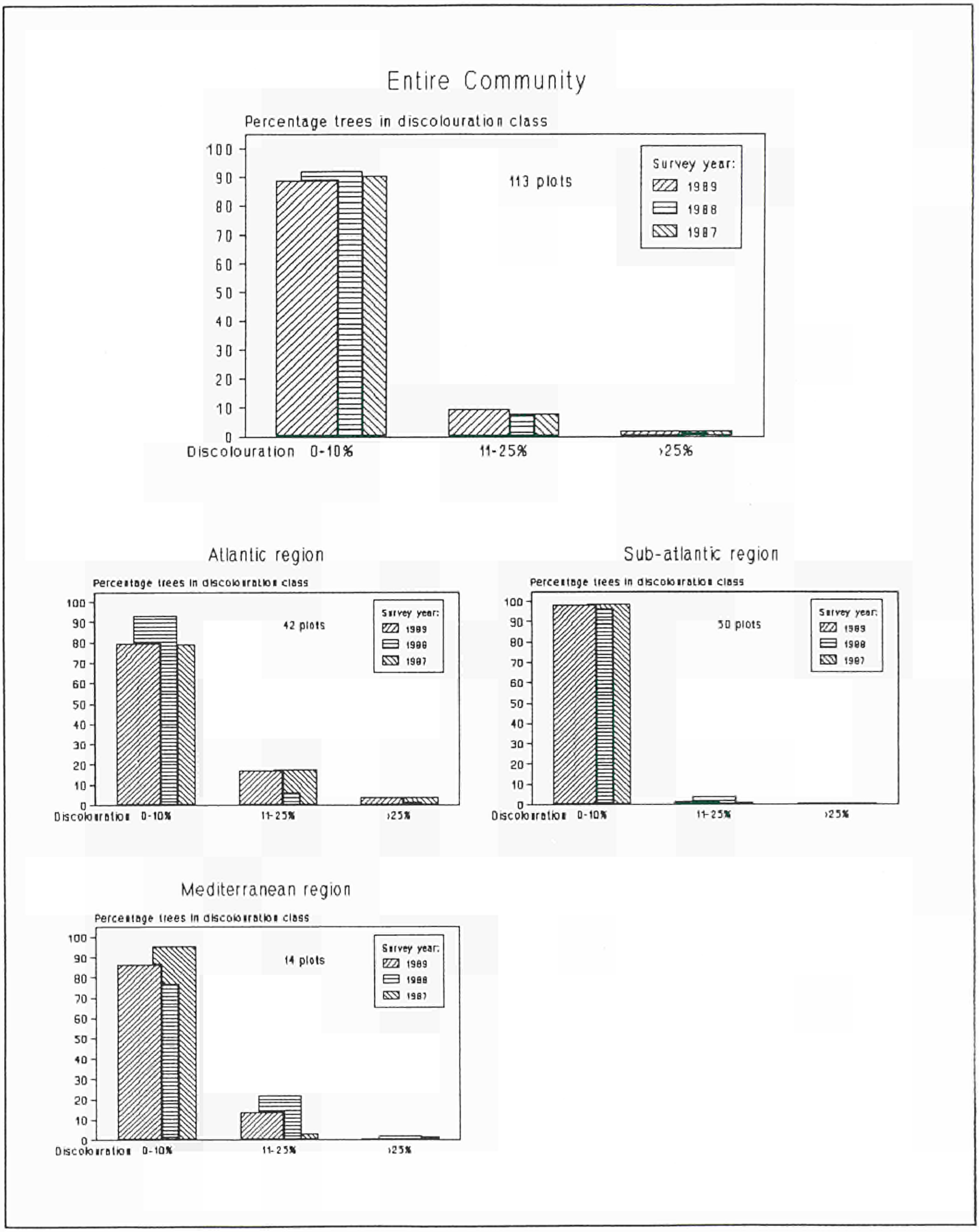


Figure 7: Changes in discolouration for *Pinus sylvestris* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

5.3.3 *Fagus sylvatica*

Defoliation		Healthy trees (def. 0-10%)		Damaged trees (def. >25%)	
Fagus sylvatica	plots	range	trend	range	trend
Total sample	93	55%	constant	10-15%	fluctuating
- Atlantic	13	40%	constant	10-30%	fluctuating
- Sub-atlantic	59	40-50%	increase	15-20%	sl. decrease
- Mediterranean	13	80-95%	decrease	2-8%	increase

When regarding the entire Community, *Fagus sylvatica* only shows very slight changes in defoliation over 1987-1989 (Figure 8). Most Common Plots are found in the Sub-atlantic zone. In this region, *Fagus* has slightly improved.
In the Atlantic region however, *Fagus sylvatica* shows some considerable fluctuations in defoliation (Figure 8). Percentages of healthy trees remained constant, but the fractions of slightly defoliated trees first increased in 1987-1988, but then dropped rapidly in 1989 (Annex III-1). The percentage of damaged trees shows a rapid increase over the last year (Figure 8).
In the Mediterranean region, the subsample of *Fagus sylvatica* shows remarkably high percentages of not-defoliated trees (Annex III-1, Figure 8). This percentage is however decreasing, and the percentage of damaged trees is slightly increasing in the Mediterranean region.

Discolouration		Not-discoloured (disc. 0-10%)		Slightly discoloured (disc. 11-25%)	
Fagus sylvatica	plots	range	trend	range	trend
Total sample	93	90%	constant	6%	constant
- Atlantic	13	70-80%	fluctuating	9-20%	fluctuating
- Sub-atlantic	59	95%	constant	4%	constant
- Mediterranean	13	85-95%	fluctuating	1-11%	fluctuating

When regarding all Common Plots, no changes in discolouration have occurred for *Fagus sylvatica* (Figure 9). However, differences exist between the different regions.
In the Sub-atlantic region, also no change occured in total discolouration. The Atlantic and Mountainous regions however show large fluctuations in discolouration. The percentage of slightly and moderately/severely discoloured trees is remarkably high in the Atlantic region (Figure 9).

Regarding all Common Plots, the overall vitality of *Fagus sylvatica* has not changed. In the Atlantic region, the rapid increase in the percentage of damaged trees in 1988-1989 is accompanied by a decrease in the percentage of trees showing discolouration. In the Sub-atlantic region, the slight improvement in foliation is not found with respect to discolouration.
In the Mediterranean region, the last year shows a decrease in not-defoliated and not-discolourated trees, suggesting a deterioration of vitality.

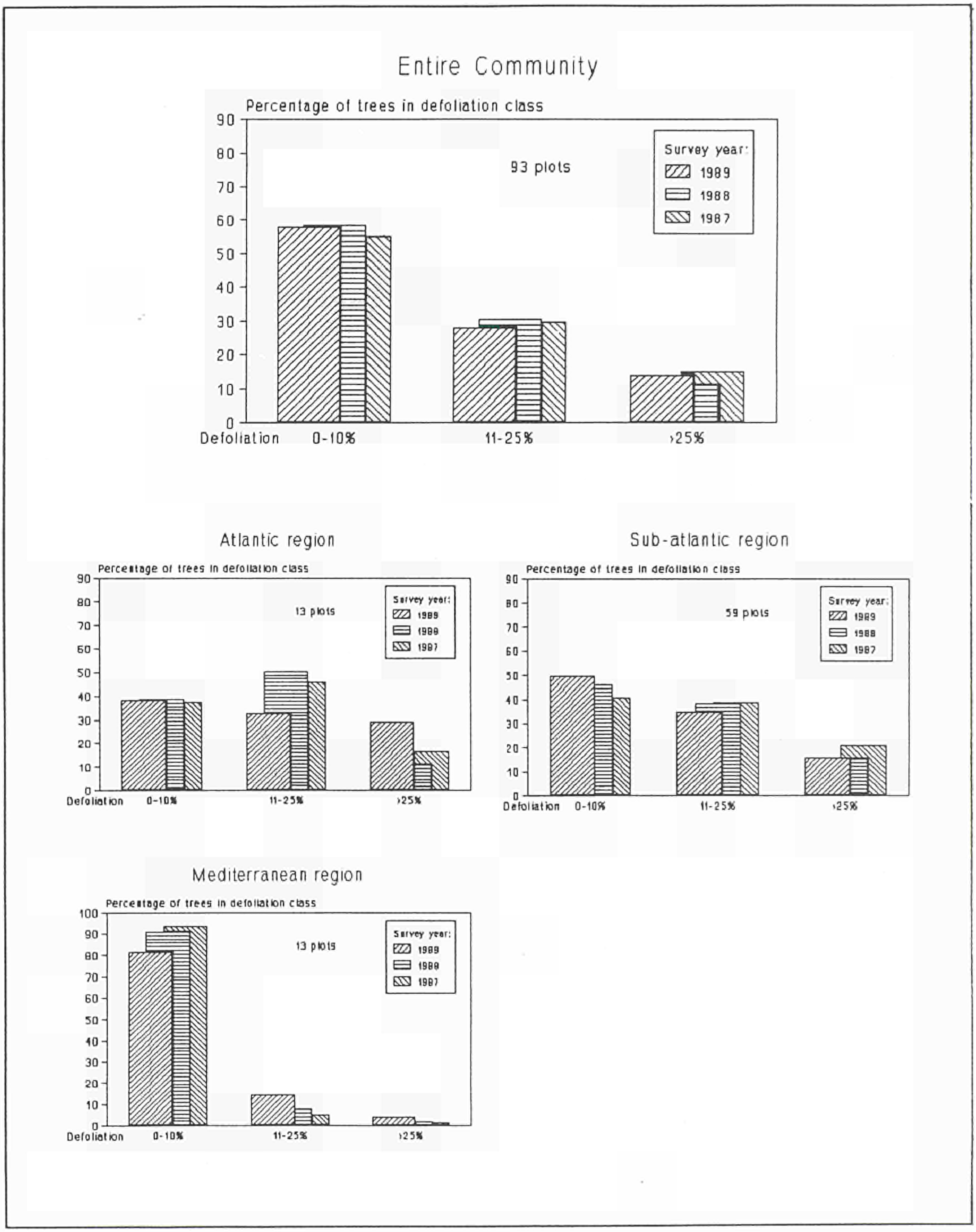


Figure 8: Changes in defoliation for *Fagus sylvatica* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

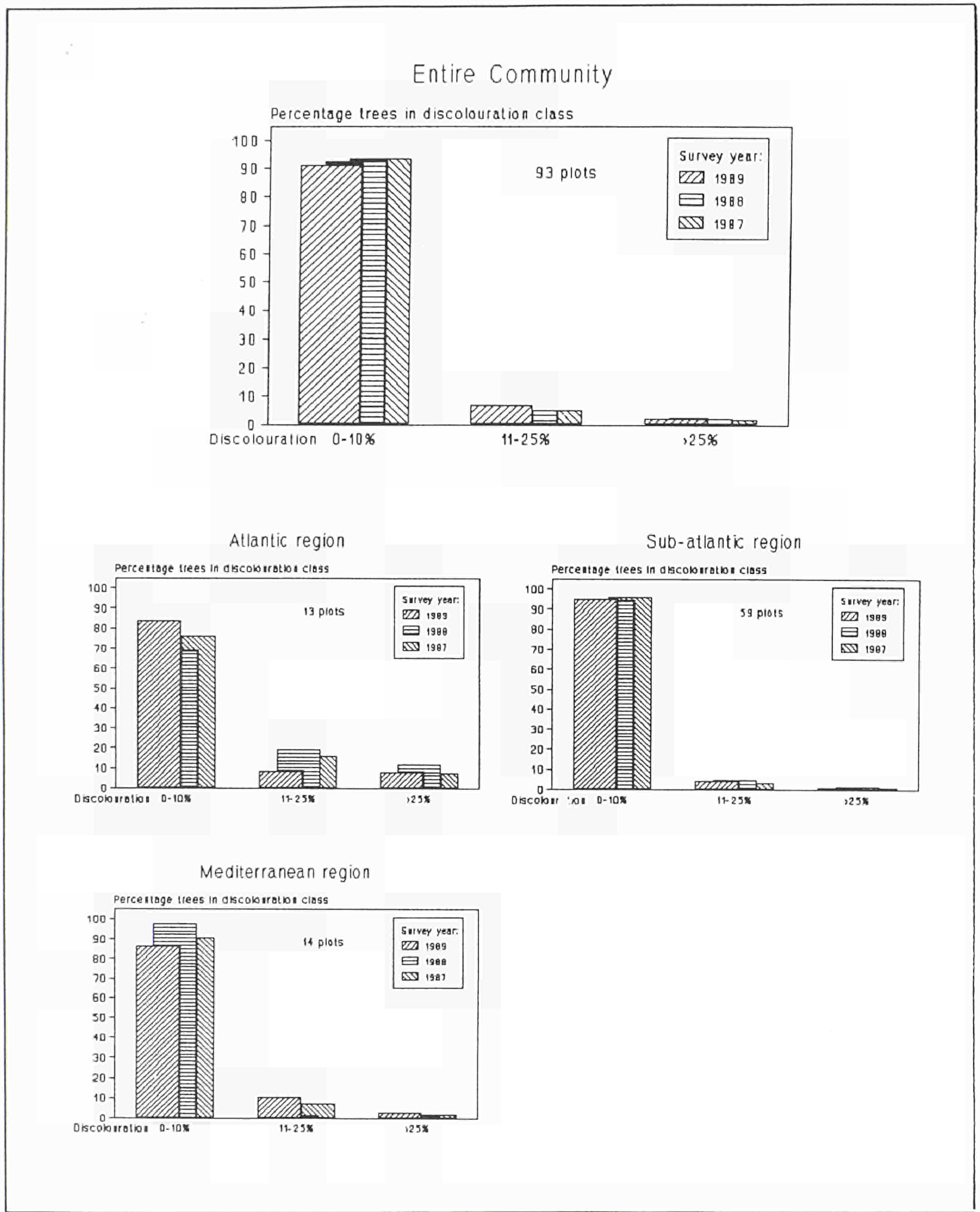


Figure 9: Changes in discolouration for *Fagus sylvatica* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

5.3.4 *Quercus ilex*

Defoliation		Healthy trees (def. 0-10%)		Damaged trees (def. >25%)	
Quercus ilex	plots	range	trend	range	trend
Total sample	57	50-65%	increase	5-15%	decrease
- Mediterranean	56	50-65%	increase	5-15%	decrease

Except for one plot, all Common Plots in the period 1987-1989 containing *Quercus ilex* were found in the Mediterranean region. Within the three year period, *Quercus ilex* has gradually improved in foliation (Figure 10). The percentage of not-defoliated trees increased, while the percentage of damaged trees decreased.

Discolouration		Not-discoloured (disc. 0-10%)		Slightly discoloured (disc. 11-25%)	
Quercus ilex	plots	range	trend	range	trend
Total sample	57	60-90%	increase	10-30%	decrease
- Mediterranean	56	60-90%	increase	10-30%	decrease

As to discolouration, *Quercus ilex* has clearly improved over the last three years (Figure 10). Most improvement occurred in the period 1987-1988, and has stabilized in 1989.

Overall, the increase in percentages of not-defoliated and not-discoloured trees suggests an improvement in vitalilty of *Quercus ilex* in the Common Plots. However, the total number of trees in the common plots increased considerably (Table 14) so it is not possible to draw reliable conclusions from these figures.

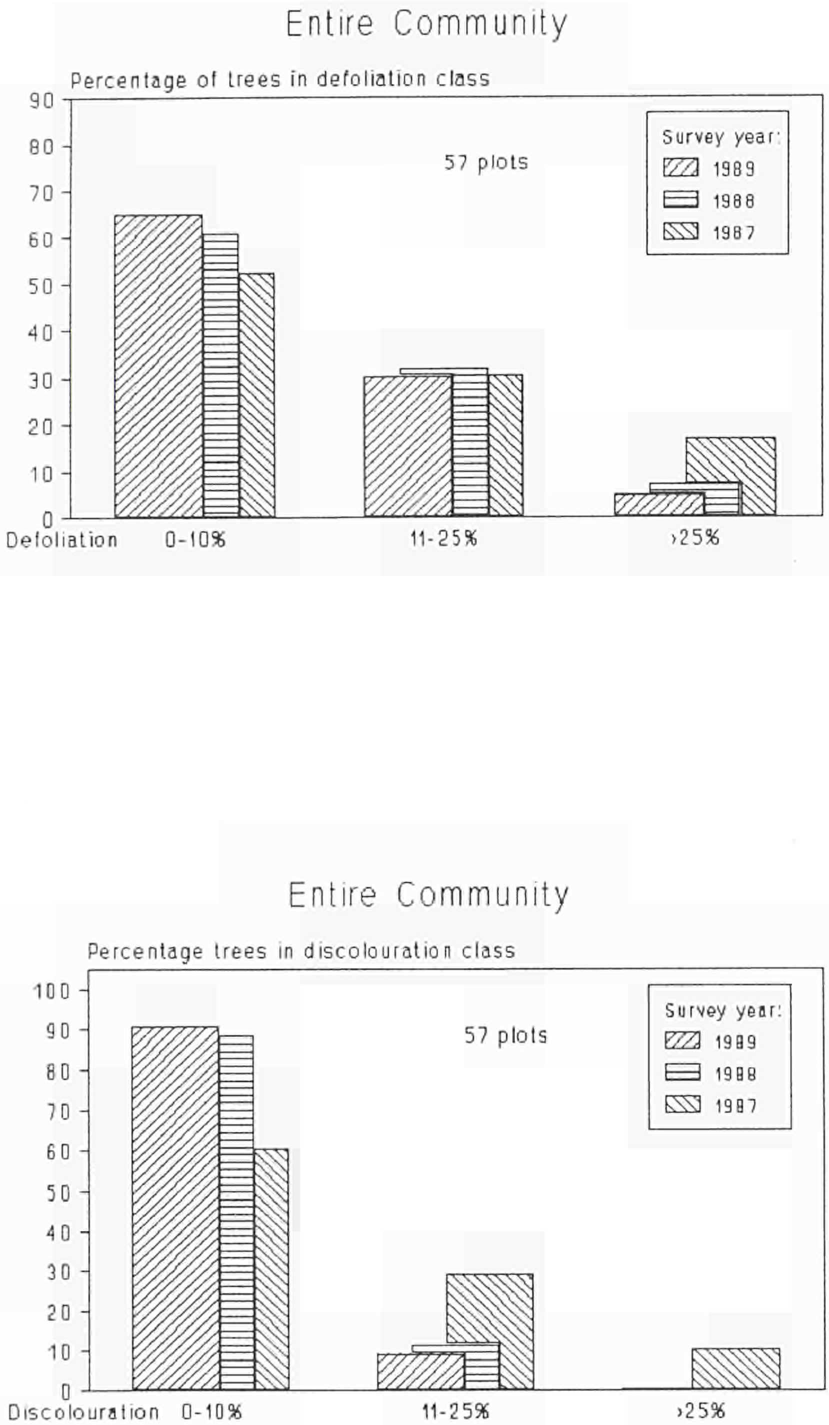


Figure 10: Changes in defoliation and discolouration for *Quercus ilex* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

5.3.5 *Pinus halepensis*

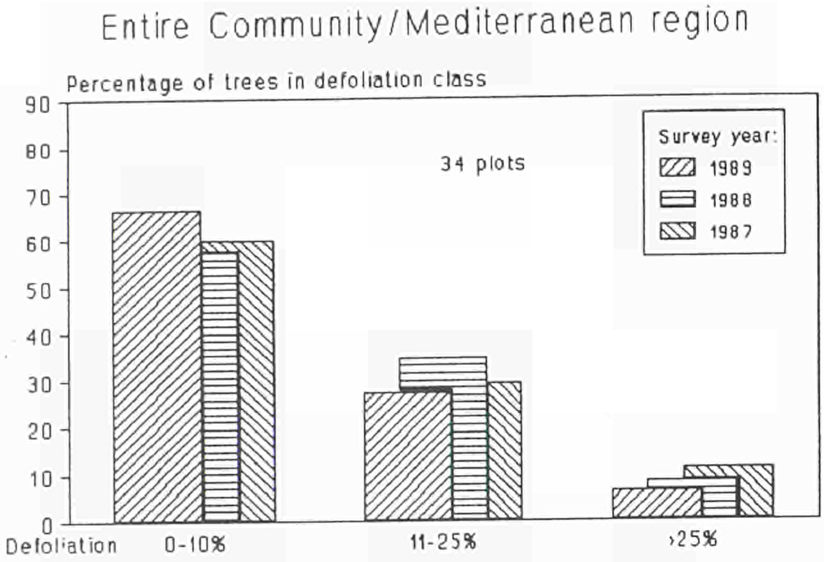
Defoliation		Healthy trees (def. 0-10%)		Damaged trees (def. >25%)	
Pinus halepensis	plots	range	trend	range	trend
Total sample	34	60-65%	fluctuating	5-10%	decrease
- Mediterranean	34	60-65%	fluctuating	5-10%	decrease

All Common Plots with *Pinus halepensis* were located in the Mediterranean region. The percentage of damaged trees gradually decreased in the period 1987-1989 (Figure 11). The fraction of healthy trees fluctuates, but shows a slight net increase over 1987-1989.
The total number of trees in the Common Plots increased with 7.2% (Table 14), and therefore these trends cannot be considered as conclusive.

Discolouration		Not-discoloured (disc. 0-10%)		Slightly discoloured (disc. 11-25%)	
Pinus halepensis	plots	range	trend	range	trend
Total sample	34	65-75%	fluctuating	20-25%	sl. fluctuat.
- Mediterranean	34	65-75%	fluctuating	20-25%	sl. fluctuat.

No large changes have occurred with respect to discolouration of *Pinus halepensis*. The percentage of not-discoloured trees fluctuated but show a slight net increase. The percentage of slightly discoloured trees fluctuated (Figure 11).

The slight improvements regarding defoliation and discolouration suggest that the overall vitality of *Pinus halepensis*, based on the Common Plots, has slightly improved in the period 1987-1989.



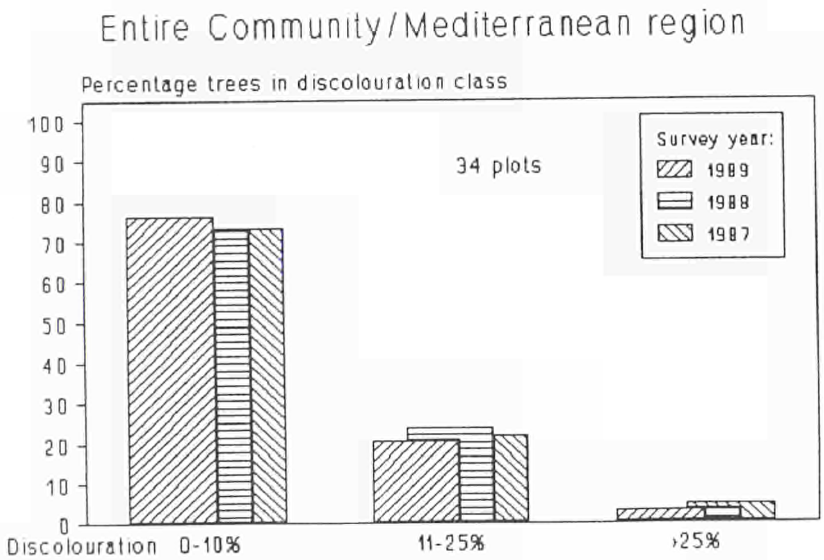


Figure 11: Changes in defoliation and discolouration for *Pinus halepensis* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

5.3.6 *Pinus nigra*

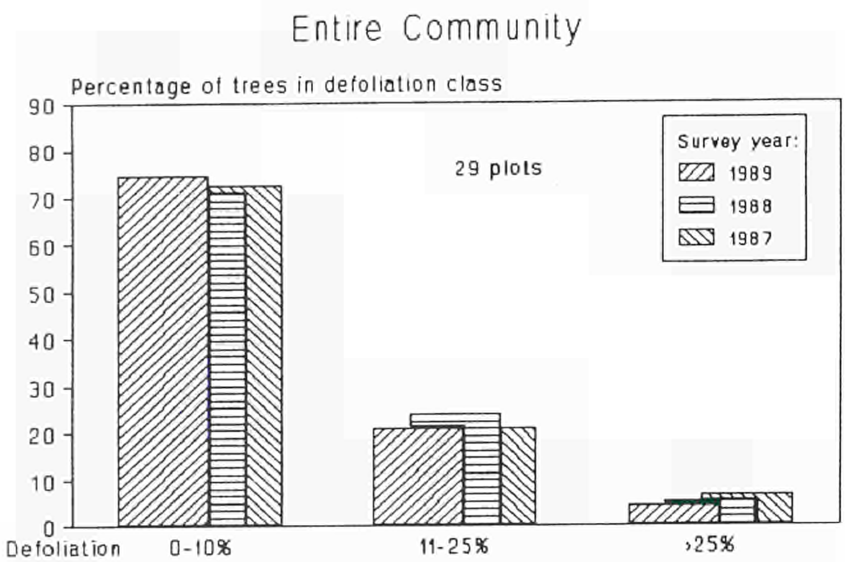
Defoliation		Healthy trees (def. 0-10%)		Damaged trees (def. >25%)	
Pinus nigra	plots	range	trend	range	trend
Total sample	29	70%	constant	6-10%	sl. decrease
- Mediterranean	23	70-80%	fluctuating	3%	constant

Regarding the entire subsample, no clear trends are apparent in the percentages of healthy or damaged trees. The fraction of damaged trees only slightly decreased, the fractions of healthy trees fluctuated during this period (Figure 12, Annex III-1).
Most Common Plots with *Pinus nigra* are located in the Mediterranean region. Within this region, the percentage of damaged trees remained constant. The percentages of healthy and slightly defoliated trees show larger fluctuations as compared to the subsample for the entire Community (Figure 12)

Discolouration		Not-discoloured (disc. 0-10%)		Slightly discoloured (disc. 11-25%)	
Pinus nigra	plots	range	trend	range	trend
Total sample	29	80%	constant	15%	constant
- Mediterranean	23	85-90%	fluctuating	10-15%	fluctuating

The total sample of *Pinus nigra* shows no changes in discolouration (Figure 13). In the Mediterranean region, slight fluctuations have occurred in the percentages of trees in the different disclouration classes.

Overall, no changes in vitality occurred for *Pinus nigra* in the Common Plots.



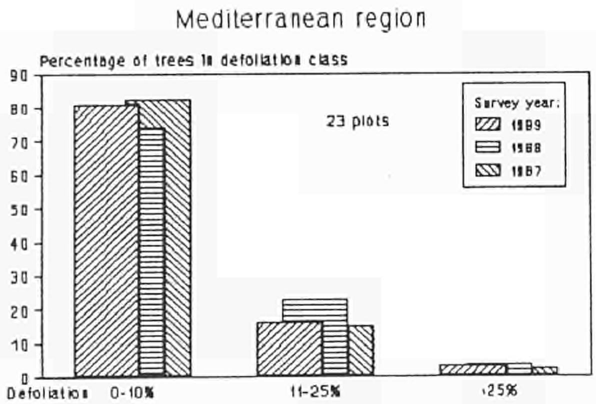
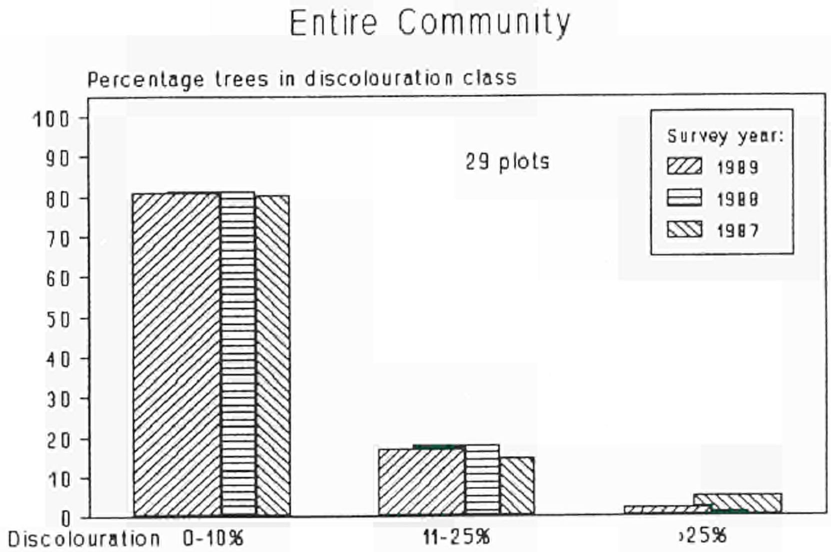


Figure 12: Changes in defoliation for *Pinus nigra* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.



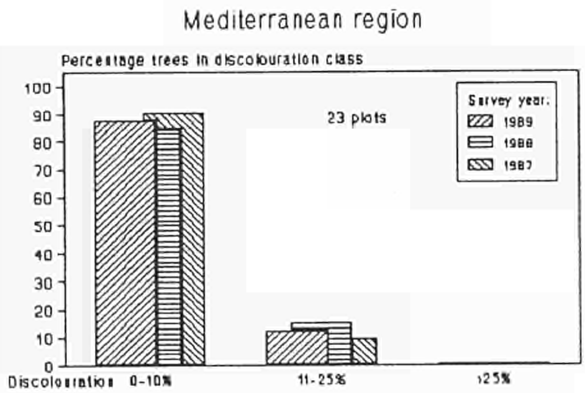


Figure 13: Changes in discolouration for *Pinus nigra* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

5.3.7 *Pinus pinaster*

Defoliation		Healthy trees (def. 0-10%)		Damaged trees (def. >25%)	
Pinus pinaster	plots	range	trend	range	trend
Total sample	28	70%	constant	10-15%	decrease
- Atlantic	10	60-70%	fluctuating	1-8%	increase
- Mediterranean	17	70%	constant	10-15%	decrease

When considering the entire subsample, the percentage of damaged trees of *Pinus pinaster* shows a slight gradual decrease (Figure 14). The two regions in which *Pinus pinaster* is represented show opposite trends.
In the Atlantic region, the fraction of damaged trees increases, while in the Mediterranean region the percentage of damaged trees decreases (Annex II-1, Figure 14). In the Atlantic region the percentages of healthy and slightly defoliated trees show a high fluctuation (Figure 14). However, the number of plots are small, so these figures cannot be considered as conclusive.

Discolouration		Not-discoloured (disc. 0-10%)		Slightly discoloured (disc. 11-25%)	
Pinus pinaster	plots	range	trend	range	trend
Total sample	28	75-85%	sl. increase	10-15%	increase
- Atlantic	10	95%	sl. decrease	1-6%	increase
- Mediterranean	17	70-80%	increase	15%	constant

Regarding the total subsample of Common Plots, *Pinus pinaster* shows a slight improvement with respect to discolouration. The percentage of not-discoloured trees slightly increased, while the percentage of moderately/severely discoloured trees decreased in the period 1987-1989 (Figure 15).
Most improvement occured in the Mediterranean region. In the Atlantic region, total discolouration shows a minor increase.

The overall slight increase in percentages of not-defoliated and not-discolourated trees in the Common plots suggest a slight improvement of the vitality of *Pinus pinaster*.

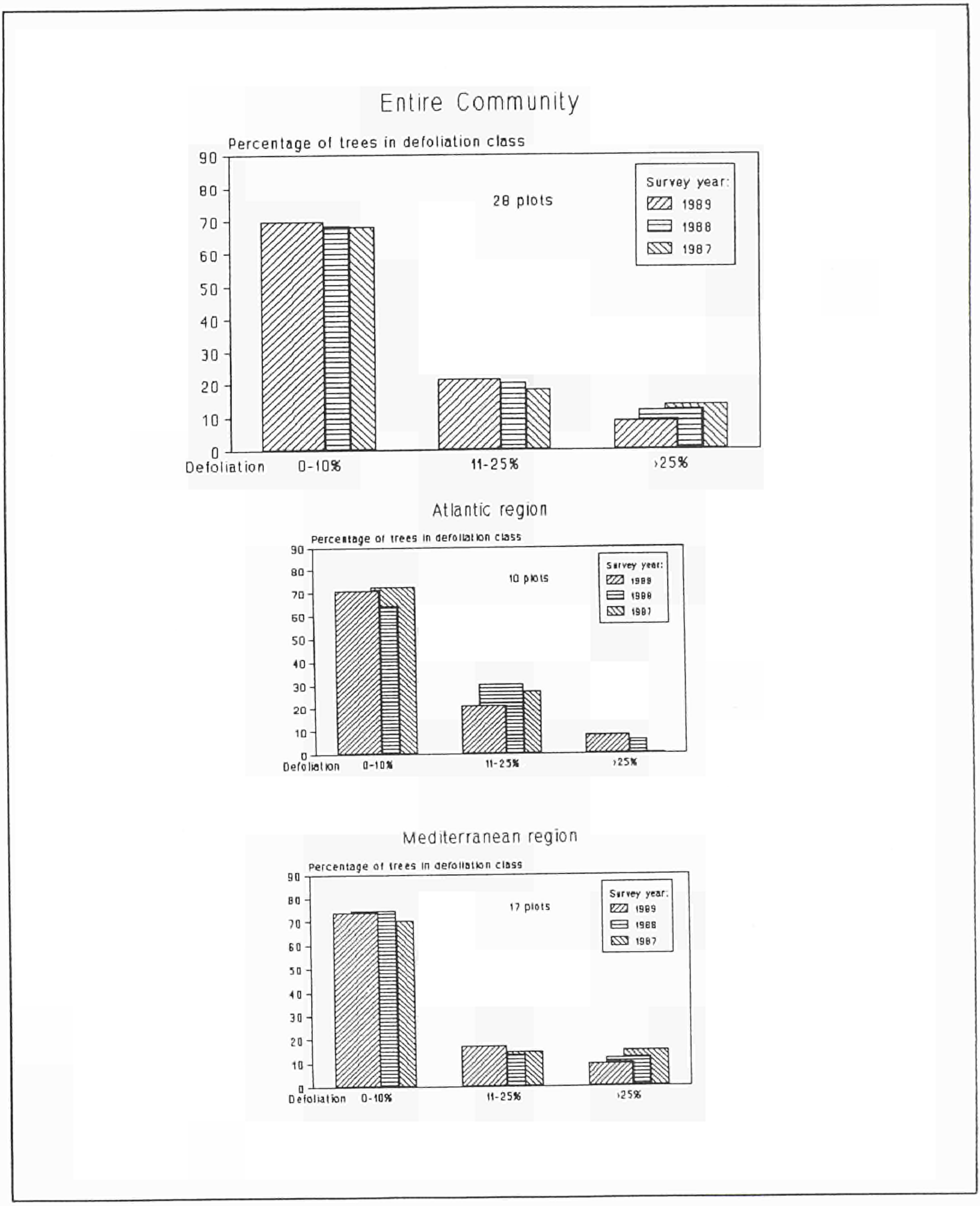


Figure 14: Changes in defoliation for *Pinus pinaster* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

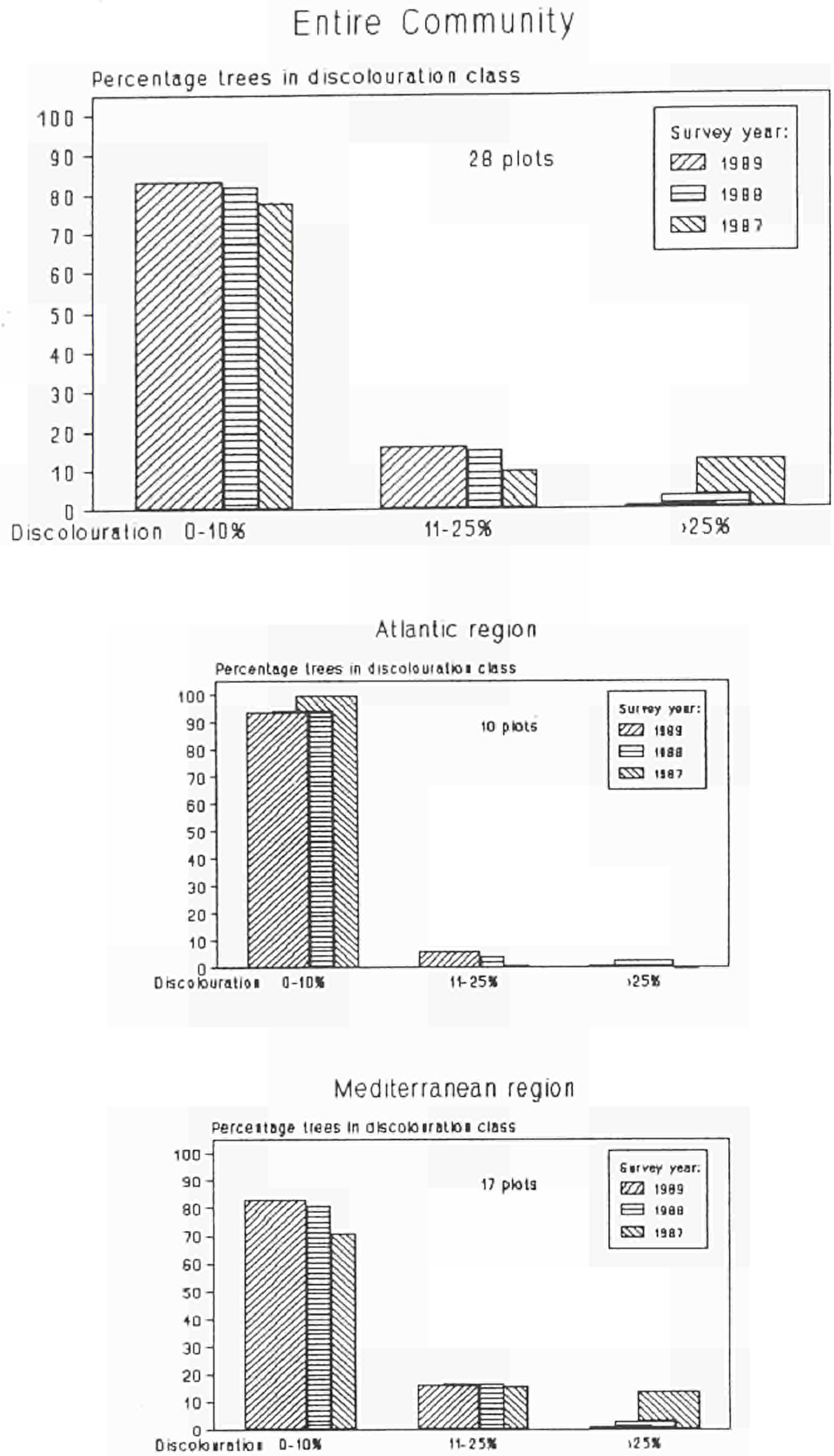


Figure 15: Changes in discolouration for *Pinus pinaster* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

5.3.8 *Castanea sativa*

Defoliation		Healthy trees (def. 0-10%)		Damaged trees (def. >25%)	
Castanea sativa	plots	range	trend	range	trend
Total sample	27	65-80%	fluctuating	6-9%	sl. increase
- Sub-atlantic	10	70-90%	fluctuating	5%	sl. increase
- Mediterranean	14	50-70%	decrease	10%	sl. increase

The percentage of healthy trees of *Castanea* shows large fluctuations in the period 1987-1989. The total percentages of healthy trees are highest in the Sub-atlantic region (Figure 16). In the Sub-atlantic, as well as in the Mediterranean region the percentage of damaged trees slightly increased. It is not possible to establish clear trends in foliation because of the large fluctuations and low number of plots.

Discolouration		Not-discoloured (disc. 0-10%)		Slightly discoloured (disc. 11-25%)	
Castanea sativa	plots	range	trend	range	trend
Total sample	27	70-80%	fluctuating	15-25%	fluctuating
- Sub-atlantic	10	85-95%	fluctuating	5-15%	fluctuating
- Mediterranean	14	70-55%	fluctuating	20-35%	increase

The total sample of Common Plots with *Castanea sativa* shows fluctuating percentages of discolouration (Figure 17). The percentage of not-discoloured trees is remarkably low in the Mediterranean region as compared to the Sub-atlantic region. Also, in the Mediterranean region the percentage of slightly discoloured trees shows a gradual increase, but no distinct trends in overall discolouration are apparent in this region.

No clear changes in vitality have occurred for *Castanea sativa*. It is interesting to see that defoliation and discolouration are fluctuating congruously.

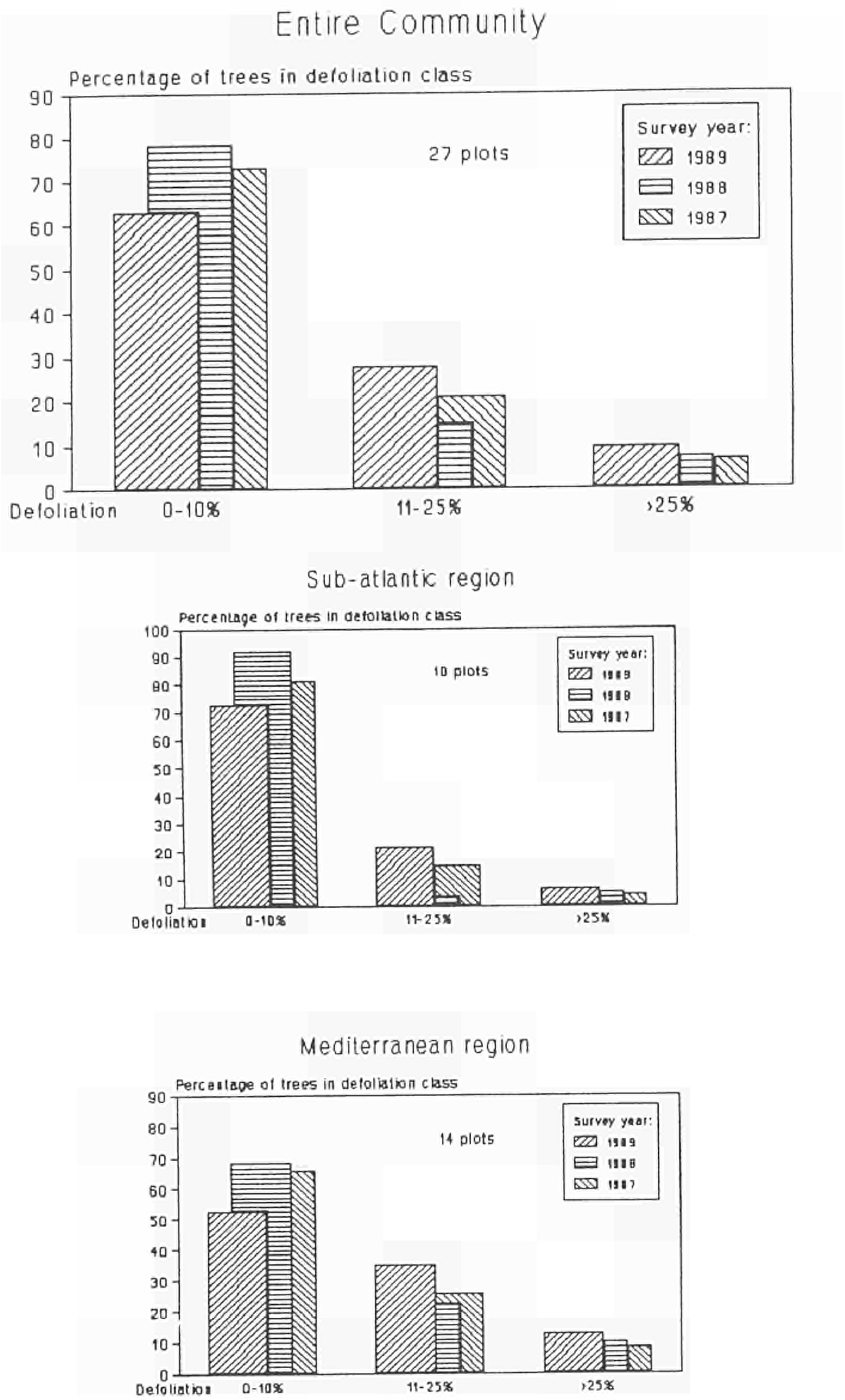


Figure 16: Changes in defoliation for *Castanea sativa* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

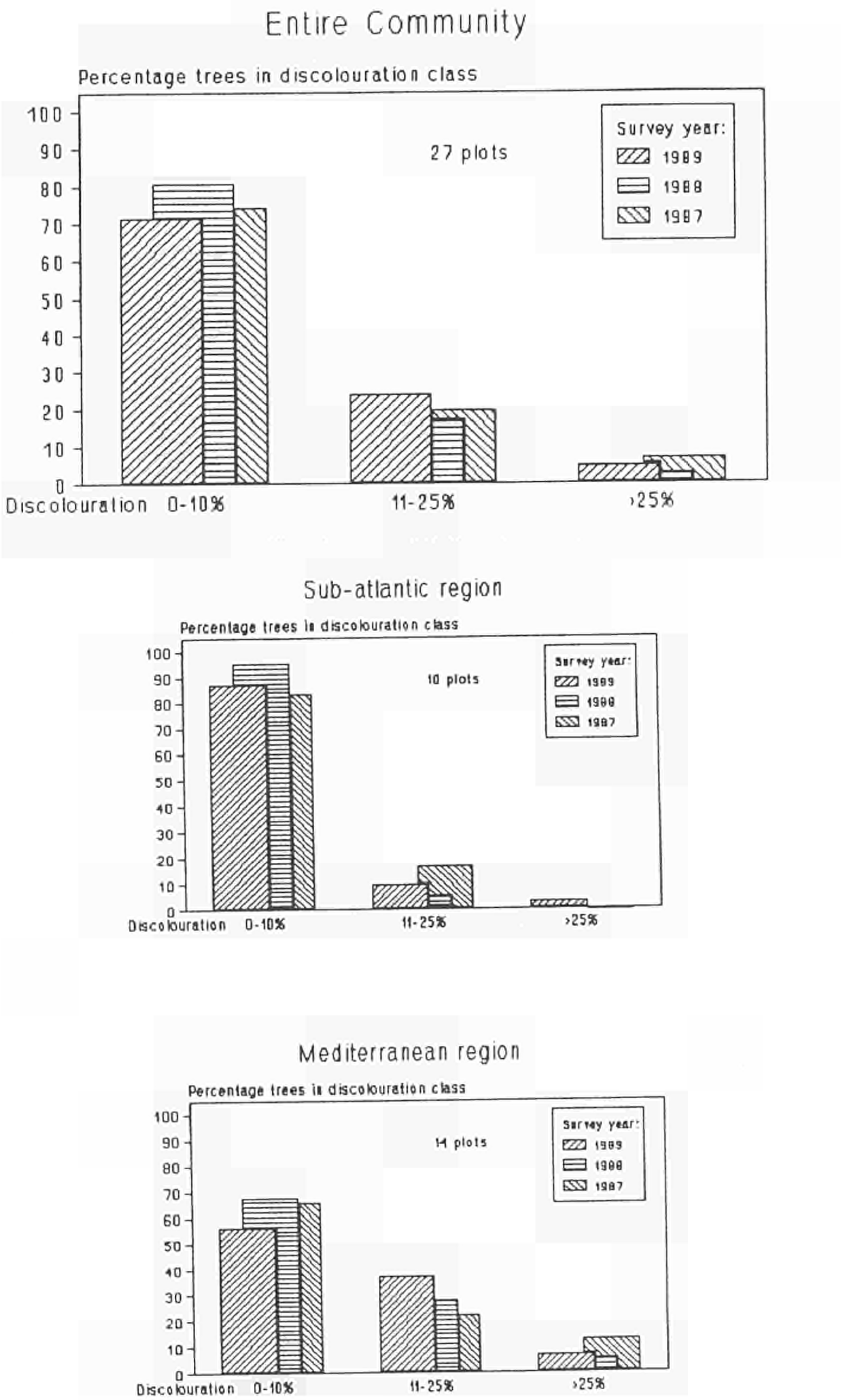


Figure 17: Changes in discolouration for *Castanea sativa* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

5.3.9 *Picea sitchensis*

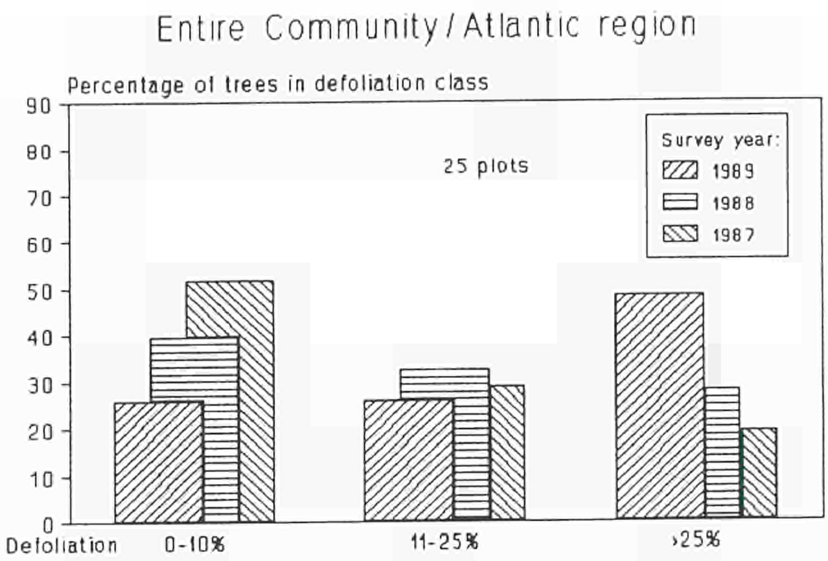
Defoliation		Healthy trees (def. 0-10%)		Damaged trees (def. >25%)	
Picea sitchensis	plots	range	trend	range	trend
Total sample	25	25-50%	decrease	20-50%	increase
- Atlantic	25	25-50%	decrease	20-50%	increase

All Common Plots containing *Picea sitchensis* are located in the Atlantic region. *Picea sitchensis* shows a pronounced detoriation with regards to foliation in the period 1987-1989 (Figure 18). The percentage of healthy trees drops rapidly in this period.
Special attention should be given to *Picea sitchensis* in the future to determine whether this trend will abide.

Discolouration		Not-discoloured (disc. 0-10%)		Slightly discoloured (disc. 11-25%)	
Picea sitchensis	plots	range	trend	range	trend
Total sample	25	75-85%	increase	8-15%	decrease
- Atlantic	25	75-85%	increase	8-15%	decrease

The trees in the Common Plots for *Picea sitchensis* show an overall decrease in discolouration over the period 1987-1989 (Figure 18). The percentage of not-discoloured trees increased in the last two years.

Based on the percentages of defoliation, the vitality of *Picea sitchensis* has deteriorated dramatically over the last three years. However, this deterioration is not apparent in the changes regarding discolouration. According to the National Report on forest health of the United Kingdom, this increase in defoliation was greatly due to attacks of the Green spruce aphid (*Elatobium abietinum*).



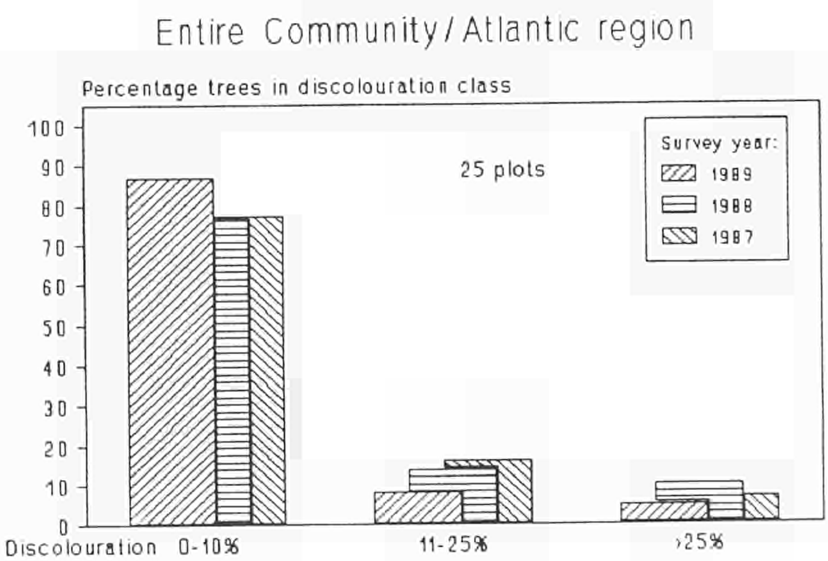


Figure 18: Changes in defoliation and discolouration for *Picea sitchensis* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

5.3.10 *Quercus robur*

Defoliation		Healthy trees (def. 0-10%)		Damaged trees (def. >25%)	
Quercus robur	plots	range	trend	range	trend
Total sample	25	40-55%	fluctuating	15-25%	fluctuating
- Atlantic	16	30-55%	fluctuating	15-35%	fluctuating

The percentages of trees in the different defoliation classes are highly fluctuating over the period 1987-1989 (Figure 19). There are no overall trends visible. Remarkable however is the strong improvement of the last year, with a rapid increase in the percentage of healthy trees, and a rapid decrease in the percentage of damaged trees.

Discolouration		Not-discoloured (disc. 0-10%)		Slightly discoloured (disc. 11-25%)	
Quercus robur	plots	range	trend	range	trend
Total sample	25	90%	constant	9%	constant
- Atlantic	16	90%	constant	9%	constant

No clear changes in discolouration occurred in the Common Plots of *Quercus robur* in the period 1987-1989 (Figure 20).

The overall vitality of *Quercus robur* in the Common Plots, based on changes in defoliation, has improved in the period 1988-1989. This improvement was not expressed by changes in discolouration.

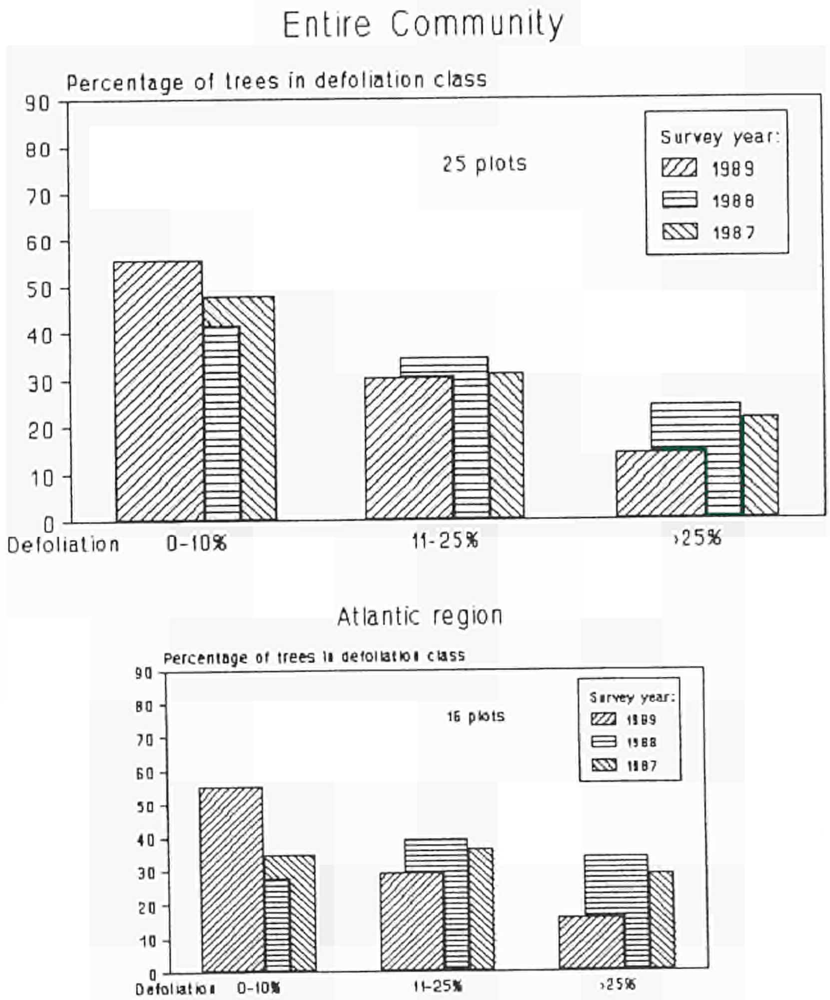
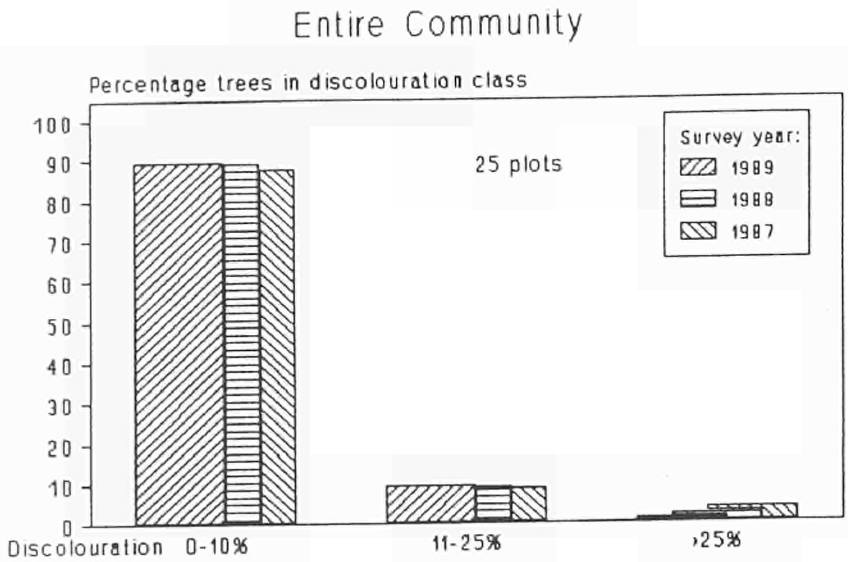


Figure 19: Changes in defoliation for *Quercus robur* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.



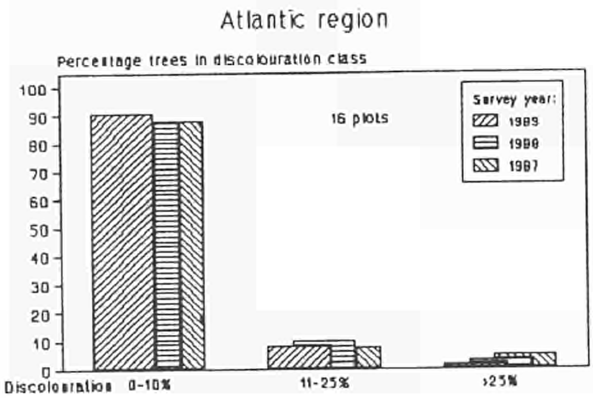


Figure 20: Changes in discolouration for *Quercus robur* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

5.3.11 *Quercus pubescens*

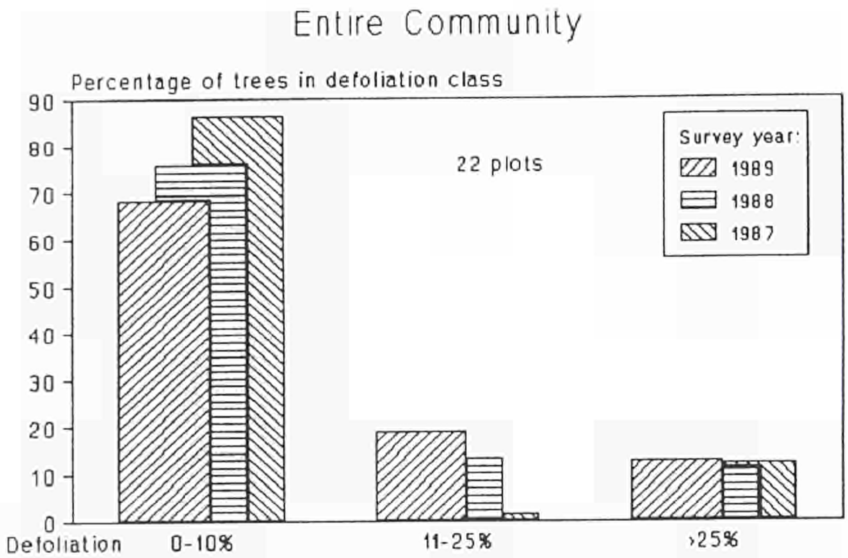
Defoliation		Healthy trees (def. 0-10%)		Damaged trees (def. >25%)	
Quercus pubescens	plots	range	trend	range	trend
Total sample	22	70-85%	decrease	12%	constant
- Mediterranean	17	70-80%	decrease	9-15%	decrease

When regarding the entire subsample, the percentage of damaged trees of *Quercus pubescens* has remained constant. The percentage of not-defoliated trees decreased, while the percentage of slightly defoliated trees increased. In the Mediterranean region however, the percentage of damaged trees has gradually decreased in the period 1987-1989 (Figure 21). This decrease in damaged trees is accompanied by a decrease in the percentage of healthy trees. This results in a sharp increase in slightly defoliated trees. Because of this shift in classes from both healthy and damaged trees to slightly defoliated trees, it is difficult to interprete the overall pattern as either an improvement or deterioration of the health status of this species.

Discolouration		Not-discoloured (disc. 0-10%)		Slightly discoloured (disc. 11-25%)	
Quercus pubescens	plots	range	trend	range	trend
Total sample	22	80-90%	fluctuating	0-14%	increase
- Mediterranean	17	75-85%	fluctuating	1-20%	increase

Quercus pubescens has somewhat improved with respect to discolouration. The percentage of not-discoloured trees fluctuated, but the percentage of trees in the classes with moderately to severely discolouration clearly decreased in the period 1988-1989 (Figure 22).

No clear changes in vitality have become apparent for *Quercus pubescens* in the Common Plots.



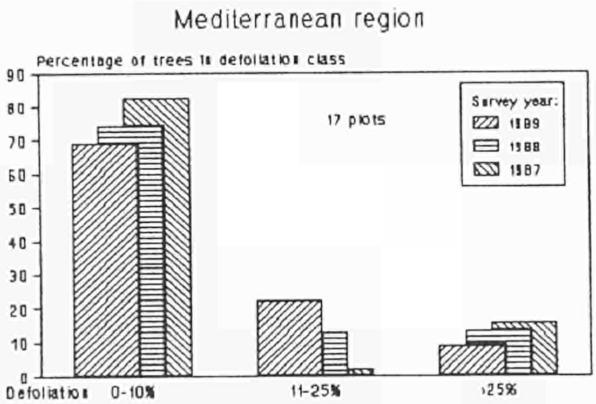
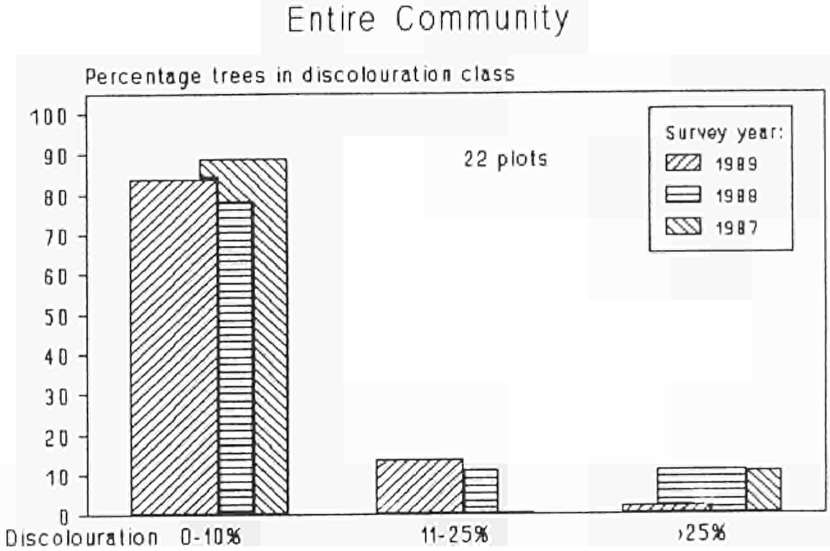


Figure 21: Changes in defoliation for *Quercus pubescens* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.



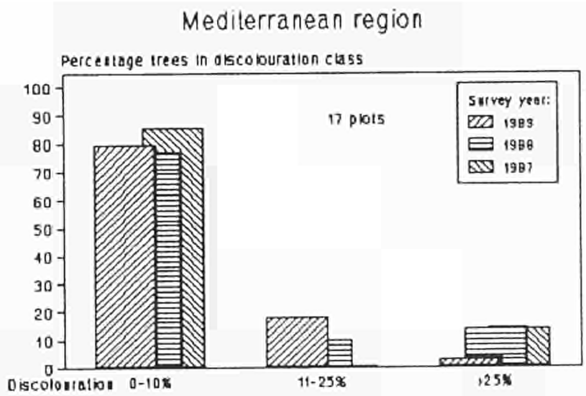


Figure 22: Changes in discolouration for *Quercus pubescens* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

5.3.12 *Quercus petraea*

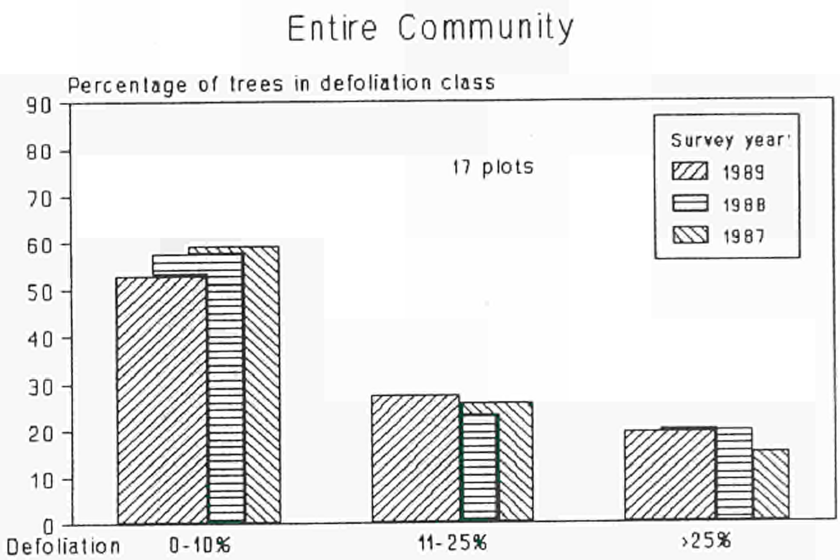
Defoliation		Healthy trees (def. 0-10%)		Damaged trees (def. >25%)	
Quercus petraea	plots	range	trend	range	trend
Total sample	17	50-60%	sl. decrease	15-20%	sl. increase
- Sub-atlantic	16	50-55%	sl. decrease	15-20%	sl. increase

The percentage of healthy trees of *Quercus petraea* has slowly decreased over the years (Figure 23). The fraction of damaged trees increased in 1987-1988, but has remained constant in 1988-1989. Overall the changes are small, so no trends can be derived from these figures.

Discolouration		Not-discoloured (disc. 0-10%)		Slightly discoloured (disc. 11-25%)	
Quercus petraea	plots	range	trend	range	trend
Total sample	17	98%	constant	2%	constant
- Sub-atlantic	16	98%	constant	2%	constant

No clear changes in discolouration occurred for *Quercus petraea* in the period 1987-1989 (Figure 23).

The vitality of *Quercus petraea* within the subsample has not clearly changed over the last three years.



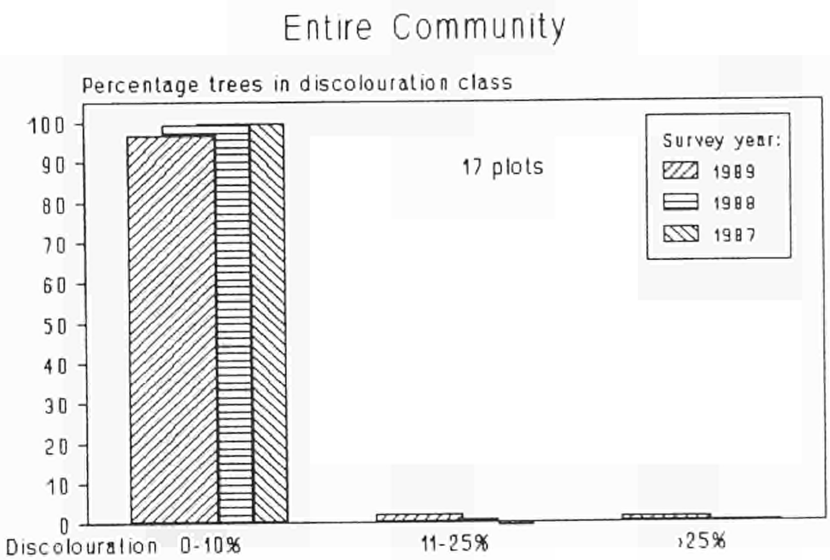


Figure 23: Changes in defoliation and discolouration for *Quercus petraea* in period 1987-1989. Plots common to the 1987, 1988 and 1989 inventory, and containing at least 10 individuals of this species.

5.4 Closing remarks

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. Because of the incomplete surveys of 1987 and 1988, the trees in the Common Plots only represent a small part of the total tree sample of the inventory network. The slight changes in vitality that were observed for some species could therefore in many cases not be regarded as conclusive because of the low number of plots.

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%.

General trends in tree vitality over the period 1987-1989 were suggested for:

* *Fagus sylvatica*: a deterioration of vitality for trees in the Mediterranean region (however based on only 13 plots).

* *Quercus ilex*: an improvement of vitality (but data are based on an increasing number of observed trees, so this improvement may be caused by the inclusion of relatively healthy trees in the plots).

* *Pinus halepensis*: a slight improvement of vitality.

* *Pinus pinaster*: a slight improvement of vitality.

* *Picea sitchensis*: a strong deterioration of vitality (based on defoliation only; percentage of not-discoloured trees showed an increasing trend). This increase in defoliation was greatly due to attacks by the Green spruce aphid (*Elatobium abietinum*) in the United Kingdom.

Future surveys of the entire network can provide more complete and useful data for the establishment of possible trends in vitality of the different species included in the inventory.

6 Extended evaluation

The vitality of forests in general depends on a large number of parameters. These parameters can be site specific (such as soil, climate, altitude, pollution, etc.), of human origin (species selection, forest management, etc.) or random (pests, fires, etc.). Further, some parameters remain relatively constant over a longer period, while others may vary from year to year, affecting forest vitality in either a positive or negative way. An **extended evaluation** was carried out to investigate the possible relationships between a number of site and stand dependent parameters and forest vitality.

6.1 Parameters used in the extended evaluation

A number of site dependent parameters was evaluated with respect to their influence on forest vitality, as recorded for each sample plot in the inventory. These include: **water availability** to principal tree species, **humus type**, **altitude**, and **exposition** (aspect). A general climatic region is assigned to each plot. As a stand dependent parameter, the **mean age** of the stand is recorded. In addition, a first evaluation has been conducted using additional parameters which were not recorded as such in the inventory. These parameters include the general **soil type** and levels of **air pollution**.

Forest vitality is assessed by sampling individual trees on two characteristics: the degree of **defoliation** and **discolouration** with respect to a certain reference tree. When regarded together, these two characteristics are assumed to give an indication of tree health.

In order to investigate the effect of a certain parameter on forest vitality, the property of this parameter was related to the amount of defoliation and/or discolouration found for trees growing under the conditions determined by the parameter.

6.2 Evaluation of parameters included in the inventory

6.2.1 Selection of the sub-sample

The effect of site- and stand dependent parameters on tree health was examined using the data for the **Federal Republic of Germany** of the **1988** Forest Health Inventory. This data set was selected, since it included sufficient observations within each category of parameters to conduct extended analyses.
In order to reduce variation due to differences in general climate, only trees in the **Sub-atlantic region** were included in the investigation. This region was most represented in the data set of the Federal Republic of Germany.
The investigations were carried out using data for the **most common species** in the data set: *Picea abies*, *Pinus sylvestris*, *Fagus sylvatica* and *Quercus robur*. The effect of the different parameters on forest vitality is directly related to species composition of the forest. Species may widely differ in the susceptibility to water stress, air pollution, nutrient deficiency, etc. When investigating the effect of the different parameters on forest vitality, it is therefore important to investigate these effects for individual species, rather than to regard a number of species together.
Furthermore, only plots were regarded containing at least **10** individuals of a single species. This way, the influence of competition with other tree species is lessened.

Since the recorded parameters concern characteristics of the sample plot, vitality was expressed on **plot level**. As an index of vitality, for each species in a sample plot the percentages were calculated of trees in the different defoliation classes. The amount of discolouration was not used since it showed very low variation throughout the data set; the vast majority of the trees was not-discoloured.

The **site dependent** parameters can be divided into parameters relating to soil properties (water availability and humus type), and parameters relating to altitude and expositon (aspect). As a **stand dependent** parameter, the effect of mean stand age on forest vitality was evaluated.

6.2.2 Soil properties

The two parameters representing soil properties are **water availability** and **humus type**. In the data set used, no relations were found between these two parameters and the percentages per plot of trees in the different defoliation classes (an example regarding humus type is given in Figure 24). The overall mean percentages showed some differences, but the variation in the data was too high to establish significant differences in vitality between water availability classes or humus types.

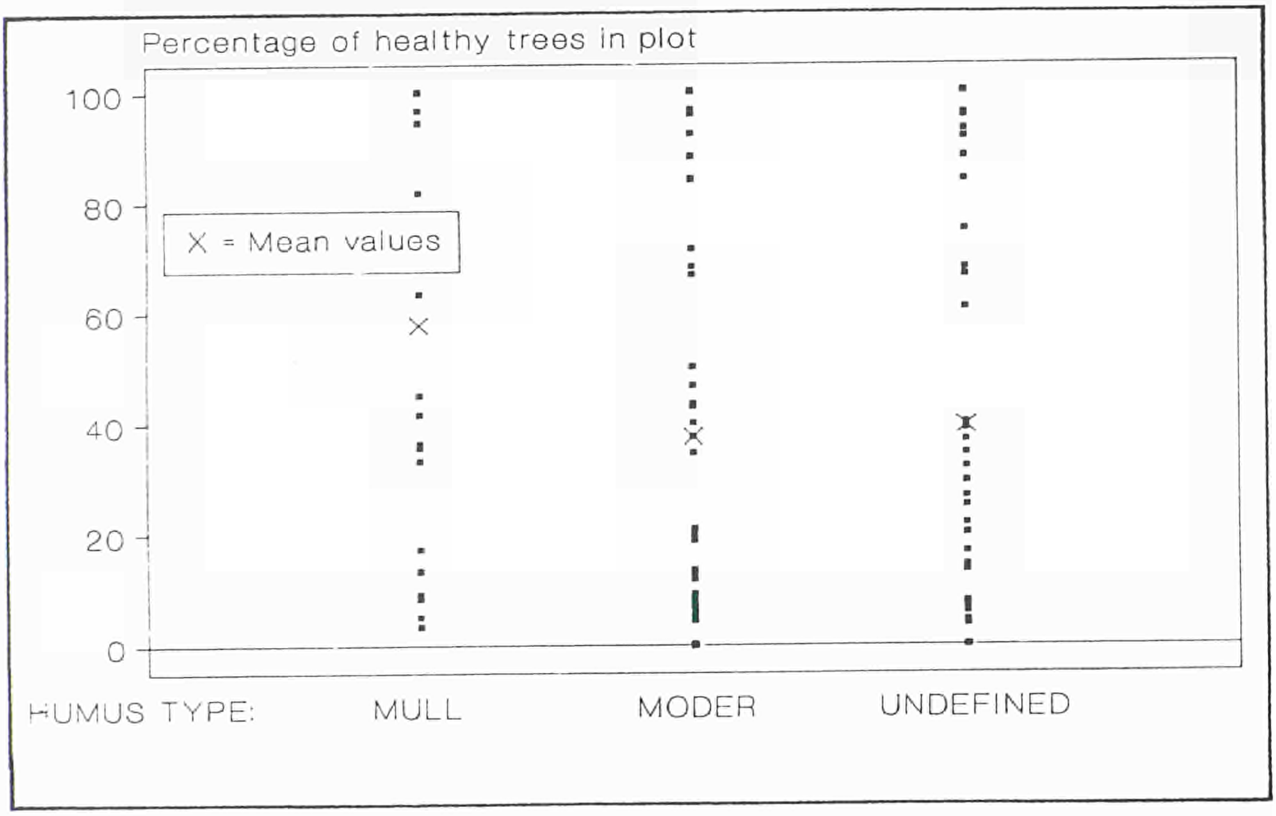


Figure 24: The effect of **humus type** on the percentage of **not-defoliated trees** in a plot for *Picea abies, showing the extreme variation in the percentages of not-defoliated trees*. Data represent plots with <u>sufficient water</u> available to the trees.

6.2.3 Altitude and Exposition

With respect to both **altitude** and **exposition** (aspect), no relationships were found with the percentages per plot of trees in the different defoliation classes. Again, the variation was too high to establish any trends (see Figure 25 for an example regarding altitude).

Figure 25: The effect of **altitude** on the percentage of **not-defoliated trees** in a plot for *Picea abies, showing the extreme variation in the percentages of not-defoliated trees*. Data represent plots with <u>sufficient water</u> available to the trees.

Altitude and exposition can be expected to have a **combined** influence on site conditions. Growth conditions in a plot at a certain altitude with northern exposition may be similar to growth conditions in a plot at a higher altitude but with southern exposition. A combination of altitude and exposition did however not show any relationship with the amount of defoliation.

6.2.4 Discussion site dependent parameters

For each site dependent parameter, relationships with defoliation were investigated using the data of sample plots that had **equal** characteristics with respect to another parameter (for instance the effect of humus type on defoliation in plots with only sufficient water availability). Despite the fact that this procedure potentially reduced the variation, still no relationships were found between the different parameters and defoliation.

The fact that no relationships were found between defoliation and the site dependent parameters recorded in the inventory does not imply that defoliation is random with regard to site conditions. Forest vitality is influenced by a large number of, generally interacting, forest components and site conditions. The lack of relationships is possibly due to the fact that the recorded parameters do not provide accurate information on site conditions that directly relate to defoliation (or forest vitality). For instance soil characteristics are dependent on a large number of variables, each having an effect on the growth conditions of trees, either individually or in combination with other variables. The recorded soil properties in the current inventory do not properly distinguish relevant differences in soil characteristics between sample plots.

The amount of water available to the trees for instance is recorded at the time of the sampling. Therefore, the determination of water availability is dependent on the weather conditions prior to the sampling. No information is given on the characteristics of the water table, water capacity of the soil, etc. Also humus type as a single parameter does not provide a good indication of soil properties, since it only gives a limited description of top soil characteristics.

6.2.5 Mean stand age

In a number of cases the percentages of not-defoliated and slightly defoliated trees showed relatively high correlations with **stand age**, in particular within certain humus types (Annex IV-1, see also section 3.7).

The figures in Annex IV-1 show that the percentages of not-defoliated trees gradually **decrease** with increasing age. On the other hand, percentages of slightly defoliated trees gradually **increase** with increasing age. These trends could indicate an overall worsening of tree vitality with increasing age. However, tree vitality is generally evaluated by using the percentages of not- and slightly defoliated trees together. For these two defoliation classes as a whole, no high correlations with mean age are present. Furthermore, **no trends** were found for **discolouration** in relation to mean age.

6.3 Evaluation of additional parameters

In the inventory, no information was recorded with respect to levels of air pollution or soil type. A tentative investigation was carried out to evaluate the effects or influences of air pollution and different soil types on forest vitality.

6.3.1 Selection of the subsample

For this evaluation, the data were used of the **1988** inventory from the **Federal Republic of Germany**, **Belgium** and the **Netherlands**. 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*). Only plots were included that contained at least 10 individuals of a single species. The data were not specified with respect to climatic region.

6.3.2 Air pollution

Research has indicated that air pollution in many cases plays a significant role in forest decline. Since no specific information regarding air pollutants is recorded in the inventory, such a relationship between defoliation or discolouration and levels of air pollution in the Community could not be directly assessed.

In order to obtain some information on the levels of air pollution in the plots, the **general distribution maps** for a number of air pollutants were used, as have been published by the Norwegian Institute for Air Research (1). These distribution maps cover the entire Community, and show **mean isoclines**, determined over the period **1983-1987**, for:

* **SO2** (sulpher dioxide) in air (ug S/m3)
* **SO4** (sulphate) in aerosols (ug S/m3)
* **SO4** (sulphate) in precipitation (mg S/l)
* **NO3** (nitrate) in precipitation (mg N/l)
* **pH** (acidity) in precipitation

The data on SO4 and NO3 in precipitation were converted to **mean wet deposition** using the distribution map of precipitation for the entire Community, published by the European Commission (2).

For all five species, **no relationships** were found between defoliation and the mean levels of the different air pollutants and precipitation pH (Figure 26, Annex IV-2).
The information on levels of air pollution that was used here is extremely general; actual immissions of air pollutants can show a large variation over short distances, can vary with altitude and are dependent on the forest structure, etc. However, the isoclines on the maps that were used are constructed by extrapolation of data from a limited number of observation stations over large distances. Local variation could therefore not be accounted for.

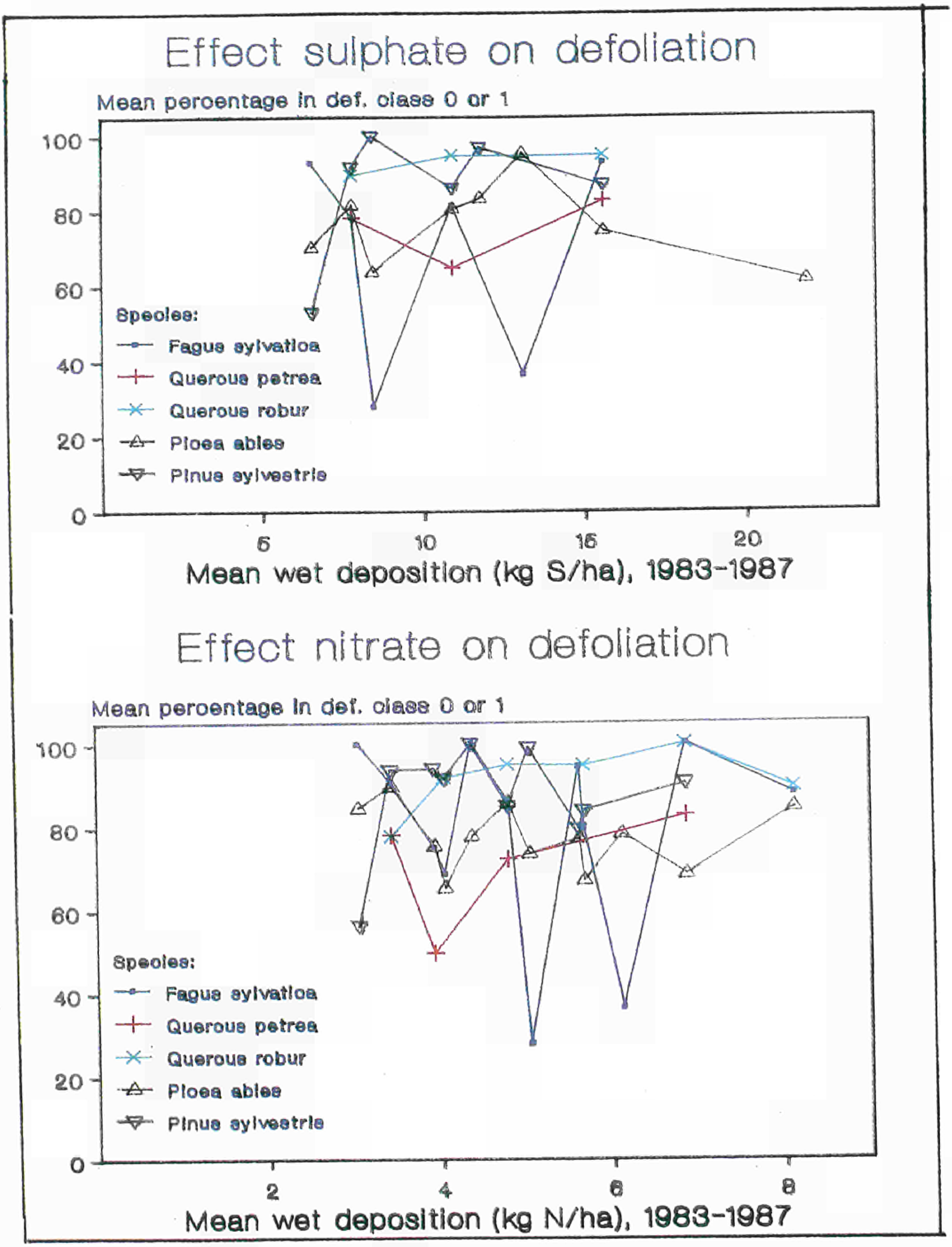


Figure 26: The relationship between the percentages of not- to slightly defoliated trees and calculated mean wet deposition of sulphate (SO4) and nitrate (NO3).

6.3.3 Soil type

No relationships were found between defoliation and the two parameters describing soil properties (water availability and humus type). It was therefore investigated whether relationships exist between defoliation and the general soil type.
The general soil types were determined per plot, using the Soil Map of the European Communities as published by the Commission of the European Communities (3). Four general **soil units** were used in the investigation:

* **Luvisols**
* **Cambisols**
* **Podzols**
* **Histosols**

No clear relationships were found between defoliation and soil unit (Figure 27). The soil units which have been distinguished all include a wide range of soil types, representing differences in nutrient availability, soil humidity, basidity, etc. Consequently, the variation within each soil unit is too high to detect possible relationships between soil type and forest vitality.

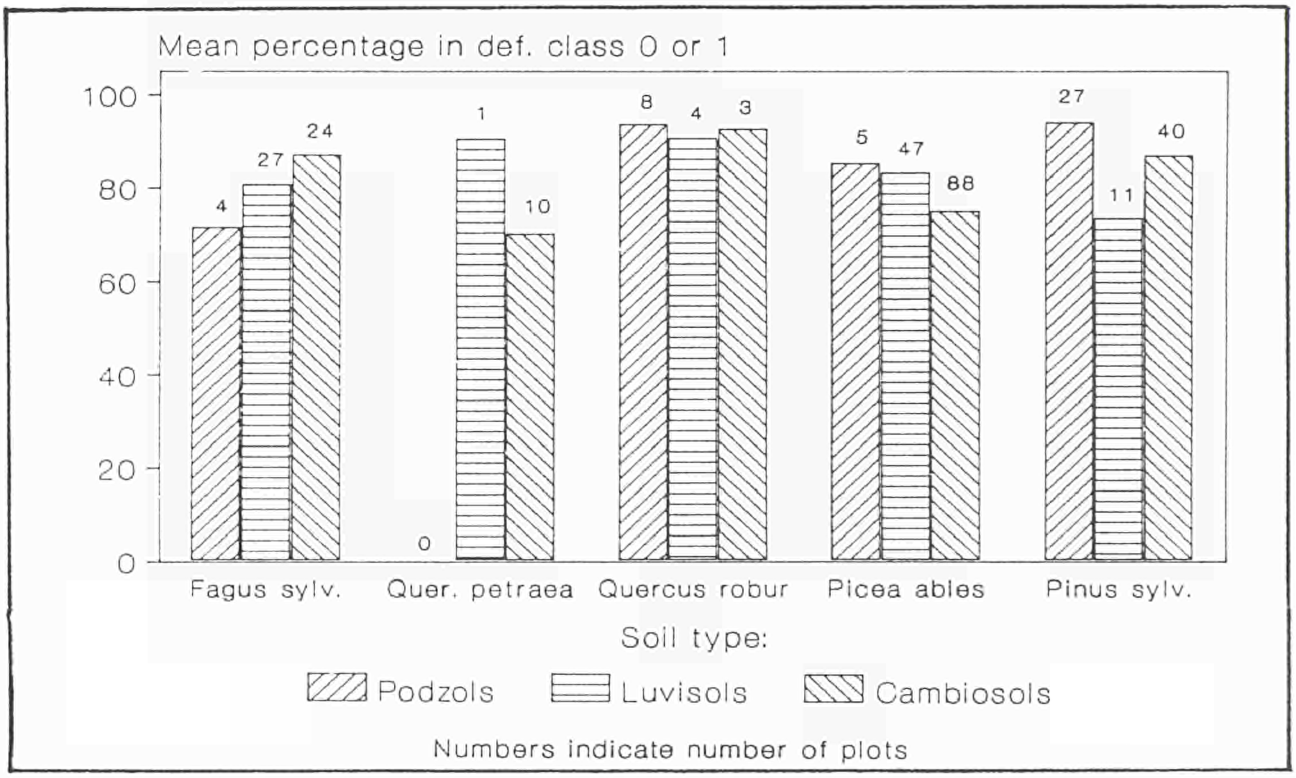


Figure 27: Mean percentages of not- to slightly defoliated trees for five species, separated by soil unit.

(1) Hanssen, J.E., U. Pedersen, J. Schaug and A. Semb, 1990. EMEP - An overview and some measurement results. A contributed paper for presentation at the NAPAP 1990 International Conference on "Acid Deposition: State of Science and Technology", 11-16 February 1990. Hilton Head Island, USA. Norwegian Institute for Air Research, Lillestrom, Norway.

(2) Briggs, D.J. (ed), 1987. Die Lage der Umwelt in der Europäischen Gemeinschaft 1986. Kommission der Europäischen Gemeinschaften. Amt für amtliche Veröffenlichungen der Europäischen Gemeinschaften, Luxemburg.

(3) Commission of the European Communities, Directorate-General for Agriculture, 1985. Soil Map of the European Communities 1:1,000,000. Office for Official Publications of the European Communities.

7 National forest damage inventories 1989

7.1 General overview

In many of the EC Member States a number of plots are inventoried in addition to the plots in the 16 x 16 km. grid. In Table 16 an overview is given of a number of national data by Member State.

In 1989 the coverage of the forests by the national grids is complete in most countries. Exceptions are France, Ireland, Italia (Sicily and Sardinia) and The Netherlands.
The grid density varies from 0.3 x 0.3 in some areas in Germany to 16 x 16 km. In Greece an extra wide grid is used for the maquis area (32 x 32 km).

TABLE 16 : Summary of National Forest Damage Inventories 1989

Country	Area (1000 ha)	Coverage (%)	Conifers (%)	Broadl. (%)	Grid density (km x km)	Number of plots	Number of trees	Average trees/plot
BELGIE ')	617	100.0	47.0/50.1	53.0/49.9	8x8	117	2808	24
DANMARK	460	100.0	59.4	40.6	7x7/16x16	68	1610	24
DEUTSCHLAND	7388	100.0	66.1	33.9	.3X.3 - 16x16	3252	67807	21
ELLAS	2512	100.0	54.0	46.0	16x16/32x32*	84/19*	2008/455*	23
ESPANA	11921	100.0	48.6	51.4	16x16	455	10901	24
FRANCE	13845	94.6	33.2	66.8	16x16	510	3375+6804	24/20
IRELAND	261	81.5	100.0	--	16x16	22	462	21
ITALIA	8675	82.5	22.4	77.6	3x3	220	5614	30
LUXEMBOURG	84	100.0	36.4	63.6	2x2	210	1868+3155	24
NEDERLAND	330	85.0	67.4	32.6	1x1	1400	33125	25
PORTUGAL	3060	100.0	40.2	59.8	16x16	155	4650	30
UNITED KINGDOM	2112	100.0	62.5	37.5	16x16	76	1812	24
ENTIRE COMMUNITY	51265	95.4	43.3	56.7	--	6588	147571	22

') (Belgium) = Flanders/Wallon region
\+ (Number of trees) = differentiation between Conifers and Broadleaves
/ (Grid) = grid in 7x7 and 16x16 km.
\- (Grid) = grid ranges from .3 x .3 up to 16 x16 km.
* (Greece) = for maquis area

7.2 Defoliation by Member State

When comparing the percentages of damaged trees (defoliation classes 2 - 4) between the various EC Member States it can be seen that the highest percentages of damaged trees are recorded in the UK (28%) and Denmark (25%) (Table 17). The lowest percentages of damaged trees are found in Spain (3.3%) and France (5.6%).
It is remarkable that Portugal has the highest percentage of dead trees (class 4), while in this country the percentage severely defoliated trees (class 3) is the lowest of all Member States.

TABLE 17: 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

7.3 Discolouration by Member State

In Table 18 an overview is given of the recorded discolouration in the EC Member States. When the data of discoloured trees (discolouration classes 1 - 4) are compared between the various EC Member States it can be seen that the highest percentage of discoloured trees is recorded in The Netherlands (65%). The lowest percentage of discoloured trees is found in Denmark (2%).
It is remarkable that the tree sample in Denmark showed a very low discolouration, while the degree of defoliation was relatively high.

TABLE 18 : Summary of National Forest Damage Inventories 1989
Discolouration in the EC Member States.

Country	Forest Area (1000 ha)	Discolouration (0 - 10%)	(11 - 25%)	(26 - 60%)	(> 60%)
BELGIE ')	617	72.0/69.5	24.3/23.1	3.1/5.2	0.6/2.2
DANMARK	460	98.0	1.0	0.0	1.0
DEUTSCHLAND	7388	94.6	4.4	0.9	0.1
ELLAS	2512	72.6	23.4	3.4	0.5
ESPANA	11921	88.5	10.9	0.5	0.1
FRANCE	13845	85.4	11.4	2.6	0.7
IRELAND	261	56.5	37.4	6.1	0.0
ITALIA	8675	85.2	11.7	2.1	1.0
LUXEMBOURG	84	81.7	16.1	2.2	0.0
NEDERLAND	330	35.1	58.7	2.3	4.0
PORTUGAL	3060	65.7	24.2	9.6	0.5
UNITED KINGDOM	2112	83.0	15.0	2.0	0.0

') Flanders/Wallon region

7.4 Comparison between defoliation of broadleaves and conifers

The most damaged broadleaves have been recorded in Denmark (23%), while the least damaged broadleaves have been recorded in Spain (3.2%) (Table 19). For conifers the higest percentage of damaged trees has been recorded in the UK (34%), while the lowest percentage of damaged conifers has been found in Spain. In Portugal the highest percentage of dead trees has found for conifers (4.8%). It is remarkable that the highest percentage of not defoliated trees (class 0) is also found for conifers in Portugal.

TABLE 19 : Summary of National Forest Damage Inventories 1989
Defoliation for broadleaves and conifers

		Defoliation				
Country		(0 - 10%)	(11 - 25%)	(26 - 60%)	(> 60%)	(Dead)
BELGIE ')	Broadl.	52.7/66.8	39.3/24.1	6.2/7.5	1.7/1.4	0.2/0.2
	Conifers	35.9/47.6	49.0/28.5	13.6/20.0	1.4/3.9	0.0/0.0
	Total	44.2/57.2	44.2/26.3	10.0/13.8	1.5/2.6	0.1/0.1
DANMARK	Broadl.	44.0	32.0	23.0	0.0	0.0
	Conifers	61.0	13.0	17.0	9.0	1.0
	Total	54.0	21.0	20.0	5.0	1.0
DEUTSCHLAND	Broadl.	38.2	41.5	19.2	0.9	0.2
	Conifers	51.5	35.5	12.3	0.7	0.2
	Total	47.0	37.4	14.6	0.8	0.2
ELLAS	Broadl.	30.8	50.8	16.0	2.2	0.2
	Conifers	57.8	35.3	5.9	0.5	0.3
	Total	45.4	42.5	10.6	1.2	0.2
ESPANA	Broadl.	77.3	19.4	2.6	0.6	0.0
	Conifers	78.6	17.8	3.1	0.4	0.0
	Total	78.0	18.7	2.8	0.5	0.0
FRANCE	Broadl.	80.1	14.5	4.7	0.6	0.1
	Conifers	75.0	17.6	6.8	0.5	0.1
	Total	78.4	15.6	5.4	0.6	0.1
IRELAND	Broadl.	-	-	-	-	-
	Conifers	47.2	39.6	12.6	0.6	0.0
	Total	47.2	39.6	12.6	0.6	0.0
ITALIA	Broadl.	75.3	15.2	8.0	0.7	0.8
	Conifers	77.2	14.6	7.6	0.5	0.1
	Total	75.8	15.1	7.9	0.6	0.6
LUXEMBOURG	Broadl.	55.6	30.5	11.4	1.8	0.7
	Conifers	74.9	15.6	7.7	1.6	0.2
	Total	60.9	29.0	7.8	1.8	0.5
NEDERLAND	Broadl.	51.3	35.6	10.2	2.1	0.8
	Conifers	53.2	29.2	15.5	1.5	0.7
	Total	52.6	31.3	13.7	1.8	0.8
PORTUGAL	Broadl.	69.5	21.9	7.6	0.3	0.7
	Conifers	83.5	6.7	4.9	0.1	4.8
	Total	75.2	15.8	6.5	0.2	2.3
UNITED KINGDOM	Broadl.	47.0	32.0	19.0	2.0	0.0
	Conifers	36.0	30.0	25.0	9.0	0.0
	Total	41.0	31.0	22.0	6.0	0.0

') Flanders/Wallon region

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

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.

7.5.1 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, The 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 The Netherlands)

7.5.2 Insects

Insects have been recorded in most countries. Severe attacks have been recorded in Belgium, Denmark, the 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*).

7.5.3 Fungi

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

7.5.4 Forest fires

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

7.5.5 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.

There is a major problem in **separating** changes in crown density or colouration **attributable to pollution from those caused by 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.

7.5.6 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*).

7.5.7 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*)

8 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 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 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.

The **trend** that was found in **defoliation** with **mean age** may not directly reflect a decrease in vitality (indicated for example by the constant values for discolouration with changing age), but may be caused by a **natural process of changing foliation with increasing age**. If this is the case, **the percentage of defoliation may be determined more accurately by using reference trees of various age classes.**
Additional research regarding this subject is recommended.

Annex I-1 List of Species - 1989 Entire Community

ALL COUNTRIES

SPECIES	OBSERVED TREES COUNT	OBSERVED TREES %	OBSERVED PLOTS COUNT	OBSERVED PLOTS %
Acer campestre	92	0.20	37	0.88
Acer monspessulanum	40	0.09	15	0.36
Acer opalus	14	0.03	8	0.19
Acer platanoides	11	0.02	8	0.19
Acer pseudoplatanus	273	0.60	70	1.66
Alnus cordata	80	0.18	8	0.19
Alnus glutinosa	243	0.53	39	0.92
Alnus incana	15	0.03	3	0.07
Alnus viridis	11	0.02	2	0.05
Betula pendula	506	1.11	99	2.35
Betula pubescens	131	0.29	24	0.57
Buxus sempervirens	25	0.05	6	0.14
Carpinus betulus	441	0.97	90	2.13
Carpinus orientalis	13	0.03	4	0.09
Castanea sativa	1315	2.89	133	3.15
Corylus avellana	27	0.06	9	0.21
Eucalyptus sp.	1052	2.31	62	1.47
Fagus moesiaca	121	0.27	6	0.14
Fagus orientalis	11	0.02	1	0.02
Fagus sylvatica	3831	8.41	352	8.34
Fraxinus angustifolia	1	0.00	1	0.02
Fraxinus excelsior	525	1.15	107	2.53
Fraxinus ornus	67	0.15	20	0.47

(CONTINUED)

ALL COUNTRIES

SPECIES	OBSERVED TREES COUNT	OBSERVED TREES %	OBSERVED PLOTS COUNT	OBSERVED PLOTS %
Ilex aquifolium	15	0.03	6	0.14
Juglans nigra	35	0.08	2	0.05
Juglans regia	3	0.01	3	0.07
Olea europaea	117	0.26	19	0.45
Ostrya carpinifolia	245	0.54	34	0.81
Platanus orientalis	70	0.15	4	0.09
Populus alba	34	0.07	3	0.07
Populus canescens	12	0.03	1	0.02
Populus hybrides	404	0.89	22	0.52
Populus nigra	84	0.18	12	0.28
Populus tremula	170	0.37	53	1.26
Prunus avium	205	0.45	74	1.75
Prunus dulcis	7	0.02	1	0.02
Pyrus communis	15	0.03	8	0.19
Quercus cerris	619	1.36	60	1.42
Quercus coccifera	286	0.63	19	0.45
Quercus faginea	357	0.78	45	1.07
Quercus frainetto	319	0.70	20	0.47
Quercus fruticosa	19	0.04	2	0.05
Quercus ilex	3084	6.77	201	4.76
Quercus macrolepsis	21	0.05	1	0.02
Quercus petraea	1849	4.06	209	4.95
Quercus pubescens	1501	3.29	138	3.27

(CONTINUED)

ALL COUNTRIES

SPECIES	OBSERVED TREES		OBSERVED PLOTS	
	COUNT	%	COUNT	%
Quercus pyrenaica	898	1.97	52	1.23
Quercus robur	2204	4.84	260	6.16
Quercus rotundifolia	683	1.50	35	0.83
Quercus rubra	116	0.25	13	0.31
Quercus suber	1470	3.23	91	2.16
Quercus trojana	41	0.09	5	0.12
Robinia pseudacacia	220	0.48	30	0.71
Salix alba	6	0.01	3	0.07
Salix caprea	36	0.08	15	0.36
Salix eleagnos	5	0.01	1	0.02
Salix sp.	30	0.07	11	0.26
Sorbus aria	40	0.09	23	0.54
Sorbus aucuparia	37	0.08	11	0.26
Sorbus domestica	12	0.03	8	0.19
Sorbus torminalis	18	0.04	16	0.38
Tilia cordata	139	0.31	26	0.62
Tilia platyphyllos	25	0.05	6	0.14
Ulmus glabra	13	0.03	9	0.21
Ulmus minor	58	0.13	12	0.28
Arbutus unedo	73	0.16	9	0.21
Arbutus andrachne	2	0.00	1	0.02
Cercis siliquastrum	11	0.02	2	0.05
Phillyrea Latifolia	29	0.06	6	0.14

(CONTINUED)

ALL COUNTRIES

	OBSERVED TREES		OBSERVED PLOTS	
	COUNT	%	COUNT	%
SPECIES				
Phillyrea Augustifolia	17	0.04	1	0.02
Pistacia lentiscus	2	0.00	1	0.02
Pistacia terebinthus	10	0.02	1	0.02
Other broadleaves	226	0.50	57	1.35
Abies alba	803	1.76	90	2.13
Abies borisii-regis	179	0.39	10	0.24
Abies cephalonica	292	0.64	14	0.33
Abies grandis	7	0.02	3	0.07
Abies nordmanniana	19	0.04	2	0.05
Cedrus atlantica	1	0.00	1	0.02
Cedrus deodara	1	0.00	1	0.02
Cupressus sempervirens	33	0.07	7	0.17
Juniperus communis	34	0.07	9	0.21
Juniperus oxycedrus	68	0.15	18	0.43
Juniperus phoenica	43	0.09	8	0.19
Juniperus sabina	3	0.01	1	0.02
Juniperus thurifera	242	0.53	20	0.47
Larix decidua	590	1.29	80	1.90
Larix kaempferi	171	0.38	18	0.43
Picea abies	4705	10.32	287	6.80
Picea sitchensis	845	1.85	51	1.21
Pinus brutia	101	0.22	6	0.14
Pinus cembra	42	0.09	3	0.07

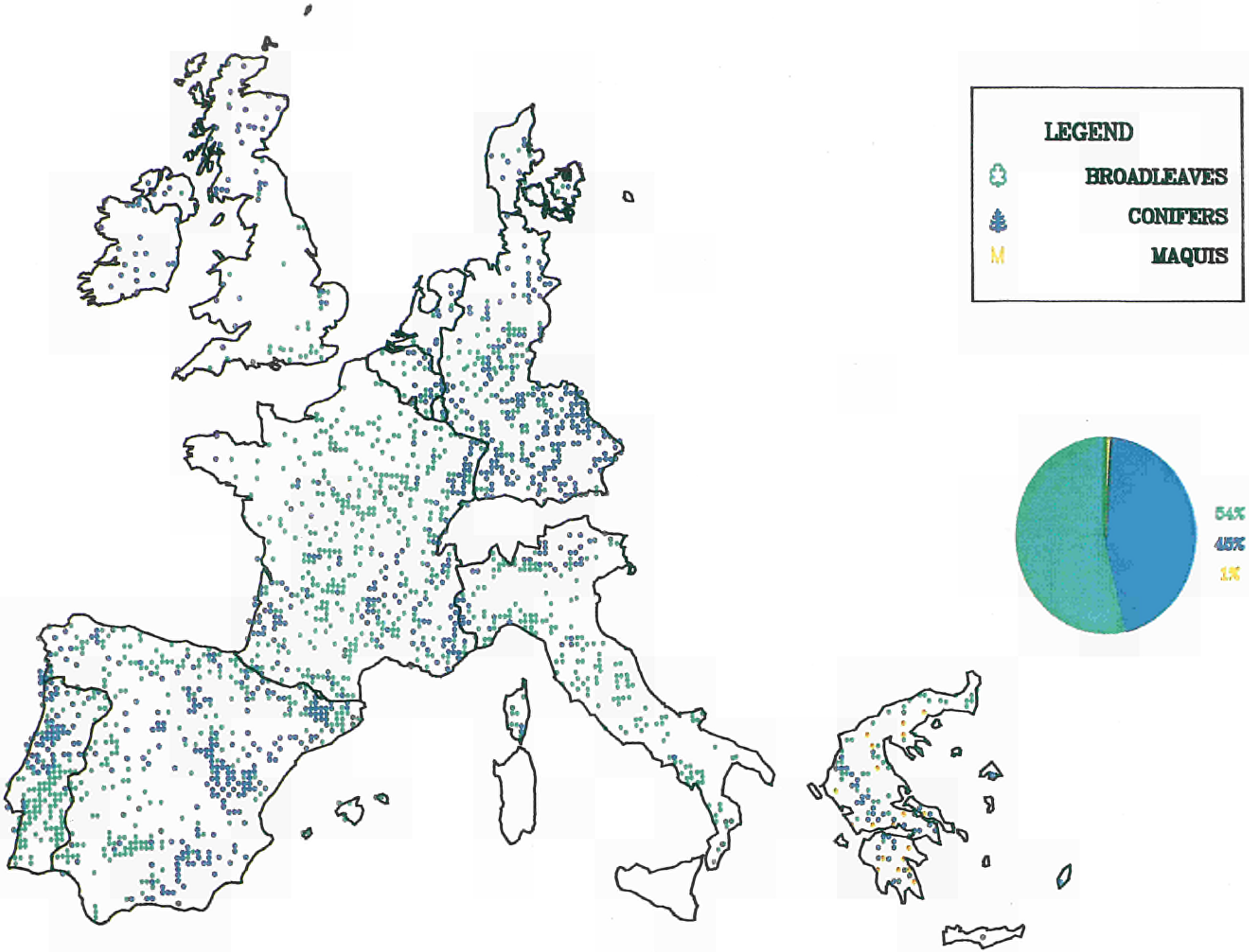
(CONTINUED)

ALL COUNTRIES

SPECIES	OBSERVED TREES COUNT	OBSERVED TREES %	OBSERVED PLOTS COUNT	OBSERVED PLOTS %
Pinus contorta	290	0.64	20	0.47
Pinus halepensis	1804	3.96	105	2.49
Pinus leucodermis	11	0.02	1	0.02
Pinus mugo	25	0.05	2	0.05
Pinus nigra	1464	3.21	103	2.44
Pinus pinaster	3645	8.00	188	4.45
Pinus pinea	360	0.79	31	0.73
Pinus radiata	164	0.36	10	0.24
Pinus strobus	53	0.12	5	0.12
Pinus sylvestris	4188	9.19	316	7.49
Pinus uncinata	126	0.28	9	0.21
Pseudotsuga menziesii	477	1.05	44	1.04
Taxus baccata	1	0.00	1	0.02
Thuya sp.	7	0.02	2	0.05
Tsuga sp.	14	0.03	2	0.05
Other conifers	27	0.06	7	0.17
TOTAL	45572	100.00	4221	100.00

Broadleaves and conifers over the Community - 1989

BROADLEAVES AND CONIFERS OVER THE COMMUNITY



Source: 1989 Community Inventory of Forest Damage

Annex I-3 **Defoliation by species group and climatic region - 1989**

EUROPEAN COMMUNITY	DEFOLIATION						
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	TOTAL	TOTAL
	%	%	%	%	%	%	NO.
SPECIES							
Castanea sativa	71.0	20.4	6.5	1.1	1.1	100.0	1315
Eucalyptus sp.	95.4	2.9	1.4	.	0.2	100.0	1052
Fagus sp.	63.8	27.1	8.8	0.3	0.1	100.0	3963
Quercus (deciduous) sp.	69.8	20.7	8.5	0.8	0.2	100.0	7506
Quercus ilex	69.5	27.0	3.2	0.1	0.2	100.0	3084
Quercus suber	63.6	26.1	9.0	1.1	0.2	100.0	1470
Other broadleaves	68.4	22.3	8.0	1.0	0.4	100.0	6347
TOTAL BROADLEAVES	69.2	22.4	7.4	0.7	0.3	100.0	24737
Abies sp.	56.0	26.7	15.5	1.3	0.5	100.0	1300
Larix sp.	66.1	24.0	9.3	0.3	0.3	100.0	761
Picea sp.	46.5	33.5	17.4	2.6	0.1	100.0	5550
Pinus sp.	69.1	23.0	6.6	0.7	0.6	100.0	12273
Other conifers	73.7	17.6	8.4	0.3	.	100.0	951
TOTAL CONIFERS	62.3	25.8	10.2	1.2	0.4	100.0	20835
TOTAL	66.1	24.0	8.7	0.9	0.3	100.0	45572

Annex I-4 **Discolouration by species group and climatic region - 1989**

EUROPEAN COMMUNITY	DISCOLOURATION						
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	TOTAL	TOTAL
	%	%	%	%	%	%	NO.
SPECIES							
Castanea sativa	76.7	17.3	4.1	0.8	1.1	100.0	1315
Eucalyptus sp.	83.6	13.0	3.1	0.1	0.2	100.0	1052
Fagus sp.	88.4	9.7	1.5	0.3	0.1	100.0	3963
Quercus (deciduous) sp.	87.8	10.2	1.3	0.5	0.2	100.0	7506
Quercus ilex	93.0	6.5	0.2	0.1	0.2	100.0	3084
Quercus suber	54.2	31.8	12.6	1.2	0.2	100.0	1470
Other broadleaves	79.7	14.8	4.6	0.6	0.4	100.0	6347
TOTAL BROADLEAVES	83.7	12.6	2.9	0.4	0.3	100.0	24737
Abies sp.	76.6	18.9	3.7	0.2	0.5	100.0	1300
Larix sp.	89.2	8.7	1.8	.	0.3	100.0	761
Picea sp.	89.8	7.9	1.6	0.6	0.1	100.0	5550
Pinus sp.	81.8	14.8	2.5	0.3	0.6	100.0	12273
Other conifers	89.6	9.1	1.2	0.1	.	100.0	951
TOTAL CONIFERS	84.2	12.8	2.2	0.3	0.4	100.0	20835
TOTAL	84.0	12.7	2.6	0.4	0.3	100.0	45572

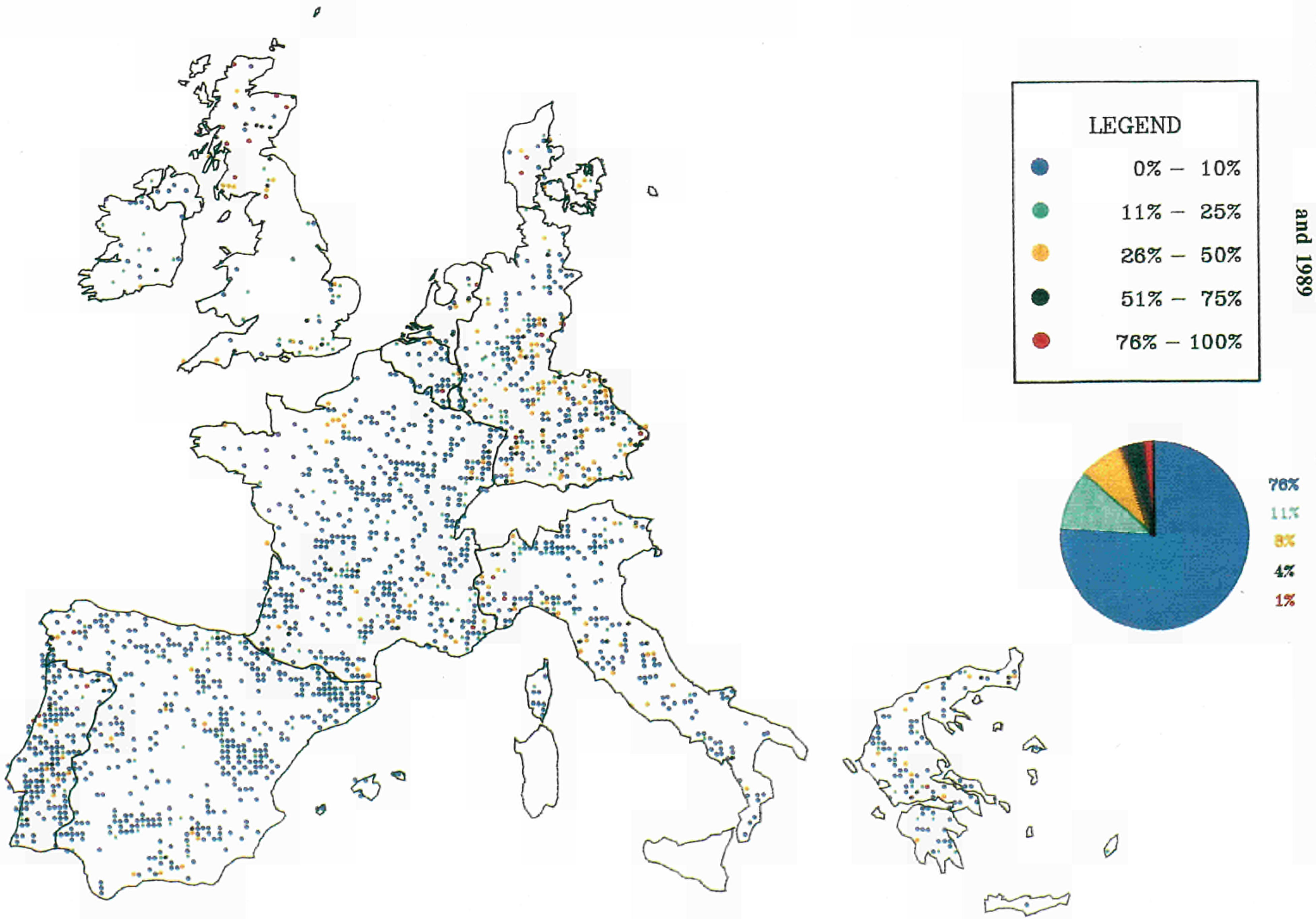
ATLANTIC	DISCOLOURATION					TOTAL	TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD		
SPECIES	%	%	%	%	%	%	NO.
Castanea sativa	80.21	17.08	1.87	0.21	0.62	100.00	480
Eucalyptus sp.	100.00	.	.	.	.	100.00	115
Fagus sp.	79.96	14.29	4.82	0.93	.	100.00	539
Quercus (deciduous) sp.	91.51	7.07	0.67	0.58	0.17	100.00	2404
Quercus ilex	94.44	5.56	.	.	.	100.00	18
Other broadleaves	84.37	13.06	1.88	0.56	0.13	100.00	1593
TOTAL BROADLEAVES	87.24	10.45	1.57	0.56	0.17	100.00	5149
Abies sp.	90.12	9.88	.	.	.	100.00	81
Larix sp.	83.89	9.40	6.04	.	0.67	100.00	149
Picea sp.	83.12	13.50	3.21	0.17	.	100.00	1185
Pinus sp.	80.98	15.02	3.09	0.36	0.55	100.00	2750
Other conifers	87.35	9.88	2.78	.	.	100.00	324
TOTAL CONIFERS	82.27	13.97	3.14	0.27	0.36	100.00	4489
TOTAL	84.92	12.09	2.30	0.43	0.26	100.00	9638

SUB-ATLANTIC	DISCOLOURATION					TOTAL	TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD		
	%	%	%	%	%	%	NO.
SPECIES							
Castanea sativa	88.73	7.35	2.45	0.74	0.74	100.00	408
Fagus sp.	92.37	6.30	1.06	0.22	0.04	100.00	2255
Quercus (deciduous) sp.	91.31	7.35	0.72	0.48	0.14	100.00	2094
Other broadleaves	84.56	9.06	5.56	0.62	0.21	100.00	1943
TOTAL BROADLEAVES	89.55	7.49	2.34	0.45	0.16	100.00	6700
Abies sp.	85.02	12.96	1.52	0.17	0.34	100.00	594
Larix sp.	95.99	3.68	0.33	.	.	100.00	299
Picea sp.	91.97	5.94	1.21	0.77	0.11	100.00	3787
Pinus sp.	85.61	11.43	2.55	0.16	0.26	100.00	1925
Other conifers	93.50	5.00	1.00	0.50	.	100.00	200
TOTAL CONIFERS	89.79	7.98	1.57	0.50	0.16	100.00	6805
TOTAL	89.67	7.74	1.95	0.47	0.16	100.00	13505

MEDITERRANEAN	DISCOLOURATION					TOTAL	TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD		
	%	%	%	%	%	%	NO.
SPECIES							
Castanea sativa	61.36	27.17	8.20	1.41	1.87	100.00	427
Eucalyptus sp.	81.54	14.62	3.52	0.11	0.21	100.00	937
Fagus sp.	82.92	15.53	1.19	.	0.36	100.00	837
Quercus (deciduous) sp.	82.19	14.92	2.18	0.34	0.37	100.00	2976
Quercus ilex	93.02	6.49	0.23	0.07	0.20	100.00	3066
Quercus suber	54.22	31.77	12.59	1.22	0.20	100.00	1470
Other broadleaves	72.21	20.84	5.73	0.57	0.65	100.00	2634
TOTAL BROADLEAVES	78.70	16.54	3.94	0.42	0.40	100.00	12347
Abies sp.	62.00	29.94	7.10	0.38	0.58	100.00	521
Larix sp.	92.31	7.69	.	.	.	100.00	13
Picea sp.	97.06	2.94	.	.	.	100.00	34
Pinus sp.	81.42	15.21	2.31	0.32	0.74	100.00	6888
Other conifers	89.00	11.00	.	.	.	100.00	409
TOTAL CONIFERS	80.61	15.91	2.49	0.31	0.69	100.00	7865
TOTAL	79.44	16.29	3.37	0.38	0.51	100.00	20212

MOUNTAINOUS	DISCOLOURATION					TOTAL	TOTAL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD		
	%	%	%	%	%	%	NO.
SPECIES							
Fagus sp.	89.16	10.84	.	.	.	100.00	332
Quercus (deciduous) sp.	100.00	.	.	.	.	100.00	32
Other broadleaves	96.61	2.26	1.13	.	.	100.00	177
TOTAL BROADLEAVES	92.24	7.39	0.37	.	.	100.00	541
Abies sp.	91.35	4.81	1.92	.	1.92	100.00	104
Larix sp.	85.00	13.33	1.33	.	0.33	100.00	300
Picea sp.	88.60	9.93	1.29	.	0.18	100.00	544
Pinus sp.	78.59	19.58	1.55	0.14	0.14	100.00	710
Other conifers	100.00	.	.	.	.	100.00	18
TOTAL CONIFERS	84.01	14.20	1.43	0.06	0.30	100.00	1676
TOTAL	86.02	12.54	1.17	0.05	0.23	100.00	2217

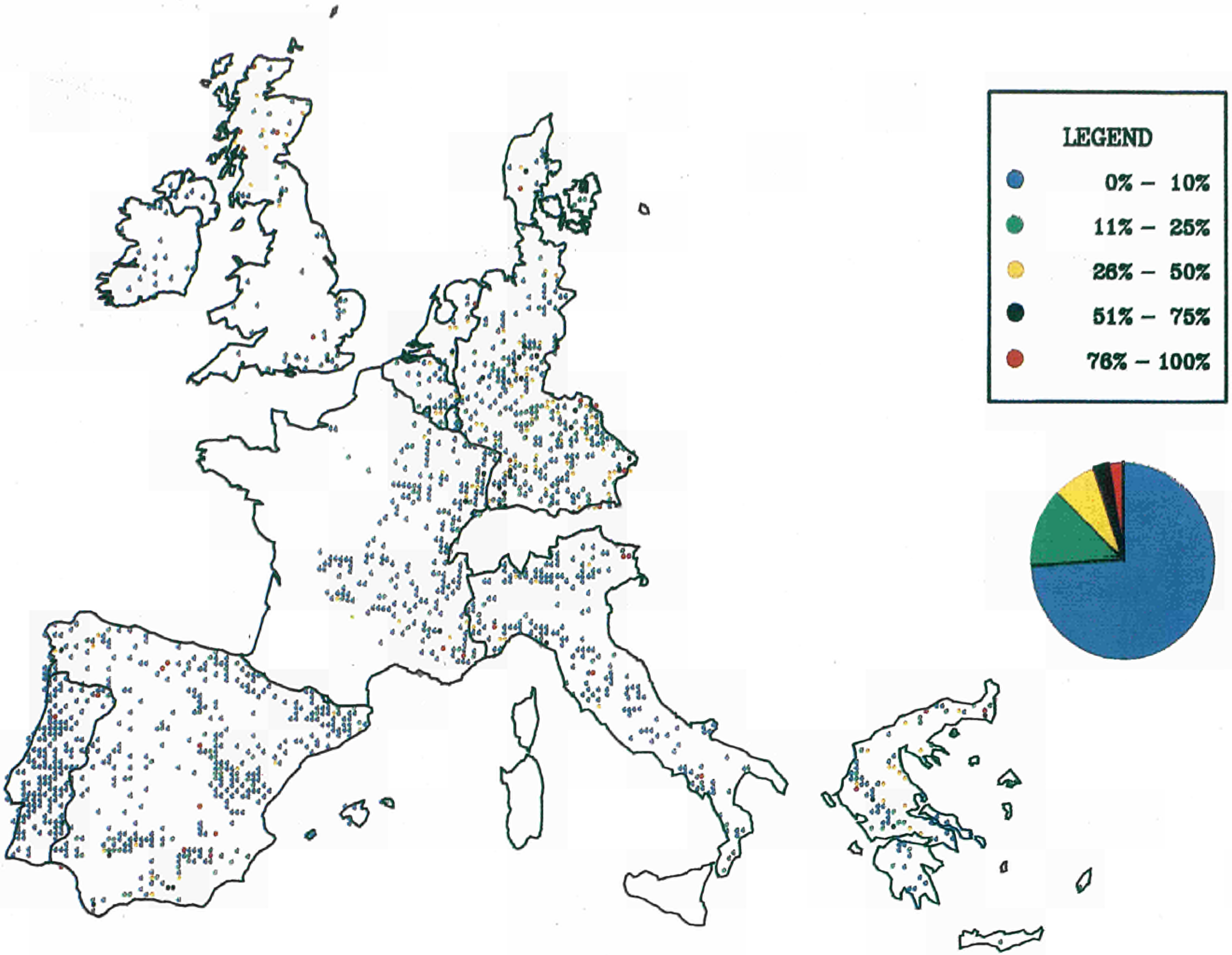
PERCENTAGE OF TREES DAMAGED OVER THE COMMUNITY



Source: 1989 Community Inventory of Forest Damage

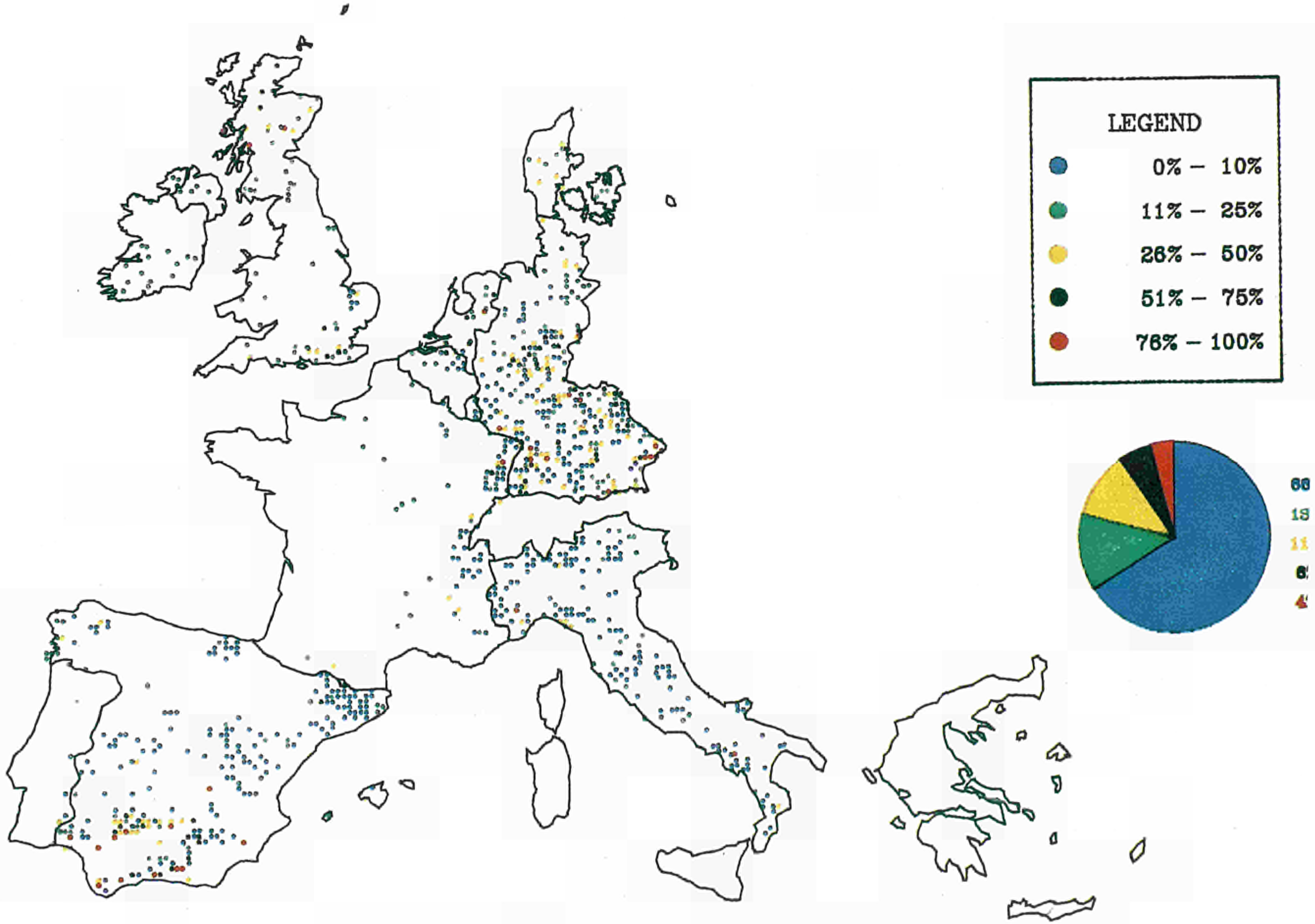
Percentage of trees damaged over the Community - 1987, 1988 and 1989

PERCENTAGE OF TREES DAMAGED OVER THE COMMUNITY



Source: 1988 Community Inventory of Forest Damage

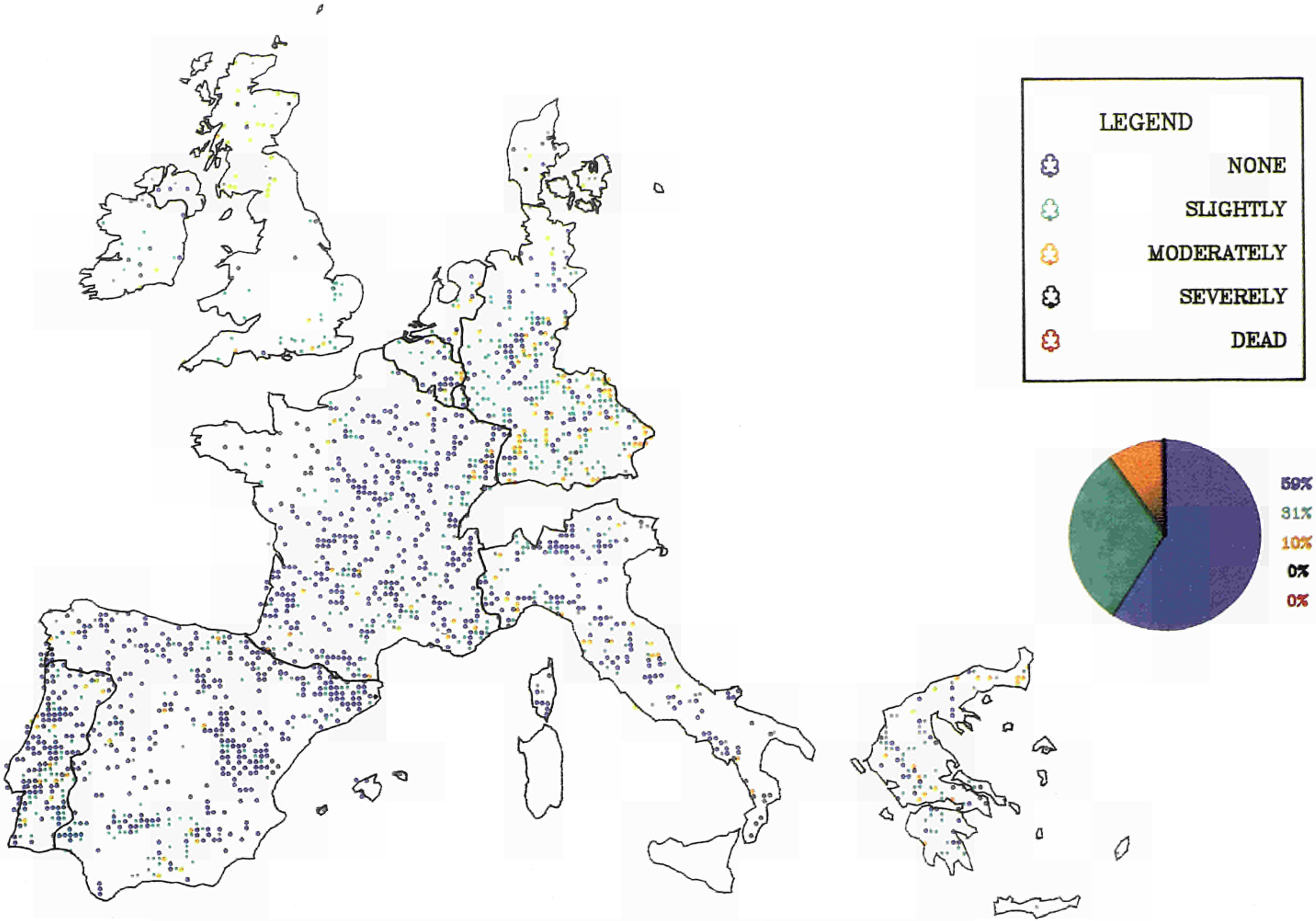
PERCENTAGE OF TREES DAMAGED OVER THE COMMUNITY



Source: 1987 Community Inventory of Forest Damage

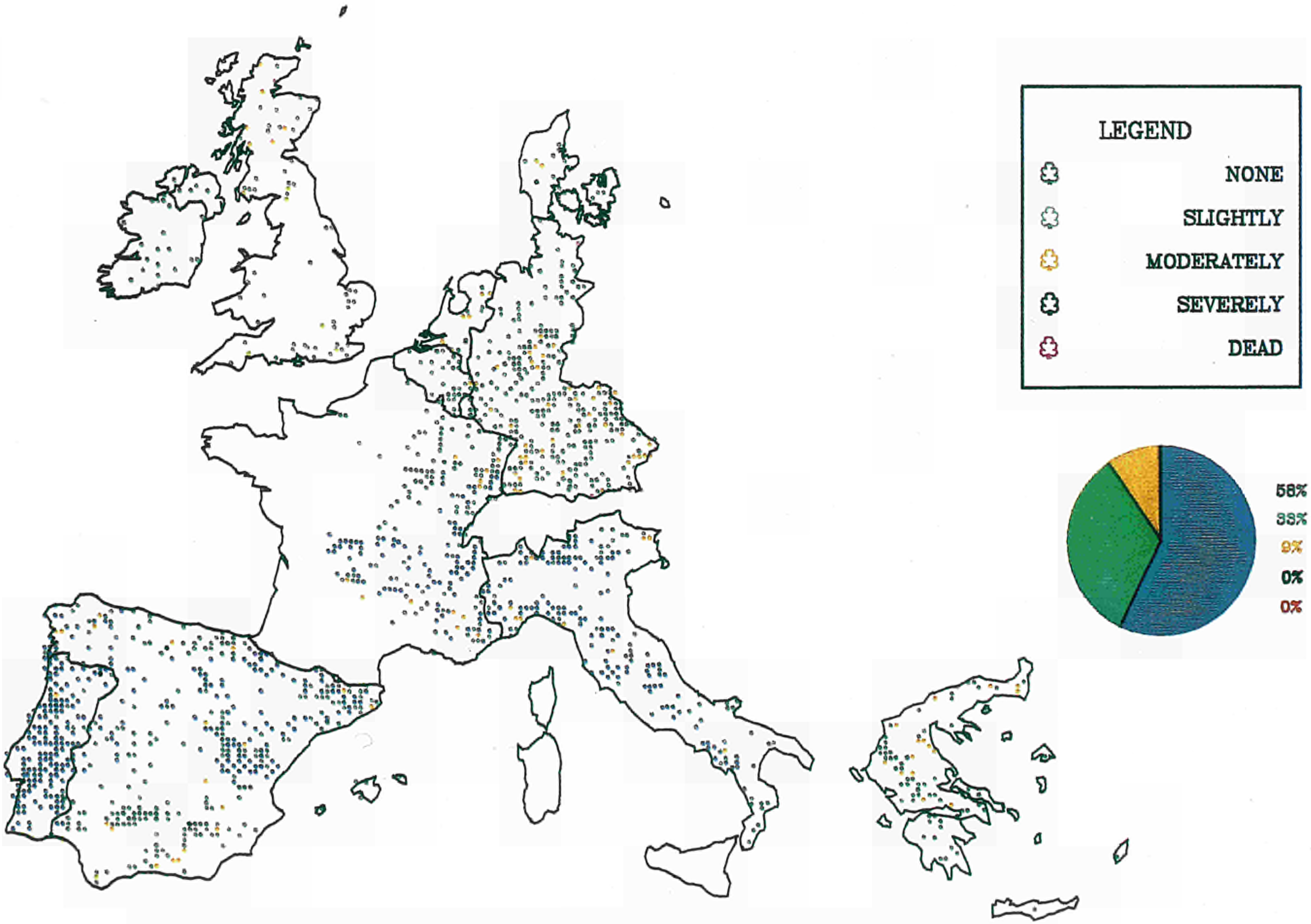
Plot defoliation for the Community - 1987, 1988 and 1989

PLOT DEFOLIATION FOR THE COMMUNITY



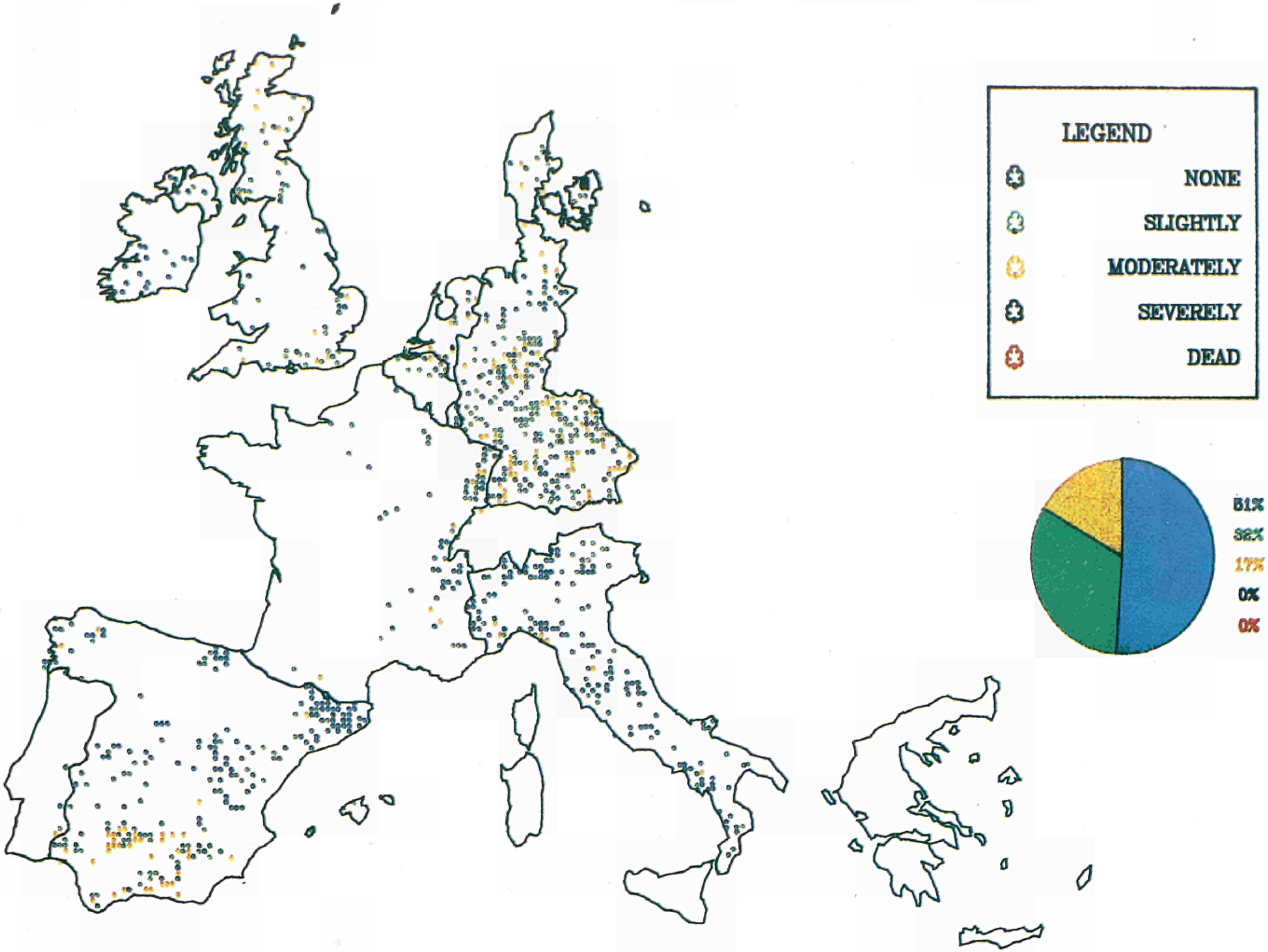
Source: 1989 Community Inventory of Forest Damage

PLOT DEFOLIATION FOR THE COMMUNITY



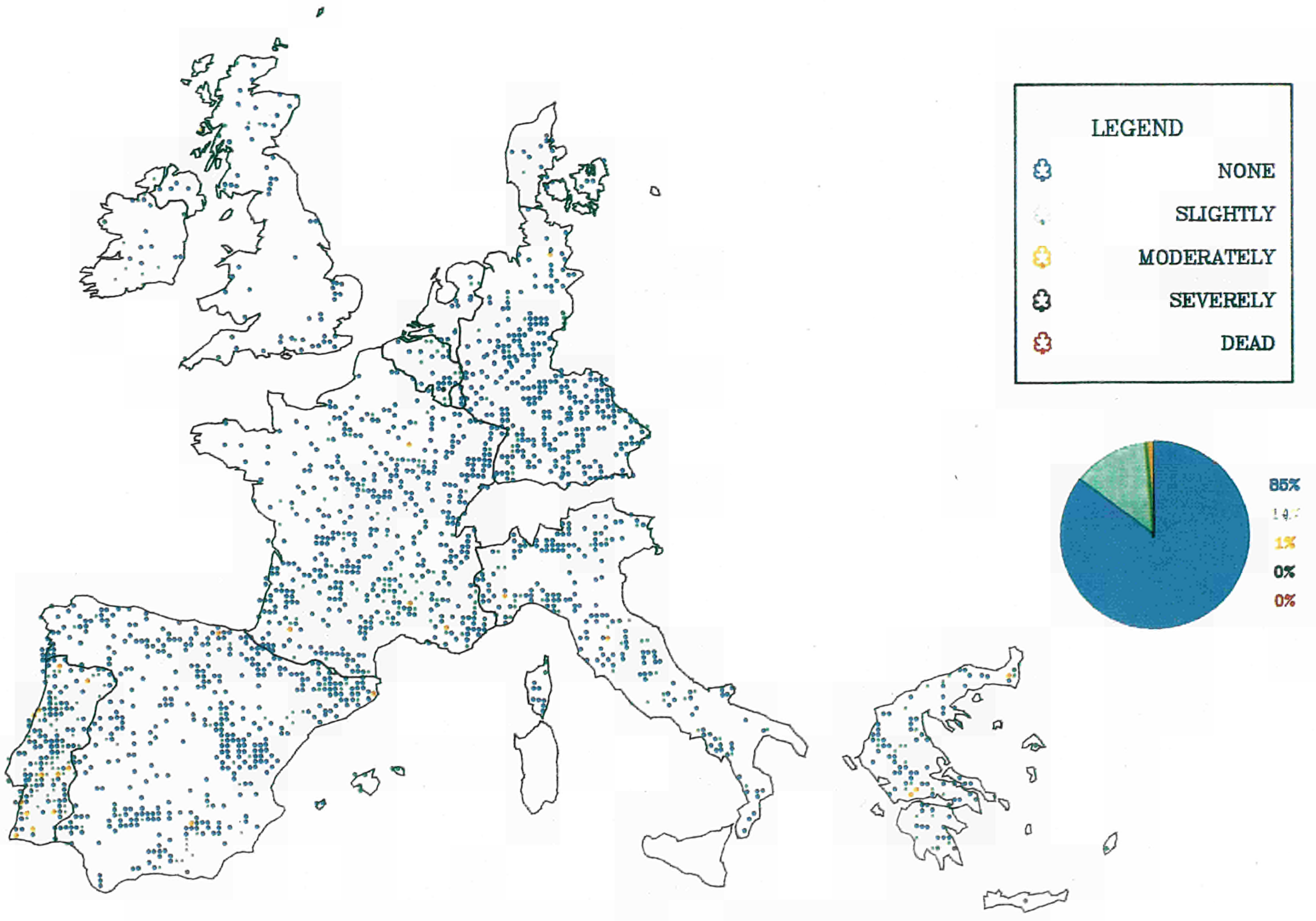
Source: 1988 Community Inventory of Forest Damage

PLOT DEFOLIATION FOR THE COMMUNITY



Source: 1987 Community Inventory of Forest Damage

PLOT DISCOLOURATION FOR THE COMMUNITY

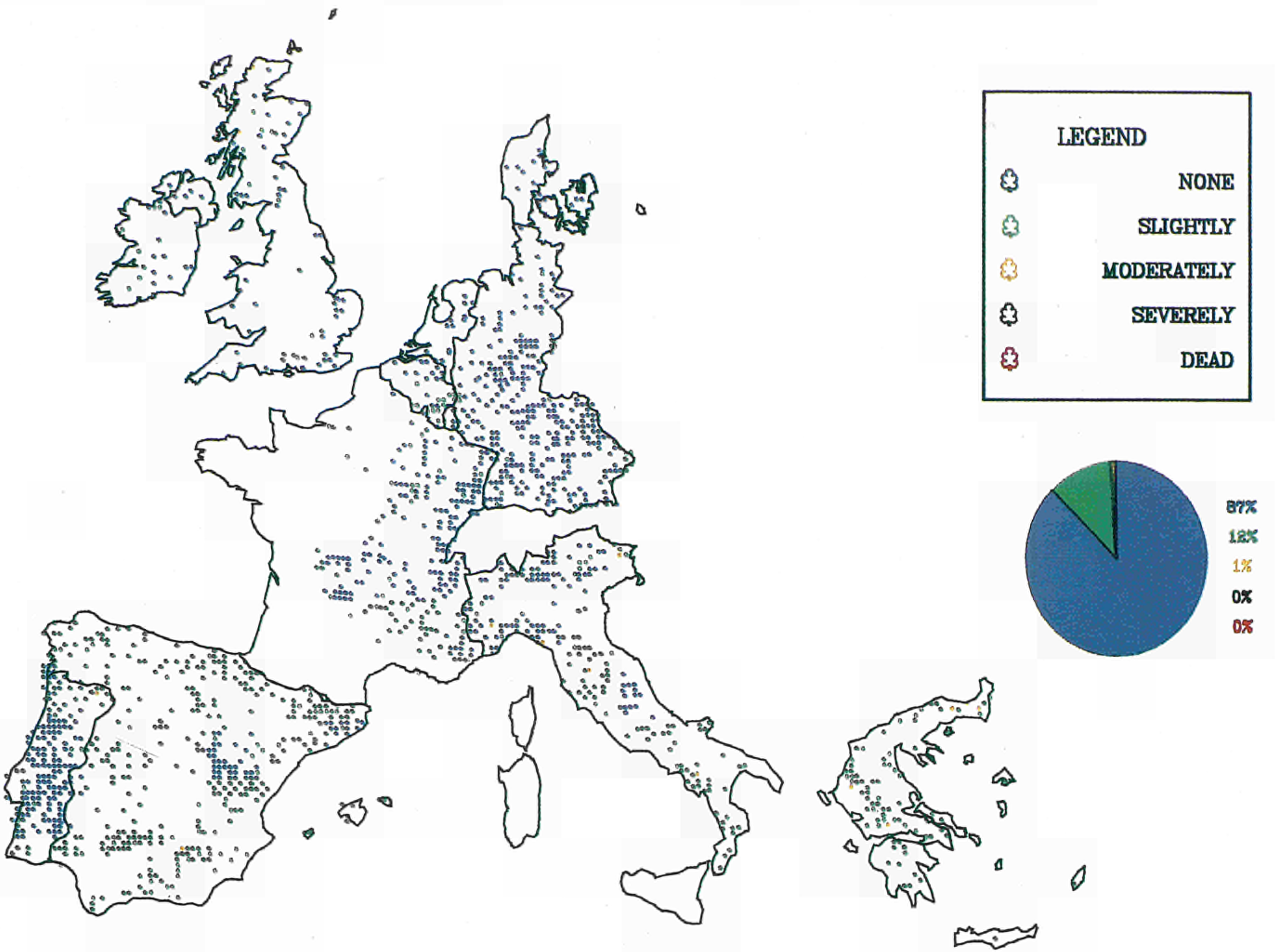


Source: 1989 Community Inventory of Forest Damage

Annex I-7

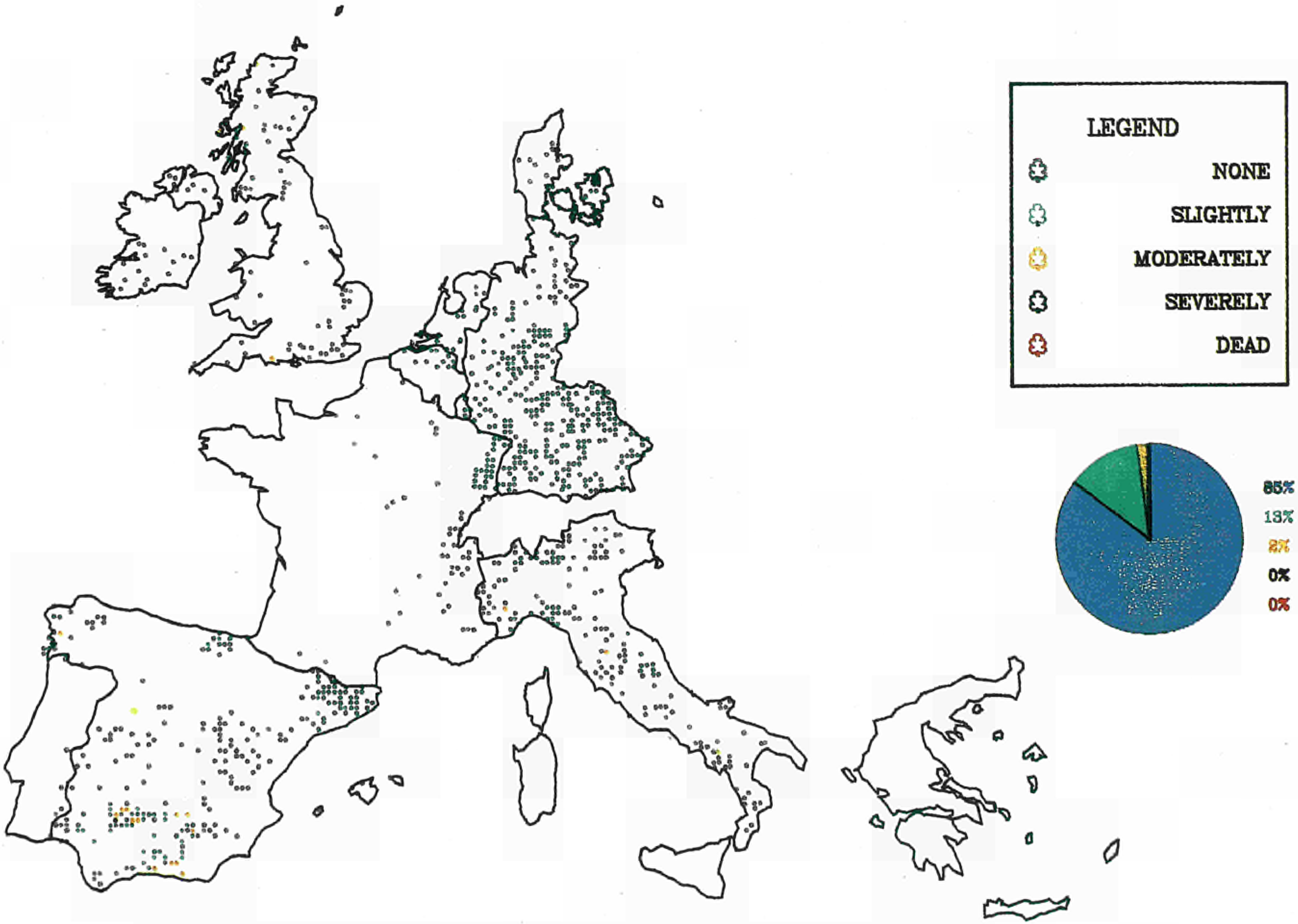
Plot discolouration for the Community - 1987, 1988 and 1989

PLOT DISCOLOURATION FOR THE COMMUNITY



Source: 1988 Community Inventory of Forest Damage

PLOT DISCOLOURATION FOR THE COMMUNITY



Source: 1987 Community Inventory of Forest Damage

Annex I-8 **Defoliation and discolouration by altitude - 1989**

EUROPEAN COMMUNITY	DEFOLIATION									
	NOT OR SLIGHTLY		MODERATELY		SEVERELY		DEAD		TOTAL	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
ALTITUDE										
0- 250 m	11879	88.2	1350	10.0	184	1.4	55	0.4	13468	100.0
251- 500 m	10345	89.2	1090	9.4	102	0.9	57	0.5	11594	100.0
501- 750 m	6803	88.9	765	10.0	73	1.0	14	0.2	7655	100.0
751-1000 m	4923	92.4	358	6.7	31	0.6	17	0.3	5329	100.0
1001-1250 m	3669	93.4	234	6.0	19	0.5	6	0.2	3928	100.0
1251-1500 m	1929	94.2	107	5.2	5	0.2	6	0.3	2047	100.0
>1500 m	1360	96.4	47	3.3	3	0.2	1	0.1	1411	100.0
TOTAL	40908	90.0	3951	8.7	417	0.9	156	0.3	45432	100.0

EUROPEAN COMMUNITY	DISCOLOURATION											
	NONE		SLIGHT		MODERATE		SEVERE		DEAD		TOTAL	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
ALTITUDE												
0- 250 m	10681	79.3	2113	15.7	556	4.1	63	0.5	55	0.4	13468	100.0
251- 500 m	10001	86.3	1213	10.5	281	2.4	42	0.4	57	0.5	11594	100.0
501- 750 m	6585	86.0	829	10.8	174	2.3	53	0.7	14	0.2	7655	100.0
751-1000 m	4717	88.5	515	9.7	64	1.2	16	0.3	17	0.3	5329	100.0
1001-1250 m	3262	83.0	587	14.9	69	1.8	4	0.1	6	0.2	3928	100.0
1251-1500 m	1706	83.3	300	14.7	32	1.6	3	0.1	6	0.3	2047	100.0
>1500 m	1176	83.3	217	15.4	16	1.1	1	0.1	1	0.1	1411	100.0
TOTAL	38128	83.9	5774	12.7	1192	2.6	182	0.4	156	0.3	45432	100.0

Annex I-9 **Defoliation and discolouration by aspect - 1989**

EUROPEAN COMMUNITY	DEFOLIATION											
	NONE		SLIGHT		MODERATE		SEVERE		DEAD		TOTAL	
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
ASPECT												
N	3986	69.9	1254	22.0	424	7.4	30	0.5	11	0.2	5705	100
NE	3298	68.7	1042	21.7	401	8.4	36	0.7	23	0.5	4800	100
E	2551	68.8	823	22.2	250	6.7	54	1.5	30	0.8	3708	100
SE	2487	65.4	895	23.5	356	9.4	44	1.2	20	0.5	3802	100
S	3022	66.3	1154	25.3	351	7.7	26	0.6	7	0.2	4560	100
SW	2510	67.2	888	23.8	285	7.6	37	1.0	15	0.4	3735	100
W	2504	63.5	927	23.5	428	10.9	62	1.6	21	0.5	3942	100
NW	3186	65.4	1212	24.9	428	8.8	35	0.7	11	0.2	4872	100
FLAT	6456	62.8	2694	26.2	1023	9.9	92	0.9	18	0.2	10283	100
TOTAL	30000	66.1	10889	24.0	3946	8.7	416	0.9	156	0.3	45407	100

EUROPEAN COMMUNITY	DISCOLOURATION										TOTAL	
	NONE		SLIGHT		MODERATE		SEVERE		DEAD			
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
ASPECT												
N	4963	87.0	660	11.6	59	1.0	12	0.2	11	0.2	5705	100
NE	4048	84.3	587	12.2	125	2.6	17	0.4	23	0.5	4800	100
E	2982	80.4	566	15.3	115	3.1	15	0.4	30	0.8	3708	100
SE	3112	81.9	533	14.0	103	2.7	34	0.9	20	0.5	3802	100
S	3719	81.6	669	14.7	154	3.4	11	0.2	7	0.2	4560	100
SW	3166	84.8	422	11.3	115	3.1	17	0.5	15	0.4	3735	100
W	3205	81.3	554	14.1	144	3.7	18	0.5	21	0.5	3942	100
NW	4071	83.6	628	12.9	139	2.9	23	0.5	11	0.2	4872	100
FLAT	8830	85.9	1160	11.3	240	2.3	35	0.3	18	0.2	10283	100
TOTAL	38096	83.9	5779	12.7	1194	2.6	182	0.4	156	0.3	45407	100

Annex I-10 **Defoliation and discolouration by water availability - 1989**

EUROPEAN COMMUNITY	DEFOLIATION										TOTAL
	NONE		SLIGHT		MODERATE		SEVERE		DEAD		
WATER AVAILABILITY	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.
INSUFFICIENT	3650	58.4	1845	29.5	673	10.8	63	1.0	24	0.4	6255
SUFFICIENT	25877	67.5	8864	23.1	3154	8.2	327	0.9	130	0.3	38352
EXCESSIVE	447	56.9	184	23.4	125	15.9	27	3.4	2	0.3	785
TOTAL	29974	66.0	10893	24.0	3952	8.7	417	0.9	156	0.3	45392

EUROPEAN COMMUNITY	DISCOLOURATION										TOTAL
	NONE		SLIGHT		MODERATE		SEVERE		DEAD		
WATER AVAILABILITY	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.
INSUFFICIENT	5153	82.4	846	13.5	193	3.1	39	0.6	24	0.4	6255
SUFFICIENT	32322	84.3	4822	12.6	963	2.5	115	0.3	130	0.3	38352
EXCESSIVE	610	77.7	109	13.9	36	4.6	28	3.6	2	0.3	785
TOTAL	38085	83.9	5777	12.7	1192	2.6	182	0.4	156	0.3	45392

Annex I-11 **Defoliation and discolouration by humus type - 1989**

EUROPEAN COMMUNITY	DEFOLIATION										TOTAL	
	NONE		SLIGHT		MODERATE		SEVERE		DEAD			
HUMUS TYPE	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
MULL	12701	71.4	3681	20.7	1265	7.1	91	0.5	58	0.3	17796	100
MODER	11204	63.8	4709	26.8	1475	8.4	106	0.6	72	0.4	17566	100
MOR	4173	68.8	1147	18.9	572	9.4	153	2.5	17	0.3	6062	100
ANMOR	128	83.1	25	16.2	1	0.6	.	.	.	.	154	100
PEAT	244	44.3	176	31.9	98	17.8	33	6.0	.	.	551	100
OTHER	1513	47.1	1127	35.1	533	16.6	33	1.0	9	0.3	3215	100
TOTAL	29963	66.1	10865	24.0	3944	8.7	416	0.9	156	0.3	45344	100

EUROPEAN COMMUNITY	DISCOLOURATION										TOTAL	
	NONE		SLIGHT		MODERATE		SEVERE		DEAD			
HUMUS TYPE	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%
MULL	14482	81.4	2519	14.2	650	3.7	87	0.5	58	0.3	17796	100
MODER	15001	85.4	2178	12.4	278	1.6	37	0.2	72	0.4	17566	100
MOR	5203	85.8	668	11.0	128	2.1	46	0.8	17	0.3	6062	100
ANMOR	150	97.4	4	2.6	.	.	.	.	.	.	154	100
PEAT	353	64.1	147	26.7	49	8.9	2	0.4	.	.	551	100
OTHER	2862	89.0	247	7.7	87	2.7	10	0.3	9	0.3	3215	100
TOTAL	38051	83.9	5763	12.7	1192	2.6	182	0.4	156	0.3	45344	100

Annex I-12 **Defoliation and discolouration by mean age for broadleaves and conifers - 1989**

EUROPEAN COMMUNITY		DEFOLIATION						
		NONE	SLIGHT	MODERATE	SEVERE	DEAD	TOTAL	TOTAL
		%	%	%	%	%	%	NO.
BROAD-LEAVES	MEAN AGE							
	0- 20 years	83.00	11.42	4.57	0.64	0.36	100.00	3895
	21- 40 years	71.73	19.84	7.20	0.81	0.43	100.00	6543
	41- 60 years	65.69	26.12	6.99	0.91	0.29	100.00	4077
	61- 80 years	65.27	27.08	7.09	0.43	0.12	100.00	2537
	80-100 years	68.56	22.41	8.27	0.67	0.09	100.00	2249
	101-120 years	52.89	33.71	12.39	0.61	0.41	100.00	985
	>120 years	40.89	40.70	17.58	0.64	0.19	100.00	1570
	Irregular Stands	74.52	20.51	4.46	0.36	0.14	100.00	2779
	SUB-TOTAL	69.15	22.49	7.40	0.68	0.28	100.00	24635
CONIFERS	MEAN AGE							
	0- 20 years	74.10	16.00	7.55	2.09	0.26	100.00	3444
	21- 40 years	75.46	16.65	6.28	1.28	0.33	100.00	6006
	41- 60 years	62.22	28.09	7.89	1.09	0.71	100.00	3777
	61- 80 years	51.63	38.44	8.92	0.66	0.35	100.00	2276
	80-100 years	30.07	47.81	21.60	0.28	0.23	100.00	1759
	101-120 years	33.97	43.42	21.23	1.17	0.21	100.00	942
	>120 years	25.73	32.87	37.71	2.55	1.15	100.00	785
	Irregular Stands	72.64	19.97	6.51	0.50	0.39	100.00	1798
	SUB-TOTAL	62.38	25.76	10.25	1.20	0.41	100.00	20787
TOTAL		66.05	23.98	8.70	0.92	0.34	100.00	45422

EUROPEAN COMMUNITY		DISCOLOURATION NONE %	SLIGHT %	MODERATE %	SEVERE %	DEAD %	TOTAL %	TOTAL NO.
BROAD-LEAVES	MEAN AGE							
	0- 20 years	83.95	12.40	3.08	0.21	0.36	100.00	3895
	21- 40 years	84.11	12.87	1.97	0.63	0.43	100.00	6543
	41- 60 years	84.96	12.09	2.38	0.27	0.29	100.00	4077
	61- 80 years	82.03	13.56	3.67	0.63	0.12	100.00	2537
	80-100 years	79.28	15.92	4.18	0.53	0.09	100.00	2249
	101-120 years	77.36	16.14	5.38	0.71	0.41	100.00	985
	>120 years	77.58	14.97	6.69	0.57	0.19	100.00	1570
	Irregular Stands	90.90	7.45	1.26	0.25	0.14	100.00	2779
	SUB-TOTAL	83.65	12.67	2.95	0.45	0.28	100.00	24635
CONIFERS	MEAN AGE							
	0- 20 years	83.91	12.63	2.56	0.64	0.26	100.00	3444
	21- 40 years	83.00	14.09	2.48	0.10	0.33	100.00	6006
	41- 60 years	83.96	12.36	2.22	0.74	0.71	100.00	3777
	61- 80 years	83.17	13.66	2.68	0.13	0.35	100.00	2276
	80-100 years	87.49	10.35	1.53	0.40	0.23	100.00	1759
	101-120 years	87.90	10.30	1.59	.	0.21	100.00	942
	>120 years	87.52	9.55	1.66	0.13	1.15	100.00	785
	Irregular Stands	83.98	13.68	1.72	0.22	0.39	100.00	1798
	SUB-TOTAL	84.20	12.79	2.25	0.34	0.41	100.00	20787
TOTAL		83.90	12.73	2.63	0.40	0.34	100.00	45422

Annex I-13: Percentage of trees in defoliation and discolouration classes 0 (0-10%), 1 (11-25%) and 0+1 (0-25%).
Data separated by mean stand age and climatic region.

DEFOLIATION

Mean age/	Atlantic			Sub-atlantic			Mediterranean			Mountainous			Entire EC			Sampled trees
class	0	1	0+1	0	1	0+1	0	1	0+1	0	1	0+1	0	1	0+1	
0 - 20	67.1	17.4	84.5	86.9	7.8	94.7	82.3	13.1	95.4	86.0	12.8	98.8	78.8	13.6	92.4	7339
21 - 40	65.6	20.8	86.4	82.3	12.3	94.6	73.3	19.6	92.9	77.1	19.4	96.5	73.5	18.3	91.8	12549
41 - 60	68.6	21.8	90.4	61.1	29.9	91.0	61.2	29.5	90.7	81.2	16.4	97.6	64.0	27.1	91.1	7854
61 - 80	64.5	23.7	88.2	46.8	44.1	90.9	65.8	27.3	93.1	73.5	18.6	92.1	58.8	32.5	91.3	4813
81 - 100	71.8	20.9	92.7	35.5	42.6	78.1	64.6	27.1	91.7	82.1	16.8	98.9	51.7	33.6	85.3	4008
101 - 120	54.6	23.2	77.8	36.6	43.6	80.2	55.4	34.7	90.1	53.8	26.9	80.7	43.6	38.5	82.1	1927
>120	55.3	26.2	81.5	19.6	44.2	63.8	54.6	33.4	88.0	43.3	30.0	73.3	43.6	38.1	81.7	2355
Irregular	60.0	25.5	85.5	78.3	18.5	96.8	76.4	19.3	95.7	70.3	21.8	92.1	35.8	20.3	56.1	4577
Total	65.9	21.1	87.0	56.9	30.2	87.1	71.4	21.7	93.1	74.5	19.4	93.9	66.1	24.0	90.1	45422

DISCOLOURATION

Mean age/	Atlantic			Sub-atlantic			Mediterranean			Mountainous			Entire EC			Sampled trees
class	0	1	0+1	0	1	0+1	0	1	0+1	0	1	0+1	0	1	0+1	
0 - 20	82.6	13.5	96.1	84.9	7.4	92.3	83.9	13.6	97.5	95.1	4.3	99.4	83.9	12.5	96.4	7339
21 - 40	83.2	13.5	96.7	91.1	6.5	97.6	80.5	16.3	96.8	86.2	12.7	98.9	83.6	13.5	97.1	12549
41 - 60	84.9	13.0	97.9	87.4	8.8	96.2	80.9	15.0	95.9	92.0	8.0	100.0	84.5	12.2	96.7	7854
61 - 80	86.8	10.3	97.1	90.0	8.5	98.5	72.3	20.8	93.1	85.2	12.0	97.2	82.6	13.6	96.2	4813
81 - 100	93.2	6.2	99.4	94.2	5.1	99.3	60.4	28.8	89.2	44.2	55.8	100.0	82.9	13.5	96.4	4008
101 - 120	85.0	14.6	99.6	88.6	9.1	97.7	64.9	23.3	88.2	80.7	17.2	97.9	82.5	13.3	95.8	1927
>120	82.5	11.3	93.8	89.8	8.1	97.9	64.5	23.1	87.6	90.0	6.7	96.7	80.9	13.2	94.1	2355
Irregular	89.7	7.0	96.7	88.0	10.2	98.2	88.4	10.1	98.5	86.0	11.7	97.7	88.2	9.9	98.1	4577
Total	84.9	12.1	97.0	89.7	7.7	97.4	79.3	16.4	95.7	85.9	12.7	98.6	83.9	12.7	96.6	45422

10-May-90

Annex I-14 Defoliation and discolouration by identifiable damage type - 1989

EUROPEAN COMMUNITY	DEFOLIATION OF SAMPLE TREES						
	NONE	SLIGHT	MODERATE	SEVERE	DEAD	ALL	ALL
	%	%	%	%	%	%	NO.
GAME AND GRAZING	46.43	35.57	12.20	5.80	.	100.00	672
INSECTS	57.12	31.12	9.86	1.67	0.23	100.00	8689
FUNGI	66.30	22.61	9.26	1.23	0.60	100.00	3175
ABIOTIC AGENTS	55.40	27.23	14.66	2.30	0.41	100.00	2953
ACTION OF MAN	59.29	30.17	9.21	0.42	0.91	100.00	2648
FIRE	67.59	17.08	8.76	3.80	2.77	100.00	685
KNOWN POLLUTION	46.07	25.84	25.84	2.25	.	100.00	89
OTHER	62.85	26.59	9.34	1.11	0.10	100.00	4859
ANY IDENT. DAMAGE	59.03	28.60	10.32	1.60	0.45	100.00	17671
NO IDENT. DAMAGE	70.54	21.06	7.64	0.48	0.27	100.00	27901
MULTIPLE DAMAGE	61.26	26.78	9.89	1.69	0.38	100.00	4974

EUROPEAN COMMUNITY	DISCOLOURATION OF SAMPLE TREES					ALL	ALL
	NONE	SLIGHT	MODERATE	SEVERE	DEAD		
	%	%	%	%	%	%	NO.
GAME AND GRAZING	73.36	19.49	4.76	2.38	.	100.00	672
INSECTS	78.25	18.13	2.98	0.41	0.23	100.00	8689
FUNGI	75.50	18.52	4.66	0.72	0.60	100.00	3175
ABIOTIC AGENTS	57.09	33.22	7.25	2.03	0.41	100.00	2953
ACTION OF MAN	65.94	24.96	7.48	0.72	0.91	100.00	2648
FIRE	64.09	21.31	9.93	1.90	2.77	100.00	685
KNOWN POLLUTION	67.42	17.98	13.48	1.12	.	100.00	89
OTHER	81.77	14.10	3.56	0.47	0.10	100.00	4859
ANY IDENT. DAMAGE	73.26	20.48	5.01	0.79	0.45	100.00	17671
NO IDENT. DAMAGE	90.72	7.75	1.10	0.15	0.27	100.00	27901
MULTIPLE DAMAGE	74.91	19.72	4.10	0.88	0.38	100.00	4974

ANNEX II-1: Changes in defoliation and discolouration for trees common to the 1988 and 1989 sample.
First number: percentage of trees in class in 1988.
Second number: percentage of trees in class in 1989.

Climatic region:	Defoliation						
	0-10%	11-25%	0-25%	26-60%	>60%	dead	No. of trees
Atlantic	56.5/54.4	29.9/27.5	86.4/81.9	11.3/14.3	2.2/3.3	0.2/0.5	5584
Sub-atlantic	57.3/54.5	29.4/31.6	86.6/86.1	12.7/12.9	0.6/0.8	0.1/0.2	11822
Mountainous	71.2/74.9	21.6/19.0	92.8/93.9	6.8/ 5.5	0.3/0.4	0.2/0.3	1951
Mediterranean	74.5/72.0	18.8/21.2	93.4/93.2	5.6/ 5.6	0.9/0.5	0.1/0.7	16121
Total	65.7/63.6	24.2/25.6	90.0/89.1	8.9/ 9.4	1.0/1.0	0.1/0.4	35478

	Discolouration						
	0-10%	11-25%	0-25%	26-60%	>60%	dead	No. of trees
Atlantic	85.9/82.7	11.6/13.5	97.5/96.2	2.1/3.0	0.3/0.4	0.2/0.5	5584
Sub-atlantic	90.5/89.5	7.2/ 7.7	97.7/97.2	1.9/2.0	0.3/0.5	0.1/0.2	11822
Mountainous	81.9/84.6	15.2/13.8	97.1/98.4	2.5/1.3	0.2/0.1	0.2/0.3	1951
Mediterranean	85.2/77.6	12.6/17.5	97.8/95.1	1.9/3.9	0.2/0.4	0.1/0.7	16121
Total	86.9/82.8	10.8/13.4	97.7/96.2	2.0/3.0	0.3/0.4	0.1/0.4	35478

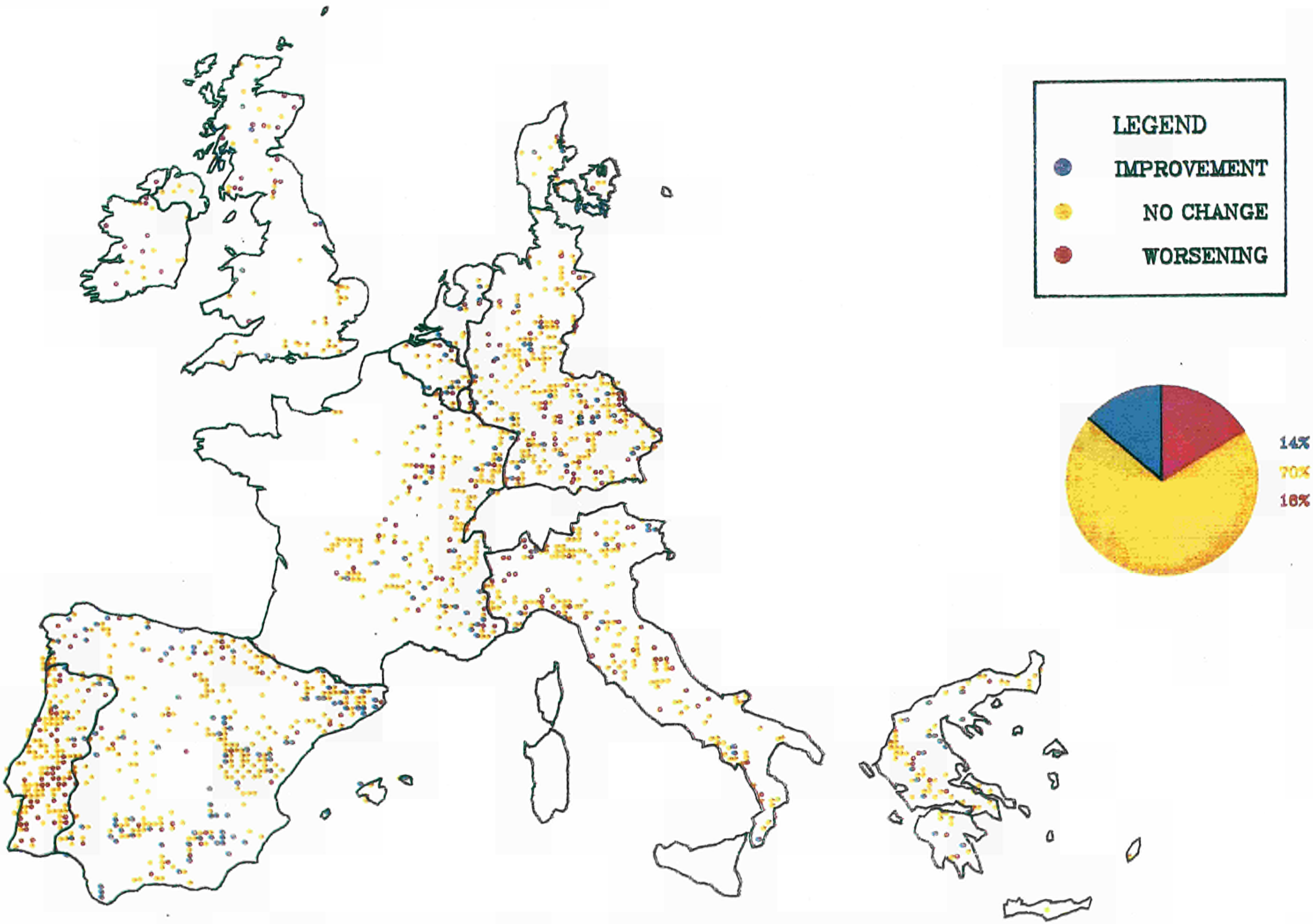
ANNEX II-2: Changes in defoliation for trees common to the 1988 and 1989 sample, by species group.
First number: percentage of trees in class in 1988.
Second number: percentage of trees in class in 1989.

Species group	Defoliation					No. of trees
	0-10%	11-25%	26-60%	>60%	dead	
Castanea sativa	76.4/66.7	13.7/23.3	5.4/ 7.5	4.0/1.1	0.6/1.5	952
Eucalyptus sp.	95.8/95.5	3.9/ 3.1	0.3/ 1.2	--/--	--/0.2	873
Fagus sp.	60.0/60.3	28.3/29.5	11.2/ 9.8	0.5/0.3	0.0/0.1	3327
Quercus sp. (deciduous)	64.0/63.0	22.9/25.2	11.5/10.4	1.4/1.0	0.1/0.4	4436
Quercus ilex	62.0/70.6	31.3/25.7	6.1/ 3.3	0.6/0.1	--/0.3	2165
Quercus suber	89.7/62.5	8.7/27.0	1.4/ 9.2	0.2/1.1	--/0.2	1384
Other broadleaves	77.8/66.9	16.7/23.7	4.8/ 7.9	0.5/1.0	0.2/0.5	4411
Total broadleaves	70.8/66.2	20.9/24.7	7.4/ 8.1	0.9/0.7	0.1/0.4	17548
Abies sp.	53.0/55.5	26.4/26.6	18.5/15.9	1.6/1.4	0.4/0.6	1135
Larix sp.	64.7/66.1	27.5/23.6	7.6/ 9.7	--/0.3	0.3/0.3	688
Picea sp.	50.0/45.8	33.9/33.9	15.0/17.7	1.1/2.6	0.0/0.1	5219
Pinus sp.	66.5/68.1	24.9/23.5	7.4/ 6.9	1.1/0.8	0.1/0.7	10159
Other conifers	68.6/74.2	20.6/16.9	9.5/ 8.6	1.2/0.3	0.1/--	729
Total conifers	60.9/61.0	27.6/26.4	10.4/10.8	1.1/1.3	0.1/0.5	17930
Total species	65.8/63.6	24.2/25.6	8.9/ 9.4	1.0/1.0	0.1/0.4	35478

ANNEX II-3: Changes in discolouration for trees common to the 1988 and 1989 sample, by species group
First number: percentage of trees in class in 1988.
Second number: percentage of trees in class in 1989.

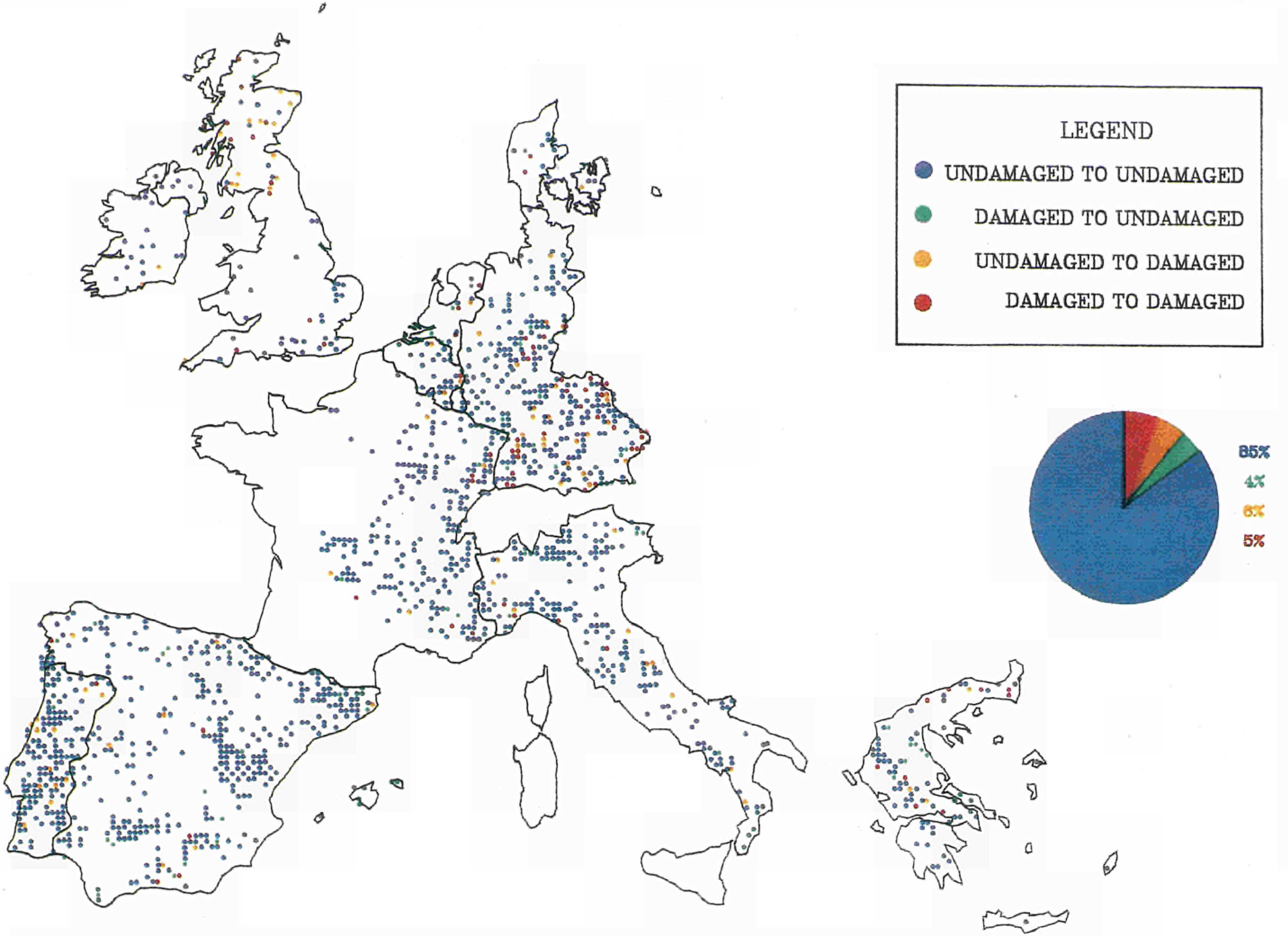
Species group	Discolouration					No. of trees
	0-10%	11-25%	26-60%	>60%	dead	
Castanea sativa	83.3/75.2	11.6/17.3	3.9/ 5.1	0.6/1.0	0.6/1.5	952
Eucalyptus sp.	99.5/81.9	0.3/14.1	0.1/ 3.8	--/ --	--/0.2	873
Fagus sp.	87.2/88.8	10.4/ 9.2	2.1/ 1.6	0.3/0.3	0.0/0.1	3327
Quercus sp. (deciduous)	86.7/86.2	9.3/11.5	3.5/ 1.5	0.5/0.4	0.1/0.4	4436
Quercus ilex	91.5/93.1	8.4/ 6.6	0.1/ --	0.1/ --	--/0.3	2165
Quercus suber	87.8/52.3	12.1/33.0	0.1/13.2	--/1.3	--/0.2	1384
Other broadleaves	90.1/78.1	7.4/15.2	2.0/ 5.6	0.3/0.6	0.2/0.5	4411
Total broadleaves	88.8/82.0	8.8/13.5	2.0/ 3.6	0.3/0.5	0.1/0.4	17548
Abies sp.	75.1/77.2	19.0/18.1	5.2/ 3.9	0.3/0.3	0.4/0.6	1135
Larix sp.	90.4/88.5	8.3/ 9.3	1.0/ 1.9	--/ --	0.3/0.3	688
Picea sp.	88.9/89.4	8.2/ 8.2	2.6/ 1.7	0.3/0.6	0.0/0.1	5219
Pinus sp.	83.2/80.4	15.1/15.9	1.4/ 2.7	0.2/0.3	0.1/0.7	10159
Other conifers	92.9/88.6	7.0/10.3	--/ 1.0	--/0.1	0.1/--	729
Total conifers	85.0/83.5	12.7/13.3	1.9/ 2.4	0.2/0.4	0.1/0.5	17930
Total species	86.9/82.8	10.8/13.4	2.0/ 3.0	0.3/0.4	0.1/0.4	35478

CHANGES IN PLOT DEFOLIATION OVER THE COMMUNITY



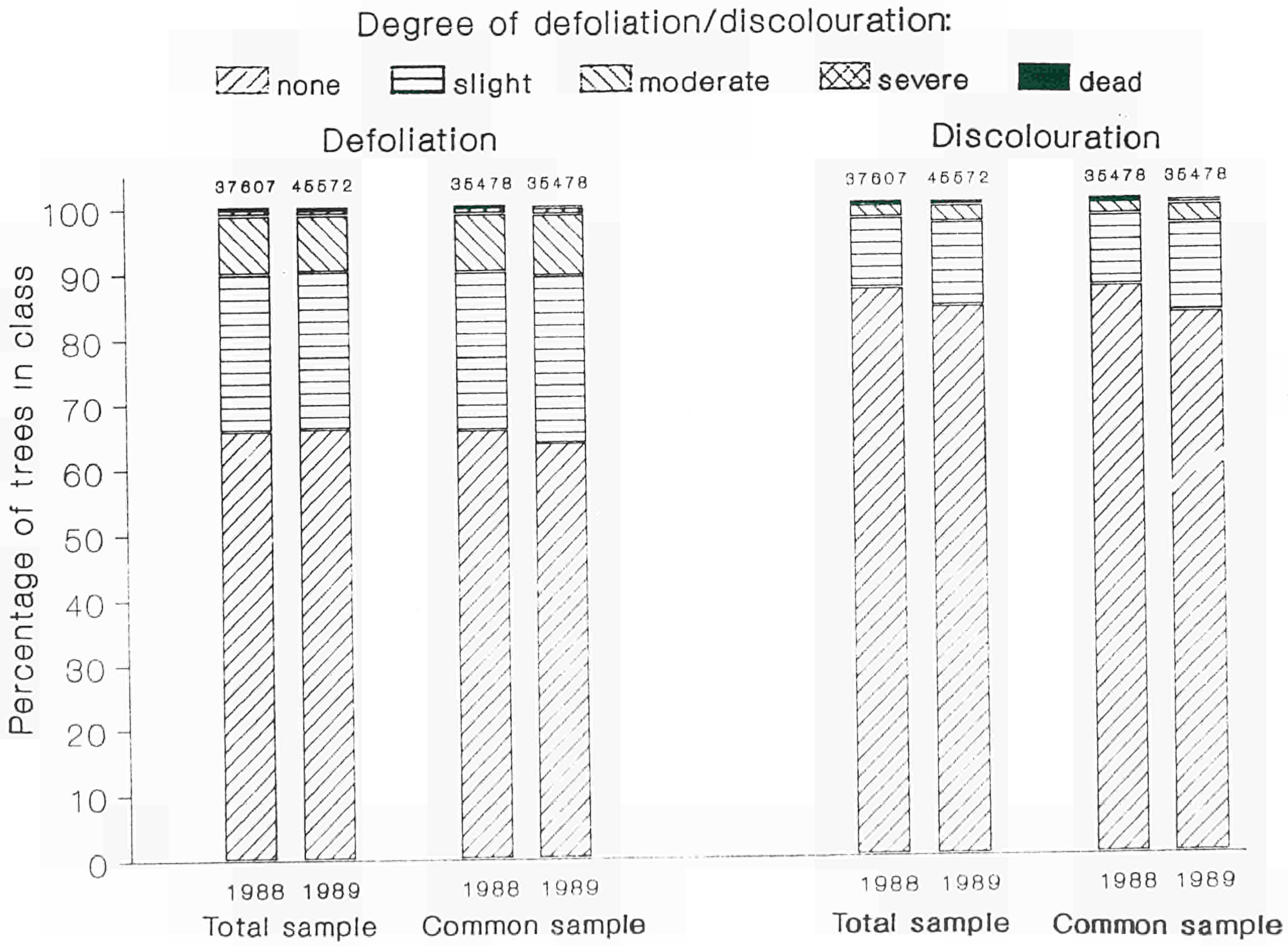
Source: Trees Common to the 1988 & 1989 Inventories of Forest Damage

CHANGES IN PLOT DAMAGE CLASSES OVER THE COMMUNITY



Source: Trees Common to the 1988 & 1989 Inventories of Forest Damage.

Defoliation/discolouration in Total Sample and Common Sample



Annex III-1 Defoliation of 12 most common species 1987, 1988 and 1989

Annex III-1: Percentages of trees in defoliation classes 0 (0-10%), 1 (11-25%) and 2+3+4 (>25% or dead) for 12 most represented species in Common Plots, for all individuals and by climatic region (see text).

Species/ Class	87	88	89	87	88	89	87	88	89	87	88	89
Picea abies	All trees			Atlantic			Sub-atlantic			Mountainous		
0-10%	46.1	45.5	43.3	59.6	62.1	66.7	43.2	42.8	40.0	58.8	54.4	52.3
11-25%	33.9	37.4	38.3	25.3	24.3	25.6	35.2	39.4	39.8	28.9	31.2	34.6
>25%	20.0	17.1	18.5	15.2	13.6	7.7	21.6	17.8	20.1	12.3	14.5	13.2
Pinus sylvestris	All trees			Atlantic			Sub-atlantic			Mediterranean		
0-10%	55.5	51.7	50.8	68.4	63.0	55.0	34.5	37.3	37.4	86.4	60.6	74.2
11-25%	34.0	37.2	37.3	21.1	26.7	34.4	51.9	48.8	47.3	11.4	31.8	22.6
>25%	10.5	11.1	11.8	10.5	10.3	10.5	13.6	13.9	15.3	2.3	7.5	3.2
Fagus sylvatica	All trees			Atlantic			Sub-atlantic			Mediterranean		
0-10%	55.2	58.4	57.9	37.4	38.6	38.4	40.5	46.2	49.6	93.6	91.0	81.3
11-25%	29.8	30.5	28.1	46.0	50.5	32.5	38.7	38.3	34.6	5.1	7.4	14.5
>25%	15.0	11.1	14.0	16.7	10.9	29.1	20.8	15.5	15.7	1.3	1.6	4.2
Quercus ilex	All trees			Mediterranean								
0-10%	52.3	60.8	64.9	52.2	61.1	65.2						
11-25%	30.6	32.0	30.4	30.5	31.8	30.1						
>25%	17.0	7.2	4.8	17.2	7.2	4.7						
Pinus halepensis	All trees			Mediterranean								
0-10%	59.9	57.2	66.4	59.9	57.2	66.4						
11-25%	29.1	34.5	27.2	29.1	34.5	27.2						
>25%	11.0	8.3	6.4	10.9	8.3	6.4						
Pinus nigra	All trees			Mediterranean								
0-10%	72.6	70.8	74.5	82.5	73.6	80.7						
11-25%	20.8	24.1	21.1	14.8	22.9	16.3						
>25%	6.6	5.1	4.4	2.6	3.5	3.0						

Survey years / Climatic region

(continued)

ANNEX III-1 (continued).

Species/ Class	87	88	89	87	88	89	87	88	89
	Survey years / Climatic region								
Pinus pinaster	All trees			Atlantic			Mediterranean		
0-10%	68.0	67.8	69.8	72.4	63.6	71.0	70.1	74.7	73.8
11-25%	18.5	20.3	21.4	27.1	30.1	20.8	14.8	13.2	16.9
>25%	13.5	11.9	8.8	0.5	6.2	8.2	15.1	12.1	9.4
Castanea sativa	All trees			Sub-atlantic			Mediterranean		
0-10%	72.7	78.2	62.8	81.1	92.0	72.3	65.8	68.1	52.5
11-25%	20.9	14.6	27.8	14.8	3.0	21.3	25.8	22.0	34.9
>25%	6.4	7.2	9.3	4.1	5.0	6.4	8.4	9.9	12.7
Picea sitchensis	All trees			Atlantic					
0-10%	51.7	39.6	25.9	51.7	39.6	25.9			
11-25%	28.9	32.5	25.9	28.9	32.5	25.9			
>25%	19.3	27.9	48.2	19.3	27.9	48.2			
Quercus robur	All trees			Atlantic					
0-10%	47.6	41.2	55.6	34.8	27.2	55.1			
11-25%	31.0	34.5	30.3	36.2	39.0	29.2			
>25%	21.4	24.3	14.1	29.0	33.8	15.7			
Quercus pubescens	All trees			Mediterranean					
0-10%	86.3	75.8	68.3	82.5	74.2	69.0			
11-25%	1.5	13.3	18.9	2.0	12.8	22.2			
>25%	12.1	10.9	12.8	15.5	13.1	8.9			
Quercus petraea	All trees			Sub-atlantic					
0-10%	59.2	57.5	52.9	56.3	54.2	49.3			
11-25%	25.8	22.8	27.5	27.6	24.5	29.6			
>25%	15.1	19.7	19.7	16.1	21.2	21.2			

Annex III-2 Discolouration of 12 most common species 1987, 1988 and 1989

Annex III-2: Percentages of trees in discolouration classes 0 (0–10%), 1 (11–25%) and 2+3+4 (>25% or dead) for 12 most represented species in Common Plots, for all individuals and by climatic region (see text).

Species/ Class	Survey years / Climatic regions											
	87	88	89	87	88	89	87	88	89	87	88	89
Picea abies	All trees			Atlantic			Sub–atlantic			Mountainous		
0-10%	93.6	94.1	93.3	97.8	97.6	95.2	95.2	95.1	94.0	81.7	87.0	88.5
11-25%	5.3	4.2	5.7	2.2	2.4	4.8	3.9	3.8	5.0	15.5	7.5	10.3
>25%	1.1	1.7	1.0	0.0	0.0	0.0	0.9	1.1	1.0	2.8	5.5	1.2
Pinus sylvestris	All trees			Atlantic			Sub–atlantic			Mediterranean		
0-10%	90.4	92.1	88.7	78.7	93.2	79.2	98.6	96.0	98.1	95.5	76.3	86.4
11-25%	7.8	7.0	9.4	17.5	5.5	17.0	0.9	3.7	1.3	3.0	21.9	13.6
>25%	1.8	0.9	2.0	3.7	1.2	3.8	0.5	0.4	0.6	1.5	1.8	0.0
Fagus sylvatica	All trees			Atlantic			Sub–atlantic			Mediterranean		
0-10%	93.3	92.4	91.2	76.3	68.8	83.7	95.9	93.9	94.8	90.8	97.7	86.5
11-25%	5.0	5.3	6.8	16.2	19.3	8.4	3.2	4.8	4.0	7.3	1.0	10.6
>25%	1.7	2.3	2.1	7.6	11.9	7.9	0.9	1.3	1.1	1.9	1.3	2.9
Quercus ilex	All trees			Mediterranean								
0-10%	60.6	88.4	90.6	61.1	88.3	90.6						
11-25%	29.0	11.5	9.2	28.4	11.5	9.2						
>25%	10.4	0.2	0.2	10.5	0.2	0.2						
Pinus halepensis	All trees			Mediterranean								
0-10%	73.3	72.9	76.3	73.3	72.9	76.3						
11-25%	21.8	24.0	20.5	21.8	24.0	20.5						
>25%	4.9	3.1	3.2	4.9	3.1	3.2						
Pinus nigra	All trees			Mediterranean								
0-10%	80.2	81.2	81.0	90.4	84.6	87.6						
11-25%	14.5	18.0	17.0	9.6	14.9	12.1						
>25%	5.2	0.8	2.0	0.0	0.4	0.2						

(continued)

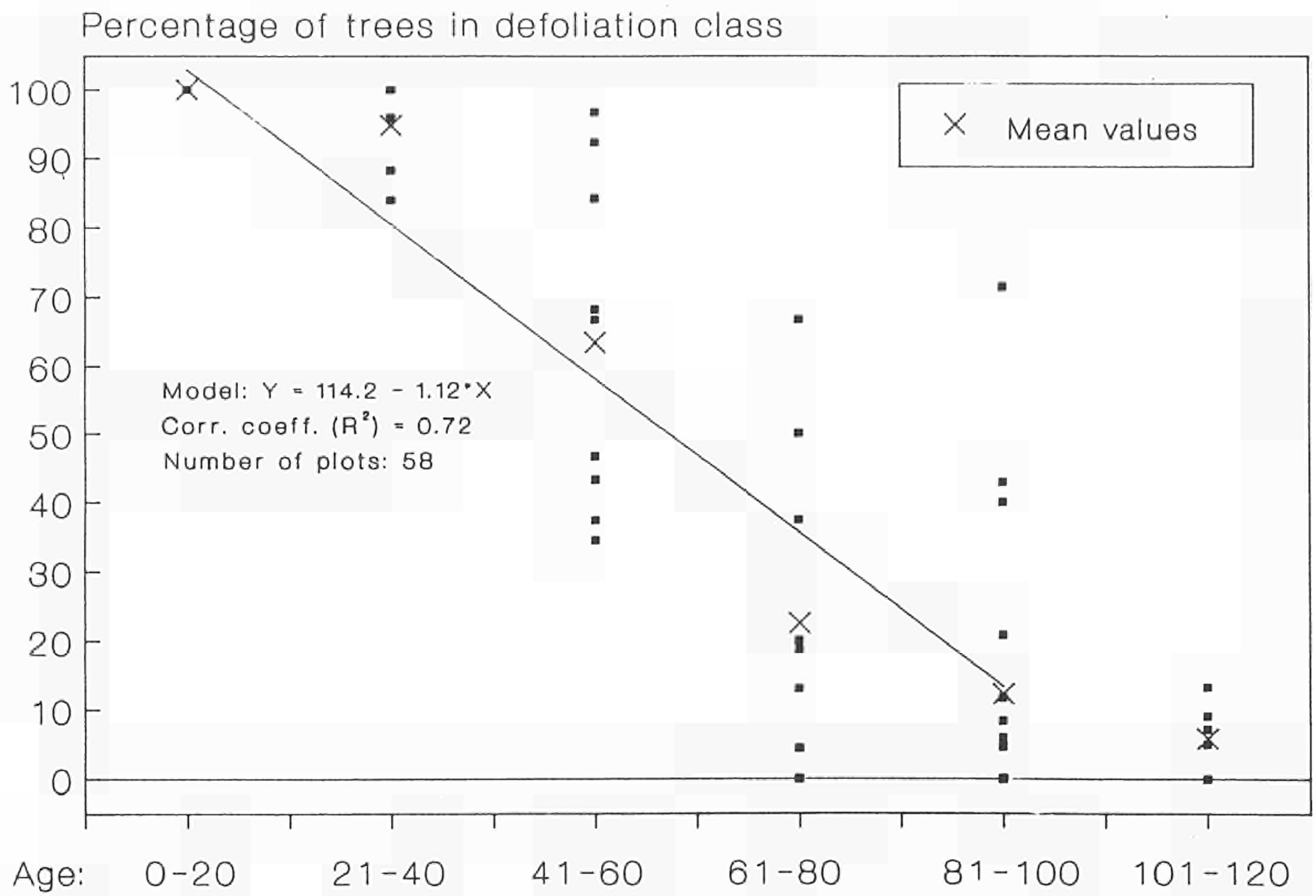
ANNEX III-2 (continued)

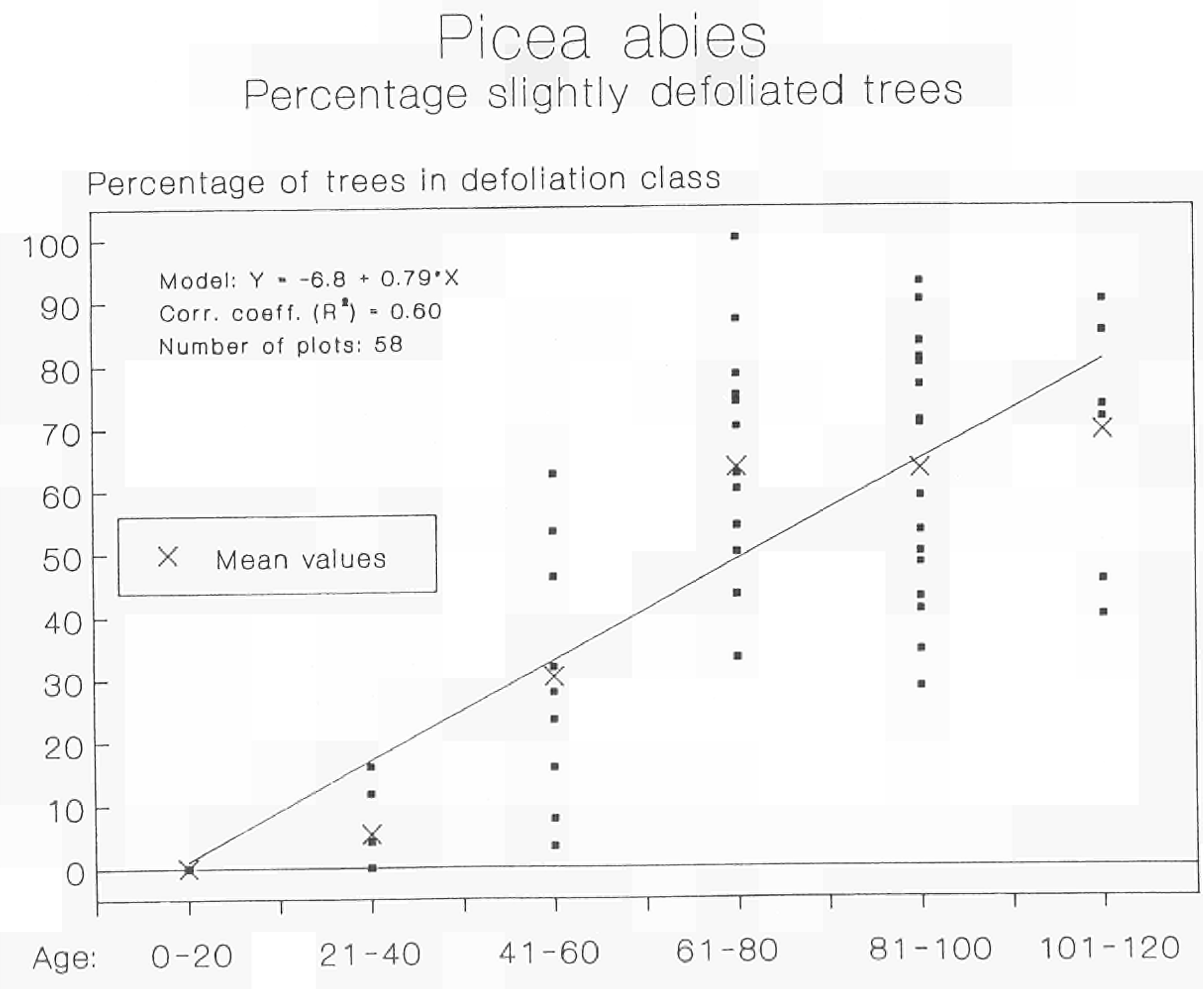
Species/ Class	Survey years / Climatic regions								
	87	88	89	87	88	89	87	88	89
Pinus pinaster	All trees			Atlantic			Mediterranean		
0-10%	77.8	81.9	83.3	99.5	93.8	93.7	70.7	80.5	82.9
11-25%	9.7	14.9	16.0	0.5	3.8	5.8	15.6	16.8	16.3
>25%	12.5	3.2	0.7	0.0	2.4	0.5	13.7	2.7	0.8
Castanea sativa	All trees			Sub-atlantic			Mediterranean		
0-10%	73.9	80.7	71.2	83.2	95.0	87.2	65.8	67.8	56.3
11-25%	19.5	16.7	23.9	16.8	5.0	9.6	21.8	27.5	37.0
>25%	6.6	2.5	4.9	0.0	0.0	3.2	12.4	4.8	6.7
Picea sitchensis	All trees			Atlantic					
0-10%	77.2	76.2	87.0	77.2	76.2	87.0			
11-25%	16.1	13.8	8.1	16.1	13.8	8.1			
>25%	6.7	10.0	4.9	6.7	10.0	4.9			
Quercus robur	All trees			Atlantic					
0-10%	87.7	89.2	89.6	87.7	87.5	90.5			
11-25%	8.7	8.6	9.3	7.5	9.8	8.2			
>25%	3.6	2.3	1.1	4.8	2.8	1.3			
Quercus pubescens	All trees			Mediterranean					
0-10%	88.7	78.0	84.0	85.6	76.7	79.2			
11-25%	0.4	10.9	13.8	0.6	9.7	18.0			
>25%	10.8	11.1	2.1	13.8	13.6	2.8			
Quercus petraea	All trees			Sub-atlantic					
0-10%	99.7	99.3	96.6	99.6	99.3	96.4			
11-25%	0.0	0.7	2.0	0.0	0.7	2.2			
>25%	0.3	0.0	1.4	0.4	0.0	1.5			

Defoliation by mean age of Picea abies and Fagus sylvatica

Picea abies

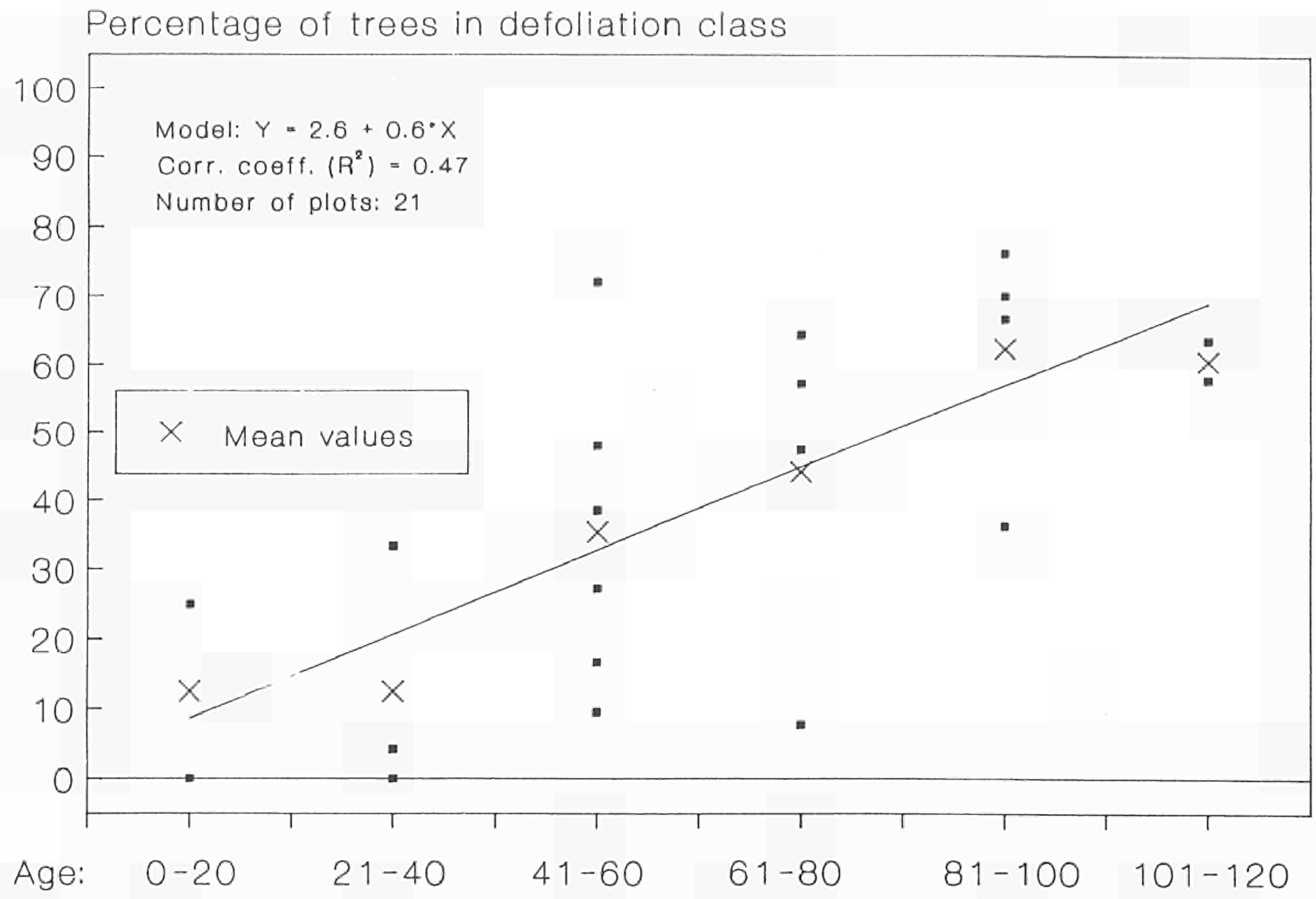
Percentage not defoliated trees in plot

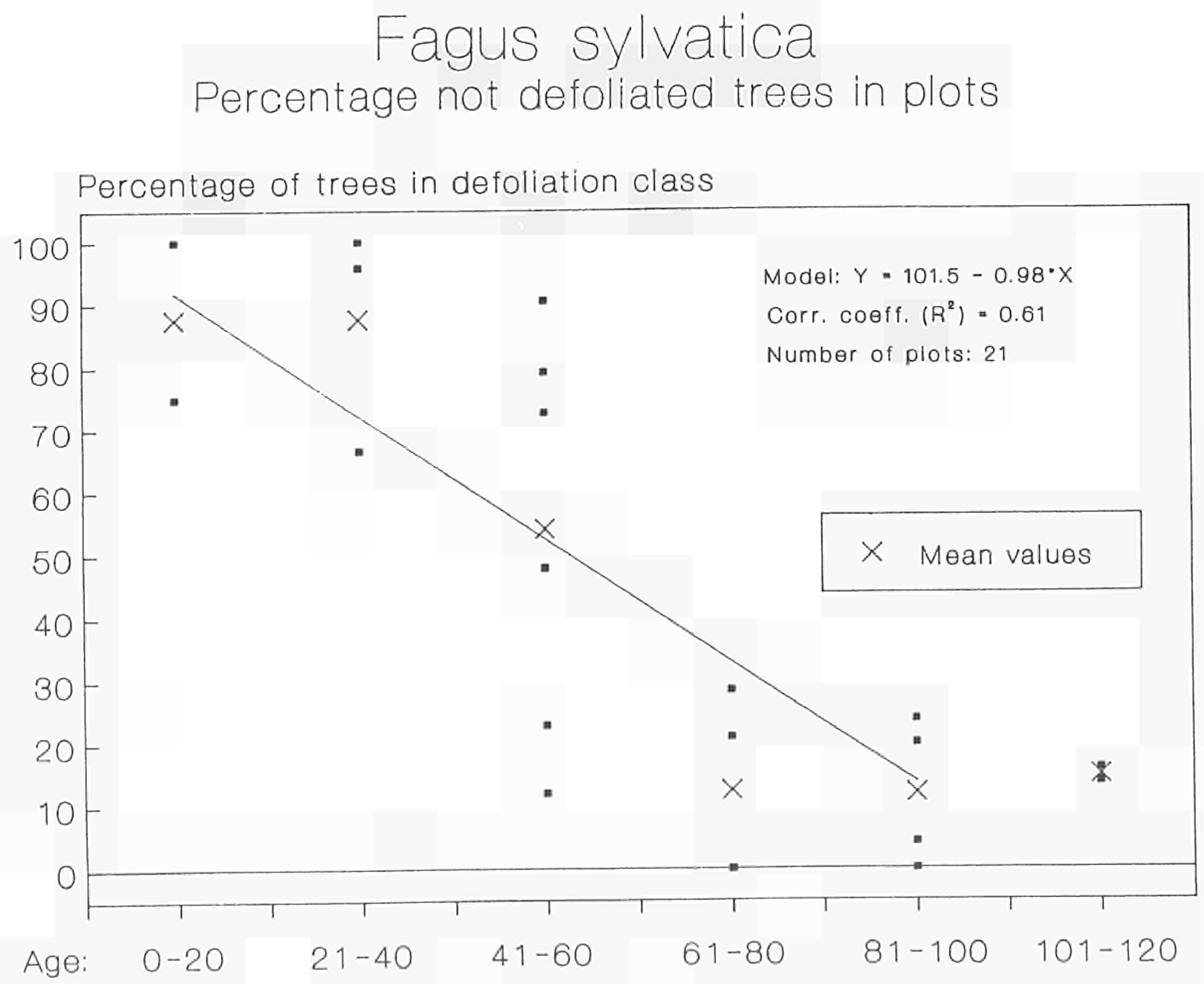



Picea abies
Percentage slightly defoliated trees
Percentage of trees in defoliation class
Model: Y = -6.8 + 0.79*X
Corr. coeff. (R²) = 0.60
Number of plots: 58
Mean values
100
90
80
70
60
50
40
30
20
10
0
Age: 0-20 21-40 41-60 61-80 81-100 101-120

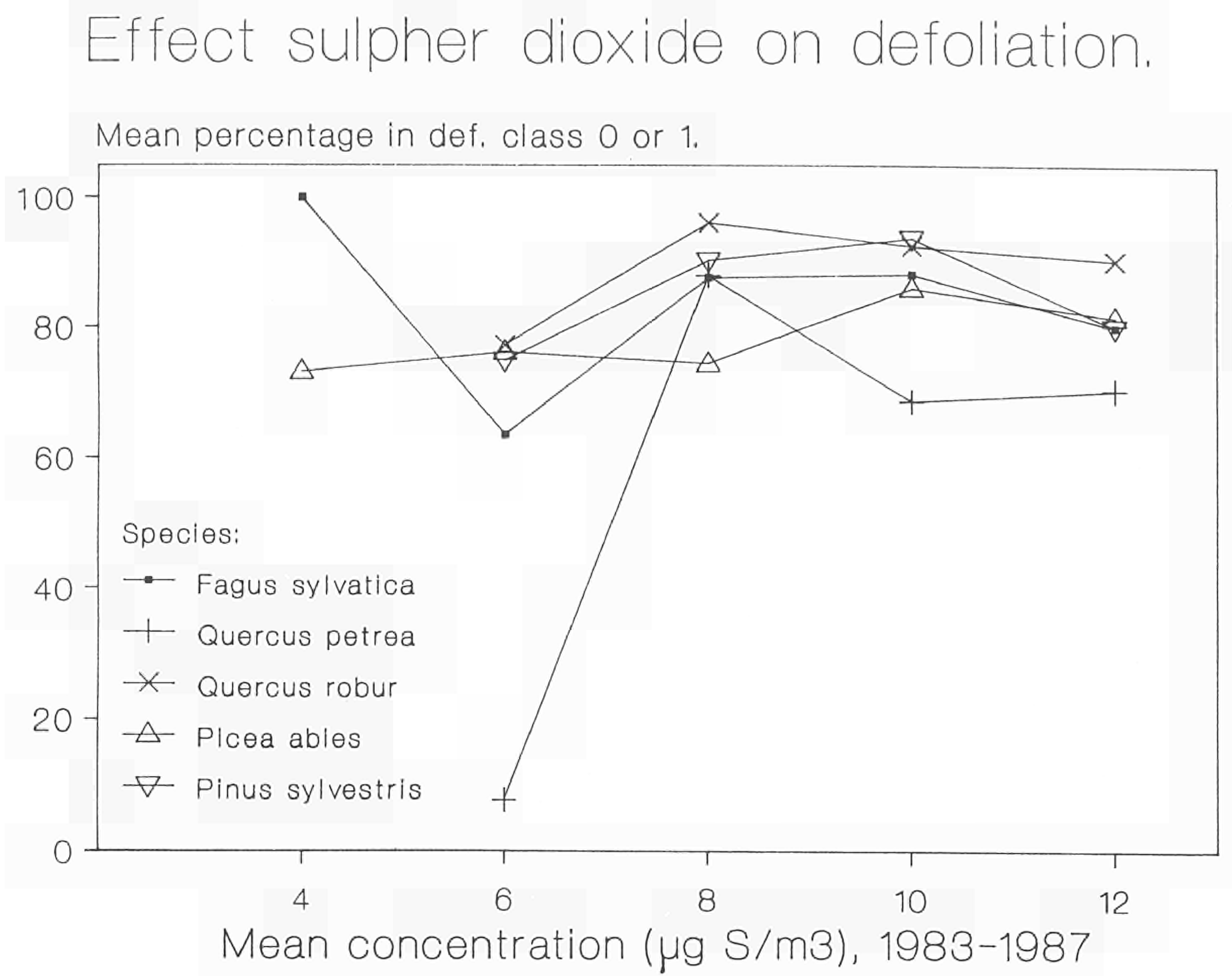
Fagus sylvatica

Percentage slightly defoliated trees

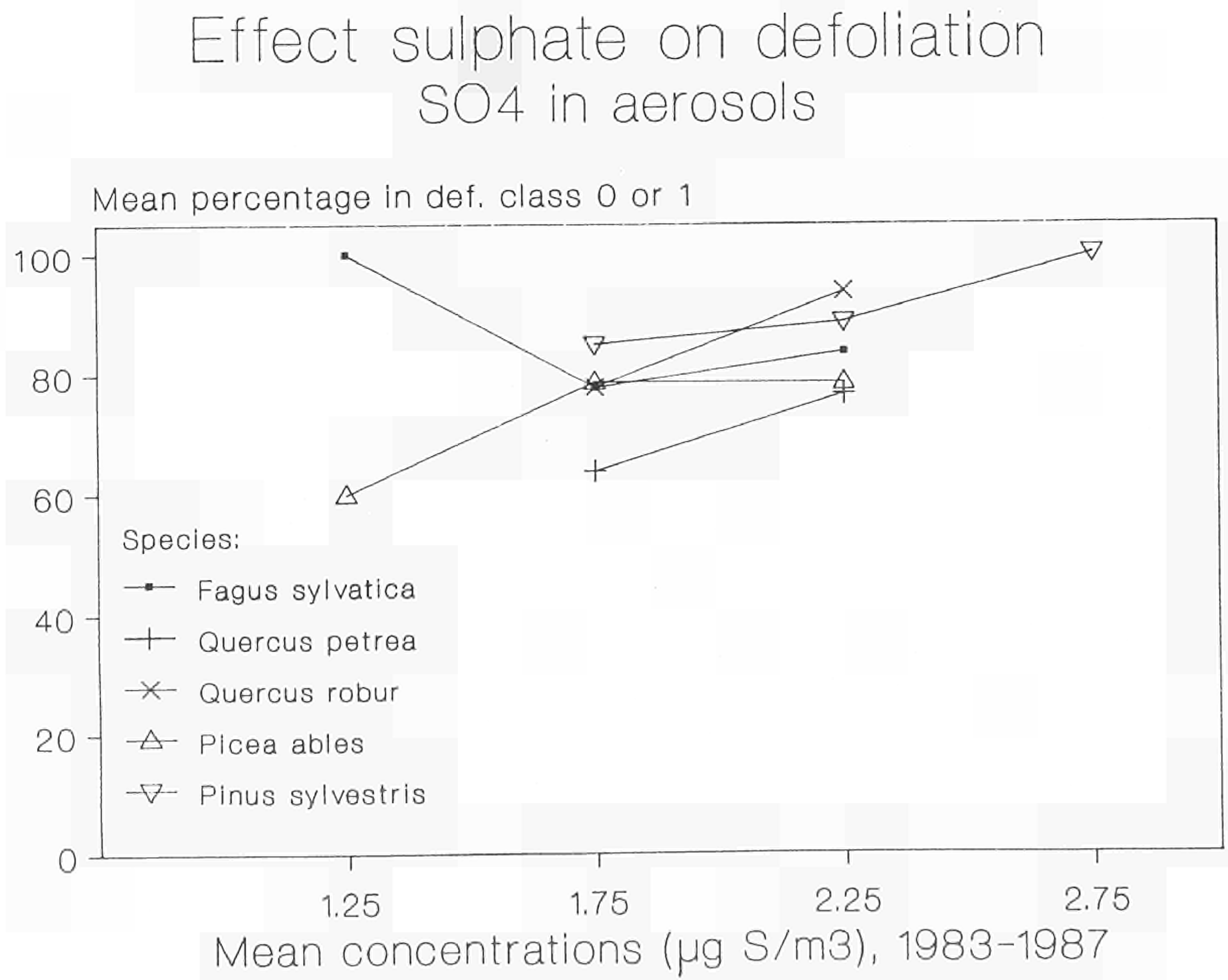


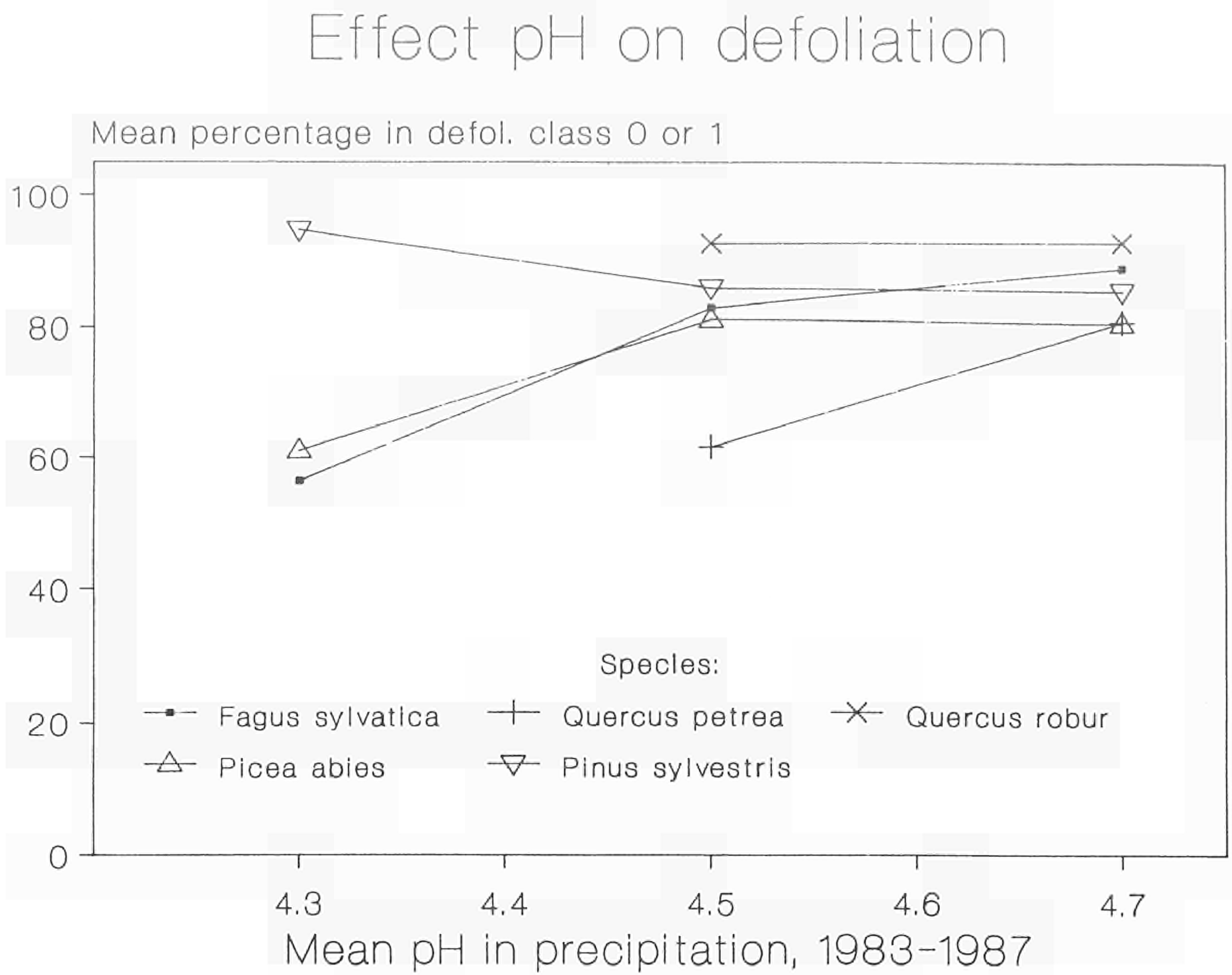


Fagus sylvatica
Percentage not defoliated trees in plots
Percentage of trees in defoliation class
Model: Y = 101.5 - 0.98*X
Corr. coeff. (R²) = 0.61
Number of plots: 21
Mean values
100
90
80
70
60
50
40
30
20
10
0
Age:
0-20
21-40
41-60
61-80
81-100
101-120



Annex IV-2 **Defoliation by different levels of sulphur dioxide in air, sulfate in aerosols, and pH in precipitation**


Effect sulphate on defoliation
SO4 in aerosols
Mean percentage in def. class 0 or 1
100
80
60
40
20
0
Species:
Fagus sylvatica
Quercus petrea
Quercus robur
Picea ables
Pinus sylvestris
1.25
1.75
2.25
2.75
Mean concentrations (µg S/m3), 1983-1987



Effect pH on defoliation
Mean percentage in defol. class 0 or 1
100
80
60
40
20
0
Species:
Fagus sylvatica
Quercus petrea
Quercus robur
Picea abies
Pinus sylvestris
4.3
4.4
4.5
4.6
4.7
Mean pH in precipitation, 1983-1987

Annex V Forms used for recording of inventory data

FORM 1

Common forest damage inventory data to be forwarded to the Commission

Country (1)		Date of observation (6)	
Observation point number (2)		Actual latitude coordinate (7)	
Availability of water to principal species (3)		Actual longitude coordinate (7)	
Humus types (4)		Aspect (8)	
Altitude (5)		Mean age of predominant story (9)	

Sample tree number (10)	Species (11)	Defoliation (12)	Discolouration (13)	Easily identifiable causes of damage Type: T (14)								Identification of damage type if possible (15)	Other observations (16):
				T 1	T 2	T 3	T 4	T 5	T 6	T 7	T 8		
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
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For the replacing of trees of the sample see the form in Annex.

FORM 1 — Annex

Replaced trees ([17])

Sample tree number ([10])	Species ([11])	Defoliation ([12])	Discolouration ([13])	Easily identifiable causes of damage Type: T ([14])								Identification of damage type if possible ([15])
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Annex VI: The shift in defoliation classes of individual trees

In this report, the changes in the percentages of trees in the various defoliation classes have all been calculated over all individuals of a species. However, if a change has been found of, for example, +5% for not-defoliated trees and -5% for slightly defoliated trees, one could get the impression that 5% of the trees moved from slightly defoliated to not-defoliated. As will be demonstrated in the example below, the percentage of trees that show changes in defoliation is much higher.

A subsample was defined for the Sub-atlantic region of the Federal Republic of Germany, containing the common sample trees of the 1987 and 1988 inventories. For each individual tree of a certain species the changes in defoliation were determined. The percentages were calculated of all trees that were assigned to defoliation class A in 1987 and defoliation class B in 1988 (note that, if no changes occurred, A = B).
The results can be presented in several ways (Figure VI). Figure VI-A shows the bar graph for *Picea abies* of the total percentages of trees in the different defoliation classes for 1988. Each section of a bar represents the percentage of trees that were assigned to a certain defoliation class in 1987.
Figure VI-B represents the same information as figure VI-A, but the sections of the bars have been re-ordered in order to show what proportion of the trees, that were assigned to a certain defoliation class in 1987, remained in the same defoliation class, or moved up (improved) or down (worsened) one or more defoliation classes in 1988.

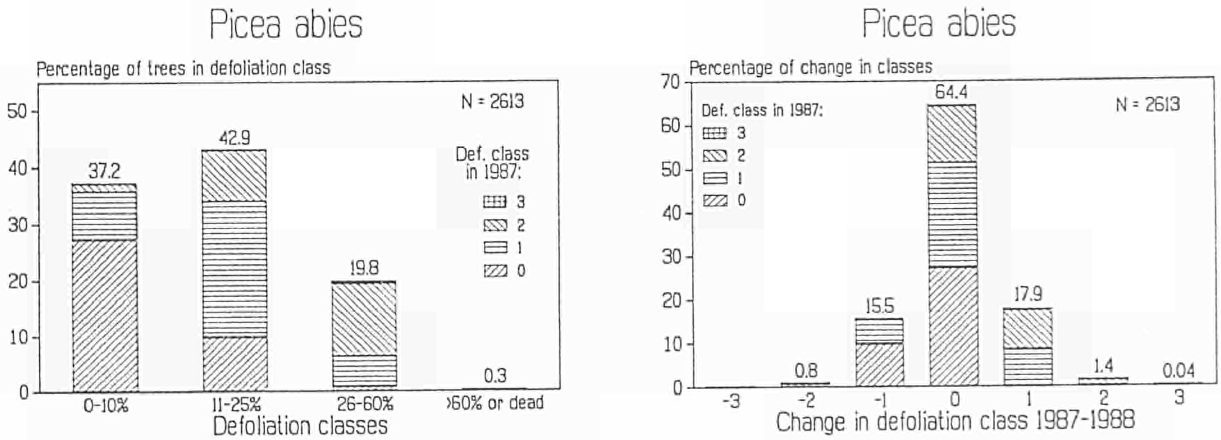

Figure VI: Total percentages of trees in the different defoliation classes in 1988 (A), and the shift in percentages of trees from defoliation class in 1987 to a another defoliation class in 1988 (B).
Each section of a bar represents the proportion of the trees that belonged to a certain defoliation class in 1987.

In the period 1987-1988, only minor changes occurred in the total percentages of trees in the different defoliation classes. It can however be derived from Figure VI that many individual trees (35.6%) have changed in defoliation within this one year interval. This illustrates the fact that it is not possible to directly derive trends in defoliation from the total percentages of trees in the different defoliation classes. Appearantly there exists a large dynamic in the degree of defoliation for an individual tree over the years.

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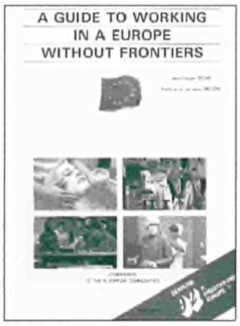

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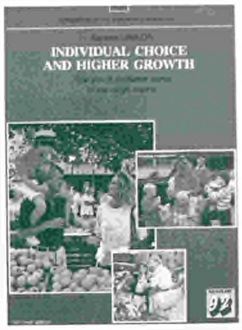

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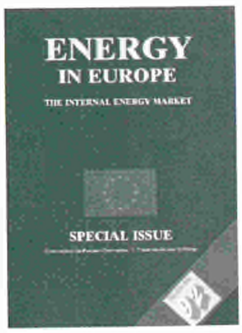

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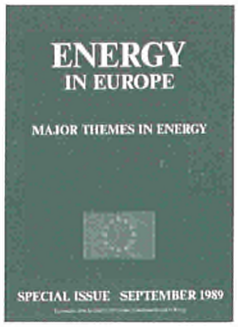

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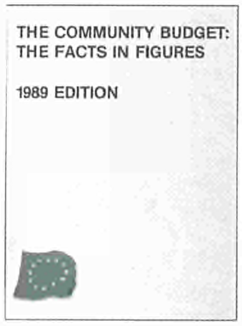

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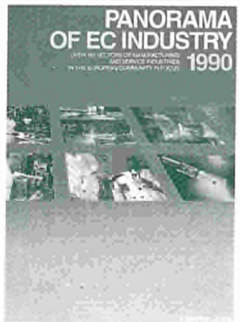

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