# *CHAPTER V: FOREST CONDITION AND DAMAGE TO FORESTS AND OTHER WOODED LAND*[1]

## Introduction

The TBFRA-2000 enquiry has collected information from National Correspondents on the forest resources of temperate and boreal forests. The first such assessment was published in 1947, and concentrated very much on the wood resources of the boreal and temperate zones. Subsequent enquiries were similar in emphasis, although the 1990 assessment was extended to include non-wood goods and services. TBFRA-2000 differs from earlier assessments in that it has sought information not only on the extent of the resource, but also on its condition. There have been particular concerns over the issues of forest condition and forest damage, as the maintenance of forest condition is a clear prerequisite for the sustainable management of forest resources. Consequently, these issues have received a considerable amount of attention from both scientists and policy makers. This chapter provides a preliminary assessment of the information available on forest condition in the temperate and boreal region. At the same time, it highlights the difficulties associated with making such an assessment.

There is considerable concern about forest health and a general desire that forest health (also sometimes known as forest condition, or forest vitality) is maintained. This stems from observations of forests that are clearly unhealthy, such as those devastated by air pollution from smelters (e.g. at Nikel, Monchegorsk and Noril'sk in the northern part of the Russian Federation). However, there is no universal set of criteria for defining a healthy forest, and existing concepts vary widely. The idea of the forest as an ecosystem is now standard, so definitions based on the health of individual trees are no longer strictly applicable. However, trees form the dominant structural element of a forest, so their health plays an important part in the overall health of the ecosystem. Today most definitions of forest health fall in a continuum between the health of some form of super-organism (the forest ecosystem) and the long-term sustainability of the forest. As ideas on the subject are still being developed, it is not possible to say that any one definition is correct. This creates major problems for an inventory such as the TBFRA-2000.

Similar concerns exist over the extent of damage to forests. Strictly speaking, the term damage often implies an economic loss. However, this is rather inconsistent with the idea that forests perform multiple functions, some of which cannot at present be valued economically (see Chapter VI). As a result of this conceptual problem, combined in some cases with a lack of appropriate data, many countries had difficulties in providing quantitative or even qualitative estimates of the damage to forests caused by particular agents. A further difficulty was that the extent of damage qualifying for inclusion was not stated. All of the different damaging agents can cause differing degrees of damage. In some cases, damage is related to loss of yield, but this is very much an economic definition and is of questionable applicability in, for example, a forest reserve. There is also a problem with the reporting of damage. At what point does an area that was damaged in the past no longer count as damaged? For example, an area damaged by industrial pollution can be counted in the year that the damage occurred or in every year that the damage persists. Conversely, in the case of fires, the area of damage is normally reported in the year of the fire, but damage may persist much longer. With fire, there is the added problem that in some cases, it is a natural component of the ecosystem and the use of the term damage to describe its effects is therefore questionable.

In many countries, there are no formal inventories of forest health, although major inventories of tree defoliation exist in both Europe and North America. There are also records of fire frequency and extent in many countries. Information on other damaging agents is more scattered and, in many cases, the figures submitted by National Correspondents represent the best available estimates for particular damaging agents, rather than the results of specific surveys and inventories.

This chapter provides an overview of the data on forest condition in 55 countries, collected or collated by the TBFRA. Some statistical information is available from all countries involved in the TBFRA, and this has been summarized in Main Tables 70 to 78. The information covers the most important agents causing damage to forests, the number and extent of fires in forests and OWL and the extent of defoliation, a widely used indicator of tree condition. Two sets of tables (Main Tables 70-71, 72-75) therefore deal with the causes of damage to forest, whereas the third (defoliation, Main Tables 76-78) looks at the response.

[1] This chapter was prepared by Mr. John L. Innes (see Appendix V).

**Material collected by the TBFRA-2000.**

Information on forest condition for the TBFRA-2000 has been summarized in Main Tables 70 to 78. Main Tables 70 and 71 present information on the extent of damage to forests by known and unknown causes in each country. The material is based on the submissions made by individual countries. Main Tables 72-75 are based partly on the submissions from individual countries and partly on a separate forest fires database maintained by the Timber Section, Trade Division of the UN Economic Commission for Europe, also based on official data, supplied annually by countries. Main Tables 76-78 are drawn from the reports of the International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (organized by the UN Economic Commission for Europe under the auspices on the Convention on Long-Range Transboundary Air Pollution) and the European Union Scheme on the Protection of Forests Against Atmospheric Pollution, supplemented with information supplied by individual countries. Additional tables are also presented in the text, and the sources of information for these are given individually.

**Damage to forest and other wooded land (Main Tables 70 and 71).**

The aim of these tables is to present sufficient data to enable the assessment of the condition of the forest and other wooded land, and the extent that the forest is under threat, and to provide information on damage to the forest from different causes. The indicators used for the condition of forests and other wooded lands, the level of threat and the causes of damage. are given below:

- Total area of forest and other wooded land with damage by known causes
- Primarily damaged by insects and disease
- Primarily damaged by wildlife and grazing
- Primarily damaged by fire
- Primarily damaged from known local pollution sources
- Primarily damaged by storm, wind, snow or other identifiable abiotic factors
- Total area of forest and other wooded land with damage from unidentified causes

The questionnaire requested information on the areas of forest damaged by specific agents. The level of damage that would qualify for entry was not specified, but countries were invited to comment on this. Very few did, although in Norway, the figures for damage refer to areas where growth has been reduced by more than 10 per cent. No data were supplied by Sweden (except for damage by wildlife and grazing) because of the uncertainties associated with the unclear terminology. The figures on damage by insects and disease for Slovakia represent the sum of slightly and heavily damaged areas.

In Poland, a variety of different concepts exist for damage. This means that the figures for each category cannot be directly compared. Damage by insects and disease refers to the area over which chemical control should be carried out. Damage by wildlife was assessed on the basis of where heavy damage occurred over at least 20 per cent of the stand area. Damage by fire refers to those forest areas destroyed by fire. Damage by abiotic factors was assessed by a questionnaire survey and refers to the areas in which significant damage was reported. Although producing problems for comparisons between different causes of damage, this approach seems more useful than an overall assessment of unspecified damage levels in forests.

A second source of information on this subject is the annual survey of crown condition undertaken by the ICP Forests programme. This is based on a systematic grid of plots across Europe (mainly 16 x 16 km), with each plot normally having a fixed number of trees (usually 24). An exception is Switzerland, where fixed-area plots are used. As the majority of the data set is compiled from variable-area plots, it is not possible to directly relate the data to the area of forest affected. The information is given in Table 5.1. The assessments are based on the presence or absence of a particular agent on a particular tree, so any one tree can be scored for having more than one damaging agent present. The nature of the original data collection form means that it is now difficult to ascertain from the forms whether a blank entry means that an agent was absent or that it was not assessed.

The interpretation of the data in Main Table 70 is complicated by differences in the ways individual countries handled the questionnaire. Some information was made available in the written comments to the questionnaire, or in subsequent discussions with the National Correspondents, but many uncertainties remain. A particularly important point is the differing nature of the data in Main Table 70. For some countries, the figures represent the mean damaged area for a particular 5- or 10-year period. In others, they are the values for a single year. In yet others, the figures represent the cumulative totals (over variable time periods) of forest areas damaged each year by specific agents.

No information was available for some countries. In Australia, for example, there is no national survey of forest damage although some information is available on the relative importance of pests and diseases (Table 5.2). Additional information relates to forest dieback that is widespread and severe in five States, widespread and having an adverse effect in the Australian Capital Territory (ACT), and widespread in the Northern Territory. Various causes are involved,

TABLE 5.1

**Percentages of trees assessed in 1997 by ICP Forests for each damage type, based on the total tree sample for Europe**

| Damage type | Total Europe | | |
|---|---|---|---|
| | Not assessed | Assessed and not present | Assessed and present |
| Game and grazing | 61.8 | 37.2 | 1.0 |
| Insects | 56.4 | 34.8 | 8.8 |
| Fungi | 57.6 | 37.0 | 5.4 |
| Abiotic agents | 58.2 | 36.4 | 5.4 |
| Action of man | 58.0 | 38.1 | 3.9 |
| Fire | 61.1 | 38.5 | 0.4 |
| Classical smoke damage | 63.0 | 36.9 | 0.1 |
| Other causes | 59.7 | 35.6 | 4.7 |

Source: UN/ECE and EC 1988, Forest Condition in Europe, Geneva and Brussels, 1998.

TABLE 5.2

**Pests and diseases in Australian forests, by State or Territory**

| Pest of disease | Australian Capital Territory | New South Wales | Northern Territory | Queens-Land | South Australia | Tasmania | Victoria | Western Australia |
|---|---|---|---|---|---|---|---|---|
| Vertebrates | | | | | | | | |
| Dogs (***Canis familiaris***) | 3 | 3 | 3 | 3 | - | - | 1 | - |
| Foxes (***Vacis vulpes***) | 5 | 4 | 1 | 5 | 3 | | 3 | 5 |
| Goats (***Capra hircus***) | 1 | 1 | 3 | 3 | 1 | 2 | 1 | - |
| Kangaroos (***Macropus* spp.**) | 5 | 3 | 3 | 3 | 3 | - | 3 | - |
| Mice (***Mus musculus***) | 3 | 3 | 3 | 3 | 3 | - | 1 | - |
| Pigs (***Sus scrofa***) | 5 | 3 | 5 | 5 | - | - | 1 | 3 |
| Possums | 3 | 3 | 3 | 3 | 1 | 5 | 1 | - |
| Rabbits (***Oryctolagus cuniculus***) | 5 | 4 | 3 | 3 | 5 | 4 | 3 | 3 |
| Pathogens and fungi | | | | | | | | |
| Fungi (***Phytophthora* spp.**) | 4 | 3 | 3 | 5 | - | 5 | 5 | 5 |
| Invertebrates | | | | | | | | |
| Bees (***Apis mellifera***) | 4 | - | 3 | 3 | - | 3 | 3 | 3 |
| Christmas beetle (***Anoplognathus* spp.**) | 3 | 4 | 3 | 3 | - | 1 | 3 | - |
| Grasshoppers (***Acridids***) | 1 | - | 3 | 5 | 3 | 3 | 1 | 5 |
| Mosquitoes (***Culicids***) | 1 | - | 3 | 1 | - | 3 | 3 | 5 |
| Sirex wasp (***Sirex noctilio***) | 3 | 3 | - | 1 | 5 | 3 | 2 | - |
| Plant pests | | | | | | | | |
| Bracken fern (***Pteridium esculentum***) | 3 | - | - | 3 | 5 | 3 | 3 | - |
| Blackberry (***Rubus vulgaris***) | 5 | 5 | - | 3 | 1 | 4 | 5 | 3 |
| Grasses, exotic (Unidentified ***Poaceae***) | 4 | 2 | 3 | 5 | 4 | 1 | 1 | 4 |
| Lantana (***Lantana camara***) | - | 3 | 1 | 5 | - | - | 1 | - |

1 Occurs but is not widespread, has little impact, and requires little or no control.

2 Extent and impact are limited but control measures are extensive.

3 Widespread or having adverse impacts.

4 Widespread and having adverse impacts.

5 Very widespread and having severe adverse impact.

Source: Montreal First Approximation Report (1997).

including tree age, changes to soil as a result of sheep and cattle grazing and increasingly intensive pasture production practices, changes to groundwater, depredation by insect attacks (such as pasture scarabs), attack by pathogens, and drought. *Phytophthora* and *Armillaria* species can cause dieback-like diseases. Other fungal pathogens, particularly native ones, are present and may affect forest trees under seasonal conditions, but do not appear to be the cause of any long-term problems. Several native and exotic insects are considered as pests in plantations and native forests managed for timber production.

In Australia, cats, dingoes, dogs, deer, donkeys, horses, goats, hares, rats, mice, possums, kangaroos and foxes are all widespread in forests and represent a serious threat to forest species and ecosystems. Possums and kangaroos can seriously damage regenerating young plantations by browsing on seedlings. Foxes are the most widespread exotic animals adversely affecting forest ecosystems. They occur across Australia and have severely limited populations of ground-dwelling mammals. Such mammals are important components of the ecosystem by helping to spread mycorrhizal fungi upon which the health of the trees depends. Feral animals may also spread disease that adversely affects trees and other plants. Pigs, for instance, are known to spread *Phytophthora cinnamomi* and may act as a feral "reservoir" of potentially devastating animal diseases such as footrot.

Similar problems exist in New Zealand, where there are also no national data available in the format required for Main Table 70. Significant damage has been done to the indigenous forest by introduced mammals, particularly the Australian brush-tailed possum (*Trichosurus vulpecula*) and a variety of deer species, but has not been quantified (see Table 5.3). This table illustrates the extent of the area of Department of Conservation land at risk from browsing mammals if no control operations were in place. Some 1.76 million hectares out of a total 7.97 million hectares of land areas administered by the Department of Conservation would be considered to be at risk of major change without control operations. Storm damage (primarily from wind) occurs infrequently in New Zealand. In the past, there were significant areas of plantation forest where blowdown was a serious risk but forest management practices have been developed to minimize the risk. The last significant storm damage was in 1988, when tropical cyclone Bola struck. This cyclone did more damage to the steep hill country cleared for grazing than to forested areas, although 5,000 ha of forest were estimated to have been damaged in 1988. About 1,000 ha of forest are thought to be primarily damaged by storms each year in New Zealand.

TABLE 5.3

**The area of Department of Conservation (DoC) land in New Zealand at risk from browsing mammals**

| Likely impact if no control operations were in place [1] | North Island (ha) | South Island (ha) | Total DoC estate (ha) |
|---|---|---|---|
| Total forest collapse [2] | 245 000 | 305 000 | 550 000 |
| Major composition change [3] | 364 000 | 681 000 | 1 045 000 |
| Major loss of biodiversity [4] | 20 000 | 149 000 | 169 000 |
| Area at risk of major change | 629 000 | 1 135 000 | 1 764 000 |
| Minor loss of biodiversity [5] | 213 000 | 1 100 000 | 1 313 000 |
| Area at risk of major or minor change | 842 000 | 2 235 000 | 3 077 000 |

[1] Control operations covered 1.3 million hectares in 1995/96, 70 per cent of the major risk areas.

[2] Total canopy loss, significant species loss, replacement of forest by shrubland/grassland.

[3] Significant canopy and species loss, change in forest structure from complex to simple.

[4] Significant species loss and change.

[5] Some species loss and change.

Source: The State of New Zealand's Environment 1997, Ministry of Environment, Wellington, pp. 8-45.

The figures for Canada are very large, reflecting the large forest area of the country. However, in the Canadian system, the areas affected by individual pests and diseases are reported separately, and the figures in Main Table 70 reflect the sum of all reported areas. Thus, if an area is affected by two different disorders, it will be reported twice. In addition, the figure is the sum of all areas affected in each year in the period 1986-1995. If a particular area was affected by the same problem in more than one year, it will have been counted more than once. Only areas with moderate (30 to 69 per cent) or severe (70 to 100 per cent) defoliation are reported. Figures for individual years are much lower, as shown in Table 5.4. There is substantial year-to-year variation in the incidence of particular pests (Table 5.5). In peak years, such as for the Forest Tent Caterpillar in 1991, the area of moderately and severely defoliated forest may be very large. For example, almost 19 million ha were affected in Quebec in 1991, a figure that is more than double the average of 8 million ha of damage reported from Europe from all causes (Main Table 70). To put these figures in perspective, the forest area of Quebec is 83.9 million ha, whereas the forest area of Europe is just over double, at 176.6 million ha.

Some countries, including Denmark, Iceland, Japan, Switzerland, and the United Kingdom indicated that their figures in Main Table 70 are estimates, as no formal inventory is undertaken. Germany was unable to supply any information on damage, although the National Correspondent noted that damage due to insects, wind and game was present. Similarly, no estimates were available for Greece, although the presence of disease problems in *Castanea* and *Cupressus* was noted.

Peak years of damage are reported in Main Table 71. As might be expected, there are no clear patterns in the data, although it is evident that damage by a specific agent in a particular year can be substantial.

TABLE 5.4

**Selected major pests in Canada in 1994: area of moderate to severe defoliation**

| Province or Territory | Eastern Spruce Budworm | Jack Pine Budworm | Eastern Hemlock Looper | Forest Tent Caterpillar |
|---|---|---|---|---|
| | *Choristoneura fumiferana* | *Choristoneura pinus ssp. pinus* | *Lambdina fiscellaria ssp. Fiscellaria* | *Malacosoma disstria* |
| | | *(1000 ha)* | | |
| Newfoundland and Labrador | 0.0 | - | 11.6 | - |
| Nova Scotia | 0.0 | - | 0.0 | - |
| New Brunswick | 0.0 | - | 0.0 | 392.0 |
| Prince Edward Island | 2.5 | - | - | - |
| Quebec | 2.0 | 0.3 | 0.4 | 3.7 |
| Ontario | 4266.7 | 419.3 | 1.1 | 166.1 |
| Manitoba | 48.5 | 0.0 | - | 4.5 |
| Saskatchewan | 52.3 | 0.0 | - | 23.1 |
| Alberta | 173.7 | 0.0 | - | 102.1 |
| British Columbia | 173.4[1] | - | 5.2[2] | 93.6 |
| Northwest Territories | 370.3 | - | - | - |
| Yukon | - | - | - | - |
| Total | 5089.4 | 419.6 | 18.3 | 785.1 |

[1] Includes other budworms.

[2] Includes Western Hemlock Looper (***Lambdina fiscellaria ssp. lugubrosa***).

Source: J. P. Hall, 1996, "Forest Insect and Disease Conditions in Canada 1994", Forest Insect and Disease Survey, Natural Resources Canada, Canadian Forestry Service, Ottawa.

### Interpretation of Main Tables 70 and 71

The figures presented in Main Table 70 should be interpreted with care. In particular, comparisons should not be made between countries, as some countries cumulated damage during the reference period whereas others reported averages. Yet others only reported damage from a single year.

### Insects and diseases

Insects and diseases represent the most important causes of damage in many forests. However, it is difficult to identify a level at which damage should be reported. In some countries (e.g. Norway), defoliation attributable to this cause was only reported if it was associated with significant growth losses. In others, it was related to mortality. In addition, some countries (e.g. Canada) assess insect damage by species, and a given area may be affected by more than one species at any one time. This means that the figures may represent double and triple counting in areas affected by more than one insect, inflating the extent of the total area defoliated. The majority of trees have some foliar damage caused by insects. This does not necessarily mean that growth losses or mortality will occur, and a tree may even recover the same season as the infestation. What is important to note is that the impacts of specific insects and diseases vary. For example, spruce budworm (*Choristoneura fumiferana* Clemens) can defoliate the same area for several years before there is mortality, but growth losses occur quickly after defoliation reaches about 30 per cent. In contrast,

TABLE 5.5

**Area of moderate and severe defoliation caused by the Eastern Spruce Budworm (*Choristoneura fumiferana*) and Forest Tent Caterpillar (*Malacosoma disstria*) in Canada, 1990-1994**

| Province or Territory | 1990 | 1991 | 1992 | 1993 | 1994 |
|---|---|---|---|---|---|
| | | (1000 ha) | | | |
| Eastern Spruce Budworm | | | | | |
| Newfoundland and Labrador | 2.2 | 2.3 | 1.9 | 0.0 | 0.0 |
| Nova Scotia | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| New Brunswick | 237.0 | 266.0 | 84.3 | 0.0 | 0.0 |
| Prince Edward Island | 0.1 | 0.1 | 35.0 | 33.8 | 2.5 |
| Quebec | 871.8 | 290.0 | 20.7 | 0.4 | 2.0 |
| Ontario | 6 783.0 | 9 066.0 | 9595.8 | 8 991.2 | 266.7 |
| Manitoba | 19.0 | 30.0 | 26.3 | 13.8 | 48.5 |
| Saskatchewan | 18.7 | 16.0 | 87.0 | 22.6 | 52.3 |
| Alberta | 109.1 | 141.0 | 34.2 | 46.5 | 173.7 |
| British Columbia | 398.1 | 245.0 | 139.0 | 170.0 | 173.4 |
| Northwest Territories | 113.6 | 130.0 | 80.0 | 53.6 | 370.3 |
| **Total** | **8 552.6** | **10 186.4** | **10 104.2** | **9 331.9** | **5 089.4** |
| Forest Tent Caterpillar | | | | | |
| New Brunswick | 0 | 2.9 | 77.5 | 196.0 | 392.0 |
| Quebec | 92.0 | 50.0 | 37.0 | 39.9 | 3.7 |
| Ontario | 9 486.0 | 18 870.0 | 16 051.4 | 656.3 | 166.1 |
| Manitoba | 15.2 | 58.1 | 51.2 | 3.6 | 4.5 |
| Saskatchewan | 260.9 | - | 0.0 | 375.8 | 23.1 |
| Alberta | 609.2 | 129.9 | 0.0 | 19.0 | 102.1 |
| British Columbia | 206.0 | 131.0 | 47.3 | 86.0 | 93.6 |
| **Total** | **10 669.3** | **19 241.9** | **16 264.4** | **1 376.6** | **785.1** |

Source: J. P. Hall, 1996, "Forest Insect and Disease Conditions in Canada 1994", Forest Insect and Disease Survey, Natural Resources Canada, Canadian Forestry Service, Ottawa.

hemlock looper (*Lambdina fiscellaria* Guen.) defoliates quickly and can easily kill trees in one or two years, whereas forest tent caterpillar (*Malacosoma disstria* Hubner) defoliates extensive areas, causing growth losses but seldom causing mortality.

The data presented in Main Table 71 provide an indication of the peak amount of damage by a specific problem in the last ten-year reference period. In absolute terms, Canada had the largest area damaged by insects in any one year (41,900,000 ha. in 1992), but this may reflect the Canadian system of assessment, with some areas being counted more than once if they have two or more insect pests present. Relative to the national forest area, the greatest amounts of damage were reported in the Republic of Moldova (19.9 per cent of the forest area damaged by insects in 1990, Portugal (14.4 per cent in 1992), Albania (14.6 per cent in 1994) and Hungary (12.4 per cent in 1996).

Reporting of insect and disease damage is not done systematically in most countries. Indeed, the sporadic nature of the damage in part precludes such assessments. The extent and accuracy of the reporting is very much dependent on the density of forest managers and pest managers in different parts of the world, and reporting of such problems from privately owned forests may also be restricted. Consequently, the figures reported here are likely to under-represent the full extent of damage in the temperate and boreal region.

### Wildlife and grazing

Many countries reported difficulties in the assessment of damage caused by wildlife and grazing. In most cases, the damage is primarily to regeneration, with selective browsing by ungulates being particularly important. However, in Australia and New Zealand, there is significant damage to mature trees caused by arboreal mammals. Other countries also have such damage, but the amounts reported were generally very low. In some cases, the damage is

associated with introduced species, such as the grey squirrel in the UK and the brush-tailed possum in New Zealand. Of those countries that made an assessment, damage by wildlife and grazing was generally less than that caused by insects and disease. However, exceptions to this occurred, and grazing/browsing damage was more important than insects and disease in a third of the countries reporting data (Austria, Belgium, Bulgaria, Denmark, Iceland, Japan, Liechtenstein, Norway, Poland, Romania and the United Kingdom).

**Fire**

The figures presented for fire in Main Tables 70 and 71 bear no relation to those presented in Main Tables 72-75. The information in the latter appears to be more reliable, and is discussed below.

**Local pollution sources**

Very few countries reported damage from local pollution sources. This is inconsistent with other published material, and the extent of damage by air pollution is much greater than reported here. For example, no damage was reported from the Russian Federation, yet official reports, including those of the UN/ECE, indicate that the extent of damage is substantial. There is, however, uncertainty over what constitutes a local source as this is scale-dependent. For example, should the photo-oxidant damage in the San Bernardino Mountains of California be classed as a local or regional problem? As for other forms of damage, there is also difficulty in determining for how long an area should be considered as damaged. Should the area around Sudbury, Ontario, still be considered as damaged even though trees are now being successfully established throughout most of the area?

The greatest levels of damage were reported in south-eastern Europe, with 11,900 ha in Albania, 7,000 ha in Austria, 18,000 ha in the Czech Republic, 66,900 ha in Romania and 64,900 ha in Yugoslavia. A further 12,000 ha of damage was reported from the USA. In relation to the forest area, Liechtenstein had the highest proportion of forest damaged by local pollution sources (4.05 per cent), followed by Yugoslavia (1.86 per cent), Albania (1.15 per cent), Romania (1 per cent) and the Czech Republic (0.68 per cent). In all other countries reporting this form of damage, the area affected was less than 0.5 per cent. The data reported in Main Table 70 do not suggest that air pollution from local sources is a serious problem, except in a few cases. However, while acute damage, involving visible symptoms, can be relatively easily diagnosed, chronic damage, involving invisible symptoms, may be much more difficult to recognize, and may only be apparent through the increased susceptibility of trees to other stresses (e.g. insect attack).

**Storms, wind, snow or other identifiable abiotic factors**

Damage by storms and other abiotic processes is highly episodic. Much research has gone into making plantations less susceptible to windthrow and some of this is now being translated into management activities.

**Damage from unidentified causes**

The extent to which the causes of damage can be identified in the field is highly dependent on the skills of the observer. In the surveys of crown condition coordinated by ICP Forests, assessments are usually made in July and August (i.e. mid- to late summer), when the causes of any damage may not be immediately apparent. There are clear differences to the way that this is reported. For example, in Switzerland, defoliation is only assigned to a specific cause if the observer is certain. In some other countries, an “educated guess” is made, based on the observers’ experience. Very few countries employ trained pathologists to look at the causes of damage in their inventories, and the figures should be interpreted with this in mind.

**Forest fires (Main Tables 72-75)**

The aim of these Tables is to provide information about the extent of fire damage and the average fire size, as well as about trends over time. The indicators used for forest fires (Main Tables 72-75) are:

- Total number of fires on forest and other wooded land for each year in the period 1986-1997
- Total area burned
- Area of forest burned
- Area of other wooded land burned

As forest fires are defined as fires which break out or spread on forest and other wooded land or which break out on other land and spread to forest and other wooded land, the total area burned is larger than the area of forest burned, as it includes “other land” affected by the forest fires.

Of the data collected on forest condition, the forest fire information is perhaps the most reliable. However, such data are of limited value when assessing the severity or distribution of fires within countries.

An analysis of wildland fire has recently been made in Canada (Canadian Forest Service 1997). On average, there are 9,500 fires each year, burning on average 3 million hectares. The 1994-1995 fire season was an exceptional one, and 12.75 million ha were burned. Of the area burned, on average 736,000 ha consist of commercial forest, representing an annual loss of about 70 million $m^3$ of wood with a value of about Canadian $ 1 billion. Fire policies in Canada vary markedly between Provinces. Although about 93 per cent of the fires are suppressed as quickly as possible, these only account for 36 per cent of the total area burned. The remaining 7 per cent of fires are not considered to represent significant threats to life, property or resources and therefore receive a modified response. Partly as a result, they tend to be much bigger, and they account for 63 per cent of the total area burned. Only 1.4 per cent of the fires in Canada exceed 1,000 ha in size, but these fires account for 93 per cent of the total area burned. The importance in Canada of a few very large fires is clear. However, in interpreting these figures, it is important to remember that large-scale fires are a normal part of the ecological processes operating in boreal forests. Some types of forest actually need to burn if they are to regenerate, and this is being increasingly incorporated into management policies.

There is a very high incidence of forest fires in the Russian Federation (Federal Forest Service of Russia, 1997). Between 1986 and 1996, there were between 12,000 and 30,000 wildfires annually. The amount of forest burned annually varied from 360,000 ha to 1,860,000 ha, and these figures would be considerably higher if OWL were included in the statistics. The numbers of fires each year has been increasing in the Russian Federation. In Canada, there has been a recent decrease in the annual fire frequency, although the long-term trend is for an increase in fire frequency. There are also substantial differences in the causes of fires between Canada and the Russian Federation. In the latter, 88 per cent of fires are caused by humans, and this figure rises to almost 100 per cent if only the European-Ural part of the country is considered. In contrast, 58 per cent of Canadian forest fires are started by man, with the remaining 42 per cent being started by lightning.

In the USA, fires are also very important. The use of prescribed burning and mechanical fuel treatments (both excluded from this assessment) has been increasing, from 123,290 ha in 1985 to 676,968 ha in 1998. However, wildfires, including fires on non-forest land, have remained at a fairly constant level since 1987 (with exceptional fire years in 1994 and 1996). The wildfire series that extends from 1918 to 1997 is of considerable interest and is shown in Figure 5.1. During this period, the US Forest Service developed an effective fire suppression policy, although this was then changed in the 1980s with the development of prescribed burning as a means of reducing the incidence of catastrophic fires.

In Europe, the numbers of fires and their extent is very variable, depending on the climate and fire control policies. The largest numbers of fires are found in southern Europe, with countries such as Greece, Italy, Portugal, Spain and Turkey being particularly affected. Between 1990 and 1997, the numbers of fires each year in Greece and Turkey remained similar, with an annual average of 1,874 fires in Greece and 1,973 fires in Turkey. Greater inter-annual variations occurred in Italy, where fire frequency was also higher (annual average of 11,470 fires). The frequency of fires in Portugal and Spain has increased between 1990 and 1997, and there is an annual average of 20,019 fires in Portugal and 17,429 fires in Spain. As with Canada, the numbers of fires alone give a poor impression of the trend in damage caused by fire. When the total areas burned are examined, a rather different picture emerges (Figure 5.2).

FIGURE 5.1

**Wildfires in the USA**

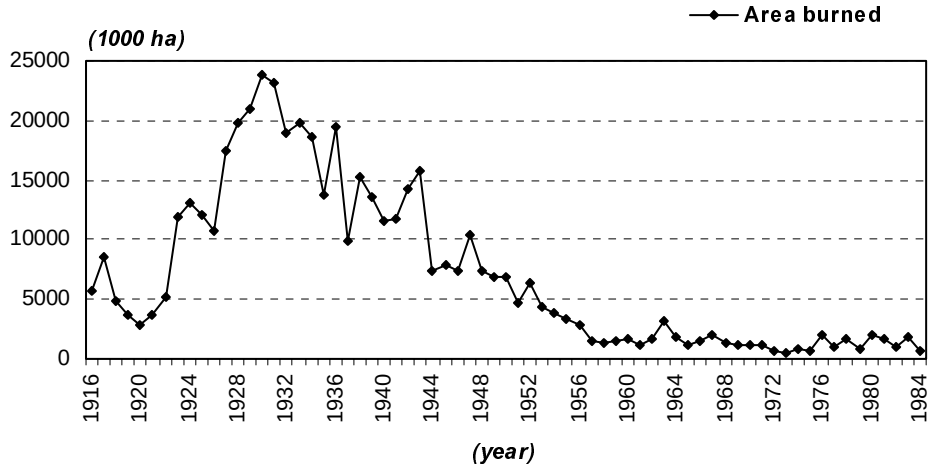


FIGURE 5.1 (*continued*)

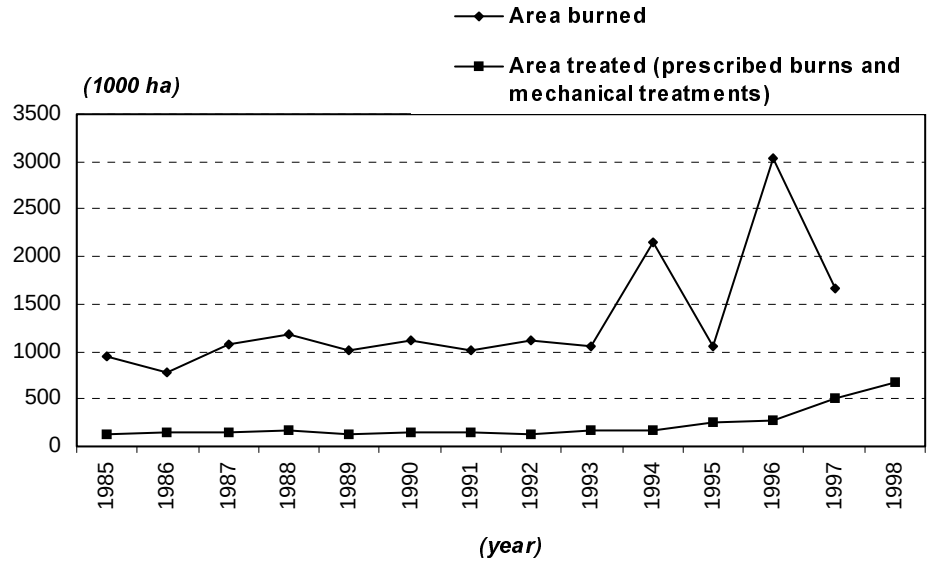
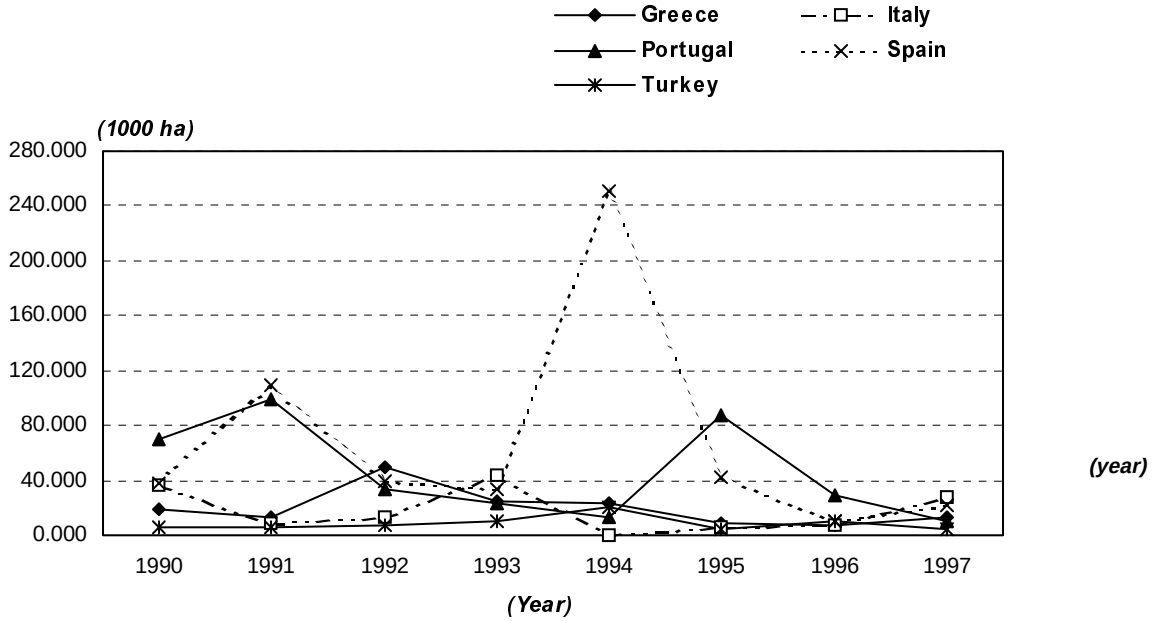



FIGURE 5.2

**Area of forest burned by fires each year in southern European countries**




**Interpretation of Main Tables 72-75**

In interpreting these tables, it is important to recognize that the role of fire in forests can be seen from a number of different perspectives. In plantation forestry, fire can be a major problem, and much effort is devoted to reducing fire hazard. When fires occur, steps are normally taken to bring the fire under control as quickly as possible and then extinguish it. In semi-natural and natural forests, the situation is less clear. In some countries, fire prevention remains a priority. In others, fire is seen as a normal ecosystem process and prescribed burning may be used as a management tool. In the USA, forests that have substantial accumulations of ground fuel as a result of fire suppression may actually be considered as unhealthy. This is because when a natural fire occurs, it may be as a destructive, stand-replacing fire. No separation was made in the data collected for Main Tables 72-75 between stand-replacing and ground-fires.

Fire is clearly a major factor influencing the condition of forests and OWL in the temperate and boreal regions. However, in some countries (e.g. the USA), there have been major changes in the ways in which fire is viewed. Rather than being a major damaging factor, it now tends to been seen as one of the normal processes operating in forests. However, years of fire suppression have substantially changed the structure of many forests, such that when fire does occur, it tends to be more damaging than it would otherwise be. The main problem is the buildup of fuel on the forest floor and below the canopy. This enables fire to reach the canopy, with subsequent damage to trees. In some areas, fuel

buildup is reduced by prescribed burning. However, it is worth noting that many structural attributes associated with the enhancement of biodiversity in forests (e.g. the presence of coarse woody debris) may actually lead to the forest being more susceptible to damaging fires.

In many areas, urban encroachment into forested land, as well as the expansion of forests into the urban periphery, has resulted in an increase in the number of reported fires. This is an issue that requires close attention, as the interaction of forest fires and residential properties results in very much higher costs than when it is only wood or other wooded land that is lost.

**Defoliation (Main Tables 76-78 and Figures in Annex 5.1)**

The aim of this material is to provide information on defoliation as an indicator of the extent of tree damage from one or a combination of causes, including air pollution. The indicators used are the percentages of trees of different defoliation classes for each year between 1986 and 1997, divided into equal to or less than 25 per cent and more than 25 per cent defoliation for all species, coniferous species and broadleaved species.

The use of defoliation as an indicator of forest health has been the subject of intensive debate. The definition of defoliation, as adopted by the UN/ECE International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests), is needle or leaf loss in the assessable crown as compared to a reference tree. Defoliation estimates are known to be subjective, and substantial differences exist in the values obtained by observers both within a country and between different countries. As pointed out in the original reports published by the ICP Forests, this means that the absolute values presented for different countries should not be compared.

One possibility is to compare trends over time between countries. Such a trend analysis assumes that there have been no changes in assessment methods over time. Given that the programme has been running for more than 10 years and that the assessments are based on subjective judgements, such an assumption seems questionable. Unfortunately, there is no reliable information available to indicate the consistency of the estimation methods over time. Although there is evidence of some trends in individual countries, these should be treated with great caution. The standard method of presentation is the percentage of trees with more than 25 per cent defoliation. There is no particular reason for this threshold, and it should not be seen as a threshold for health or damage. A more useful approach is to look at the overall distribution of defoliation classes, and the ways that this changes from year to year, but very few studies have attempted to do this. ICP Forests and the EU are increasingly presenting their transnational results as frequency distributions because of their greater objectivity. The frequency distributions follow all in all the same trends as the former results.

The figures in Annex 5.1 indicate that in about two thirds of the countries only small changes occurred, whereas defoliation increased in about one third of them. Defoliation decreased over the whole period of the observation in only a small number of countries (maybe three, depending on how small a decrease one wants to accept as such).

A comparison of the years 1992 and 1998 reveals that there are more plots in Europe (31.2 per cent) where mean crown condition deteriorated than plots where there was a significant improvement (15.4 per cent). Deteriorating plots are spread all over Europe, with an accumulation in the west (France) and south (mainly Italy). Plots with a significant recuperation are clustered in the so-called sub-Atlantic region, which mainly comprises Germany and Poland. In-depth evaluations show that in all other regions a slight deterioration took place during the last seven years. Mean crown condition remained on the same level only in the boreal region (mainly covering Scandinavia).

The difficulties associated with the interpretation of the data from individual countries (Main Tables 76-78 and the Figures in Annex 5.1) are illustrated by the data from France, Germany and the United Kingdom. In France the increase in defoliation is attributable to changes in assessment methods. In Germany, the apparent deterioration between 1991 and 1992 was an artifact caused by the combination of data from East and West Germany following re-unification. Similarly, the apparent improvement in the UK figures between 1992 and 1993 was a direct result of a change in assessment techniques. (Note: The Russian Federation's data are for Kaliningrad and Leningrad regions only). As only some such changes have been documented, evidence of changes in the data from an individual country should be treated with great care.

The tendency has been to look at overall defoliation data, regardless of species or environmental situation. Error estimates derived in Switzerland for the percentage of trees with 25 per cent or more defoliation indicate that the errors vary between species and between environments. In addition, for any interpretation of the data, it would be necessary to examine trends for individual species in specific environmental conditions, rather than aggregates arranged by political units.

**Relationship between the TBFRA data and indicators for the sustainable management of temperate and boreal forests (the pan-European and Montreal Processes)**

The maintenance of forest ecosystem health and vitality is listed as a criterion for the sustainable management of forest in both the Pan-European Process (Criterion 2) and the Montreal Process (Criterion 3). Extracts from the two international sustainable forest management initiatives relevant to the temperate and boreal zone are given below:

- Pan-European: Criterion 2. Maintenance of forest ecosystem health and vitality

  2.1 Total amount of and changes over the past 5 years in depositions of air pollutants (assessed in permanent plots)

  2.2 Changes in serious defoliation of forests using the UN/ECE and European Union defoliation classification (classes 2, 3, and 4) over the past 5 years

  2.3 Serious damage caused by biotic or abiotic agents

  a. severe damage caused by insects and diseases with a measurement of seriousness of the damage as a function of (mortality or) loss of growth
  b. annual area of burnt forest and other wooded land
  c. annual area affected by storm damage and volume harvested from these areas
  d. proportion of regeneration area seriously damaged by game and other animals or by grazing

  2.4 Changes in nutrient balance and acidity over the past 10 years; level of saturation of exchange capacity on the plots of the European network or of an equivalent national network

- Montreal: Criterion 3. Maintenance of forest ecosystem health and vitality

  a. area and percent of forest type affected by processes or agents beyond the range of historic variation, e.g. by insects, disease, exotic competition, fire, storm, land clearance, permanent flooding, salinization, and domestic animals
  b. area of forest subjected to levels of specific pollutants (e.g. sulphates, nitrate, ozone) or ultra violet B that may cause negative impacts on the forest ecosystem

Although both Processes refer to forest health and vitality, as indicated at the beginning of this chapter, the terminology associated with these concepts is complex and rather confusing. The Montreal and Pan-European agreements refer to “forest ecosystem health and vitality”, but these mean different things to different people. For example, in Canada, forest health has in the past been interpreted as the incidence of pests and diseases in forests, primarily because these impact on the allowable annual harvest. More recently, this has changed to an approach in which a healthy forest is seen as one that maintains biodiversity, resiliency, wildlife habitat, aesthetic appeal and resource sustainability. In the USA, forest health is often interpreted as its ability to fulfil its expected functions. In Europe, different approaches also exist, with forest health being equated partly with the crown condition of individual trees and partly with a number of other parameters such as the incidence of pests and diseases, soil chemistry, and nutritional status of the trees. As a result, it is impossible to provide a definition of forest health that is both universally applicable and meaningful, even within a single country, and the health of any particular forest needs to be determined in relation to the expected functions of that forest (Society of American Foresters 1997). A forest can only be considered as healthy if it meets the expectations of all its stakeholders. However, this can only be possible if individual stakeholders recognize that not all forests can satisfy all requirements. For example, the functions of a plantation of fast-growing *Pinus radiata* in New Zealand are very different to those of a forest of undisturbed, native vegetation maintained as a nature reserve. The ways in which the health of these two forest types are assessed will also differ, with different criteria and indicators being applicable.

The approach adopted in both the Helsinki and Montreal Processes is to look at both stresses to the forest and the forest responses. However, the manner in which this is done is inconsistent. For example, the area affected by particular pollutants is assessed, consistent with the use of the critical loads and levels concepts to identify areas at risk from pollution. The critical loads approach is widely accepted in Europe, partly accepted in Canada and generally not accepted in the United States, Japan, Australia and New Zealand. In contrast, storm damage assessment is not based on the magnitude-frequency relations on storms but on the extent of damage.

The TBFRA data represent an important contribution on indicators on forest ecosystem health and vitality in a context of sustainable forest management. However, there is a considerable amount of other information that needs to be collected, particularly in relation to the nature and distribution of stresses affecting forests.

**Evaluation of forest condition from data submitted to the TBFRA-2000**

It is apparent that there are a number of gaps in the material supplied to the TBFRA-2000 in relation to the internationally accepted indicators for forest ecosystem health and vitality. Specifically, there is little or no information on the following:

- air pollution, including changes in UV-B levels
- forest soil acidity, exchange capacity or nutritional status
- tree mortality
- damage specifically to regeneration
- the seriousness of any of the damage reported
- the relationship of any damage reported to the historical range of variation

Information on these is to a certain extent available, and future assessments should make use of these additional data, particularly those collected by the UN/ECE.

However, depending on how the term forest condition is interpreted, many other tables within the enquiry (Appendix II) could be relevant. In particular, Enquiry *Table 2* (Forest and other wooded land according to "naturalness"), *Enquiry Table 3* (Forest and other wooded land according to availability for wood supply), *Enquiry Table 7* (Changes in area of forest and other wooded land over time by main categories), *Enquiry Table 8* (Protection status), *Enquiry Table 10* (Forest-occurring species at risk or endangered), *Enquiry Table 11* (Regeneration and extension of forest), *Enquiry Table 12* (Species diversity and origin of planting material used in the forest), *Enquiry Table 15* (Increment), *Enquiry Table 16* (Fellings and removal), and *Enquiry Table 17* (Change in growing stock on forest available for wood supply), all contain information related to the condition of the forests in a particular country.

Main Tables 70-75 indicate that disturbances are widespread in temperate and boreal forests. How do these relate to forest health or forest condition and to what extent do they stress the forest ecosystem? Disturbances in forests can be viewed as events that significantly alter the pattern of variation in the structure or function of a system. As such, disturbances include both destructive events and environmental fluctuations, although in Main Tables 70-78 it is information about the destructive events that has been emphasized. Disturbance is being increasingly recognized as a key biological process in forests. All natural forests are subject to disturbance, and attempts by man to prevent these (e.g. through fire suppression policies) are now seen as in some cases having adverse effects on the health or condition of the forest ecosystem. Regular disturbances, such as low-intensity fires in pine forest ecosystems should be considered as a stress rather than a disturbance, whereas a fire suppression policy should be viewed as the disturbance to the forest ecosystem. This argument can also be extended to drought: the regular, seasonal droughts that occur in some climates should be seen as a stress, whereas a drought occurring in an ecosystem that has no adaptation to such a phenomenon should be seen as a disturbance. Consequently, a disturbance is seen as a normal, but infrequent, event within a system.

The problems of relating the incidence of disturbances to forest condition can be illustrated by the case of New Zealand, reported in "*The State of New Zealand's Environment 1997*" (Ministry for the Environment, Wellington). New Zealand has a land area of about 27 million ha, 33 per cent of which is covered by forests or other wooded land. The forest is divided into "undisturbed" (1,599,000 ha), semi-natural (4,799,000 ha) and plantations (1,542,000 ha). The plantations predominantly consist of *Pinus radiata* (90 per cent of the area), an exotic conifer from California, and the primary objective is wood production. With a rotation of 25-30 years, the plantations are considered to be highly productive. Pests and diseases are controlled, and nutrient deficiencies are remedied by fertilization. Consequently, most forest managers would consider the plantations to be healthy and in good condition. In contrast, the primary objective of the majority of "undisturbed" forests and much semi-natural native forest is conservation. These cannot be considered at present to be healthy. Substantial areas of forest are currently at risk, with 550,000 ha of Department of Conservation forest being considered to be at risk of total collapse (total canopy loss, significant species loss, replacement of forest by shrubland/grassland) in the absence of control operations for browsing mammals. A further 1.2 million ha would be at risk, in the absence of control measures, of either a major change in species composition or a major loss of biodiversity. Even with the controls that are in place, 800 species of 'higher' organism are listed as threatened, although these include non-forest species. Of the endemic species of land birds known to have occurred in New Zealand, 46 per cent are now extinct, and 74 per cent of the remaining species are threatened with extinction. Past habitat loss and the pervasiveness of introduced species mean that the majority of New Zealand's native forests must be considered as being in poor condition, or unhealthy.

## Summary and conclusions

1. ***Causes of damage.*** The most important reported causes of damage to forests in the boreal and temperate zones are insects and fire. For example, up to 205 million ha of forest were reported to have been damaged by insects and disease in Canada in the period 1986-1995, and almost 29 million ha of Canadian forests were damaged by fire in the same period. Damage caused by grazing and browsing was also widely reported and, in a number of European

countries (e.g. Austria, Belgium, Bulgaria, Denmark, Iceland and Poland), the area of forest and OWL with such damage was greater than from any other identified cause.

2. ***Fire.*** This is the major cause of forest damage, although its significance is not directly proportional to either the number of fires or their spatial extent. Forest fires are very important in southern Europe, where a high population density and small-scale forest ownership combine to increase the likely significance of a particular fire.

3. ***Defoliation.*** The reported figures indicate that defoliation is much more widespread in Europe than in North America. In the USA, the proportions of trees with more than 25 per cent defoliation is generally less than 1 per cent. In Canada, it is generally less than 10 per cent, whereas in Europe in recent years, it has been more than 20 per cent. This almost certainly reflects differences in standards between Europe and North America. The European figures reflect a trend for increasing defoliation. The proportion of trees assessed every year between 1988 and 1997 with more than 25 per cent defoliation has increased from 13.2 per cent in 1988 to 23.1 per cent in 1997. No information is available on the cause of this reported increase in defoliation.

4. ***Progress in assessment of forest condition.*** The material presented in Main Tables 70 to 78 represents a step forward in the assessment of forest condition at an international scale. It illustrates the diversity of methods used in individual countries to address this important issue, and highlight the gaps in our current understanding of the most important agents damaging forests.

5. ***Alternative data sources.*** Future assessments should pay much greater attention to existing alternative data sources. In particular, efforts should be made to resolve any apparent discrepancies between official published figures and those used by the TBFRA. In addition, full use should be made of all existing TBFRA data: the restriction of analyses to the material presented in the main tables means that long-term trends, spanning two or more assessment periods, cannot be utilized.

6. ***Condition of forests and their functions.*** The condition of a forest is best assessed in relation to its most important functions, and these vary from forest to forest. Consequently, any statement about the health of forests in a country must take into account the functions of those forests. Currently, no methods exist that can be used to do this.

7. ***Evolving issues.*** Many of the difficulties associated with the identification of the condition of forests in the temperate and boreal zones stem from recent changes in the ways that forests are seen. Issues such as biodiversity, water quality and carbon sequestration have all become much more important than in previous years. Forest inventory methods have in earlier periods concentrated primarily on the assessment of wood resources. This is reflected in the data that have been collected for the TBFRA-2000.

8. ***Research.*** The Assessment indicates a need for research into the following areas:

   (i) Greater attention needs to be given to the assessment of indicators of the health/condition/state of forests, keeping in mind the efforts already made and successes achieved;

   (ii) The identification of appropriate indicators and ways to assess these worldwide and the collection of appropriate data will be a major challenge for countries and for forest scientists in the coming years;

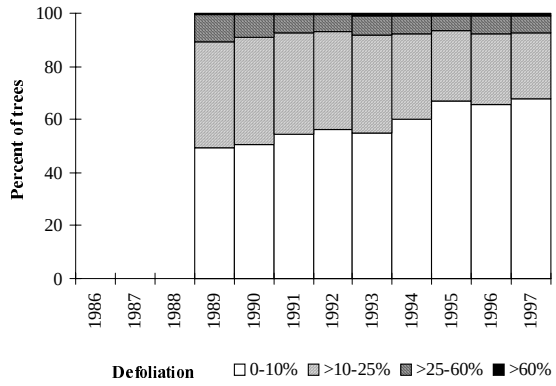
   (iii) The standardization of these methods between countries, thereby enabling comparisons to be made, will also require a major effort on the part of inventory specialists.

9. ***Objectives of data collection:*** In future assessments, it would be useful to examine the objectives of the data collection. It is possible to collect a wide array of data on forest condition, but this could swamp the data collection process. Consequently, data collection needs to be related to very precise questions, established before the design of the enquiry.

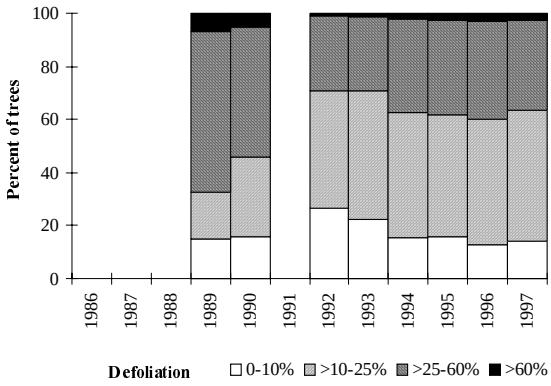
ANNEX 5.1

**Changes in defoliation of all species (1986-1997)**

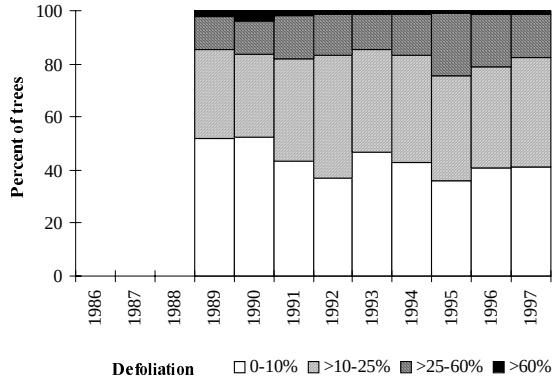
**Austria**



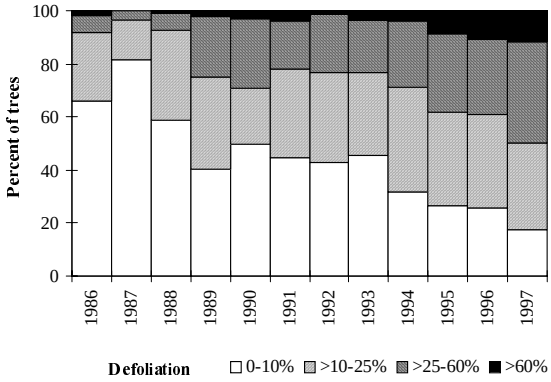

**Belarus**



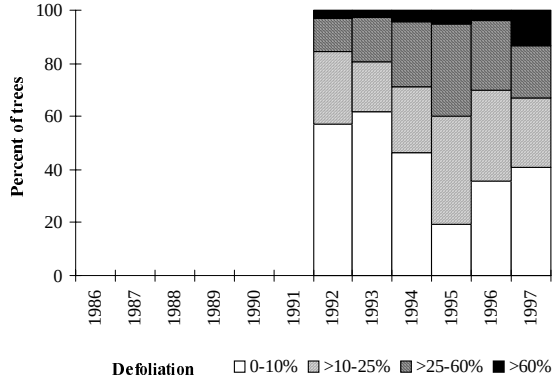

**Belgium**



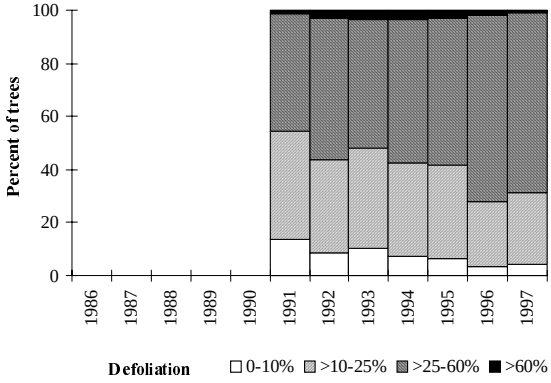

**Bulgaria**



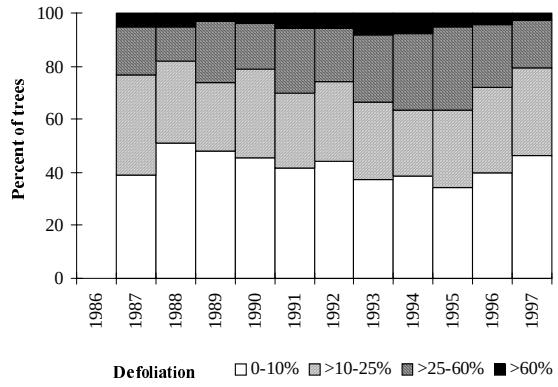

**Croatia**



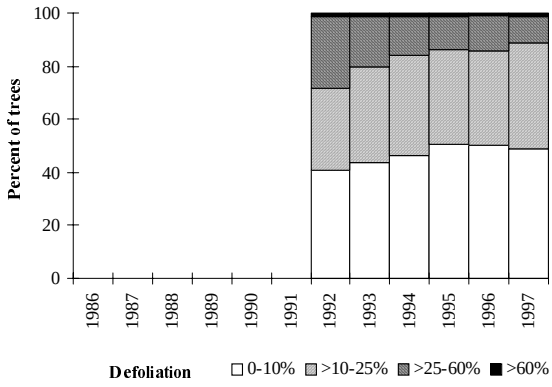

**Czech Republic**



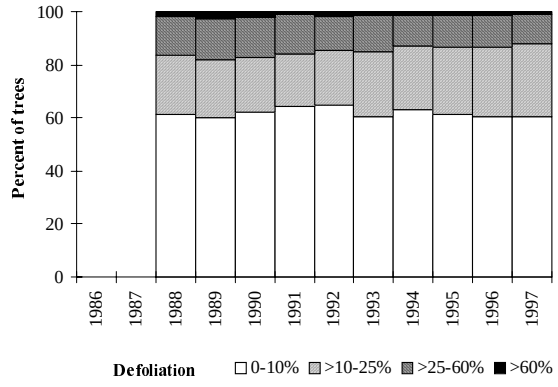
## Denmark



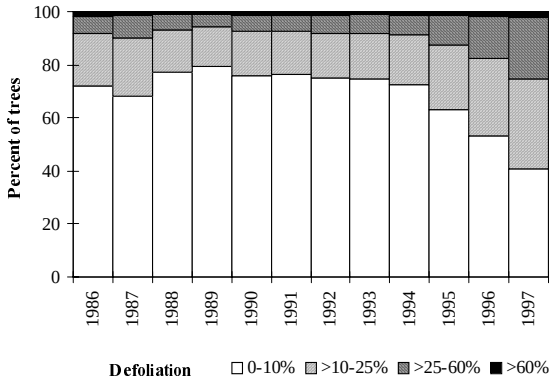

## Estonia



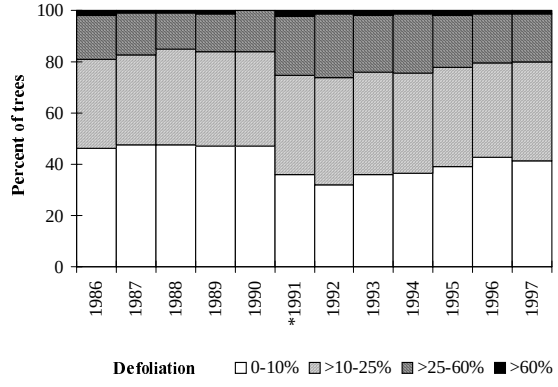

## Finland



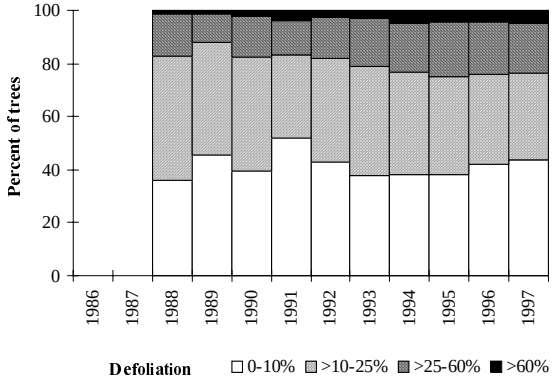

## France




## Germany

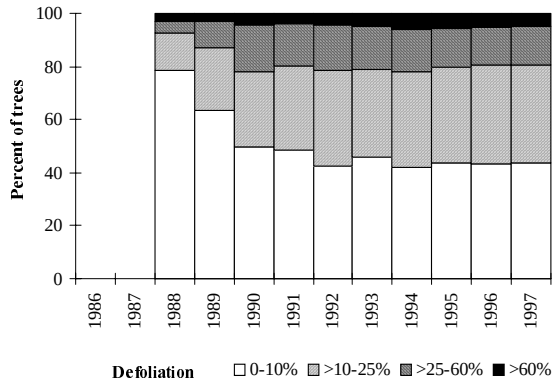



## Greece

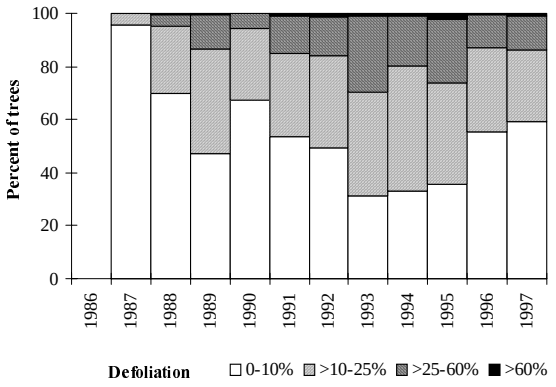



* since 1991 with former GDR

## Hungary

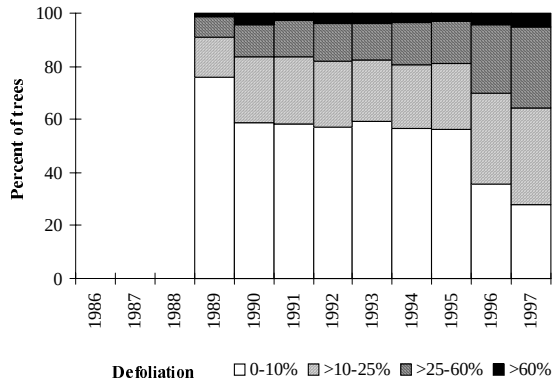



## Ireland

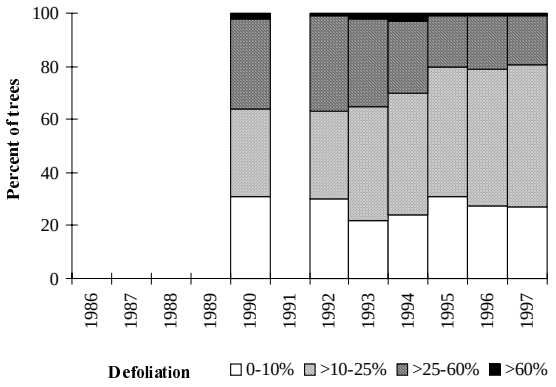



* only conifers assessed

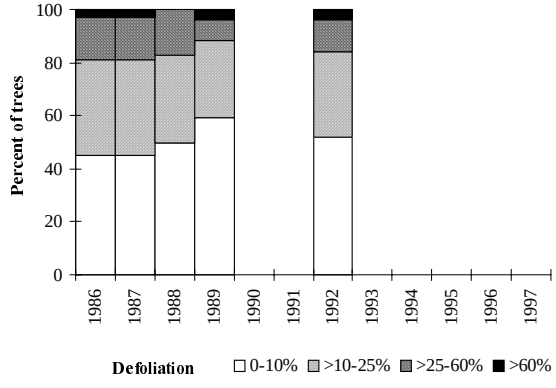
## Italy



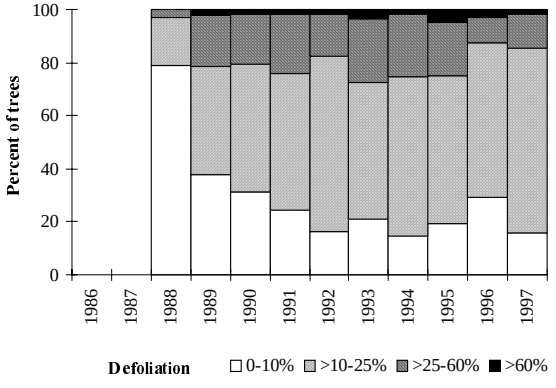

## Latvia



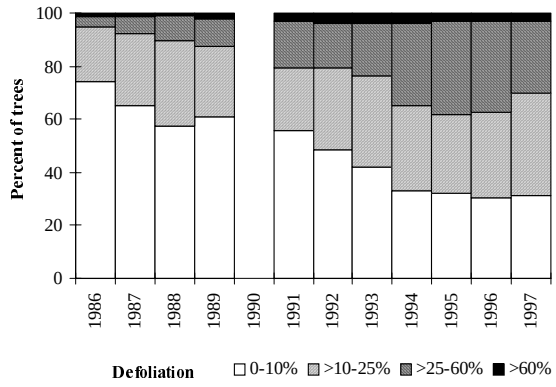

## Liechtenstein



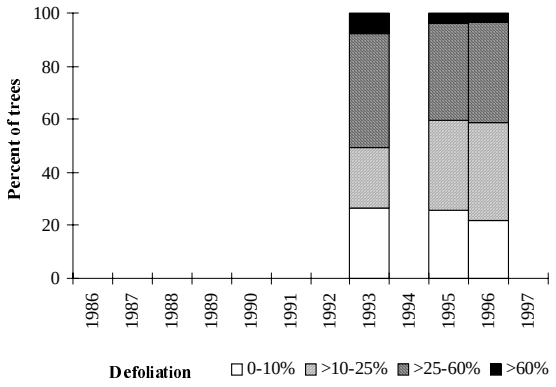

## Lithuania



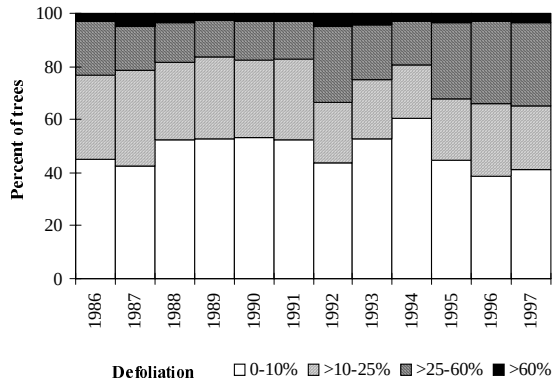
## Luxembourg



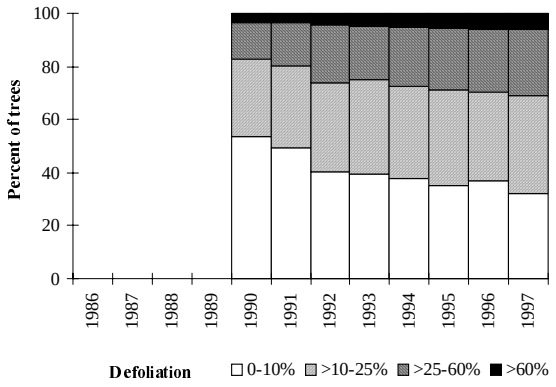

## Republic of Moldova



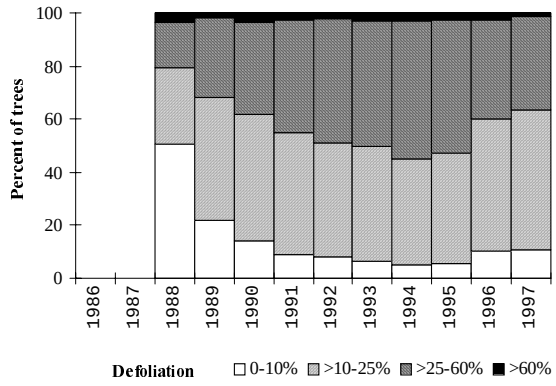

## Netherlands



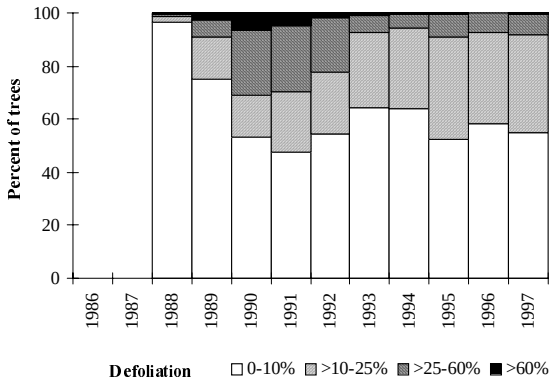

## Norway



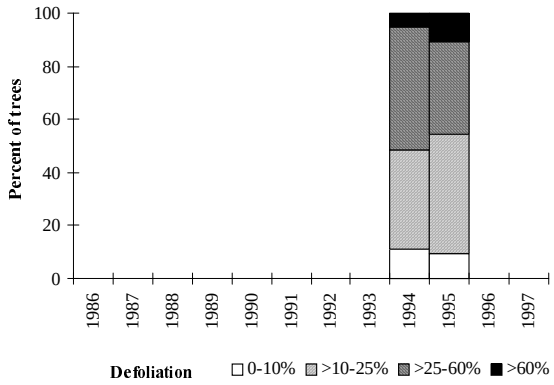

## Poland



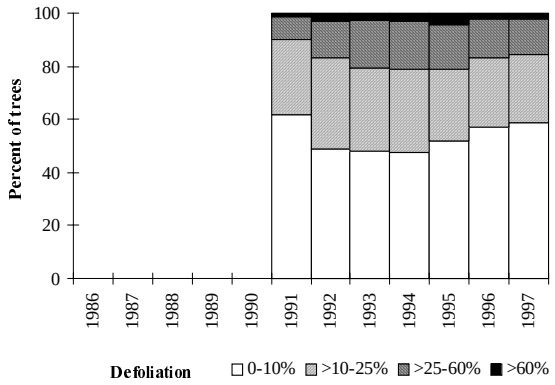

## Portugal



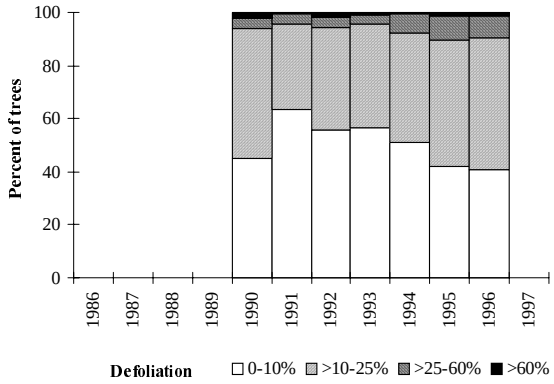
## Romania



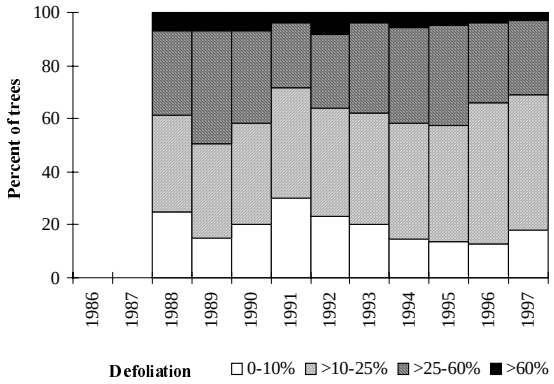

## Russian Federation (Kaliningrad Region)




## Russian Federation (Leningrad Region)

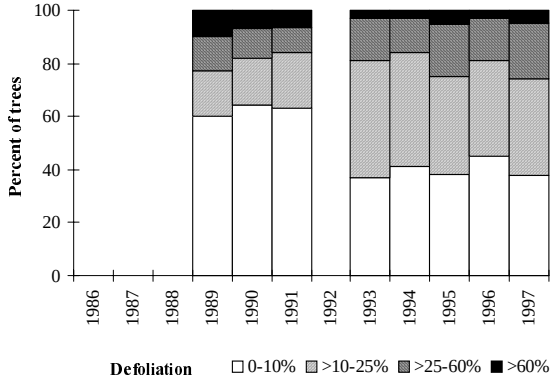



## Slovak Republic

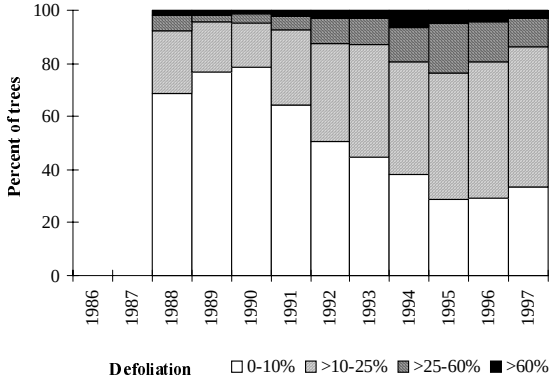



* only conifers assessed

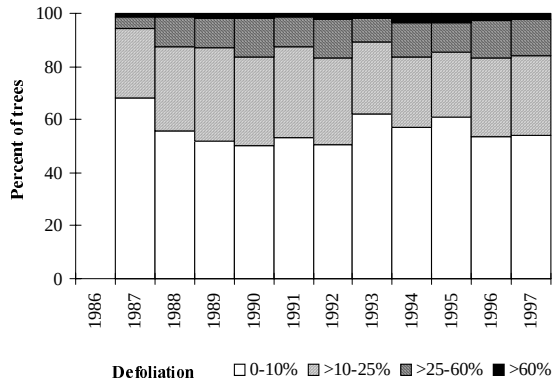
## Slovenia




## Spain

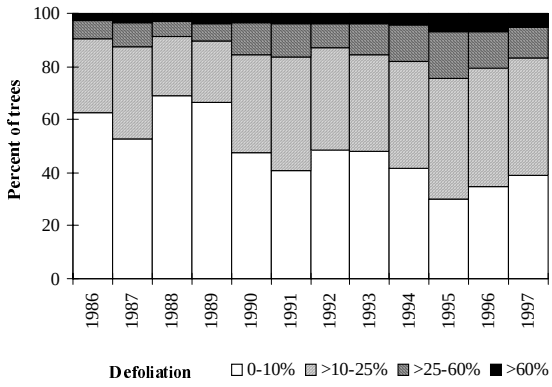


## Sweden

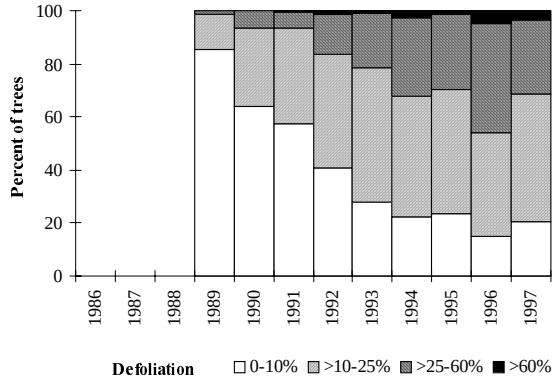



* only conifers assessed

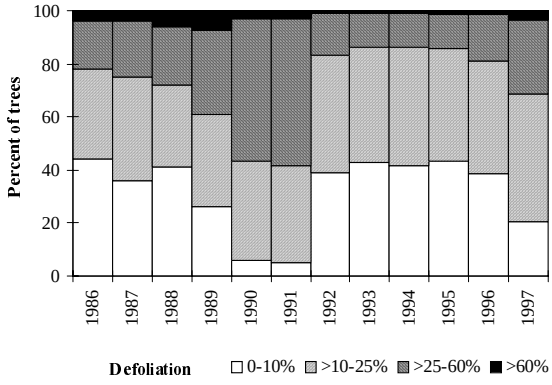
## Switzerland




## Ukraine




## United Kingdom




## Yugoslavia

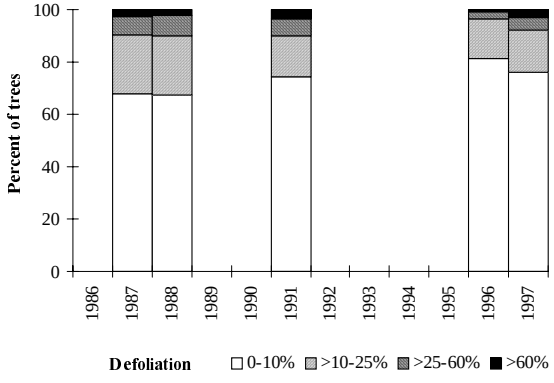


TABLE 70

## Area of damage to forest and other wooded land

| Country | Reference Period | Total area with damage by known causes | Primarily damaged by | | | | | Total area with damage by unidentified causes |
|---|---|---|---|---|---|---|---|---|
| | | | Insects and disease | Wildlife and grazing | Fire | Known local pollution sources | Storm, wind, snow or other identifiable abiotic factors | |
| | | (1000 ha) | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Albania © | 1988-94 | 718.2 | 691.0 | 12.7 | 2.6 | 11.9 | 0.0 | 0.0 |
| Austria | | 163.0 | 68.0 | 72.0 | 0.0 | 7.0 | 16.0 | 1.0 |
| Belgium © | 1988-97 | 90.0 | 42.9 | 45.8 | 1.3 | | | 0.0 |
| Bosnia and Herzegovina | | | | | | | | |
| Bulgaria | | 63.0 | 18.7 | 23.5 | 7.0 | | 13.8 | |
| Croatia | 1986-96 | 16.0 | 15.0 | 1.0 | 11.0 | | | |
| Cyprus | 1987-96 | 0.3 | | 0.2 | 0.1 | 0.0 | 0.0 | 0.0 |
| Czech Republic © | 1988-97 | 451.0 | 355.0 | 30.0 | 4.0 | 18.0 | 44.0 | 13.0 |
| Denmark © | 1990-95 | 3.7 | 0.0 | 2.5 | 0.2 | 0.0 | 1.0 | |
| Estonia | 1996 | 5.1 | 3.5 | 0.7 | 0.5 | | 0.4 | |
| Finland © | 1986-96 | 3,300.0 | 1,600.0 | 300.0 | 0.0 | 0.0 | 1,400.0 | 1,700.0 |
| France © | 1983-93 | 235.0 | 150.0 | 45.0 | 30.7 | 0.0 | 9.3 | 0.0 |
| Germany © | 1987-96 | | | | | | | |
| Greece © | | | | | 37.2 | | | |
| Hungary © | 1996 | 231.5 | 169.3 | 24.8 | 0.7 | | 36.7 | 14.2 |
| Iceland © | | 10.0 | 3.0 | 5.0 | 0.0 | 0.0 | 2.0 | |
| Ireland | 1996 | 2.0 | 0.0 | 0.0 | 1.0 | 0.0 | 1.0 | 0.0 |
| Israel © | 1997 | | 5.0 | | 0.6 | | | |
| Italy | 1995 | 129.6 | 66.0 | 6.0 | 40.0 | 0.1 | 17.5 | 6.5 |
| Latvia © | 1996 | 1.6 | 0.9 | 0.2 | 0.3 | 0.0 | 0.2 | 0.0 |
| Liechtenstein | | 0.7 | 0.1 | 0.4 | | 0.3 | | |
| Lithuania © | 1992-96 | 220.6 | 101.0 | 40.5 | 3.1 | 0.0 | 76.0 | 0.0 |
| Luxembourg | | | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Malta © | | | | | | | | |
| Netherlands © | 1990-95 | 0.3 | 0.0 | 0.0 | 0.3 | 0.0 | 0.0 | 0.0 |
| Norway © | 1994-96 | 1,164.0 | 112.0 | 218.0 | 0.0 | 2.0 | 832.0 | 0.0 |
| Poland © | 1992-96 | | 309.0 | 389.0 | 13.0 | | 196.0 | |
| Portugal © | 1995 | 603.0 | 391.0 | 23.0 | 88.0 | 0.0 | 101.0 | 38.0 |
| Romania © | 1993-97 | 67.6 | 0.0 | 0.7 | 0.0 | 66.9 | | |
| Slovakia © | | 124.3 | 86.0 | 5.7 | 2.1 | 4.4 | 26.1 | 3.2 |
| Slovenia © | 1996 | 37.2 | 0.9 | 0.9 | 0.3 | 0.1 | 35.0 | 0.4 |
| Spain © | 1990 | | 500.0 | | 100.0 | | 1,000.0 | 1,000.0 |
| Sweden © | 1992-96 | | | 551.0 | | 0.0 | | |
| Switzerland © | | 1.0 | 0.7 | | 0.2 | 0.1 | | 230.0 |
| The FYR of Macedonia | | | | | | | | |
| Turkey | 1992-96 | 22.0 | 4.0 | | 13.0 | | 5.0 | |
| United Kingdom © | 1995 | 240.0 | 30.0 | 67.0 | 8.0 | 0.0 | 135.0 | 10.0 |
| Yugoslavia © | | 78.2 | 8.8 | 0.2 | 3.5 | 64.9 | 0.8 | 0.0 |
| Armenia | 1983-96 | 4.8 | 2.0 | 0.5 | 0.3 | 1.0 | 1.0 | 1.0 |
| Azerbaijan © | | 0.1 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Belarus © | | 8.9 | 0.4 | 0.1 | 2.6 | 0.0 | 5.8 | 0.6 |
| Georgia | | | | | | | | |
| Kazakhstan | 1997 | 226.9 | 0.0 | 0.0 | 226.9 | 0.0 | 0.0 | 0.0 |
| Kyrgyzstan | | | | | | | | |
| Republic of Moldova | | 61.2 | 61.2 | | 0.0 | | | |
| Russian Federation © | 1996 | 4,759.0 | 3,566.5 | 4.7 | 1,161.0 | 0.0 | 25.7 | 0.9 |
| Tajikistan | 1995 | | | | | | | |
| Turkmenistan | | | | | | | | |
| Ukraine | 1992-96 | 100.9 | 49.0 | 0.4 | 33.1 | | 18.3 | 0.4 |
| Uzbekistan | 1995 | | | | | | | |
| Canada © | 1986-95 | | 205,000.0 | | 28,764.0 | | | |
| United States of America © | | 25,298.0 | 23,462.0 | 0.0 | 1,620.0 | 12.0 | 204.0 | |
| Australia © | | | | | | | | |
| Japan © | 1991-95 | 67.0 | 3.0 | 8.3 | 2.6 | 0.0 | 52.0 | 0.0 |
| New Zealand © | 1993-97 | 4.0 | | | 3.0 | 0.0 | 1.0 | |

© See notes and comments in Chapter V.

TABLE 71

**The heaviest annual damage by known causes which occurred in most recent 10-year period**

| Country | Primarily damaged by | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Insects and disease | | Wildlife and grazing | | Fire | | Know local pollution sources | | Storm, wind, snow or other unidentifiable abiotic factors | |
| | Year | Extent of damage | Year | Extent of damage | Year | Extent of damage | Year | Extent of damage | Year | Extent of damage |
| | | (1000 ha) | | (1000 ha) | | (1000 ha) | | (1000 ha) | | (1000 ha) |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
| Albania © | 1994 | 150.0 | 1995 | 2.5 | 1992 | 1.0 | 1988 | 3.0 | | 0.0 |
| Austria | 1992 | 68.0 | | | | | | | 1990 | 45.0 |
| Belgium © | 1997 | 18.8 | | | 1996 | 1.0 | | | 1990 | 20.0 |
| Bosnia and Herzegovina | | | | | | | | | | |
| Bulgaria | 1997 | 24.8 | 1993 | 26.7 | 1993 | 17.3 | | | 1995 | 15.9 |
| Croatia | | | | | | | | | | |
| Cyprus | | 0.0 | | 0.0 | 1988 | 0.8 | | 0.0 | | 0.0 |
| Czech Republic © | 1993 | 104.0 | 1994 | 11.0 | 1992 | 1.0 | 1996 | 16.0 | 1990 | 38.0 |
| Denmark © | 1994 | | | | 1995 | | | | 1996 | |
| Estonia | 1994 | 4.1 | 1995 | 0.8 | 1992 | 1.1 | | | 1994 | 0.4 |
| Finland © | | | | | | | | | | |
| France © | 1993 | 50.0 | | | 1989 | 75.6 | | | 1990 | 40.0 |
| Germany © | | | | | | | | | | |
| Greece © | | | | | 1988 | 88.0 | | | | |
| Hungary © | 1994 | 224.7 | 1991 | 40.6 | 1993 | 5.0 | | | 1993 | 76.1 |
| Iceland © | 1993 | 5.0 | 1987 | 10.0 | | | | | 1995 | 10.0 |
| Ireland | | | | | | | | | | |
| Israel © | | | | | 1995 | 1.6 | | | 1992 | 0.4 |
| Italy | 1992 | 237.0 | 1995 | 6.0 | 1993 | 104.0 | 1992 | 1.0 | 1995 | 17.5 |
| Latvia © | 1996 | 0.9 | 1994 | 0.3 | 1992 | 2.0 | | 0.0 | 1993 | 0.6 |
| Liechtenstein | | | | | | | | | | |
| Lithuania © | 1995 | 78.0 | 1990 | 28.6 | 1992 | 1.0 | 1988 | 0.2 | 1993 | 73.0 |
| Luxembourg | | | | | | | | | 1990 | 5.0 |
| Malta © | | | | | | | | | | |
| Netherlands © | | 0.0 | | 0.0 | 1995 | 0.1 | | 0.0 | 1987 | 0.2 |
| Norway © | | | | | | | | | 1992 | 25.0 |
| Poland © | 1994 | 775.0 | 1990 | 389.0 | 1992 | 44.0 | | | 1996 | 196.0 |
| Portugal © | 1992 | 498.0 | 1992 | 60.0 | 1991 | 125.0 | | 0.0 | 1995 | 101.0 |
| Romania © | | 0.0 | | 0.0 | | 0.0 | | 0.0 | 1995 | 12.4 |
| Slovakia © | 1993 | 24.0 | 1990 | 1.9 | 1993 | 1.2 | 1995 | 1.1 | 1996 | 6.6 |
| Slovenia © | 1993 | 6.3 | 1996 | 45.0 | 1993 | 1.6 | 1987 | 1.1 | 1996 | 35.0 |
| Spain © | | 500.0 | | | 1994 | 400.0 | | | 1995 | 5,000.0 |
| Sweden © | 1997 | | | | | | | | 1995 | |
| Switzerland © | 1993 | 1.0 | | | 1990 | 1.1 | | | 1990 | 5.0 |
| The FYR of Macedonia | | | | | | | | | | |
| Turkey | 1996 | 4.0 | | | 1994 | 21.0 | | | 1996 | 5.0 |
| United Kingdom © | 1993 | 0.9 | | | 1994 | 1.0 | | | 1987 | 16.5 |
| Yugoslavia © | 1997 | 141.5 | | 0.0 | 1996 | 3.8 | | 0.0 | 1990 | 42.0 |
| Armenia | 1992 | 1.0 | 1986 | 0.2 | 1995 | 0.2 | 1984 | 0.8 | 1986 | 0.8 |
| Azerbaijan © | 1997 | 0.1 | | 0.0 | 1992 | 0.0 | | 0.0 | | 0.0 |
| Belarus © | 1994 | 0.6 | 1993 | 0.2 | 1996 | 5.0 | | 0.0 | 1997 | 14.6 |
| Georgia | | | | | | | | | | |
| Kazakhstan | | 0.0 | | 0.0 | 1997 | 156.9 | | 0.0 | | 0.0 |
| Kyrgyzstan | | | | | | | | | | |
| Republic of Moldova | 1990 | 70.7 | | | 1994 | 0.1 | | | | |
| Russian Federation © | 1994 | 3,923.0 | 1995 | 67.9 | 1989 | 1,767.9 | 1986 | 88.0 | 1991 | 195.8 |
| Tajikistan | | | | | | | | | | |
| Turkmenistan | | | | | | | | | | |
| Ukraine | 1996 | 18.7 | 1992 | 0.2 | 1996 | 12.7 | | | 1996 | 6.9 |
| Uzbekistan | | | | | | | | | | |
| Canada © | 1992 | 41,900.0 | | | 1989 | 7,560.0 | | | | |
| United States of America © | 1995 | 27,370.0 | | 0.0 | 1995 | 2,024.0 | 1996 | 12.0 | 1996 | 224.0 |
| Australia © | | | | | | | | | | |
| Japan © | 1987 | 4.0 | 1993 | 9.0 | 1993 | 3.3 | | | 1991 | 15.8 |
| New Zealand © | | | | | 1989 | 10.0 | | | 1988 | 5.0 |

© See notes and comments in Chapter V.

TABLE 72

## Forest fires: number

| Country | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
| | (Number) | | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Albania © | 269 | 147 | 695 | 560 | 585 | 110 | 490 | 395 |
| Austria © | 225 | 78 | 165 | 178 | 94 | 64 | 41 | 66 |
| Belgium | 82 | 65 | 26 | 36 | 43 | 40 | 185 | 35 |
| Bosnia and Herzegovina © | | 139 | 139 | 158 | 104 | 156 | 139 | 139 |
| Bulgaria | 208 | 73 | 602 | 1,196 | 667 | 114 | 246 | 200 |
| Croatia | | 218 | 325 | 372 | 181 | 109 | 305 | 305 |
| Cyprus | 64 | 47 | 18 | 16 | 35 | 24 | 20 | 19 |
| Czech Republic © | | 961 | 2,586 | 1,951 | 2,052 | 1,331 | 1,421 | 1,398 |
| Denmark © | 2 | 6 | 2 | 14 | 6 | 6 | 14 | 7 |
| Estonia | 164 | 39 | 348 | 207 | 289 | 188 | 273 | 359 |
| Finland © | 571 | 287 | 852 | 286 | 1,054 | 1,031 | 1,289 | 1,125 |
| France © | 5,881 | 3,888 | 4,002 | 4,769 | 4,618 | 6,563 | 6,401 | 7,200 |
| Germany | 1,610 | 1,846 | 3,012 | 1,694 | 1,696 | 1,237 | 1,748 | 1,467 |
| Greece © | 1,322 | 858 | 2,582 | 2,406 | 1,763 | 1,438 | 1,508 | 3,113 |
| Hungary © | | | | | | | | |
| Iceland © | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ireland © | 721 | 194 | 156 | 123 | 149 | 143 | 143 | 143 |
| Israel © | 1,211 | 697 | 1,057 | 939 | 765 | 1,030 | 1,031 | 942 |
| Italy | 14,477 | 11,965 | 14,545 | 15,380 | 8,669 | 6,225 | 9,093 | 11,408 |
| Latvia © | | 1,110 | 1,510 | 965 | 854 | 582 | 1,095 | 844 |
| Liechtenstein | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lithuania | 236 | 147 | 1,154 | 635 | 714 | 472 | 889 | 565 |
| Luxembourg © | 23 | 11 | 8 | 15 | 7 | 4 | 3 | 5 |
| Malta | 3 | 8 | 8 | 1 | 3 | 8 | 12 | 4 |
| Netherlands © | 95 | 117 | 76 | 83 | 51 | 77 | 77 | 68 |
| Norway | 578 | 976 | 892 | 253 | 471 | 181 | 246 | 510 |
| Poland | 4,137 | 3,008 | 9,305 | 4,421 | 5,152 | 4,143 | 4,546 | 3,624 |
| Portugal | 18,507 | 13,118 | 14,954 | 13,919 | 18,104 | 28,044 | 29,078 | 24,429 |
| Romania | 134 | 44 | 187 | 160 | 121 | 50 | 87 | 34 |
| Slovakia © | 369 | 142 | 305 | 674 | 366 | 254 | 662 | 535 |
| Slovenia | 58 | 66 | 113 | 211 | 66 | 25 | 50 | 59 |
| Spain | 12,474 | 13,011 | 15,895 | 14,254 | 19,263 | 25,827 | 16,772 | 22,479 |
| Sweden © | | | | | 2,500 | 1,100 | 6,240 | 3,280 |
| Switzerland © | 216 | 157 | 111 | 99 | 52 | 56 | 61 | 77 |
| The FYR of Macedonia | | 150 | 150 | 294 | 137 | 18 | 41 | 73 |
| Turkey © | 1,725 | 1,445 | 2,110 | 2,547 | 3,221 | 1,768 | 1,631 | 1,339 |
| United Kingdom © | 412 | 475 | 328 | 61 | 349 | 906 | 508 | 375 |
| Yugoslavia © | | 240 | 313 | 113 | 140 | 26 | 220 | |
| Armenia | 7 | 2 | 3 | 4 | 6 | 5 | 24 | 5 |
| Azerbaijan © | | 6 | 6 | 8 | 1 | 6 | | |
| Belarus | 2,471 | 1,517 | 7,743 | 1,887 | 3,052 | 3,257 | 4,123 | 1,466 |
| Georgia | | 6 | 6 | 6 | 6 | 1 | 6 | 11 |
| Kazakhstan | 605 | 1,194 | 518 | 354 | 881 | 1,320 | 1,003 | 2,257 |
| Kyrgyzstan © | | | | | | | | |
| Republic of Moldova © | 91 | 18 | 14 | 1 | 33 | 3 | 0 | 12 |
| Russian Federation | | 17,965 | 25,777 | 18,428 | 20,287 | 25,951 | 32,833 | 31,300 |
| Tajikistan © | | | | | | | | |
| Turkmenistan © | | 9 | 9 | 2 | 16 | 9 | 2 | 9 |
| Ukraine © | 2,714 | 2,771 | 5,869 | 2,967 | 7,411 | 3,754 | 4,928 | 2,309 |
| Uzbekistan | | | | | | | | |
| Canada © | 10,058 | 10,267 | 9,026 | 6,018 | 9,727 | 8,367 | 5,853 | 5,681 |
| United States of America © | 122,763 | 117,209 | 104,189 | 97,322 | 114,043 | 130,226 | 96,363 | 86,660 |
| Australia © | | | | | | | | |
| Japan | 2,858 | 2,535 | 2,262 | 3,191 | 4,534 | 4,072 | | |
| New Zealand © | 928 | 1,234 | 992 | 990 | 2,198 | 2,023 | 1,646 | 2,010 |

© See notes and comments in Chapter V.

TABLE 73

## Forest fires: total area burned

| Country | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
| | (1000 ha) | | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Albania © | 0.42 | 0.25 | 1.01 | 0.52 | 0.71 | 0.15 | 0.41 | 0.42 |
| Austria © | 0.20 | 0.05 | 0.13 | 0.11 | 0.06 | 0.03 | 0.03 | 0.04 |
| Belgium | 0.02 | 0.05 | 0.02 | 0.11 | 0.05 | 0.07 | 1.45 | 0.28 |
| Bosnia and Herzegovina © | | 0.88 | 0.88 | 1.30 | 0.71 | 0.63 | 0.88 | 0.88 |
| Bulgaria | 1.04 | 0.51 | 5.24 | 18.16 | 19.11 | 0.55 | 2.15 | 0.78 |
| Croatia | | 4.54 | 11.13 | 20.16 | 7.94 | 4.65 | 11.21 | 11.12 |
| Cyprus | 1.45 | 0.11 | 0.01 | 0.07 | 0.18 | 0.07 | 0.12 | 0.17 |
| Czech Republic © | | 0.08 | 1.28 | 1.15 | 0.81 | 0.40 | 2.04 | 3.48 |
| Denmark © | 0.14 | 0.14 | 0.28 | 0.01 | 0.00 | 0.00 | 0.06 | 0.01 |
| Estonia | 0.19 | 0.06 | 1.79 | 0.65 | 0.46 | 0.19 | 0.58 | 1.15 |
| Finland © | 0.43 | 0.23 | 1.08 | 0.58 | 1.58 | 0.64 | 0.92 | 1.05 |
| France © | 72.60 | 10.13 | 16.61 | 16.70 | 25.00 | 18.14 | 11.40 | 21.00 |
| Germany | 0.95 | 0.92 | 4.91 | 1.49 | 1.11 | 0.59 | 1.38 | 0.60 |
| Greece © | 38.59 | 13.05 | 71.41 | 54.05 | 57.91 | 27.20 | 25.31 | 52.37 |
| Hungary © | | | | | | | | |
| Iceland © | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ireland © | 0.84 | 0.67 | 0.57 | 0.54 | 0.28 | 0.46 | 0.46 | 0.46 |
| Israel © | 5.77 | 3.48 | 6.70 | 7.17 | 3.79 | 8.30 | 6.49 | 6.19 |
| Italy | 195.32 | 99.86 | 105.70 | 203.14 | 68.83 | 22.63 | 23.81 | 65.78 |
| Latvia © | | 3.10 | 8.37 | 0.57 | 0.35 | 0.54 | 0.93 | 0.60 |
| Liechtenstein | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Lithuania | 0.12 | 0.05 | 0.86 | 0.31 | 0.30 | 0.32 | 0.39 | 0.17 |
| Luxembourg © | 0.009 | 0.004 | 0.002 | 0.008 | 0.002 | 0.001 | 0.003 | 0.002 |
| Malta | 0.000 | 0.000 | 0.000 | 0.001 | 0.002 | 0.003 | 0.007 | 0.005 |
| Netherlands © | 0.22 | 0.41 | 0.17 | 0.10 | 0.28 | 0.23 | 0.16 | 0.22 |
| Norway | 0.09 | 0.53 | 1.37 | 0.22 | 0.23 | 0.11 | 0.51 | 0.63 |
| Poland | 5.03 | 2.11 | 33.33 | 3.68 | 2.50 | 1.74 | 5.31 | 2.17 |
| Portugal | 129.84 | 182.49 | 59.07 | 49.96 | 77.32 | 169.61 | 83.05 | 26.07 |
| Romania | 0.46 | 0.28 | 0.73 | 0.55 | 0.31 | 0.20 | 0.26 | 0.06 |
| Slovakia © | 0.57 | 0.21 | 0.59 | 0.52 | 0.10 | 0.09 | 0.22 | 0.04 |
| Slovenia | 0.60 | 0.71 | 0.67 | 1.86 | 0.91 | 0.26 | 0.29 | 0.49 |
| Spain | 204.04 | 244.71 | 104.59 | 89.33 | 437.64 | 143.48 | 59.82 | 88.29 |
| Sweden © | | | 5.81 | 1.00 | 3.10 | 0.40 | 2.18 | 1.89 |
| Switzerland © | 1.10 | 0.15 | 0.05 | 0.04 | 0.29 | 0.44 | 0.23 | 1.93 |
| The FYR of Macedonia | | 5.18 | 5.18 | 10.07 | 5.37 | 0.13 | 1.78 | 5.31 |
| Turkey © | 13.00 | 7.64 | 12.31 | 13.73 | 21.00 | 4.79 | 14.92 | 6.17 |
| United Kingdom © | 0.46 | 0.11 | 0.19 | 0.15 | 1.04 | 0.54 | 0.59 | 0.33 |
| Yugoslavia © | | 1.54 | 1.97 | 6.90 | 1.58 | 1.65 | 4.59 | |
| Armenia | 0.01 | 0.02 | 0.01 | 0.00 | 0.02 | 0.15 | 0.10 | 0.02 |
| Azerbaijan © | | 0.06 | 0.08 | 0.03 | 0.01 | 0.05 | | |
| Belarus | 1.04 | 0.32 | 23.82 | 1.25 | 2.11 | 3.78 | 8.95 | 0.97 |
| Georgia | | 0.11 | 0.11 | 0.11 | 0.11 | 0.01 | 0.20 | 0.11 |
| Kazakhstan | 1.30 | 4.90 | 1.20 | 0.70 | 5.98 | 28.93 | 12.86 | 347.98 |
| Kyrgyzstan © | | | | | | | | |
| Republic of Moldova © | 0.12 | 0.02 | 0.02 | 0.00 | 0.22 | 0.00 | 0.00 | 0.07 |
| Russian Federation | | 1,126.22 | 1,142.78 | 1,200.44 | 723.08 | 462.86 | 2,311.93 | 983.72 |
| Tajikistan © | | | | | | | | |
| Turkmenistan © | | 1.25 | 1.25 | 0.01 | 2.34 | 1.40 | 1.05 | 1.60 |
| Ukraine © | 2.43 | 1.78 | 4.25 | 3.21 | 10.04 | 4.00 | 127.06 | 47.03 |
| Uzbekistan | | | | | | | | |
| Canada © | 863.65 | 1,526.33 | 868.76 | 1,840.02 | 6,182.23 | 6,569.42 | 1,877.91 | 502.22 |
| United States of America © | 2,208.00 | 1,431.00 | 762.00 | 650.00 | 1,915.00 | 931.00 | 2,455.00 | 1,473.00 |
| Australia © | | | | | | | | |
| Japan | 1.00 | 3.00 | 2.00 | 3.00 | 3.00 | 2.00 | | |
| New Zealand © | 1.78 | 3.60 | 1.00 | 2.24 | 2.81 | 3.07 | 2.66 | 3.70 |

© See notes and comments in Chapter V.

TABLE 74

## Forest fires: area of forest burned

| Country | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
| | (1000 ha) | | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Albania | 0.42 | 0.25 | 1.01 | 0.52 | 0.71 | 0.15 | 0.41 | 0.42 |
| Austria | 0.20 | 0.05 | 0.13 | 0.11 | | | | |
| Belgium | 0.02 | 0.01 | 0.02 | 0.01 | 0.02 | 0.01 | 0.78 | 0.01 |
| Bosnia and Herzegovina | | | | 1.16 | 0.56 | 0.55 | | |
| Bulgaria | 1.01 | 0.47 | 4.15 | 10.15 | 9.71 | 0.53 | 1.87 | 0.68 |
| Croatia | | 0.81 | 1.70 | 3.62 | 4.59 | 3.02 | 6.51 | 6.99 |
| Cyprus | | | | | | | | |
| Czech Republic | | 0.08 | 1.28 | 0.57 | 0.20 | 0.21 | 0.35 | 3.48 |
| Denmark | 0.08 | 0.00 | 0.07 | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 |
| Estonia | 0.11 | 0.03 | 0.78 | 0.13 | 0.13 | 0.07 | 0.15 | 0.31 |
| Finland | 0.43 | 0.23 | 1.08 | 0.58 | 1.58 | 0.64 | 0.92 | |
| France | 56.50 | 6.50 | | | | | | |
| Germany | 0.48 | 0.92 | 4.91 | 1.49 | 1.11 | 0.59 | 1.38 | 0.60 |
| Greece | 18.49 | 13.05 | 49.56 | 24.20 | 23.39 | 9.04 | 7.59 | 12.60 |
| Hungary | | | | | | | | |
| Iceland | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ireland | | 0.28 | 0.15 | 0.05 | 0.28 | | | |
| Israel | | | | | | | | |
| Italy | 36.59 | 9.21 | 12.48 | 43.99 | | 5.94 | 7.10 | 28.27 |
| Latvia | | | 3.00 | 0.29 | 0.20 | 0.20 | 0.50 | |
| Liechtenstein | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Lithuania | | 0.04 | 0.72 | 0.28 | 0.24 | 0.24 | 0.32 | 0.11 |
| Luxembourg | 0.01 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 |
| Malta | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| Netherlands | 0.04 | 0.03 | 0.02 | 0.03 | 0.02 | 0.04 | 0.03 | |
| Norway | 0.09 | 0.53 | 1.37 | 0.22 | 0.23 | 0.11 | 0.51 | 0.63 |
| Poland | 5.03 | 2.11 | 33.33 | 3.68 | 2.50 | 1.74 | 5.31 | 2.17 |
| Portugal | 69.78 | 98.77 | 33.52 | 23.84 | 13.49 | 87.55 | 28.72 | 10.57 |
| Romania | 0.36 | 0.28 | 0.72 | 0.54 | 0.31 | 0.20 | 0.26 | 0.06 |
| Slovakia | | | | | | 0.09 | 0.22 | 0.03 |
| Slovenia | | 0.30 | 0.33 | 1.05 | 0.43 | 0.08 | 0.10 | 0.23 |
| Spain | 37.77 | 109.88 | 39.96 | 33.42 | 250.43 | 42.39 | 10.54 | 21.87 |
| Sweden | | | 3.25 | | 2.40 | 0.28 | 0.59 | |
| Switzerland | 1.10 | 0.15 | 0.05 | 0.04 | 0.29 | 0.44 | 0.23 | 1.51 |
| The FYR of Macedonia | | | | 10.07 | 5.37 | 0.01 | 0.84 | 0.53 |
| Turkey | 6.13 | 5.23 | 7.95 | 9.52 | 20.16 | 3.93 | 10.17 | 4.53 |
| United Kingdom | 0.46 | 0.11 | 0.19 | 0.15 | 1.04 | 0.54 | 0.59 | 0.33 |
| Yugoslavia | | 1.54 | 1.97 | 6.90 | 1.58 | 1.65 | 3.93 | |
| Armenia | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 | 0.02 | |
| Azerbaijan | | 0.06 | 0.07 | 0.01 | 0.01 | 0.04 | | |
| Belarus | 0.75 | 0.30 | 18.60 | 1.20 | 2.10 | 3.78 | 5.60 | 0.60 |
| Georgia | | | | | | | | |
| Kazakhstan | 1.00 | 4.30 | 1.20 | 0.70 | | | | |
| Kyrgyzstan | | | | | | | | |
| Republic of Moldova | | 0.02 | 0.02 | 0.00 | 0.08 | | 0.00 | |
| Russian Federation | | 682.05 | 691.48 | 748.62 | 536.79 | 360.14 | 1,853.51 | 726.74 |
| Tajikistan | | | | | | | | |
| Turkmenistan | | | | | | | | |
| Ukraine | 2.39 | 1.72 | 4.10 | 3.18 | 10.04 | 3.14 | 126.67 | |
| Uzbekistan | | | | | | | | |
| Canada | 217.00 | 570.00 | 246.00 | 243.00 | 743.00 | 1,239.00 | 612.00 | 143.00 |
| United States of America | | | | | | | | |
| Australia | | | | | | | | |
| Japan | 1.00 | 3.00 | 2.00 | 3.00 | 3.00 | 2.00 | | |
| New Zealand | 0.46 | 0.24 | 0.15 | 0.15 | 0.18 | 0.47 | 0.25 | 0.74 |

TABLE 75

## Forest fires: area of other wooded land burned

| Country | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
| | (1000 ha) | | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Albania | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Austria | 0.00 | 0.00 | 0.00 | 0.00 | | | | |
| Belgium | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.33 | 0.05 |
| Bosnia and Herzegovina | | | | 0.14 | 0.15 | 0.09 | | |
| Bulgaria | 0.00 | 0.04 | 0.28 | 0.62 | 9.40 | 0.02 | 0.07 | 0.00 |
| Croatia | | 1.33 | 2.78 | 5.91 | 3.20 | 1.07 | 3.52 | 2.52 |
| Cyprus | | | | | | | | |
| Czech Republic | | | | 0.00 | 0.00 | 0.00 | 0.79 | |
| Denmark | | 0.00 | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Estonia | 0.04 | 0.00 | 0.10 | 0.30 | 0.12 | 0.05 | 0.03 | 0.16 |
| Finland | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| France | 16.10 | 3.60 | | | | | | |
| Germany | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Greece | | | | 23.73 | 29.25 | 10.14 | 11.66 | 16.92 |
| Hungary | | | | | | | | |
| Iceland | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ireland | | 0.00 | 0.00 | 0.01 | 0.00 | | | |
| Israel | | | | | | | | |
| Italy | 0.00 | 0.00 | 5.66 | 9.57 | | 2.22 | 1.55 | 9.25 |
| Latvia | | | | 0.04 | 0.12 | 0.12 | 0.16 | |
| Liechtenstein | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Lithuania | | | 0.07 | 0.01 | 0.05 | 0.06 | 0.04 | 0.02 |
| Luxembourg | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Malta | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Netherlands | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.01 | |
| Norway | | | | | | | | |
| Poland | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Portugal | 50.78 | 53.75 | 18.45 | 26.12 | 63.84 | 82.06 | 54.32 | 15.49 |
| Romania | 0.01 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Slovakia | | | | | | 0.00 | 0.00 | 0.01 |
| Slovenia | | 0.30 | 0.16 | 0.41 | 0.45 | 0.07 | 0.14 | 0.15 |
| Spain | 0.00 | 27.42 | 2.56 | 1.59 | 17.88 | 6.20 | 5.55 | |
| Sweden | | | 2.29 | | 0.70 | 0.12 | 0.66 | |
| Switzerland | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |
| The FYR of Macedonia | | | | 0.00 | 0.00 | 0.11 | 0.86 | 0.08 |
| Turkey | 3.33 | 2.34 | 4.35 | 3.41 | 0.80 | 0.75 | 4.33 | 1.49 |
| United Kingdom | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Yugoslavia | | | | | | | 0.66 | |
| Armenia | 0.01 | 0.02 | 0.01 | 0.00 | 0.02 | 0.00 | 0.08 | |
| Azerbaijan | | 0.00 | 0.01 | 0.02 | 0.00 | 0.01 | | |
| Belarus | 0.04 | 0.00 | 5.20 | | | | 0.10 | 0.00 |
| Georgia | | | | | | | | |
| Kazakhstan | 0.30 | 0.60 | 0.00 | 0.00 | | | | |
| Kyrgyzstan | | | | | | | | |
| Republic of Moldova | | | | | | | 0.00 | |
| Russian Federation | | 444.17 | 451.30 | 451.82 | 186.30 | 102.72 | 458.42 | 256.97 |
| Tajikistan | | | | | | | | |
| Turkmenistan | | | | | | | | |
| Ukraine | | | | | | | | |
| Uzbekistan | | | | | | | | |
| Canada | 647.00 | 956.00 | 605.00 | 1,547.00 | 5,439.00 | 5,330.00 | 1,146.00 | 359.00 |
| United States of America | | | | | | | | |
| Australia | | | | | | | | |
| Japan | | | | | | | | |
| New Zealand | 1.31 | 3.36 | 0.85 | 2.09 | 2.63 | 2.60 | 2.41 | 2.96 |

TABLE 76

**Forest condition: percentage of all trees species showing defoliation of 25 per cent or more (classes 2, 3 and 4)**

| Country | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
| | Per cent of total of sampled trees in damage classes 2, 3 and 4 | | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Albania © | | | | | | | | 10.5 |
| Austria © | 9.1 | 7.5 | 6.9 | 8.2 | 7.8 | 6.6 | 7.9 | 7.1 |
| Belgium | 16.2 | 17.9 | 16.9 | 14.8 | 16.9 | 24.5 | 21.2 | 17.4 |
| Bosnia and Herzegovina | | | | | | | | |
| Bulgaria | 29.1 | 21.8 | 23.1 | 23.2 | 28.9 | 38 | 39.2 | 49.6 |
| Croatia | | | 15.6 | 19.2 | 28.8 | 39.8 | 30.1 | 33.1 |
| Cyprus | | | | | | | | |
| Czech Republic © | | 45.3 | 56.1 | 51.8 | 57.7 | 58.5 | 71.9 | 68.6 |
| Denmark | 21.2 | 29.9 | 25.9 | 33.4 | 36.5 | 36.6 | 28 | 20.7 |
| Estonia | | | 28.5 | 20.3 | 15.7 | 13.6 | 14.2 | 11.2 |
| Finland | 17.3 | 16 | 14.5 | 15.2 | 13 | 13.3 | 13.2 | 12.2 |
| France © | 7.3 | 7.1 | 8 | 8.3 | 8.4 | 12.5 | 17.8 | 25.2 |
| Germany © | 15.9 | 25.2 | 26.4 | 24.2 | 24.4 | 22.1 | 20.3 | 19.8 |
| Greece © | 17.5 | 16.9 | 18.1 | 21.2 | 23.2 | 25.1 | 23.9 | 23.7 |
| Hungary | 21.7 | 19.6 | 21.5 | 21 | 21.7 | 20 | 19.2 | 19.4 |
| Iceland | | | | | | | | |
| Ireland © | | | | | | | | |
| Israel © | | | | | | | | |
| Italy © | 16.3 | 16.4 | 18.2 | 17.6 | 19.5 | 18.9 | 29.9 | 35.8 |
| Latvia | 36 | | 37 | 35 | 30 | 20 | 21.2 | 19.2 |
| Liechtenstein © | | | 16 | | | | | |
| Lithuania | 20.4 | 23.9 | 17.5 | 27.4 | 25.4 | 24.9 | 12.6 | 14.5 |
| Luxembourg © | | 20.8 | 20.4 | 23.8 | 34.8 | 38.3 | 37.5 | 29.9 |
| Malta © | | | | | | | | |
| Netherlands © | 17.8 | 17.2 | 33.4 | 25 | 19.4 | 32 | 34.1 | 34.6 |
| Norway © | 17.2 | 19.7 | 26.2 | 24.9 | 27.5 | 28.8 | 29.4 | 30.7 |
| Poland | 38.4 | 45 | 48.8 | 50 | 54.9 | 52.6 | 39.7 | 36.6 |
| Portugal | 30.7 | 29.6 | 22.5 | 7.3 | 5.7 | 9.1 | 7.3 | 8.3 |
| Romania | | 9.7 | 16.7 | 20.5 | 21.2 | 21.2 | 16.9 | 15.6 |
| Slovakia | 41.5 | 28.5 | 36 | 37.6 | 41.8 | 42.6 | 34 | 31 |
| Slovenia © | 18.2 | 15.9 | | 19 | 16 | 24.7 | 19 | 25.7 |
| Spain © | 4.6 | 7.3 | 12.3 | 13 | 19.4 | 23.52 | 19.4 | 13.73 |
| Sweden | | | | | | 14.2 | 17.4 | 14.9 |
| Switzerland © | 15.5 | 16.1 | 12.8 | 15.4 | 18.2 | 24.6 | 20.8 | 16.9 |
| The FYR of Macedonia | | | | | | | | |
| Turkey | | | | | | | | |
| United Kingdom © | 39 | 56.7 | 58.3 | 16.9 | 13.9 | 13.6 | 14.3 | 19 |
| Yugoslavia © | | 9.8 | | | | | 3.6 | 7.7 |
| Armenia | 10 | 6 | 7 | 7 | 7 | 8 | 20 | 30 |
| Azerbaijan © | | | | | | | | |
| Belarus | 54 | | 29.2 | 29.3 | 37.4 | 38.3 | 39.7 | 36.3 |
| Georgia | | | | | | | | |
| Kazakhstan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kyrgyzstan | | | | | | | | |
| Republic of Moldova © | | | | 50.8 | | 40.4 | 41.2 | |
| Russian Federation © | | | | | | | | |
| Tajikistan | | | | | | | | |
| Turkmenistan | | | | | | | | |
| Ukraine | 2.9 | 6.4 | 16.3 | 21.5 | 32.4 | 29.6 | 46 | 31.4 |
| Uzbekistan | | | | | | | | |
| Canada © | 4.9 | 8.1 | 10 | 4.9 | 2.7 | 3.1 | | |
| United States of America © | 0.9 | 1.7 | 1.2 | 0.4 | 0.4 | 0.4 | 0.2 | 0.2 |
| Australia © | | | | | | | | |
| Japan © | | | | | | | | |
| New Zealand © | | | | | | | | |

© See notes and comments in Chapter V.

TABLE 77

## Forest condition: percentage of coniferous species showing defoliation of 25 per cent or more (classes 2, 3 and 4)

| *Country* | *Year* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | *1990* | *1991* | *1992* | *1993* | *1994* | *1995* | *1996* | *1997* |
| | *Per cent of total of sampled trees in damage classes 2, 3 and 4* | | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Albania © | | | | | | | | 10.4 |
| Austria © | 8.3 | 7 | 6.6 | 8.2 | 7.9 | 6.6 | 7.3 | 6.3 |
| Belgium | 23.6 | 23.4 | 23 | 18.3 | 21.2 | 21 | 25.8 | 19.2 |
| Bosnia and Herzegovina | | | | | | | | |
| Bulgaria | 37.4 | 26.5 | 25.5 | 26.9 | 25 | 41.4 | 46.5 | 53.5 |
| Croatia | | | 26.2 | 33.9 | 39.3 | 57.5 | 57 | 68.7 |
| Cyprus | | | | | | | | |
| Czech Republic © | 46.9 | 46.3 | 57.9 | 51.5 | 59 | 60.7 | 74.9 | 71.9 |
| Denmark | 18.8 | 31.4 | 28.6 | 37 | 38.7 | 34.8 | 23.2 | 15.9 |
| Estonia | 20 | 28 | 29.5 | 21.2 | 16 | 14.2 | 14.6 | 11.4 |
| Finland | 18 | 17.2 | 15.2 | 15.6 | 13.1 | 13.7 | 13.7 | 12.8 |
| France © | 6.6 | 6.7 | 7.1 | 8.2 | 8.2 | 9.2 | 13.5 | 16.2 |
| Germany © | 15 | 24.8 | 23.8 | 21.4 | 21.6 | 18.3 | 16.7 | 15.4 |
| Greece © | 10 | 7.2 | 12.3 | 13.9 | 13.2 | 13.6 | 14.4 | 13.8 |
| Hungary | 23.3 | 17.8 | 20.1 | 20.1 | 21.2 | 18.7 | 17.8 | 17.4 |
| Iceland | | | | | | | | |
| Ireland © | 5.4 | 15 | 15.7 | 29.6 | 19.7 | 26.3 | 13 | 13.6 |
| Israel © | | | | | | | | |
| Italy © | 19.2 | 13.8 | 17.2 | 15.1 | 15 | 19.4 | 25.1 | 28.1 |
| Latvia | 43 | | 45 | 41 | 34 | 23 | 24.8 | 21.9 |
| Liechtenstein © | 7.1 | | 18 | | | | 0 | |
| Lithuania | 22.9 | 27.8 | 17.5 | 29.2 | 26.3 | 26.6 | 12.9 | 13.9 |
| Luxembourg © | | 7.9 | 6.3 | 9 | 12.8 | 12.9 | 12.7 | 8 |
| Malta © | | | | | | | 0 | |
| Netherlands © | 21.4 | 21.4 | 34.7 | 30.6 | 27.7 | 45.4 | 43.5 | 45.3 |
| Norway © | 17.1 | 19 | 23.4 | 20.9 | 22.4 | 24 | 25.1 | 28.5 |
| Poland | 40.7 | 46.9 | 50.3 | 50.8 | 55.6 | 54.5 | 40.5 | 36.8 |
| Portugal | 25.7 | 19.8 | 11.3 | 7.1 | 5.4 | 6.6 | 5.6 | 7.8 |
| Romania | | 6.9 | 10.9 | 16.6 | 15.5 | 15.2 | 10.4 | 10.3 |
| Slovakia | 55.5 | 38.5 | 44 | 49.9 | 50.3 | 52 | 41 | 42.2 |
| Slovenia © | 34.6 | 31.3 | | 27 | 19 | 33.6 | 26 | 32.5 |
| Spain © | 4.4 | 7.3 | 13.5 | 14.6 | 19.6 | 18.1 | 18.1 | 11.6 |
| Sweden | 16.1 | 12.3 | 16.9 | 10.6 | 16.2 | 14.5 | 16.9 | 15.9 |
| Switzerland © | 17.9 | 18 | 14.1 | 17.4 | 19.6 | 23.2 | 21.4 | 19.9 |
| The FYR of Macedonia | | | | | | | | |
| Turkey | | | | | | | | |
| United Kingdom © | 45 | 51.5 | 52.7 | 16.8 | 15 | 13 | 13.9 | 17 |
| Yugoslavia © | | 15.9 | | | | | 4.4 | 7.9 |
| Armenia | | 6 | 7 | 7 | 7 | 8 | 10 | 20 |
| Azerbaijan © | | | | | | | | |
| Belarus | 57 | | 33.7 | 33.8 | 44 | 43.9 | 43.1 | 41.2 |
| Georgia | | | | | | | | |
| Kazakhstan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kyrgyzstan | | | | | | | | |
| Republic of Moldova © | | | | 45.2 | | 33.3 | 48.4 | |
| Russian Federation © | | | | | | | | |
| Tajikistan | | | | | | | | |
| Turkmenistan | | | | | | | | |
| Ukraine | 3 | 6.4 | 13.8 | 21.7 | 34.8 | 25.7 | 45.8 | 32.7 |
| Uzbekistan | | | | | | | | |
| Canada © | 3.1 | 4.7 | 8.1 | 6.3 | 3.5 | 3.7 | | |
| United States of America © | 1.3 | 2 | 1.3 | 0.2 | 0.4 | 0.4 | 0.2 | 0.2 |
| Australia © | | | | | | | | |
| Japan © | | | | | | | | |
| New Zealand © | | | | | | | | |

© See notes and comments in Chapter V.

TABLE 78

**Forest condition: percentage of broadleaved species showing defoliation of 25 per cent or more (classes 2, 3 and 4)**

| Country | Year | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
| | Per cent of total of sampled trees in damage classes 2, 3 and 4 | | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| Albania © | | | | | | | | 10.6 |
| Austria © | 14.9 | 11.1 | 9.3 | 7.7 | 7.4 | 6.5 | 11.6 | 12.2 |
| Belgium | 10 | 13.5 | 11.8 | 11.7 | 12.8 | 26.6 | 18.5 | 16.1 |
| Bosnia and Herzegovina | | | | | | | | |
| Bulgaria | 17.3 | 15.3 | 18 | 16.6 | 34.4 | 32.7 | 33 | 43.9 |
| Croatia | | | 13.6 | 15.6 | 26.4 | 35.2 | 26 | 27.8 |
| Cyprus | | | | | | | | |
| Czech Republic © | | 37.6 | 29.2 | 54.4 | 48 | 30.6 | 34 | 26.5 |
| Denmark | 25.4 | 27.3 | 21.2 | 27 | 32.4 | 39.7 | 36.1 | 28.4 |
| Estonia | | | 0 | 1.1 | 2 | 1.1 | 5.3 | 7.4 |
| Finland | 11.6 | 7.7 | 10.1 | 12.8 | 12 | 11 | 10.3 | 8.4 |
| France © | 7.7 | 7.4 | 8.5 | 8.4 | 8.4 | 14.3 | 20.1 | 29.9 |
| Germany © | 23.8 | 26.5 | 32 | 29.9 | 30.1 | 29.9 | 30.8 | 28.6 |
| Greece © | 26.5 | 28.5 | 25 | 29.8 | 35 | 38.2 | 34.6 | 34.9 |
| Hungary | 21.5 | 19.9 | 21.8 | 21.2 | 21.8 | 20.2 | 19.5 | 19.7 |
| Iceland | | | | | | | | |
| Ireland © | | | | | | | | |
| Israel © | | | | | | | | |
| Italy © | 15.6 | 17.1 | 18.5 | 18.3 | 20.7 | 18.5 | 31.2 | 38 |
| Latvia | 27 | | 19 | 17.8 | 15 | 10 | 11.4 | 11.3 |
| Liechtenstein © | | | | | | | | |
| Lithuania | 15.8 | 14.9 | 17.6 | 23.8 | 23.3 | 20.8 | 12.2 | 15.9 |
| Luxembourg © | | 33.9 | 30.5 | 31 | 46.8 | 51.4 | 49.8 | 41.8 |
| Malta © | | | | | | | | |
| Netherlands © | 11.5 | 9.4 | 31.1 | 13.1 | 5.1 | 10.8 | 19.2 | 17.8 |
| Norway © | 18.2 | 25.1 | 38.9 | 42.1 | 47.6 | 47.4 | 45 | 38.9 |
| Poland | 25.6 | 34.8 | 40.4 | 45.6 | 51.5 | 46.7 | 37.4 | 35.8 |
| Portugal | 34.1 | 36.6 | 29.1 | 7.5 | 5.8 | 10.4 | 8.3 | 8.6 |
| Romania | | 10.4 | 18.4 | 21.4 | 22.9 | 23.1 | 18.7 | 16.9 |
| Slovakia | 31.3 | 21.1 | 30 | 29.1 | 35.6 | 35.8 | 28 | 23.3 |
| Slovenia © | 4.4 | 5.8 | | 11 | 13 | 19.3 | 15 | 21.4 |
| Spain © | 4.8 | 7.4 | 11.2 | 11.4 | 19.3 | 28.7 | 20.7 | 15.8 |
| Sweden | | | | | | 7.9 | 20.7 | 6.1 |
| Switzerland © | 12.3 | 13.3 | 11.1 | 12.7 | 16.2 | 27 | 19.8 | 12.5 |
| The FYR of Macedonia | | | | | | | | |
| Turkey | | | | | | | | |
| United Kingdom © | 28.8 | 65.6 | 67.8 | 17.1 | 12.4 | 14.5 | 15 | 22 |
| Yugoslavia © | | 8.2 | | | | | 3.5 | 7.4 |
| Armenia | 10 | | | | | | 10 | 10 |
| Azerbaijan © | | | | | | | | |
| Belarus | 45 | | 14.8 | 16.6 | 18.6 | 22.9 | 29.2 | 23 |
| Georgia | | | | | | | | |
| Kazakhstan | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Kyrgyzstan | | | | | | | | |
| Republic of Moldova © | | | | 50.9 | 21.9 | 40.5 | 41.1 | 30 |
| Russian Federation © | | | | | | | | |
| Tajikistan | | | | | | | | |
| Turkmenistan | | | | | | | | |
| Ukraine | 2.7 | 6.4 | 20.2 | 21.6 | 29.9 | 33 | 46.2 | 30.7 |
| Uzbekistan | | | | | | | | |
| Canada © | 10.3 | 18.5 | 16 | 1 | 0.8 | 1.1 | | |
| United States of America © | 0.4 | 1.4 | 1.1 | 0.6 | 0.3 | 0.5 | 0.1 | 0.1 |
| Australia © | | | | | | | | |
| Japan © | | | | | | | | |
| New Zealand © | | | | | | | | |

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## NOTES AND COMMENTS RELATING TO CHAPTER V

| Main Tables | Comments |
|---|---|

**Albania**

**70, 71**

*Enquiry Table 18*: The most important damages are by pests and diseases, about 96.2 per cent (or 691,000 ha) of the total area damaged; in second place are areas damaged by grazing and wildlife, about 1.8 per cent (or 12,650 ha); in third place are areas damaged by known local pollution sources, about 1.7 per cent (or 11,900 ha) and, in last place there is areas damaged by fires about 0.4 per cent (or 2,630 ha).

**72-75**

*Enquiry Table 19*: The data for 1997 are secretariat estimates.

**76-78**

*Enquiry Table 20*: The health situation of our forests is not so good. The mean defoliation of trees in the classes 2-3-4 of defoliation is the highest in Europe, together with Czech Republic, Slovak Republic and Poland.

Approximately, 10.4 per cent of our forests, particularly in mountainous areas, has been suffering due to air pollution.

**Australia**

**70, 71**

*Enquiry Table 18*: National data on damage to forest are unavailable, see the following text:

Currently, there are no quantitative national data on the pests and diseases that occur in Australia's forests, or on the damage they cause. Due to the climatic range across Australia very few pests and diseases are nationally distributed. Many of the pests and diseases are significant at a sub-continental scale.

There exists supportive information on "Pests and Diseases of Australian forest, by State or Territory" in tabular form in the reply to the enquiry which is available at the secretariat.

Damage to forest by insects and disease: Forest dieback is widespread and severe in five States, widespread and having an adverse effect in the Australian Capital Territory (ACT), and widespread in the Northern Territory. It is caused by various factors, including tree age, changes to soil as a result of sheep and cattle grazing and increasingly intensive pasture production practices, changes to groundwater, depredation by insects (such as pasture scarabs), attack by pathogens, and drought. The two most widespread pathogens in Australia, *Phytophthora* and *Armillaria* species, cause dieback-like diseases.

Various other fungal pathogens, especially native ones, may affect forest trees under some seasonal conditions but generally do not cause long-term problems.

A number of native and exotic insects are considered pests in plantations and native forests managed for timber production. These include defoliators and leaf miners, sap-suckers and wood and bark borers.

Damage to forest by wildlife and grazing: Cats, dingoes, dogs, deer, donkeys, horses, goats, hares, rats, mice, possums, kangaroos and foxes are all widespread in Australian forests and represent a serious threat to forest species and ecosystems. Possums and kangaroos may seriously damage regenerating young plantations by browsing on seedlings.

Foxes are the most widespread exotic animals adversely affecting forested ecosystems. They occur across mainland Australia and have severely limited populations of ground-dwelling mammals. Such mammals are important components of the ecosystem by helping to spread mycorrhiza fungi upon which the health of the trees depend. Feral animals may also spread disease which adversely affect trees and other plants. Pigs, for instance, are known to spread Phytophthora cinnamomi and may act as a feral "reservoir" of potentially devastating animal diseases such as footrot.

Damage to forest by fire: There are no national data on the amount of forest burnt annually by either bushfire or prescribed burning. However, 1994 reviews of fire management strategies and practices undertaken by State fire authorities and land management agencies in New South Wales, Queensland, Tasmania and Western Australia revealed a change in traditional approaches to fire management as governments are providing fewer resources to land management agencies to undertake fire management and are placing greater demands on volunteers. As a result, there is a reduction in expertise to ensure that prescribed burning meets prescriptions. In general, the area of forest subjected to prescribed burning each year has declined in recent years.

Damage to forest by local pollution sources: At present there is no systematic data collection to allow for reporting on pollution damage to forest. However, it is believed that few, if any, forests are affected by air pollutants.

Australia is establishing a National Pollutant Inventory. This will be a publicly available database containing information on annual releases of toxic and hazardous substances from industrial and diffuse sources, covering urban and rural areas.

Data Source: State of the Forest Report (1998).

after R. Boyle, P. Dewundege, J. Hazi, D. Hearn, C. McIntosh, A. Morrell, YL Ng and R. Serebryanikova, (1996), Report on the Air Emissions Trials for the National Pollutant Inventory, Vol.1, Environment Protection Authority, State Government of Victoria.

**72-75**

*Enquiry Table 19*: Extensive fire damage occurs in Australia, but no data are collected on a national basis.

**76-78**

*Enquiry Table 20*: No data available. See the following text:

Forest dieback is responsible for a significant decline in tree number and health. Dieback is widespread and severe in five States, widespread and having an adverse effect in the ACT, and widespread in the Northern Territory. It is caused by various factors, including fungal pathogens, insect pests and mammalian browsers and a combination of stresses imposed by the environment including tree age, changes to soil as a result of sheep and cattle grazing and increasingly intensive pasture production practices, changes to groundwater and drought. Interactions between these factors can cause stress and that may also induce disease if prolonged or intensified. A lack of regeneration in some areas compounds the problem.

The two most widespread pathogens in Australia are the *Phytophthora* and *Armillaria* species. *Phytophthora* spp. kills a range of species in all States and has caused significant dieback and death of commercially important eucalypt species in Western Australia, Victoria and Tasmania. Due to its prevalence in Western Australia, significant resources are being put towards identification and control.

Insects affect trees by defoliating them, sucking their sap or boring into the wood. This can limit tree growth or damage the wood, reducing the economic value of timber harvested from the forest. Many moth, beetle and sawfly species eat eucalypt leaves, particularly new growth, at some stage of their life cycle. For this reason, they can sometimes cause extensive damage in young plantations and regrowth forests, as well as harm young trees in mature forests.

The extent of mammalian browsing varies depending on the level of pest control imposed by forest managers and the influence of seasonal factors. Where browsing occurs, the extent of damage varies. Animals may eat out the growing tip, eat half the plant, bite the plant off at ground level, and even pull it fully out of the ground. They may also strip away bark to get the layer underneath or take off the side shoots.

Some studies indicate that eucalypts can tolerate moderate browsing without ill effect. Heavy browsing can kill young plants, or at least seriously stunt growth and cause bent or multiple stems that reduce the commercial value of the log at time of harvest.

Among the native animals, kangaroos, pademelons, possums, rats and wallabies are all extensive and sometimes serious browsing pests in many forests and eucalypt plantations. Of the introduced species, rabbits are the most destructive, causing damage to both eucalypts and pines. Additionally, goats, hares and rats all cause serious damage in some places.

Data Source: State of the Forest Report (1998). Australia's First Approximation Report for the Montreal Process, 1997.

**Austria**

**72-75**

*Enquiry Table 19*: The data for 1997 are secretariat estimates.

**76-78**

*Enquiry Table 20*: Only trees 60 years and older are assessed for the following:

In 1995: for All species;

In 1994 and 1995: for Coniferous;

In 1992, 1994 and 1995: for Broadleaved.

Only trees 50 years and older are assessed for the following:

In 1993: for Coniferous and Broadleaved.

**Azerbaijan**

**70, 71**

*Enquiry Table 18*: The figure 0.033 ha given for "Primarily damaged by fire" refers to the period 1992-1997.

**72-75**

*Enquiry Table 19*: Data are provided by the National Correspondent.

**76-78**

*Enquiry Table 20*: There is no information on defoliation in Azerbaijan. The country does not participate in annual surveys.

**Belarus**

**70, 71**

*Enquiry Table 18*: A hurricane struck Belarus on 23-24 June 1997; forests in the Brest and Minsk oblasts suffered the worst damage. The total damaged area needing clearing was 6,753 hectares, with 868,000 $m^3$ of timber. The costs of the clear-up ran to 56 billion roubles, or about 2 million US$.

**Belgium**

**70, 71**

*Enquiry Table 18*: For the Walloon Region: 1) Stands attacked by insects or diseases: taken into account when more than 25 per cent of affected trees; 2) Stands damaged by fauna: taken into account when more than 25 per cent of affected trees.

"Primarily damaged by insects and disease": In 1997, in Flanders Region, 18,800 ha of poplars have been affected by *Melampsora larici*-populina.

"Primarily damaged by storm, wind, snow etc".: Damage caused by the 1990 storms is now no longer noticeable.

**Bosnia and Herzegovina**

**72-75**

*Enquiry Table 19*: The data for1991, 1992, 1996 and 1997 are secretariat estimates.

**Canada**

**70, 71**

*Enquiry Table 18*: The figure given for area primarily damaged by insects and disease includes areas of moderate to severe defoliation due to insects such as the spruce budworm and mortality due to the mountain pine beetle.

Defoliation does not always result in mortality. For example, stands with moderate defoliation often recover and may not lose much growth. Defoliation is mapped on an insect-by-insect basis, and a given area may be afflicted by more than one insect at a time. This may result in double and triple counting on areas affected by more than one insect, exaggerating the extent of the total area defoliated. Also, since the figure given is the sum of areas affected in each of ten years, there is likely multiple counting of areas that were affected in more than one year.

**72-75**

*Enquiry Table 19*: The figures for 1996 and 1997 are estimates.

The figures reported are for forest and other wooded land only. Areas of non-stocked timber-productive land are included in the area of other wooded land burnt.

**76-78**

*Enquiry Table 20*: Percentages are based on area infested.

Data for defoliation by insects only. There is minimal defoliation by other causes.

Data for broadleaved trees relate mostly to defoliation by aspen twoleaf tier, forest tent caterpillar and gypsy moth.

There is minimal defoliation by other insects. Some areas may be infested by more than one insect, resulting in overestimation of area infested.

It is assumed that coniferous and broadleaved species occur on the forest land of Canada in the ratio 75/25.

**Czech Republic**

**70, 71**

*Enquiry Table 18*: No forest damage from radio contamination. There is information (in tabular and graphic form) on identifiable abiotic factors in the original reply to the enquiry, which is available at the secretariat.

**72-75**

*Enquiry Table 19*: Areas of burnt "other land" not reported.

**76-78**

*Enquiry Table 20*: Mainly trees older than 60 years assessed for the following:

In 1997: for All species, Coniferous, and Broadleaved.

**Denmark**

**70, 71**

*Enquiry Table 18*: No statistics or collected data exist on these matters. The figures are rough subjective estimates.

Concerning "Primarily damaged by wildlife and grazing": It is difficult to estimate in a proper way. Most young stands in the eastern part of the country will be damaged by roe deer or sometimes hares if they are not fenced. In the western and central part of Jutland red deer often can make such severe damage on the bark of conifers that the wood will be unusable by the timber industry.

The figure for "Primarily damaged by wildlife and grazing" is a rough, subjective estimate on how big a forest area annually is damaged so much by wildlife that the 'stands break down' and should be re-established. Much of the damage is taking place on the same areas period after period. Therefore the sum of about 3,715 ha can not be multiplied directly, e.g. over 100 years it would come to an area almost as much as the total Danish forest area.

**72-75**

*Enquiry Table 19*: The data for 1988, 1989 and 1991 are secretariat estimates.

**Finland**

**70, 71**

*Enquiry Table 18*: Damage due to competition between trees (300,000 ha) is now included in "Total area of forest and other wooded land with damage from unidentified causes". Damage describes the current state. The occurrence year of the heaviest damage is not available.

**72-75**

*Enquiry Table 19*: The data for 1997 are secretariat estimates.

**France**

**70, 71**

*Enquiry Table 18*: Source: Ministère de l'agriculture et de la Pêche, Département de la santé des forêts.

Data for "Total area of forests and other wooded land with damage by known causes": minimum area.

Data for "Primarily damaged by insects and disease": the reference period extends between 1983 and 1993.

The area of forest in which there have been significant losses attributable to insects or fungal diseases but the future of the stands is not jeopardized is put, by expert estimates, at 150,000 hectares. The area of forest needing to be reconstituted following insect or fungal damage is estimated at 2,500 hectares.

The most serious damage by insects and diseases was recorded in 1993. Of the estimated 200,000 hectares damaged, 50,000 hectares were due to an infestation of *Lymantria dispar* which culminated in France between 1992 and 1994. Locally, this caused extensive die-offs of trees, particularly in the Centre-West region and in Alsace, where almost 20,000 hectares of broadleaved high forest were defoliated in 1993, 3,000 of them completely. It has not been possible to estimate the total area of France defoliated by this pest. The extent of the damage indicated here (50,000 hectares) should be regarded as a minimum.

Data for "Primarily damaged by wildlife and grazing": The damaged area shown (45,000 ha) is a minimum, according to a 1993 survey (see below).

In the aftermath of a spectacular increase in the population of deer (50,000 head in 1995), roe deer (1,200,000 head), and wild boar (250,000 head), damage due to large game animals is now an extremely important problem in France, although in the case of forests it has not been quantified. According to a 1993 survey, between 40,000 and 45,000 hectares of land under regeneration (i.e. 12-14 per cent of the total area under regeneration) is protected against large game animals at any time. Land under regeneration is of course not the only woodland suffering damage by wild animals, but no estimate for other types of woodland is available.

Data for "Primarily damaged by fire" the reference period extends from 1986 to 1995.

Data for "Primarily damaged by storm, wind, snow or other identifiable abiotic factors": the reference period extends from 1985 to 1994. Damage due to drought has not been taken into account under damage due to abiotic factors. Although often significant, water shortages being one of the main factors affecting forest growth and vigour, such damage is very difficult to estimate.

There were a number of storms at the beginning of 1990, on 25 January, 3 February, 12 to 15 February and from 26-28 February onward, among others. They resulted in extensive windblow (7 million $m^3$, 30 per cent of it coniferous and 60 per cent beech), chiefly in Lorraine, Picardy and Normandy, i.e. the northern half of France. The area-equivalent of the volume destroyed has been calculated from the average volume per hectare of normal high forest, which is the type of woodland most commonly affected by windblow. The storm in Brittany in October 1987 caused 6 million $m^3$ of windblow.

**72-75**

*Enquiry Table 19*: Data for 1997: Provisional figures for 1997.

Source: Ministry of Agriculture and Fisheries, Countryside and Forests Directorate, and SCEES.

Remarks: After a fire, it is difficult to distinguish between forest and other wooded land in the south of France. For this reason, it has not been possible to assign burnt areas between forest and other wooded land since 1992. The data do not include burnt areas of "other land".

**76-78**

*Enquiry Table 20*: All species in 1987: regional survey, and lost trees (280) not included.

Coniferous in 1987: lost trees (194) not included.

Broadleaved in 1987: regional survey, and lost trees (84) not included.

**Germany**

**70, 71**

*Enquiry Table 18*: Area with damage: Precise areas cannot be reported as damage affects single stems and only the affected timber volume is covered. Damage is caused by insects, wind and game.

**76-78**

*Enquiry Table 20*: In 1991 for "All species", coniferous and broadleaved: since 1991 with former GDR.

**Greece**

**70, 71**

*Enquiry Table 18*: Damage occurs regularly from disease to *Castanea* and *Cupressus*, but no data are available.

**72-75**

*Enquiry Table 19*: The figures in the table relate only to fires on forest and other wooded land. Data are available on request covering fires on pasture and other agricultural land.

**76-78**

*Enquiry Table 20*: For "All species", coniferous and broadleaved: excluding maquis.

**Hungary**

**70, 71**

*Enquiry Table 18*: The source of the data is the "Forest damage early warning system" run by the Forest Research Institute except for fire. For fire: Extrapolation of data on fires in state forests. Source: Report on forest fires. Journal of Forestry, October 1997.

**72-75**

*Enquiry Table 19*: No data are available on forest fire statistics.

**Iceland**

**70, 71**

*Enquiry Table 18*: Numbers are very rough estimates.

Under major individual episodes: very heavy snow during winter 1994-95 caused extensive damage.

**72-75**

*Enquiry Table 19*: Forest fires are extremely rare in Iceland.

**Ireland**

**72-75**

*Enquiry Table 19*: The data for 1995, 1996 and 1997 are secretariat estimates.

**76-78**

*Enquiry Table 20*: In 1986: not assessed. From 1987 to 1997: only coniferous assessed.

**Israel**

**70, 71**

*Enquiry Table 18*: The disease damage data are related especially to *Matsucocus josephi.*

**72-75**

*Enquiry Table 19*: The data for 1997 are secretariat estimates.

**76-78**

*Enquiry Table 20*: No defoliation observed in most of the years.

Damage under "Primarily damaged by insects and disease" (*Enquiry Table 18)*: causes defoliation up to 100 per cent.

**Italy**

**76-78**

*Enquiry Table 20*: In 1996 and 1997 for "All species", coniferous and broadleaved: excludes Sardinia.

**Japan**

**70, 71**

*Enquiry Table 18*: Estimates of annual average damage are made by the secretariat and based on the data sent by the National Correspondent.

**76-78**

*Enquiry Table 20*: Basically, Japan has not made public information on defoliation to show tree damage.

**Kyrgyzstan**

**72-75**

*Enquiry Table 19*: No data available on forest fires.

**Latvia**

**70, 71**

*Enquiry Table 18*: In the summer of 1992, the situation with forest fires was disastrous, resulting in over 2000 ha of forest burnt. In 1994 there started an outbreak of *Ips typographus* which is still going on. In 1996, there was outbreak of *Lymantria monacha* and *Gilpinia pallida.* We have no data about the extent of forest damage before 1991.

**72-75**

*Enquiry Table 19*: The date for 1997 are secretariat estimates.

**Liechtenstein**

**76-78**

*Enquiry Table 20*: No survey from 1993 to 1997.

Liechtenstein does not participate in the annual ICP surveys. Our annual national monitoring distinguishes 5 classes: healthy; slightly sick; sick; withering; dead. The percentage of trees in the last 3 classes (roughly equivalent to more than 25 per cent defoliation) was the following:

| | *spruce* | *fir* | | *spruce* | *fir* |
|---|---|---|---|---|---|
| 1986 | 2.9 | 17.4 | 1992 | 4.6 | 20.0 |
| 1987 | 2.1 | 18.9 | 1993 | 8.8 | 18.7 |
| 1988 | 2.6 | 16.3 | 1994 | 11.3 | 23.5 |
| 1989 | 2.2 | 14.3 | 1995 | 11.1 | 28.6 |
| 1990 | 3.2 | 16.1 | 1996* | 6.6 | 8.7 |
| 1991 | 4.0 | 17.7 | 1997* | 8.7 | 13.8 |

* The classification was changed.

**Lithuania**

**70, 71**

*Enquiry Table 18*: In 1993 great windthrow damage was caused on 73 thousand ha of forest area followed in 1994-1995 by outbreaks of insects. Spruce stands were severely damaged by *Ips typographus*, while pine stands to a smaller extent by *Dendrolimus pini.*

**Luxembourg**

**72-75**

*Enquiry Table 19*: The data for 1997 are secretariat estimates.

**76-78**

*Enquiry Table 20*: In 1991 for all species: defoliation and discolouration. In 1991 for Coniferous: trees under/over 60 years. In 1995 for Broadleaved: including underwood.

**Malta**

**70, 71**

*Enquiry Table 18*: See *Enquiry Table 19* "Forest fire".

**76-78**

*Enquiry Table 20*: Very little damage is visible. The most occurs on coastal sites due to saline winds.

**Netherlands**

**70, 71**

*Enquiry Table 18*: Sources: Storm 1990 Ekkelboom, J. NBT 62 nr 8. No gross stormfellings, Insects 1995. Moraal L., 1995 NBT 68 nr. 3. No gross damage by insects.

General comments: Data on other damage to the forest are inventoried occasionally when substantial damage occurs. There is no intention to conduct a more continuous inventory-system on this subject.

**72-75**

*Enquiry Table 19*: The data for 1997 are secretariat estimates.

Sources: IKC-natuurbeheer, 1995. Statistiek van branden in bos- en natuurterreinen in 1993. Werkdocument IKCN nr. 75. Wageningen. Bosdata 1997. Enquiry on forest fires 1994-1996.

There is every year more burnt area in so called 'natuurterreinen' (nature areas) which can not be classified as other wooded land. They are not presented in this table.

General comments: Data on forest fires were available from the administration system of forest fires upto 1995. The registration system was recently stopped.

**76-78**

*Enquiry Table 20*: In 1991 for All species: defoliation and discolouration.

**New Zealand**

**70, 71**

*Enquiry Table 18*: No national data in this format are available for New Zealand. Significant damage has been done to the indigenous forest by introduced mammals (see *Enquiry Table 10* "Forest-occurring species at risk or endangered") but this is not quantified in the format of this table. Storm damage (primarily from wind) occurs infrequently. In the past there were significant areas of the plantation forest where blowdown was a serious risk but forest management practices have been developed to minimise the risk. The last significant storm damage was in 1988 when tropical cyclone Bola struck. This cyclone did more damage to the steep hill country cleared for grazing than to forested areas but no quantitative data are available on the extent of the damage to forested areas. It is considered that on average less than 1,000 hectares of forest are primarily damaged by storm each year in New Zealand.

**72-75**

*Enquiry Table 19*: The figures are for the year ended June.

The source of this table is the New Zealand Fire Service Commission. Forest fires in New Zealand in terms of the areas reported as burnt each year are not nationally significant, but this is because of the precautions taken to minimise the risk of fire damage occurring in the forest plantations. Most of the fires reported are in shrubland (other wooded land) rather than in forest. The total area reported does not include "burnt other land".

**76-78**

*Enquiry Table 20*: Data in this format cannot be supplied as New Zealand does not compile national forest condition statistics. Defoliation from introduced pests, especially possums, is a significant forest condition problem in New Zealand but is not currently quantified at the national level. Likewise, forest inspections are made to assess forest health, especially for some fungus diseases. The information for these inspections is not quantified at the national level.

**Norway**

**70, 71**

*Enquiry Table 18*: Area with damage refers to stands in which the production have been reduced by more than 10 per cent. The extent of heaviest damage is a rough estimate of the area more or less totally destroyed by storm in 1992.

The area primarily damaged from known local pollution sources is the estimate which includes areas where occasional damage to needles or leaves has been observed, but not necessarily any detectable reduction of production or increased mortality. Changed lichen vitality may have been detected over larger areas, but this cannot be described as a "forest damage".

**76-78**

*Enquiry Table 20*: From 1992 to 1997 for broadleaved: special study on birch.

**Poland**

**70, 71**

*Enquiry Table 18*: For damage caused by wildlife and storm etc, data for one year are only available.

Detailed interpretation of this table is as below:

The source data used in this table originates from different sources and periods. For some groups of damage data are incomplete, for others relevant information was not available. Due to those problems the "significant" damage qualifier has a different meaning in each class of agents.

– "Primarily damaged by insects and disease": the presented data (average for 1992-1996 period) are of the area where chemical control should be carried out;

– "Primarily damaged by wildlife": results of periodical wildlife damage inventory (conducted in 1990) are presented. Stands were shown as significantly damaged where the heavy damage occurred over at least on 20 per cent of stand area;

– "Primarily damaged by fire": the average area of forests destroyed by fire is presented. In the mentioned period the heaviest losses occurred in 1992, with two big forest fires in Rudy Raciborskie (9,062 ha of burnt forest) and Potrzebowice (4,980 ha of burnt forest);

– "Primarily damaged by known local pollution sources": no available data;

– "Primarily damaged by storm, wind, snow and other identifiable abiotic factors": the presented figure originates from the results of the questionnaire on biotic and abiotic damages of forest (in 1996). Forest Districts reported the areas where losses from abiotic agents occurred in a significant way, but with differentiated intensity.

Due to the differentiated intensity of every kind of reported damage, incompleteness of data and high probability of several types of agents occurring at the same area, the correspondents decided not to show the total area of forest with damage done by known causes.

**Portugal**

**70, 71**

*Enquiry Table 18*: Observing the general evolution trend we consider that in Portuguese forests the damage follows closely the occurrence of drought. The years of 1989, 1990 and 1991 were extremely dry (damage rose and was maximal in 1991). During dry years insect attacks and fungi infestations were stronger; at the same time fires were more devastating compared to years with higher precipitation.

The years of 1992, 1993 and 1994 still were dry to a certain extent, but rain occurred during the spring and the beginning of summer. The changing patterns of precipitation thus explain the changes in forest condition; 1995 again was a very dry year, and this was accompanied by again increasing forest damage. *Quercus suber* and *Quercus ilex* rotundifolia have their main occurrence in southern Portugal, where rain is more scarce. It is there also that the most damaged trees are recorded.

**Republic of Moldova**

**72-75**

*Enquiry Table 19*: The data for 1997 are secretariat estimates.

**76-78**

*Enquiry Table 20*: In 1994 and 1997: only broadleaved assessed.

**Romania**

**70, 71**

*Enquiry Table 18*: The heaviest damage occurred in 1995-1996.

Primarily damaged by insects and disease: Infestations of forests by pests occur yearly. Due to predictions and treatments carried out, significant damage is prevented.

Primarily damaged by fire: An estimated annual average forest area (for the reference period) of 300 ha is reported; the forest is hardly damaged by fires.

Primarily damaged from known local pollution sources: Forest area moderately to severely affected, according to studies carried out for the main local pollution sources.

Primarily damaged by storm, wind, snow or other identifiable abiotic factors: Statistics don't provide data on the forest area specifically damaged by abiotic factors. Wind and snow damages occur, but the respective area is usually recorded in the same category as "occasional cuttings" (clear-cutting for forest roads, lines between compartments, for geology, mining or hydrology works, electric power transportation facilities). However, when important events take place, due attention is given consequently, as it is the case in 1995-1996, when an estimated 139,100 ha of forest was affected by wind and snow damage, of which 12,400 thousand ha heavily.

**Russian Federation**

**70, 71**

*Enquiry Table 18*: Damage is calculated from the total area of stands damaged by insects and disease or by fire, or stunted by various (biotic and abiotic) factors.

All information comes from the reports of the Russian Federal Forestry Service, annual reports on forest (protection) conservation (statistical form No. 12-LX) and State Committee on Statistics information (fires).

To relate form 12-LX data to forests managed by all Government departments, the indicators available are multiplied by a coefficient of 0.06 (according to the forestry fund account report for 1 January 1993, forests managed by other departments represent 6 per cent of the total).

Data on forest fires from Goskomstat cover all forest resource owners: the Russian Federal Forestry Service, the forestry complex enterprises of the former USSR Ministry of Forestry, the Ministry of Agriculture and Food, the Ministry of Environmental Protection and Natural Resources and the Ministry of Defence.

**76-78**

*Enquiry Table 20*: Information for only some regions (Kaliningrad and Leningrad regions) available.

**Slovakia**

**70, 71**

*Enquiry Table 18*: A source of information was a statistical document matter L116: Hlásenie o výskyte škodlivých cinitelov ...(Report on the occurrence of injurious agents...) and literary sources processed every year from available data. They are as follows:

– J. Novotný, et al. 1995: Evidencia skodlivých cinitelov v lesoch Slovenska za rok 1994 a prognóza ich vývoja na rok 1995. (Records on injurious agents in the forests of Slovakia for 1994 and trends for 1995). Deposited at LVU Zvolen, 45 p.

– D. Surovec, et al. 1992: Evidencia skodlivých faktorov v lesoch SR za rok 1991 a ich prognóza na rok 1992. (Records on injurious factors in the forests of SR for 1991 and trends for 1992). Deposited at LVU Zvolen, 64 pp.

– D. Surovec, et al. 1993: Evidencia skodlivých faktorov v lesoch SR za rok 1992 a ich prognóza na rok 1993. (Records on injurious factors in the forests of SR for 1992 and trends for 1993). Deposited at LVU Zvolen, 68 pp.

– M. Turcáni, et al. 1994: Evidencia skodlivých cinitelov v lesoch Slovenska za rok 1993 a prognóza ich vývoja na rok 1994. (Records on injurious agents in the forests of Slovakia for 1993 and trends for 1994). Deposited at LVU Zvolen, 38 pp.

– J. Varínsky, et al. 1996: Evidencia skodlivých cinitelov v lesoch Slovenska za rok 1995 a prognóza ich vývoja na rok 1996. (Records on injurious agents in the forests of Slovakia for 1995 and trends for 1996). Deposited at LVU Zvolen, 45 pp.

In the row “area damaged by insects and diseases”. the value given represents the sum of slightly and heavily damaged areas (by leaf-eating insects).

A synergetic impact of several agents on the same plot is not excluded.

For bark beetles, abiotic agents, fungal diseases, air pollutants and unidentifiable causes of damage, the forest statistics are not giving the area of damaged stands but the volume of damaged wood. A resultant value for certain specific agents (excluding leaf-eating pests) was calculated as a sum of reduced area damaged in young stands (ha) and of the volume of attacked area in older stands in hectares (it was calculated as a proportion of the volume of damaged wood in $m^3$ of mean growing stock per 1 ha-400 $m^3$).

A conclusive value of the data is relatively high as until 1989 the data were provided by the bodies of State Forests which managed almost 100 per cent of the area of stands in SR. After 1989, when also other, non-state, bodies started to manage the forests, the area of the stands, according to available information, has decreased to about 85 per cent.

The following are the important events of recent years:

– an outbreak of gypsy moth (*Lymantria dispar*) in the years 1993-1994

– a whirlwind in the region of Horehronie-July 1996.

**72-75**

*Enquiry Table 19*: The source of information was a statistical document L116 (Report on the occurrence of injurious agents...) and literary sources processed every year from available data.

Because insufficient information for recent years was available, the data of the PTEU Bratislava (the Technical and Expert Institute for Fires) were also used. As both sources (LVU, PTEU) did not provide equivalent information, in some cases interpolations had to be made. In future data obtained from the forest statistics (L116) at LVU will be used as a basis for area (ha) and for damaged wood ($m^3$). This will be complemented by the data on the number of fires and their causes from PTEU.

**Slovenia**

**70, 71**

*Enquiry Table 18*: The figure of 45,000 ha for the extent of damage by “Primarily damaged by wildlife and grazing” refers to time period 1986-1996.

**76-78**

*Enquiry Table 20*: In 1991 for All species: combined assessment method. No survey in 1992.

**Spain**

**70, 71**

*Enquiry Table 18*: The data for "Primarily damaged by fire" are > 400.

Not all of the areas shown in "Primarily damaged by storm, wind, snow or other identifiable abiotic factors" and "Total area of forest and other wooded land with damage from unidentified causes" were damaged. Damage occurred within these total areas.

**76-78**

*Enquiry Table 20*: In 1994, for all species, coniferous and broadleaved: excludes Canary Islands.

**Sweden**

**70, 71**

*Enquiry Table 18*: See *Enquiry Table 14* "Total woody biomass and the volume of growing stock".

Data available on "Forest" only.

Source: Swedish University of Agricultural Sciences / Department of Forest Resource Management and Geomatics. Section of Forest Survey / BSc (For) Hans Toet.. (Kompletterande uppgifter Table 18 SLU/Resgeom).

Sweden has chosen not to deliver any data (n.a.) in most cells in this column. There are two reasons for this:

1) the table is difficult to fill in for logical reasons. How many trees have to be damaged per ha to consider the stand damaged? Is the limit 1, 2, 10, 100 or what? To some extent of course all stands are damaged. One can always find trees that have either small or big insect damage, root rot, snow-breaks or something else. Also, how long is a damage considered a damage? For example a damage by insects can fade away after a couple of years, but one will still have a permanent impact on the growth, etc.;

2) The National Forest Survey is basically depending on a sample plot inventory, where most of the plots are temporary, and the knowledge of the stand history is limited to what can be seen on the plot. Therefore the reason for the damage and the year of damage are more or less impossible to decide with any accuracy.

However, the presented figures are about wildlife and grazing damages as these are more easily defined and can be better determined in the field.

**72-75**

*Enquiry Table 19*: The date for 1997 are secretariat estimates.

**Switzerland**

**70, 71**

*Enquiry Table 18*: "Most Recent 5-year period, Annual average": "Total area of FOWL with damage by known causes": Estimation;

"Primarily damaged by insects and disease": The calculation of the annual average (in 1000 ha) is based on the damaged volume (in $m^3$). Assumption: average volume per ha: 500 $m^3$.

"Primarily damaged by wildlife and grazing": No quantitative analysis yet available.

"Primarily damaged from known local pollution sources": Estimation

"Primarily damaged by storm, wind, snow or other identifiable abiotic factors": No data available. Only remarkable events are recorded.

"Total area of FOWL with damage from unidentified causes": 19 per cent of the forest trees show a defoliation of >25 per cent — > 230,000 ha of 1,200,000 ha.

"Total area of FOWL with damage from unidentified causes"--"extent of damage": Reduced data-set.

**72-75**

*Enquiry Table 19*: "Area of forest burnt" and "Area of OWL burnt", no differentiation made between forest and other wooded land.

**76-78**

*Enquiry Table 20*: In 1992, 1993 and 1994 for "All species" and "Coniferous", and in 1993 and 1994 for "Broadleaved": weighted according to diameter at breast height (d.b.h.).

**Tajikistan**

**72-75**

*Enquiry Table 19*: Data are not available.

**Turkey**

**72-75**

*Enquiry Table 19*: Traditionally, forest fire control activities have always been given higher importance. Both the forestry community and the public itself are very sensitive to forest fires. The average annual recurrent cost (for operations only, investments and prevention activities are not included) for forest fire control is around 60-70 million US $.

**Turkmenistan**

**72-75**

*Enquiry Table 19*: The data for 1997 are secretariat estimates.

**Ukraine**

**72-75**

*Enquiry Table 19*: The data for 1997 are secretariat estimates.

**United Kingdom**

**70, 71**

*Enquiry Table 18*: Information on date, extent, etc. where there have been major individual episodes (e.g. a large wind-blow, snow storm, etc.):

Wind-blow: October 1987, affected most of Southern England; Insects: 1993 Pine Beauty moth.

Other comments:

Area with damage has been interpreted as area in which there is some damage present; not all this area is damaged.

"Primarily damaged by wildlife and grazing": The data are estimates from Countryside Survey 1990; FC Research unable to offer alternative.

"Primarily damaged by storm, wind, snow or other identifiable abiotic factors": estimate is 100,000 windblow + 35,000 other (drought, etc), where windblow is compromise between estimate of 125,000 ha with windblow in CS1990,and range based on Forest Research monitoring areas.

Area in defoliation classes 3 + 4 (estimate 75,000 ha, to be checked against table 20) has been split 30 insects + diseases, 35 other abiotic, 10 unidentified (rough guesses, to be checked).

"Primarily damaged by fire": The data are rough guess based on annual damage. The data for extent of damage represent State forest only.

"Primarily damaged from known local pollution sources": It is negligible (much less than 1000 ha).

"Extent of damage" for single year is the area damaged.

Item 18.2 of this *Enquiry Table* from S Gregory (Forest Research); and Item 18.4 from *Enquiry Table 19.*

18.6 of this *Enquiry Table* from C. Quine (Forest Research) - area requiring clearance after 1987 storm.

**72-75**

*Enquiry Table 19*: Figures are for financial years, running from April to March of following year and cover land owned by the Forest Enterprise, including other (non-forest) land.

**76-78**

*Enquiry Table 20*: There is a clear discontinuity in the United Kingdom data between 1992 and 1993. There is a change in the assessment method after 1992. The assessment of defoliation is the same - the change is between comparing sample trees with an "ideal" tree, or with a "local" tree. Comparisons are now compiled on both bases.

**United States of America**

**70, 71**

*Enquiry Table 18*: Source: Fire data from *Enquiry Table 22* "Indigenous and tribal peoples" source. Other data based on 1996 data from USDA Forest Service, State & Private Forestry Branch, Forest Health Protection staff.

Information on major individual episodes (e.g. a large wind snow storm, etc.):

| *Strong winds, hurricanes, tornadoes* | | *Area (ha)* |
|---|---|---|
| 1995 | – Idaho, Utah, Colorado | 12,141 |
| | – North-eastern U.S. | 99,627 |
| | – Alabama (25 per cent of forest) | 2,218,970 |
| 1995 | – North-eastern U.S. | 607 |
| | – N. Carolina, Virginia (Bertha, Fran) | 107, 518 |
| ***Drought*** | | |
| 1995 | – North-eastern U.S. | 4,212 |
| 1996 | – Arizona | 24,739 |
| ***Flooding*** | | |
| 1993 | – Midwest | 4,452 |
| 1994 | – Iowa | 532 |
| 1995 | – Missouri | 73,273 |
| 1996 | – Iowa, Vermong | 5,463 |
| ***Ice*** | | |
| 1993 | – Iowa | 62 |
| ***Air pollution*** | | |
| 1996 | – Northeast U.S. (sulfur dioxide) | 12,141 |

Extent of damage due to wildlife and grazing is currently unknown for the United States. Methods of obtaining better information are under review.

**72-75**

*Enquiry Table 19*: Source: USDA Forest Service, Fire & Aviation Management Wildfire Statistics for all burnt acreage.

Data presented are for all fires reported to the national reporting system. This includes fires on non-wooded as well as wooded lands. Recent data for federal lands suggest that about 25 per cent of fires and 33 per cent of acreage burnt were on non-forested areas. The user may wish to use this information to extrapolate from the data presented, but is cautioned to note all such extrapolations. Information to separate forest from other wooded land was unavailable.

In the section on forest fires, the data for the United States include wildlife on all lands (not just forest and other wooded land).

The numbers of prescribed burning and mechanical treatment for the United States are efforts by the Forest Service only, not the United States in total.

**76-78**

*Enquiry Table 20*: Source: USDA Forest Service, State & Private Forestry Branch, Forest Health Protection staff.

Defoliation of trees in classes 0 and 1 is not visible from the air and was not measured. Also, data not collected by percent of sample trees but as area affected. These areas were converted to percent of total forest. Some areas may be affected by more than one pest causing a slight overestimate.

**Yugoslavia**

**70, 71**

*Enquiry Table 18*: Statistical Bulletin “Sumarstvo” 1996, 1997, 1990.

**72-75**

*Enquiry Table 19*: Statistical Bulletin “Sumarstvo” 1991-1996.

**76-78**

*Enquiry Table 20*: The figures for 1991 are for former Yugoslavia excluding Croatia and Slovenia.

No survey was done in 1992, 1993, 1994 and 1995.

The figures for 1996 are for Serbia and Montenegro.