UNITED
NATIONS

E

Economic and Social
Council

Distr.
RESTRICTED

EB.AIR/WG.1/R.117
17 June 1996

Original: ENGLISH

ECONOMIC COMMISSION FOR EUROPE

EXECUTIVE BODY FOR THE CONVENTION ON
LONG-RANGE TRANSBOUNDARY AIR POLLUTION

Working Group on Effects
(Fifteenth session, Geneva, 3-5 July 1996)
Item 5 (a) of the provisional agenda

FOREST CONDITION IN EUROPE

Executive report on the results of the 1995 survey */

*/ The tables, figures and annexes are presented in document EB.AIR/WG.1/R.117/Add.1.

GE.96-31072

CONTENTS

Summary

1. The report documents the forest condition in Europe based on the results of the transnational and national surveys, conducted annually within the International Cooperative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) of the United Nations Economic Commission for Europe (ECE) and by the European Commission (EC). Thirty European countries submitted national reports. The results represent 25 170 plots with 635 736 sample trees, covering about 197 million hectares of forest. Thirty countries also participated in the transnational survey on the basis of the 16 km x 16 km grid. For the transnational forest condition assessment, 5 388 plots with 117 035 trees were investigated.

2. The reports indicate that forest damage is still a serious problem in Europe. Although forest condition has improved in some locations, the overall forest damage seems to be on the increase.

3. Of the total sample of 117 035 trees (transnational sample) assessed in 1995, 25.3% showed signs of defoliation above 25%. In 10.2% of all sample trees more than 10% of leaves were discoloured. The share of damaged common sample trees (CSTs) for 1994-1995 increased from 25.2% to 26.8%. The largest increases (from 15.3% to 19.4%) occurred in the Mediterranean (lower) and in the Mediterranean (higher) regions (from 20.8% to 25.1%), particularly in Quercus suber, Quercus ilex and Eucalyptus spp., and were mainly attributed to heat and drought. However, this last species showed the lowest damage in the Mediterranean regions. The Boreal (temperate) region, in contrast, showed a distinct improvement in forest condition (21.3% to 17.6%). Epecially the improvement in Pinus sylvestris contributed to the better health condition. The changes in forest condition in the Sub-Atlantic, Mountainous (north) and Atlantic (south) regions did not prove statistically significant. Deterioration in the Boreal, Atlantic (north) and Mountainous (south) regions was mainly influenced by the abundant occurrence of severely damaged trees (e.g. deciduous Quercus spp. Fagus sylvatica in central Europe). In addition to adverse weather conditions, air pollution was also blamed for the deteriorating forest condition in some regions.

4. In the sub-sample of the common trees of the surveys from 1988 to 1995, the development of the defoliation of 12 species was analysed. The crown condition of almost all tree species deteriorated. Drought and subsequent insect attacks, but also air pollution were considered as important factors worsening the condition of the tree species. For Picea abies and Pinus sylvestris, however, decreasing air pollution as well as better weather conditions than in previous years were thought to have positively affected the tree species according to the respective national reports. The most severe deterioration was observed in the main damage areas of Germany, the Czech Republic, Poland and Slovakia in Fagus sylvatica, Quercus robur, Quercus petraea and Abies alba. The highest increases in defoliation were observed in the Mountainous (south) region for Fagus sylvatica and Quercus petraea. In the Sub-Atlantic region Quercus robur and Abies alba were seriously impaired. The least affected tree species with respect to long-term forest condition were Pinus sylvestris and Pinus pinaster, the latter being confined to areas with a warmer climate.

5. The national reports referred to various causes for the deteriorating forest condition. Drought and heat had a particularly high impact. Pest infestation, action of man, game and grazing also negatively impaired the health of the assessed forests, as was stated in both transnational and national surveys.

6. The direct and indirect effects of air pollution are considered to be the cause of forest decline in some areas, particularly in central Europe. However, only in a few cases hasair pollution been identified as a cause of damage. Other sources of information, including the national reports submitted by individual countries, suggest that air pollution may predispose trees to decline over much wider areas, but the extent of these effects remains uncertain. Level II and III investigations are being designed to help resolve this.

7. In addition to the ongoing forest condition survey on level I, which is referred to in the above paragraphs, soil and foliar analyse extend the level I survey activities. Indirect air pollution effects on forest condition are assessed by means of the forest soil condition survey and the chemical analysis of leaves and needles. While sulphur depositions have dropped drastically since the seventies, nitrogen deposition from different sources is still high, impairing soil chemistry and foliar nutrient status in some areas. The forest soil condition survey and the foliar analyses may help to reveal the impact of air pollution on these parameters.

8. Also presented in this report is the design of the intensive monitoring (level II). On 660 permanent plots scattered throughout Europe, different parameters are monitored over the long term. All European Union (EU) member States and 11 other countries participate in the level II survey. 440 plots are chosen in the EU, and 220 plots are to be assessed in non-EU countries. Crown condition, soil and foliar analyses and increment studies are carried out on all plots. Atmospheric deposition will be monitored on 65% of the plots in EU countries, and on 81% of the plots in the other countries. On many plots additional studies, such as meteorology and phytopathology, are performed.

9. The general plot data have been recorded and submitted by most of the participating countries. Among the most abundant tree species are two conifers (Pinus sylvestris and Picea abies) and three broad-leaved trees (Fagus sylvatica, Quercus petraea and Quercus robur). Age distribution shows that only a small number of the plots are younger than 20 years. The majority of the plots are located in 41 to 60-year old forest stands. Most of the plots lie within a distance of about 10 km to a meteorological monitoring station or closer.

I. INTRODUCTION

10. Forest condition monitoring on the European scale is based on national grids of different densities and on the transnational grid of 16 km x 16 km. This extensive monitoring approach (referred to as level I) comprises annual crown condition assessments, a soil condition survey, and analyses of the chemical contents of needles and leaves.

11. Crown condition assessments have been conducted annually since 1986 on the national grids and since 1987 on the transnational grid by an increasing

number of countries. The forest soil condition survey has been implemented by about half the participating countries on the transnational grid between 1991 and 1995. An optional survey of the chemical content of needles and leaves is also carried out (1991-1996).

12. The main benefits of level I monitoring are a more detailed knowledge of the spatial and temporal variation of forest condition with respect to crown condition, soil condition and the chemical contents of needles and leaves.

13. To contribute to a better understanding of cause-effect relationships, a more intensive monitoring approach (level II) has been adopted. This approach is based on the use of a smaller number of monitoring plots situated in selected forest ecosystems and having a higher monitoring intensity per plot. Besides crown condition assessments, soil and foliar analyses, level II also covers increment studies, deposition measurements and meteorological measurements.

14. Chapter II provides an overview of the objectives and the design of the above-mentioned extensive monitoring activities (level I), as well as the background and methodological details. This information is essential for the understanding and interpretation of results. In addition, general information on the intensive monitoring programme (level II) is provided.

15. Chapter III presents the results of the 1995 transnational and national surveys. The transnational results (chap. III.A) reflect forest condition in Europe without regard to national borders and refer to correlations between defoliation and discoloration with site parameters. The national reports (chap. III.B) reflect forest condition in individual countries with emphasis on its interpretation in connection with the multitude of damaging agents, particularly air pollution. Both the transnational and the national survey results are interpreted together in chapter III.C, also paying special attention to the effects of air pollution.

16. Annexes I to VII (see EB.AIR/WG.1/R.117/Add.1) contain tables concerning the national results.

II. OBJECTIVES AND DESIGN OF THE MONITORING PROGRAMME

A. Extensive monitoring on the large-scale grid (level I)

1. Crown condition surveys

(a) Transnational survey

17. The transnational survey's objective is to document the spatial distribution and the development of forest condition on the European level. This is achieved by monitoring the crown condition of forest trees on a large scale using a number of site parameters on a 16 kmx16 km transnational grid of sample plots. In several countries the plots of this transnational grid are a sub-sample of a denser national grid.

(b) National surveys

18. The national surveys aims at documenting the forest condition and its development in the respective country. Therefore, the national surveys are conducted on national grids. The densities of these national grids vary between 1 km x 1 km and 32 km x 32 km due to differences in the size of forest area, in the structure of forests and in forest policies. Any comparisons between the national surveys of different countries should be made with great care because of differences in species composition, site conditions and reference trees.

(c) Selection of sample trees

19. Ideally at least 20 sample trees are selected according to standardizsed procedures on each sampling point of the national and transnational grids situated in a forest. Predominant, dominant, and co-dominant trees (according to the system of KRAFT) of all species qualify as sample trees, provided that they have a minimum height of 60 cm and that they do not show significant mechanical damage. Trees removed by management operations, blown over by wind or dead trees must be replaced by newly selected trees. Due to the small percentage of removed trees, this replacement does not distort the survey results, as a special evaluation (Forest Condition Report 1994) has shown.

(d) Assessment parameters and data presentation

20. On each plot the defoliation of the sample trees is assessed in comparison to a reference tree of full foliage and without discoloration. Alternatively, photo guides suitable for the region under investigation may be used if no reference tree can be found in the vicinity of the sample trees.

21. In principle, the transnational survey results for defoliation are reported in 5% steps and the national survey results for defoliation according to the traditional classification (table 1). Most countries also report their national results for defoliation in 10% steps. The assessment down to the nearest 5 or 10% permits studies of the annual variation of foliage with far greater accuracy than the traditional system of only five classes of uneven width. Discoloration is reported according to the traditional classification both in the transnational and in the national surveys

22. Changes in defoliation and discoloration attributable to air pollution cannot be differentiated from those caused by other factors. Consequently, defoliation due to other factors is included in the assessment results, although known causes should be recorded.

23. In the presentation of results a change is called "significant" if a statistical test was performed at a 95% probability level.

24. Besides defoliation and discoloration, additional parameters have to be assessed on the plots of the transnational survey. Within the transnational crown condition survey, the following plot and tree parameters should be reported for each plot: country, plot number, plot coordinates, altitude, aspect, water availability, humus type, soil type (optional), mean age of dominant storey, tree numbers, tree species, observations of easily indentifiable damage, date of observation.

25. The tree and plot parameters of the transnational survey are submitted in digital format via EC or directly to the Programme Coordinating Centre (PCC) West of ICP Forests for screening, storage and evaluation. The national survey results are submitted on paper to PCC West as country-related mean values, classified according to species and age groups. These data sets are accompanied by national reports providing explanations and interpretations. The survey results are presented mainly in terms of the percentages of the tree sample falling into the traditional five defoliation or discoloration classes. This classification reflects to a certain extent the experience gathered in forest damage assessments in central Europe between 1980 and 1983. At that time, any loss of foliage exceeding 10% was considered as abnormal, indicating impaired forest health. Assumptions based on physiological investigations of the vitality of differently defoliated trees led to the establishment of uneven class widths. Consequently and in order to ensure comparability with previous presentations of survey results, the traditional classification of both defoliation and discoloration has been retained for comparative purposes, although it is considered arbitrary by some countries.

26. A certain natural range is taken into account by defining a level of defoliation up to 25% as "undamaged". Defoliation of >10-25% indicates a "warning-stage". Therefore, in the present report a distinction has often been made only between defoliation classes 0 and 1 (0-25% defoliation) on the one hand, and classes 2, 3 and 4 (defoliation > 25%) on the other.

27. Classes 2, 3 and 4 represent considerably defoliated trees and are thus referred to as "damaged". Like the sample trees, the sample points are referred to as "damaged" if the mean defoliation or their trees (expressed as percentages) falls into class 2 or higher. Otherwise the sample point is considered as "undamaged".

28. The most important results have been tabulated separately for all participating countries (called "total Europe") and for those 12 countries that were being EU Member States in the survey year 1994. As Austria, Finland and Sweden became EU Member States in 1995, they are included in the EU total from this year's report onward. For those countries from which suitable data sets of their national surveys have been received, the basic results of the national surveys are presented in 10% defoliation classes in order to enhance resolution and thus be able to study changes in defoliation.

2. Forest soil condition survey

(a) Soil changes induced by atmospheric pollution

29. The large-scale transnational soil survey's purpose is to assess basic information on the chemical soil status and on the soil properties which determine its sensitivity to air pollution. Therefore, soil sampling and analysis were carried out by the national focal centres (NFCs). In collaboration with EC and the Flemish Institute for Forestry and Game Management, ICP Forests set up a Forest Soil Co-ordinating Centre (FSCC) at the University of Ghent for the processing of the soil condition results. The results of the national surveys were to be submitted to FSCC before 31 December 1995. They are stored in a European database and will be presented in a "Report on the European forest soil condition" by the end of March 1997.

30. The ICP "Manual on methods and criteria for harmonized sampling, assessment, monitoring and analysis of the effects of air pollution on forests" describes reference methods for sampling and analysis of forest soils on the level I observation plots. Details of national methods may, however, deviate from the reference methods.

31. Any addition of pollutants to soil, i.e. those compounds that may have adverse effects on soil functioning, can be defined as soil pollution.

Principal soil functions are the plant growth function and the ecological function of soil, with its important contribution to element cycling.

32. Because most soils have a certain buffering capacity, it usually takes some time before negative effects become apparent. The buffering capacity of soils can be described as the capacity to allow the contents of compounds, once present at optimum level, to increase without the actual occurrence of negative effects. Several potentially hazardous compounds, such as Cu and Zn, are also prerequisites for good soil functioning and show a positive effect at low concentration levels. The buffering capacity is a function of the nature of the pollutant and of many soil properties and system conditions.

33. A possible reason for the European forests' loss of vitality is the persistent input of atmospheric pollutants. Besides the direct effect of gaseous pollutants ("dry deposition") and solutes ("wet deposition") on needles and leaves, air pollution might affect forests indirectly through changes in the soil. The most important air pollutants are SO_2, NO_x, O_3 and NH_y. H^+ and H_2O_2 deposition from fog and low clouds may be considerable at high altitude sites.

(b) Methods

34. The pedological characterization is optional for level I study plots. It includes at least one detailed profile description and is carried out before starting soil measurements. It provides background information on the soil in order to improve the interpretation of other data collected on that plot. It is mandatory to classify the soil on the study plots according to the Soil Legend (1988) of the Food and Agriculture Organization of the United Nations (FAO). Such soil classification requires information on several items that are observed during the profile description. The profile description(s) is (are) carried out according to the FAO guidelines for profile description on a location that is representative for the actual sampling area.

35. The actual sampling area is selected in a homogeneous part of the study plot. The sampled soil should be representative for the forest stand on the study plot. The organic top layer is sampled separately. A distinction is made between O- and H-horizons, as defined in the FAO guidelines for soil description.

36. After removal of the litter, the mineral soil is sampled following genetic horizons or by layers with predetermined depths. The method using predetermined depth layers is preferred because it facilitates comparison between soils. For every sampled layer or horizon, one representative composite sample or several samples are taken. The number of sub-samples collected is reported.

37. The mandatory and optional parameters assessed and the number of countries having submitted the respective data so far are shown in figure 1.

38. The forest soil condition results are submitted to FSCC in digital format. A file with plot information contains plot coordinates, altitude code and FAO soil unit. The chemical parameter data are submitted in separate files for mandatory and optional parameters, respectively. Supplementary information on parent material, soil texture class, bulk density and coarse fragments content is submitted on a voluntary basis in another file. Table 2 gives an overview about available data.

39. The first forest soil condition results have shown the necessity to relate the chemical soil properties to physical conditions, such as bulk density and particle size distribution. In order to determine absolute values of nutrient availability, information on physical soil properties is required, and should be foreseen as mandatory parameters in future soil surveys. Parent material and texture data are mainly used to differentiate soil groups.

3. Chemical analyses of needles and leaves

40. Foliar sampling and analysis are tools for assessing the effects of air pollution on forests. For many decades foliar analyses have been used in some European countries in local or regional investigations to show the influence of air pollution on the nutrient content, the nutrient balance and the accumulation of sulphur or fluorine in leaves or needles. Based on these data, guidelines or regulations were provided in several countries in order to use the possibilities of foliar analysis to demonstrate the impact of air pollution. More than 10 years have passed since some countries began to use foliar analysis also in connection with monitoring on the national level.

41. In the framework of ICP Forest the first relevant activities were started in 1992 at the eighth Task Force Meeting in Avignon (France). It gave a mandate to the Foliar Analysis Expert Panel to work out:

- Sampling methods adapted to the different cases; number of trees, where and when to harvest the needles/leaves;
- A list of mandatory and advised elements to be analysed in the permanent plots of level II and eventually of level I if considered opportune by the expert panel;
- A list of acceptable mineralization methods for each element;
- A list of acceptable determination methods compatible with mineralization methods for each element;
- A proposal for guaranteeing the comparability of the results between laboratories;
- A proposed frequency for analysis in level II permanent plots and also for level I plots, if considered opportune by the expert panel;

- The format and the structure of the data transfer;
- The format and the structure of the report.

42. Moreover this the Foliar Analysis Expert Panel should identify the main problems of foliar analysis interpretation (threshold values for nutrient deficiencies or potential toxic effects). The experts participating in the Panel were mandated to negotiate both the technical matters (sampling analysis) and the financial consequences of the proposals.

43. As one of its first activities, the Foliar Analysis Expert Panel developed a draft manual entitled "Sampling and analysis of needles and leaves". It provided information on sampling and analysis procedures, including the following details:

Sampling: frequency, date, number of trees to be sampled and analysed, selection of the sample trees, selection of leaves and needles to be sampled, orientation, quantity of material to be sampled, means of sampling, pretreatment before sending the samples to the laboratories for analysis;

Chemical analysis: treatment before analysis, elements to be determined, digestion (or ashing) and analysis.

44. It was decided to make foliar analysis mandatory on the intensive monitoring plots (level II); it should be performed at least every other year. A number of countries intend to include the level I plots as well. The first common sampling in all participating countries was carried out in 1995, for deciduous species and larch during the summer and for other conifers in the following dormancy period. In general, the sampling is done on at least five predominant or dominant trees (level II) in the vicinity of the soil sampling location. Trees must not be felled, and the sampling of branches can be done by pruning devices, climbing or shooting. After drying and grinding, the samples will be analysed for the major elements N, P, K, Ca, Mg, and S.

45. The draft manual was adopted by the Task Force of ICP Forests as part of the 3rd edition of the ICP Forests Manual. Furthermore, the Task Force decided to carry out intercalibration tests on samples with unknown determination values in order to make the results of the individual laboratories comparable.

46. Laboratories from the following countries took part in the first intercalibration test: Austria, Belgium, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Spain, Switzerland, and the United Kingdom. A number of other countries contributed their results later. In general, the intercalibration test showed fairly good results, but, as expected, they varied between the laboratories as well as with regard to the elements and the methods applied. Six of the laboratories showed excellent results for all elements in both samples. Evaluation of the

results clearly showed which method of analysis for all individual elements gave only poor results. For this reason the meeting felt the necessity to carry out the second intercalibration test with 39 laboratories from 25 countries. The finalization of this test with the participating laboratories was planned for the end of 1995. A German laboratory agreed to draw up a report on the accuracy of the individual methods and to distribute it to the participants in the spring of 1996.

47. Threshold values for an all-European assessment of the analytical needle and leaf data were determined. Since very different terms are being used for the same values or range of values in European countries, and in order to avoid misinterpretation or wrong conclusions, it was decided that, for the evaluation at European level, classifications of only 3 classes and without more specific names or descriptions should be determined. After that basic decision, the classification values of the major nutrients for spruce, pine, beech and oak (which are the main tree species on the level I and level II plots in Europe) were determined (table 3). The sulphur values for oak still have to be determined. In this respect the results from the foliar analysis, notably those from the Mediterranean region in Spain, have to be taken into account as there are many oak plots.

48. As a next step, the Foliar Analysis Expert Panel will concentrate on the determination of classification values of micronutrients which are optional on level I and level II plots. When determining these values the results of 1995/1996 samples should be taken into consideration. Apart from the determination of the classification values for micronutrients, the results of the second intercalibration test and the draft report on the results of the level I plots will be discussed.

B. Intensive monitoring (level II)

49. In order to contribute to a better understanding of the impact of air pollution and other factors which may influence forest ecosystems, the large-scale systematic sampling was extended by adding intensive and continuous monitoring of forest ecosystems. This second level of monitoring is carried out on 660 permanent observation plots in 26 countries. 440 of these plots have been selected and installed in the European Union (Regulation (EC) Nº 1091/94 and its amendment). This monitoring programme is a consequence of both Resolution S1 of the first Ministerial Conference on the Protection of Forests in Europe (Strasbourg, 1990) and of Resolution H1 of the second Ministerial Conference on the Protection of Forests in Europe (Helsinki, 1993).

50. This second level of monitoring is defined as "intensive monitoring of forest condition aimed at the recognition of factors and processes with

special regard to the impact of air pollutants on the more common forest ecosystems in Europe". The intensive monitoring programme contains continuous and intensive surveys such as crown condition assessments, soil and foliar surveys, increment studies, deposition measurements and the observation of meteorological parameters over a period of at least 15 to 20 years. Several countries carry out additional activities and several groups of experts are working at specifying recommended methods for survey and analysis of some additional activities (vegetation, soil water and remote sensing). By the end of 1996 the first submission of the survey data is foreseen, and first results are expected to become available in 1997, but it will take at least 5 to 10 years before trends can be identified, as for instance increment is surveyed only every 5 years and soil only every 10 years.

51. The second edition of the report ’General information on the permanent observation plots in Europe (level II)’, which was published in January 1996, contains more information on the intensive monitoring programme of the member States of the European Union and 11 non-EU countries, as was available by the end of 1995.

52. The data of the intensive monitoring programme are evaluated first at national level and, after submission, at European level. At national level the national focal centres (NFCs) have been appointed for data management and evaluation. At European level a Consultant has been appointed to carry out the management of the data (Forest Intensive Monitoring Coordinating Institute (FIMCI)). To ensure correct procedures in data management, evaluation and interpretation, a Scientific Advisory Group (SAG) has been formed, which consists of experts working in the related fields.

1. Establishment of the intensive monitoring plots

(a) Number of plots selected

53. Based on the agreed selection criteria, laid down in Commission Regulation (EC) Nº 1091/94, the EU member States made plans, in 1994, to select and install a certain number of plots. After acceptance of the relevant parts of the ICP Forest Manual (Task Force meetings in Lillehammer (1994) and Prague (1995)), the non-EU countries also started with the selection and installation process. In most countries the selection and installation of plots have now been completed. For inclusion in this report of the intensive monitoring programme, the minimum size and the minimum set of surveys (crown, soil, foliar and increment on all plots and deposition on at least 10%) are used as a general rule to determine the actual number of plots in the intensive monitoring programme.

54. The situation is shown in table 4. For the EU member States, where the installation is complete, there are in total 440 plots for the intensive monitoring programme. For the non-EU countries the installation is not yet complete: of the 220 selected plots 203 plots have already been installed. The grand total for the intensive monitoring programme in Europe, based on the information of the EU and the 11 non-EU countries, is 660 plots. With the possible inclusion of other non-EU countries which participate in the ICP Forests, it could rise to 900 plots.

55. In the 26 participating countries, which have submitted information, the selection of the plots seems to be completed. Several other non-EU countries which participate in the ICP Forests (e.g. Slovenia and Belarus) are expected to participate in the intensive monitoring programme in the near future. The geographical distribution of all plots located in the EU member States and non-EU member States is shown in figure 2.

(b) Monitoring activities

56. Level II comprises the following monitoring activities:

- Crown condition assessment (at least once a year);
- Chemical analysis of the contents of needle and leaves (at least every 2 years);
- Soil analysis (every 10 years);
- Increment studies (every 5 years);
- Deposition measurements (on at least 10% of the plots);
- Meteorology monitoring (in a test phase for one year, optional).

57. Details on the common methodologies for these surveys, such as sampling method, analysis procedures, data format for submission, etc. are set out in Regulations (EC) Nº 1091/94 (Annex III - VII) and 690/95 (Annex VIII and IX) and in the Manual of ICP Forests.

58. In addition to the surveys of this programme, many countries carry out other surveys on their intensive monitoring plots. In the summer of 1995 the Chairman of the Scientific Advisory Group for the intensive monitoring sent out a questionnaire requesting the countries to indicate the surveys, their frequency and the number of plots on which they are (or will be) executed. Table 5 gives an overview of these surveys.

59. For the 440 plots of the EU member States, deposition measurements are carried out on 288 plots (65%) and meteorology is monitored on 172 plots (39%). Besides the surveys of the agreed common programme, phytopathology (211 plots), ground vegetation (248 plots), litterfall (266 plots), soil solution (201 plots) and phenology (71 plots) are or will be carried out.

60. It is remarkable that almost all non-EU countries intend to carry out ground vegetation surveys and most of them also phytopathology. The surveys indicated as mandatory in the Regulation (EC) Nº 1091/94 will be carried out on 660 plots in all, including 11 non-EU countries. The deposition measurements will be carried out on 465 plots (70%)and the meteorological parameters will be monitored on 260 plots (45%). In addition, measurements will be carried out in the following areas: phytopathology (390 plots), ground vegetation (465 plots), litterfall (330 plots), soil solution (229 plots) and phenology (107 plots). It is therefore important to continue the harmonization of the assessment of soil solution and ground vegetation. For the assessment of phytopathology, litterfall and phenology, the possibilities of harmonization should be reviewed.

61. Several other investigations are carried out on a limited scale. Among the more common investigations are dendrochronology in six countries (163 plots), studies of lichens and/or mosses in five countries (63 plots), insects in three countries (149 plots) and mycorrhiza and/or fungi in three countries (41 plots). Aerial photography (or remote sensing) is carried out by three countries (55 plots), while some countries intend to carry out an even more in-depth study on soil physiology, soil water regimes, air quality, gas exchange, etc.

2. Thematic description of the plots

62. The data reported for the various parameters have been evaluated with respect to their distribution among the established plots .

Main tree species

63. From 651 plots, the main species has been reported. According to the information received the top five tree species in the plots are:

(a) *Pinus sylvestris* (205 plots);
(b) *Picea abies* (162 plots);
(c) *Fagus sylvatica* (84 plots);
(d) *Quercus petraea* (36 plots); and
(e) *Quercus robus* (34 plots).

Altitude

64. Altitude is known for 651 of the plots. Most of the selected plots are located at lower altitudes; the number of plots slowly decreases with higher altitudes.

Mean age

65. For most of the plots, the mean age of the trees has been reported. In 24 plots, the mean age is not specified yet. There are only nine plots of young stands (age class 20 ≤years). There is a concentration of 206 plots in the class 41-60 years.

Yield estimate

66. For almost all plots the estimated yield (in cubic metres per hectare per year) has been received (95%). The yield estimates consist of an absolute and a relative yield estimate. The absolute yield is the estimated average yield over the total life period of the stand. These figures are based on estimates in the field. In a later stage when the increment studies have been completed, more detailed information will become available. Participating countries were asked to indicate whether the estimated yield was considered to be low, normal or high for these species under these plot conditions. This information was received for 85% of the total plot number. Its evaluation showed that the yield is normal in most plots.

Distance to nearby monitoring or meteorological stations

67. Ideally, the plots should have been selected nearby an existing meteorological or other monitoring station. For 248 plots descriptions with information of nearby stations have been received. In most cases the nearby station was a monitoring station, but also integrated monitoring plots, and other research plots were mentioned. Based on the coordinates supplied for these stations, the distance between the plot and the nearest station has been calculated. The distribution of this distance showed that the majority of plots are located within 10 km from a meteorological station.

3. Data collection and evaluation

68. By the end of 1996, the results of the first surveys will become available at the European level. First these data will be collected, validated, evaluated and interpreted at local or national level by the national focal centre (NFC). By 31 December 1996, the data will be submitted to the EC Consultant for the data management. At the beginning of 1997 the validation, evaluation and interpretation at European level will start. At European level a strategy for the evaluation of the data will need to be developed during 1996. This will be done by the EC consultant for the data management, in close collaboration with the Scientific Advisory Group (SAG) and the NFCs.

69. After 1996, the data from additional surveys will be submitted yearly. Procedures and deadlines for the submission will have to be further elaborated

in close collaboration with the SAG and the NFCs. Amendments to the data requirements, methods, forms, etc., which will have to be discussed and agreed upon in the respective expert panels or working groups and SAG, will be presented to the Standing Forestry Committee of the EC and the Task Force of the ICP Forest for decision.

70. Well-defined conditions for data handling also permit external institutes to obtain a part of the database for specified evaluations. The coordination of this external evaluation with the internal evaluation, the evaluation strategy and the interpretation of the results will also be part of the work of FIMCI, which will carry this out in close collaboration with SAG.

III. RESULTS OF THE 1995 SURVEYS

A. Transnational survey

1. The sample trees and plots in 1995

71. In 1995, the transnational grid was further extended. The database is now more comprehensive than ever before, comprising 117 305 trees assessed on 5 388 plots. This is more than four and a half times as large as the database of the starting year 1987. This extension is mainly caused by participation of a growing number of non-EU countries in the survey since 1990. However, it is also a consequence of the completion of the grid within EU member States, such as in Finland and Sweden in 1995. With one non-EU country more than in 1994 (Russian Federation), the number of participating countries reached 30, i.e. all 15 EU member States and 15 non-EU countries, the largest number of countries ever.

72. Besides the above-mentioned 5 388 plots, 8 plots were surveyed on the Azores and the Canary Islands. These plots appear in the relevant maps of the present report, although they were not included in the total plot sample for the transnational evaluation.

73. Of the 117 305 sample trees of the 1995 survey, 25.3% were rated as damaged, i.e. had a defoliation of more than 25% (defoliation classes 2-4). The conifers had nearly the same proportion of damaged trees (25.5%) as the broadleaves (25.0%). Table 6 shows the results in greater detail. Discoloration was reported for only 111 805 trees, because some countries (mostly non-EU member States) did not assess discoloration on all sample trees. 10.2% of this tree sample had a discoloration of more than 10% (table 7).

2. Forest condition by species group

74. Of the total tree sample, defoliation among the broadleaves was the

highest for Quercus spp. (30.9% damaged). The lowest defoliation observed in Castanea sativa with 16.4% and Eucalyptus spp. with 7.7% of trees damaged. Of the conifers, Abies spp. had the highest percentage of damaged trees (31.6%), whereas the lowest share of damaged trees was recorded for Larix spp. (21.1%).

75. Discoloration of the broadleaves was the highest for Castanea sativa and Quercus spp. (17.3% and 15.3%, respectively, of trees discoloured, i.e. showing discoloration greater than 10%). Betula spp. had the lowest share of discoloured trees (3.4%). Among the conifers the interspecific variation was smaller, with Abies spp. showing the highest percentage of discoloured trees (18.3%). The lowest discoloration was observed in Larix spp., with 5.2% of the trees discoloured.

3. Defoliation and discoloration by mean age

76. For both the EU member States and for total Europe, tables 8 and 9 show the percentages of trees in each defoliation and discoloration class, respectively, for seven classes of different mean stand age and for a class of irregular age composition

77. The strong positive correlation between age and defoliation is confirmed. It is strongly suspected that this reflects inherent properties associated with ageing. In the sample for total Europe, the share of non-defoliated trees (defoliation class 0) drops sharply from 62.7% at ages 0-20 to 31.3% at ages 81-100. The share of damaged trees grows gradually from 14.1% at ages 0-20 to 31.4% at ages greater than 120. This increase is more pronounced at younger ages and becomes less evident at higher ages.

78. The shares of trees in different discoloration classes do not vary greatly with age. The younger trees (0-40 years) and the older trees (81- >120 years) seem to be slightly more discoloured than the trees between 41 and 80 years.

4. Changes in defoliation and discoloration between 1994 and 1995

79. For an unbiased comparison of the 1994 and 1995 survey results, a sub-sample called common sample trees (CSTs) is defined. CSTs contain all trees that are common to both surveys. For 1994 and 1995, this common sample consists of 94 093 trees, representing 92.0% of the total tree sample of 1994 and 80.2% of the total tree sample of 1995. This is 12 088 trees or 12.8% more than in the 1994 survey. The reason for this increase in the number of CSTs is the participation of Bulgaria, Latvia and the Russian Federation in the transnational forest condition assessment since 1994.

80. Again, the common sample of 1994 and 1995 was the largest ever. The increasing number of CSTs improves the reliability of the calculation of changes in defoliation and discoloration and the consistency between the data sets in the participating countries.

81. Table 10 shows the percentages of CSTs in the different defoliation and discoloration classes in 1994 and 1995. The share of damaged CSTs was 25.2% in 1994 and 26.8% in 1995, indicating a rise in forest damage since 1994. The deterioration was most obvious in class 2, the share of which increased from 22.7% to 23.7%. The share of dead trees grew from 0.4% to 0.9%, indicating a mortality of 0.5%. The mortality is slightly lower than last year (0.8%).

82. The proportion of trees affected by discoloration decreased slightly between 1994 and 1995 in both the total tree sample and the CSTs. The slight drop in discoloured trees in the total tree sample was higher than in the common sample.

(a) <u>Changes by climatic region</u>

83. As in previous years, the total tree sample and common sample trees (CSTs) were classified into climatic regions in order to account for various climatic site conditions. The selected climatic regions largely match the most important vegetation types.

84. The percentages of damaged tres and mean plot defoliation were used to quantify the changes in defoliation in the CSTs from 1994 to 1995 for each climatic region. The following descriptions refer to the changes in the percentage of trees damaged and differences in mean defoliation between 1994 and 1995.

85. Regarding differences in mean defoliation, significant changes were found for the total CSTs of all regions and for each climatic region as well. Except for the Boreal (temperate) region, the mean defoliation increased significantly from 1994 to 1995. However, in no case did the change reach the 5% mark. The most pronounced worsening of crown condition, in terms of the percentage of damaged trees, occurred in the Mediterranean (lower) region (6.8 percentage points), followed by the Mediterranean (higher) region (4.3 percentage points). The situation in the Sub-Atlantic and the Continental regions appears to be stable as the changes there lie below 1 percentage point and are not significant. The Boreal (temperate) region is the only one showing improved forest condition, the share of damaged trees decreased significantly by 3.7 percentage points.

86. In contrast to defoliation, the percentage of discoloured trees fell in most of the climatic regions. The most noticeable improvement was a decrease

in discoloured trees of 3.1 percentage points in the Continental region. A positive development in terms of discoloration can also be seen in trees of the Boreal region, where the percentage of discoloured trees fell significantly by 2.2 percentage points. This improvement is comparable with the Sub-Atlantic region. Declining percentages of discoloured trees were also observed in the Boreal (temperate) and Atlantic (north) regions (-1.8 and -1.4 percentage points, respectively). A deterioration in forest condition in terms of discoloration occurred in the Atlantic (south), Mountainous (north) and both Mediterranean climatic regions. However, in all these regions the changes lie below 1 percentage point and are not statistically significant.

(b) Changes by species group

87. The CSTs as a whole showed a significant worsening in defoliation. The share of damaged CSTs rose from 25.2% in 1994 to 26.8% in 1995. In the coniferous CSTs the respective proportion increased slightly, namely from 26.7% to 27.3%. In the broad-leaved CSTs the proportion of trees with a defoliation above 25% rose from 23.2% to 26.2%.

88. Some of the species among the broad-leaved CSTs deteriorated dramatically, deterioration, as expressed by the shares of damaged trees. The crown condition of Quercus ilex, Quercus suber and Eucalyptus spp. deteriorated sharply. The share of damaged Quercus ilex trees rose from 13.1% to 29.5%. The respective proportion of Quercus suber increased from 14.2% to 25.5%. The proportion of damaged Eucalyptus spp. grew from 3.2% to 8.0%. However, this species still shows the lowest damage patterns in the Mediterranean area. A decrease in defoliation occurred only among Castanea sativa, the damaged share of which diminished from 17.5% to 15.2%. The proportion of damaged Betula spp. remained the same, namely 22.0%.

89. As in the previous years, the rapid changes in vitality among the principal Mediterranean species Quercus ilex, Quercus suber and Eucalyptus spp. should be interpreted in connection with typical detrimental events in the Mediterranean region, such as drought and fire, especially if only small percentages of trees are affected. Though large, these changes have less influence on the result for the total broadleaves, due to the low numbers of CSTs among these species groups.

90. The deciduous Quercus spp., with 12 080 trees, represented the largest number of broad-leaved CSTs. Consequently, their minor increase in the proportion of damaged trees from 30.3% to 30.9% kept down the increase for the broad-leaved CSTs, but greatly influenced on their high damage percentage. Also influential were Fagus spp. (9 439 trees) and "other broadleaves" (7 263 trees) with an increase in damaged trees from 19.7% to 22.8% and from 26.8% to 28.5%, respectively.

91. The species groups of the coniferous CSTs experienced mostly slight changes in defoliation between 1994 and 1995, except "other conifers" (only 893 trees), whose share of damaged trees rose steeply from 21.2% to 29.0%, and Larix spp., which showed an increase from 16.0% to 19.5%. Abies spp. showed a slight decline, but nevertheless had the highest percentage of damaged trees in 1994 and 1995, among both the conifers and the broadleaves. However, with 2 207 trees, Abies spp. had only little influence on the total coniferous result, which is dominated mainly by Pinus spp. with 30 482 trees and Picea spp. with 18 651 trees. Pinus spp. showed no change since 1994 in the proportion of damaged trees (25.7%). The share of damaged Picea spp. trees rose slightly from 28.5% to 29.8%. The proportion of damaged coniferous CSTs increased from 26.7% to 27.3%, mainly as a result of the deterioration in these most comprehensive species groups.

92. Both conifers and broadleaves suffered less discoloration in 1995 than in 1994. As in the previous year, some species groups deteriorated over the period (1994-1995), but most improved, especially the conifers.

93. Among the broad-leaved CSTs, the share of discoloured Quercus ilex (discoloration classes 1-4) increased from 6.4% to 9.1%. In contrast, the respective proportion of Quercus (dec.) spp. dropped from 17.6% to 14.7%. Further obvious increases in discoloration occurred in Eucalyptus spp. (from 9.3% to 11.7%). Other notable decreases in discoloration were found in "other broadleaves" (from 12.9% to 11.1%) and Castanea sativa (from 19.0% to 17.9%), which, however, comprise only few CSTs. The total result of the broad-leaved CSTs was dominated by the improvement in deciduous Quercus spp. and the small changes in Fagus spp., which accounted for more than half the broad-leaved CSTs with 12 080 and 9 439 trees, respectively.

94. The discoloration among the coniferous CSTs improved for the total and for all individual species groups, with the exception of "other conifers", which soared from 9.4% to 21.7%. In Abies spp. it decreased notably from 21.7% to 18.6%.

5. Changes in defoliation since 1988

95. A separate sample of trees common to the years 1988-1995 was defined in order to study the trends in forest condition over a longer period. Commencing this time series in 1987 would have resulted a far lower number of common trees. Of the total tree sample, 27 933 trees common to all surveys from 1988 to 1995 were found.

96. The evaluation was carried out species-wise, both for the total number of common trees and for the individual regions. Only the 10 most common species, each of which comprised more than 800 common trees, were evaluated,

as well as Abies alba and Picea sitchensis. These 2 species had lower tree numbers and were not to be included according to their ranking, but they are of importance in particular regions, especially in the Mountainous (south) and in the Atlantic (north) region. As in the previous surveys, there was no evaluation for those regions in which the number of trees of a certain species was lower than 100. No common trees since 1988 existed in the Boreal, the Boreal (temperate) and the Continental regions.

97. Among the conifers, the species with the highest percentage of damaged trees in 1995 were Abies alba (25.4%) and Pinus halepensis (24.8%), followed by Picea abies (22.6%) and Picea sitchensis (22.2%). Pinus pinaster has enjoyed a strinkingly even and stable health status since 1988, with a remarkably low share of damaged trees, mostly below 10%. Pinus halepensis however, seems to have continuously deteriorating its crown conditions, as the proportion of damaged trees soared from 2.7% in 1991 to 24.8% in 1995.

98. Among the broadleaves, Quercus suber shows a remarkable development. After a surge in the share of damaged trees from 0.7% in 1988 to 9.4% in 1989 and particularly to 43.2% in 1990, the maximum of 43.9% was reached in 1991. Between 1992 and 1993 the health status of Quercus suber improved continuously. In 1994 the share of damaged trees again rose to 11.7% and in 1995 it reached 23.6%. Other broad-leaved species show similar trends, indicating a slight deterioration in their health status since 1992.

B. National surveys

99. In 1995, 28 European countries submitted national reports in order to present the results of their national surveys. Thirty countries provided numerical data, which are tabulated in annexes I-VII. Annex I provides basic information on the forest area and survey design of each participating country. The distribution of the trees over the defoliation classes is tabulated for all species in annex II, for the conifers in annex III and for the broadleaves in annex IV. The annual changes in the results are presented for all species, for conifers and for broadleaves in annexes V to VII. It has to be noted, however, that no direct comparison between the annual results is possible due to differences in the samples. For several countries there are no data for certain years neither in the tables nor in the graphics, if there were large differences in the samples due to for instance, changes in the grid network, missing data for certain years or the foundation of new member States.

100. The results of the submitted national surveys concerning all species assessed can be summarized as follows.

101. Although no direct comparisons between different countries are possible because of differences in the application of the common methodology and general variations in climatic and site factors, the data point to division of the countries into three groups.

102. As in the previous year, in Ireland only conifers and in Austria only trees 60 years and older were assessed. In two countries, namely Austria and Portugal, the percentage of sample trees classified as damaged (defoliation classes 2-4) was lower than 10%.

103. In nine of the countries the percentage of sample trees classified as damaged ranged from 10% to 20%. These countries are Estonia, Finland, France, Hungary, Italy, Latvia, the Russian Federation, Sweden, and the United Kingdom.

104. In another 19 countries, namely Belarus, Belgium (including Flanders and Wallonia), Bulgaria, Czech Republic, Denmark, Germany, Greece, Ireland, Lithuania, Luxembourg, Netherlands, Norway, Poland, Romania, Slovakia, Slovenia, Spain, Switzerland and Ukraine, the percentage of sample trees classified as damaged was greater than 20%, with a maximum of 59.6%. These are nearly two thirds of the countries which reported survey results.

105. A deterioration occurred in 18 countries which reported survey results. Table 11 describes the changes in defoliation observed between 1994 and 1995 in classes 2-4 by referring to all 30 countries which submitted survey results (annexes V to VII). Changes are rated as unimportant if equal to or less than 5.0 percentage points, as slight between 5.1 and 10.0 percentage points, as moderate between 10.1 and 20.0 percentage points and as substantial if exceeding 20.0 percentage points from one year to the next.

106. As regards all species, a slight increase in defoliation occurred in four countries, whereas a slight decrease was observed only in one country. Changes in defoliation are obvious in both the conifers and the broadleaves. Concerning the conifers, a rise occurred in four countries, whereas a fall was observed only in two. In three countries the increase in the conifers was moderate, but no substantial increase was found anywhere. In comparison to 1994, the defoliation among the broadleaves clearly worsened. In five countries a slight and in two countries a moderate increase occurred. However, in none of the countries was there a substantial increase in the broadleaves. In one country a moderate decrease was observed.

C. Interpretation of the results

107. The results of the crown condition assessments are based on the transnational and national surveys of 1995. The transnational survey comprised

a total of 117 305 trees on 5 388 plots in 30 countries, which is the largest transnational database ever, due to the completion of the grid in Sweden and Finland and the inclusion of the Russian Federation. The national surveys comprised 635 736 trees on 25 170 plots in 30 countries.

108. In accordance with the objectives of the large-scale transnational and national surveys, their results can be interpreted with respect to the extent, spatial distribution (climatic regions) and temporal development of forest damage in terms of crown condition. Moreover, the relationship between crown condition and stand age is investigated.

109. The national reports contain valuable information on cause-effect relationships, which was also used for the interpretation of the survey results.

Spatial variation in crown condition between different climatic regions

110. Of the total transnational tree sample, 25.3% was classified as damaged. The extent of defoliation varied greatly between the various climatic regions. Defoliation was the highest in central Europe, with 42.2% in the Sub-Atlantic and 34.7% in the Continental regions. The lowest defoliation was recorded in the Atlantic (south) region, with, 7.8%.

111. The differences in defoliation observed between the various climatic regions, however, cannot necessarily be explained as being of climatic origin. The reason is that the various climatic regions may have different influences other than climate on crown condition. Moreover, the long-term, average climatic conditions should not reveal themselves in defoliation, because the reference trees are normally chosen so as to account for these particular climatic conditions.

112. Differences in defoliation between climatic regions may be partly due to methodological differences between countries. The main purpose of having the climatic regions is to be able to examine trends in regions of different climate and vegetation, rather than comparing absolute defoliation.

113. As in previous years, weather strongly affected forest condition in several countries. More than half the participating countries referred to meteorological patterns as influencing forest health. In most cases, drought (e.g. in the Mediterranean lower and higher regions) or cold winter temperatures (e.g. in the Boreal region) were mentioned as triggering factors for deteriorating forest health. Hot summer weather was also regarded as predisposing factor for forest decline. Subsequent pest infestation was often considered as secondary, fostered by weather conditions in 1995 or previous years. Some countries, however, reported improvements due to higher

precipitation in winter or early in the growing season.

114. The development of defoliation, as derived from the transnational survey, largely confirms the explanations given in the national reports. Mean plot defoliation deteriorated significantly in all climatic regions except in the Boreal (temperate) region. The improvement in the Boreal (temperate) region coincides with more favourable meteorological conditions in some countries in this region. Many national reports from the other climatic regions, in contrast, emphasized that hot, dry summers (or cold winters) impaired forest condition.

Relationship between crown condition and stand age

115. A strong positive correlation between forest condition and stand age proved significant throughout all Europe. The 1995 survey showed that the share of damaged trees increased from (12.6%) in young trees to 30.1% in trees older than 120 years in EU member States. For total Europe, the increase in defoliation with age was even larger. This reflects the well-known phenological interdependencies between ageing and loss of foliage. Possibly, older trees are also more susceptible to unfavourable environmental conditions than young trees.

Temporal variation in crown condition

116. The direct comparison between the 1994 and 1995 surveys or longer survey periods refers to different total tree samples. Thus the comparison between the overall results obtained for different years may distort the development of forest condition. To avoid bias caused by inhomogeneous tree samples, the actual changes are derived from the common sample trees (CSTs) (see paras. 79-80 above).

117. The share of CSTs in defoliation classes 2, 3 and 4 increased by 1.6 percentage points from 25.2% to 26.8%. The highest rise in defoliation was recorded in defoliation class 2: 1.0 percentage point. The deterioration in classes 3 and 4 appeared less distinct.

118. The most severe deterioration was observed in the Mediterranean (lower) region, where the share of damaged trees increased by 6.8 percentage points between 1994 and 1995. This result is statistically significant, as is the respective change for the Mediterranean (higher) region, 4.3 percentage points. The forest condition in the Boreal and in the Atlantic (north) regions also deteriorated significantly by 2.3 percentage points and 2.2 percentage points, respectively. In the other climatic regions, the recorded changes in forest condition were less than 2 percentage points, or the deterioration did not prove statistically significant. In the Boreal (temperate) region, on the

other hand, the forest condition improved significantly, by 3.7 percentage points.

119. In the Atlantic (north and south) climatic regions, the overall increase in damaged trees reflects the severe deterioration in Fagus sylvatica. It was mentioned in national surveys as being the species showing the highest degree of deterioration. The development of the conifers was not as clearly explainable. Although Picea abies and Pinus nigra showed generally improving health conditions in both regions, deterioration was reported locally by certain countries.

120. In southern and south-western Europe, the deterioration of forest condition was partly caused by hot and dry summers over several years. Succeeding pest infestation was recorded, e.g. in Spain, Greece and Portugal. In France and Spain, late frost periods occurred after flushing, causing severe deterioration in forest condition. The species with the highest increase in defoliation were Eucalyptus spp., Quercus ilex and Quercus suber. Eucalyptus spp, however, showed the lowest share of damaged trees of all assessed tree species. The severe impact of hot and dry summers on forest decline was also observed in the Continental region. The most severe worsening occurred in plots where the forest condition was already poor.

121. In the Sub-Atlantic region, plot defoliation decreased, mainly in Germany and in parts of Poland. The condition of Quercus spp. improved after having deteriorated during the previous years. The improvement in Pinus spp. was notable. This was held to be brought about by the improvement in environmental conditions in certain areas. Favourable weather was regarded as the main factor behind the improvement. The effect of pests was considered to be negligible. Yet the improvement in the condition of these species was not large enough to show an overall improvement in the forest condition in the Sub-Atlantic region.

122. The Boreal (temperate) region was the only climatic region where forest condition improved considerably. The national surveys stressed the high share of Pinus sylvestris among the trees showing improving health condition. On the other hand, severe deterioration was recorded for other tree species. The mild winter was blamed for pests (e.g. Lithuania). Air pollution, too, was partly regarded as impairing forest condition. The worsening condition of several tree species and the overall improvement are no contradiction: due to its high share of assessed trees, the condition of Pinus sylvestris weighs more heavily in the final results than the health condition of other tree species, which represent distinctly smaller shares of the sample.

123. With respect to the long-term comparison between 1988 and 1995, a common sample of trees was also defined. However, it comprises only the Atlantic

(north), Atlantic (south), Sub-Atlantic, Mountainous (south), Mediterranean (higher) and Mediterranean (lower) regions. Trees common to 1988-1995 representing other climatic regions were not available. The long-term comparison is based on a common sample consisting of 19 065 trees for 12 selected species.

124. 69% of the common sample was considered healthy in 1988 (defoliation class 0). This share declined annually to reach 39% in 1995. At the same time, the share of damaged trees surged (from 8.2% in 1988 to 22.2% in 1995). In the Atlantic (north), Sub-Atlantic, Mediterranean (higher) and Mountainous (south) regions, a continuous increase in damaged trees was observed. In the Mediterranean (lower region, health forest health declined between 1988 and 1992. In the next assessment period, a distinct improvement was recorded. Afterwards, the number of damaged trees rose again. In 1995, a new maximum of damaged trees was recorded.

125. Picea abies and Pinus sylvestris make up the biggest shares of the common sample (17.6% or 15.9%, respectively). Their shares of damaged trees clearly increased between 1988 and 1995. Thus, the overall result is mainly influenced by these two tree species. In the national reports a series of cold winters was considered as partly impairing the forest condition. Also mentioned was the influence of air pollution. Some national reports suggest that the slowdown in forest decline may be the result of the reduction in air pollutants, mainly SO_2.

126. The Atlantic (south) region still has the smallest share of damaged trees. Due to the small database for the long-term assessment of forest condition, a satisfactory validation by means of statistics is still missing. Nevertheless, the comparison of the long-term trends as documented by the common sample of the 1988-1995 period gives evidence of the large-scale development of forest condition in Europe.

Main factors influencing forest condition

127. Definite causes for the deterioration of forest condition are difficult to identify. National surveys offer a variety of explanations for the forest condition development in the respective countries. Adverse weather conditions play a major role as a stress factor. Frost and drought have an important impact on the forest condition in the succeeding vegetation period. Consequently, trees might be more susceptible to insect or fungi attacks. The susceptibility of trees to pest infestation may be intensified by air pollution. Almost half of the countries participating in the transnational survey of forest condition mentioned air pollution as potentially affecting trees. These countries are mainly situated in central and south-eastern Europe, where forest condition is deteriorating the most.

128. While site conditions and natural damaging agents, particularly drought, explain a substantial part of the deterioration in forest condition observed over large areas during the last decade, long-range transboundary air pollution could also be responsible for this trend, as stressed in many of the national reports submitted by individual countries. This phenomen clearly deserves particular attention.

IV. CONCLUSIONS AND RECOMMENDATIONS

129. During the last 20 years, sulphur emissions have dropped dramatically reduced over much of Europe. At the same time, forest damage has continued to increase. This apparent contradiction could be the result of many different factors. Sulphur represents only one of several different types of pollutants, the majority of which have not yet been subject to emission reductions. In many areas, the problems caused by sulphur are related to soil effects, and a considerable time lag may occur between the cuts in emissions and reductions in soil sulphur levels. A further factor is that all pollution effects are superimposed on a suite of natural stresses. These natural stresses may be sufficiently great to obscure any improvements brought about by changes in pollution. Consequently, a reduction in air pollution will not necessarily be immediately apparent in forest health trends.

130. The role of air pollution has remained difficult to separate from the influence of other stressors, as cause-effect studies were not possible with crown condition data alone. However, the full range of monitoring data on level I, i.e. the time series of crown condition data, the soil condition survey data and the foliage analysis data, open many possibilities for cause-effect studies. This holds true especially for interdisciplinary studies of the impact of air pollution on forests and the calculation of critical loads and levels in connection with other monitoring programmes. Such in-depth studies of the comprehensive level I database have been launched by ICP Forests and EC. The results will be presented inter alia in a special overview report in 1997.

131. For time-series analyses and more complex studies linking forest condition and various factors including air pollution, the continuation of level I monitoring is indispensable. It will also keep resource managers and policy makers informed of forest health status and trends, and will facilitate the assessment of the effectiveness of air pollution abatement measures in the long term. Moreover, the results of the extensive monitoring on level I may be used later for the large-scale extrapolation of findings derived from the small-scale intensive monitoring (level II) and ecosystem analysis (level III). Consequently, whilst level I is being continued and evaluated, level II is being strengthened and preparations for level III have begun.

132. With about 643 permanent plots for intensive monitoring installed within the Community scheme and ICP Forests, the level II network is nearing completion. Amendments to the respective guidelines are under preparation, aiming at an improved crown condition asssessment and soil analyses on level II plots. The inclusion of meteorological measurements, soil liquid phase analyses, ground vegetation assessments and application of aerial photography are in a test phase.

133. Although most European countries have now submitted information, it is felt that a continuing effort is needed from ICP Forests and EU to assist countries participating in the level II programme. Other interested countries should be encouraged to participate as well.

134. With respect to the implementation of level III, ICP Forests is developing a strategy intended to include harmonized monitoring activities with the Task Force on Integrated Monitoring on common plots.

135. In addition, ICP Forests has prepared a document "Ecological impacts of some heavy metals related to long-range transport" focusing on the effects of selected heavy metals on forest ecosystems. The document is based on literature supplied by the participating countries of ICP Forests and on database retrieval. It concludes that single metal concentrations in the humus layer, reported in forest soil condition surveys (i.e. level I), are so far not high enough to severely affect forest ecosystems. However, risk assessment should preferably be based on soil solution concentrations (level II), because only elements present in ionic forms in soil solution are taken up by plants. Data on soil solution chemistry, especially concerning heavy metals, are sparse; however, in future results from intensive monitoring may help to close the gap.

136. To fulfil the needs of comprehensive reporting on future results to be expected from the growing forest monitoring activities, it is recommended that a new reporting system should be developed. In the future, the annual executive forest condition report could summarize the progress made in such fields as forest soil analyses, foliage analyses, in-depth evaluations of level I and level II data and other special topics, as well as the usual results of the crown condition assessment. Besides this executive report, a number of technical reports would be issued documenting in detail the results in all fields.

137. The activities carried out within the Community scheme and ICP Forests are not only of vital importance for the protection of the European forests against atmospheric pollution and for the effective implementation of the Convention on Long-range Transboundary Air Pollution, they also contribute to meeting the objectives of Resolution S1 of the Strasbourg Ministerial

Conference and Resolution H1 of the Helsinki Ministerial Conference on the Protection of Forests in Europe, which identified the maintenance of forest ecosystem health as one of the basic criteria of sustainable forest management in Europe. In this context the common activities of ICP Forests and EU represent the most appropriate framework for providing information on the most suitable quantitative indicators for the monitoring of relevant changes of this criterion over time.