Chapter 4

Forest health and vitality

OVERVIEW

Healthy forests are essential for sustainable forest management, yet forests, like other ecosystems, are subject to a number of threats that can cause tree mortality or reduce their ability to provide a full range of goods and services. The causes of the negative impacts on forest health and vitality vary from place to place, and the magnitude and duration of the impacts are not easy to assess. Causes include, but are not limited to, fire, insects and diseases, overexploitation of wood and non-wood forest products, poor harvesting practices, poor management, uncontrolled grazing, invasive species, air pollution and extreme climatic events (e.g. drought, frost, storms and floods). The complexity and interrelationship of these factors and their impact on the health and vitality of forests are difficult to unravel. Indirect impacts may be far reaching and include social, economic and environmental dimensions.

The definition of what constitute disturbance events varies among countries. A number of indicators of forest health and vitality have been developed, e.g. under the auspices of regional and international processes on criteria and indicators for sustainable forest management. Defoliation is one indicator monitored in many boreal and temperate regions. It is influenced by many stress factors and therefore a useful measure of overall forest condition. Monitoring of defoliation is carried out mainly in Europe, Canada and the United States, and to some extent in East Asia. An indicator of forest health that is often suitable in tropical regions is the amount of post-logging woody debris after timber extraction, because excessive amounts of woody debris leave forests in a highly fire-prone state and provide insect breeding sites. However, information on these indicators is not currently available in most countries.

Generally, it may be possible to control or mitigate the extent and impact of damage from pests. However, when the damage is caused by abiotic agents (other than fire), there is little possibility to control the immediate impact, even if there are often opportunities after the fact to limit secondary damage or minimize risk. For example, some countries have made efforts to modify silvicultural practices to reduce the risk of damage by storms.

Continuous monitoring of forest ecosystems is an expensive process, which makes it problematic for developing countries and those with economies in transition. However the results of monitoring can have a considerable impact on public opinion. The monitoring of forest pollution in some European countries, for example, led to implementation of abatement policies and a decrease in the emissions of airborne pollutants (Economic and Social Council (UN) – ECOSOC, 2003). And, conversely, the resulting public support can have a positive effect on the amount of resources and effort put into data collection and monitoring activities.

Factors reported in FRA 2005

Research for FRA 2005 focused on the following factors, which to some extent are quantifiable and for which many countries record incidence and extent:

- forest fires;
- insects and diseases;
- other disturbances (including wind, snow, ice, floods, tropical storms, drought and damage by animals).

Countries were asked to provide data averaged over five years, so that a large fluctuation in a single year did not significantly skew the figures. Data on disturbance

factors are presented for 1990 (an average of the period 1988–1992) and 2000 (average of 1998–2002). No attempt was made to forecast figures for the 2005 reporting period or to obtain data on frequency, intensity and time of disturbance events.

Several disturbance factors were not included in FRA 2005 owing to lack of quantitative information in most countries: illegal logging, encroachment, overharvesting and other unsustainable management practices, pollution and the impact of invasive plant species.

Wildland fires (all vegetation fires), pests and abiotic disturbances interact. Often one disturbance factor predisposes forests and woodlands to exposure to or invasion by other factors. Hence fire, other abiotic factors and biotic factors need to be considered as a whole.

Forest fires. Fire is a major disturbance factor that has both beneficial and detrimental effects. Some forest ecosystems are adapted to fire and depend on it to retain their vigour and reproductive capacity. However fire often gets out of control and destroys forest vegetation and biomass, which in turn results in considerable soil erosion by wind and water. The damage extends to other landscapes and livelihoods as well, and results in haze pollution and deposited pollutants. Forest fires pose a serious threat to peoples' lives and to the sustainable use of natural resources. Both uncontrolled expansion of agricultural land and the increased use of forests for recreational purposes and tourism increase the risk of forest fires.

National and global monitoring must be improved if countries are to manage fires in an ecologically sound way. Data on the extent of forest affected contribute to increasing the understanding of fires, and thus to the development of appropriate risk management strategies. Additional information is needed on the ecological dynamics of fire, direct and underlying causes, impacts and the desired long-term ecosystem condition (e.g. structure, health, species).

Insects and diseases. Pests are defined as any species, strain or biotype of plant, animal or pathogenic agent that injures plants or plant products. Pest outbreaks can contribute directly or indirectly to economic and environmental losses. While insects and diseases are integral components of forests and often fulfil important functions, sporadic outbreaks can have adverse effects on tree growth and survival, yield and quality of wood and non-wood forest products, wildlife habitat and the recreational, scenic and cultural value of forests. The lack of effective quarantine measures, increased international trade in agricultural and forest products, exchange of plant materials and long-range air travel have introduced pathogens and insects into new environments, leading, in some places, to significant forest damage. The International Plant Protection Convention (IPPC), a major international treaty, aims to bring about action to prevent the transboundary spread and introduction of plant and plant-product pests (FAO, 1999b).

Risk analysis, forecasting of future pest outbreaks, and the design and implementation of cost-effective protection strategies all depend on the availability of comprehensive data at various levels. The development of phytosanitary measures to minimize transboundary movement of pests must be based on knowledge of the geographical distribution and biology of a given pest – hence the requirement for national, regional and global-level data.

Other disturbances. Climatic events such as drought, wind, snow, ice and floods have always influenced forest ecosystems. However, global climate change, primarily the result of human activities, is reportedly making forest ecosystems more prone to damage by altering the frequency, intensity and timing of fire events, hurricanes, ice storms, and insect and disease outbreaks. The number of catastrophic climatic events over the past decade seems to go well beyond what could be considered normal meteorological oscillation (ECOSOC, 2003). Climate-related shifts in the range of pest species, many of which are forest-dependent, can further exacerbate abiotic impacts on forest health.

KEY FINDINGS

Globally, information on forest and other wooded land disturbances is relatively sparse, as can be seen in Figure 4.1, and the data-collection basis for disturbances is highly variable. Although information on forest fires is available for 80 percent of the total forest area for the period 1998-2002, it is missing from many African countries. Information on the area of forest significantly affected by insects is available for more than 60 percent of the total forest area, while information on diseases and other disturbances is sporadic. Many of the small island countries and dependent territories have not provided information for this theme.

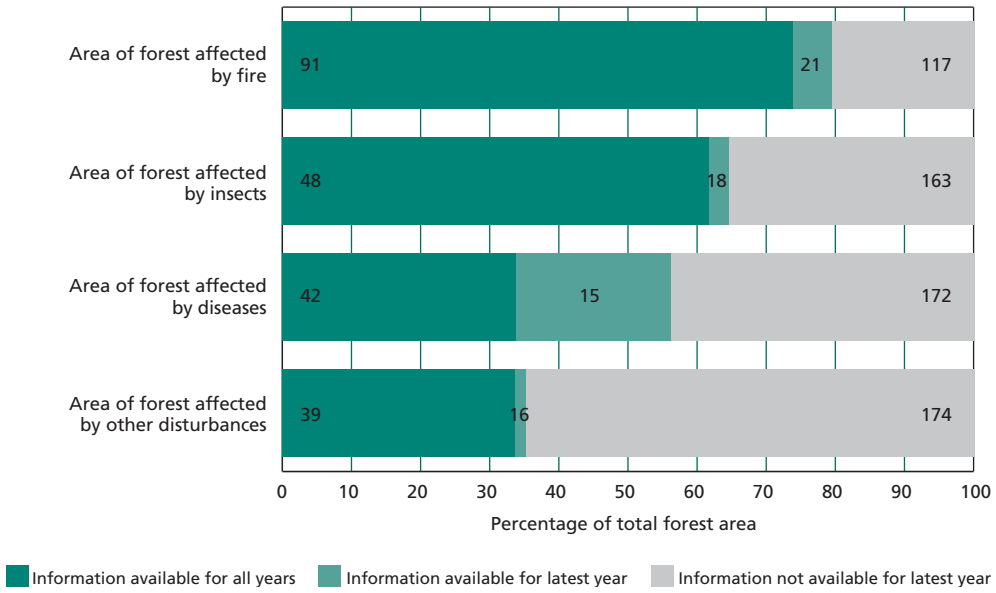
The overall conclusion drawn from the data supplied for FRA 2005 is that the area affected annually for *each* type of disturbance is usually less than 1 percent of the forest area of the reporting countries, although the affected area in individual countries can be much higher.

Total reported area for all disturbance types for 2000 was 104 million hectares or 3.2 percent of the forest area of the reporting countries. However, it should be noted that information was missing from a large number of countries – particularly on area affected by disturbances other than fire – so the actual area is likely to be significantly larger.

The submitted data indicate that, on average, 27.7 million hectares of forests and 5.1 million hectares of other wooded land burned each year of the 2000 reporting period. There was a slight decrease in area for this period when compared with the 1990 period in Africa and North and Central America, but an increase in all other regions. However, it should be noted that FRA 2005 presents a compilation of data reported by the countries and that information was missing from a large number of these. Thus the findings should be treated with caution.

There are other methodologies for identifying burned areas (for example satellite monitoring) that do not necessarily differentiate between forests and other vegetation types (Global Burnt Area 2000 Project (GBA-2000), 2000), and which indicate that a much larger area is burned annually than that indicated in FRA 2005.

FIGURE 4.1
Information availability – forest health and vitality



Note: Figures present number of countries in each category.

Reports received by FAO indicate that the extent of forest adversely affected by insects and diseases in the 2000 reporting period was 68 million hectares per year – more than twice the extent reported for fire – despite the fact that fewer countries reported on these disturbances than on fire. However, owing to recurring events and the longer duration of disturbance events caused by insects and diseases compared with those caused by fire or storms, it is difficult to assess the annually affected area accurately.

The area of forest adversely affected by insects was reported as being lower for 2000 than for 1990 – primarily owing to a substantial decrease in affected areas reported by Canada and the United States. Most other subregions and regions reported an increase in insect-affected forest area.

The total area of forest affected by disease was slightly higher in the 2000 period than in 1990 for those countries providing information on both periods. However, information was only available for one-third of the total forest area and was missing from most countries in Africa, Central and North America and Oceania.

Reporting of other abiotic and biotic disturbances was sporadic at best, with East Asia and Europe being the only ones with reports covering more than half their forest areas. The area of other disturbances almost doubled between the two reporting periods in Europe, primarily owing to the effects of severe storms such as those of December 1999.

Some single, large, sudden impact climatic events – such as extreme wind (particularly on islands), floods, snow or ice – were reported to have greater impact than fire.

It should be kept in mind that impacts from abiotic disturbances are recorded more easily than those caused by diseases and insects. The latter have a much longer duration and thus require greater resources for monitoring and recording. FRA 2005 shows that the impacts of fire, insects, diseases and other disturbances on forests can be severe in some countries, but that, in general, less than 5 percent of the world's forests are affected by such disturbances in a given year. However, the assessment also clearly highlights the lack of data.

Efforts to gather, analyse and widely disseminate reliable country-based information on forest health factors must be further strengthened in order to provide a solid basis for decision-making and enhanced field-level action. This information can provide the foundation for reliable risk analyses and the implementation of effective forest protection measures. To be successful, these must in turn ensure wide stakeholder involvement and continue to pursue both preventive and remedial action.

FOREST FIRES

Fire has been a major factor in the development and management of many of the world's forests. Some forest ecosystems have evolved in response to frequent fires from natural as well as human causes, but others are negatively affected. Every year, millions of hectares of the world's forests are consumed by fire, with loss of human and animal life and very substantial economic damage in destroyed wood and non-wood forest resources, loss of biodiversity, release of carbon to the atmosphere, burned housing, degraded real estate, high costs of fire suppression, and damage to other environmental, recreational and amenity values (Davidenko and Eritsov, 2003; FAO, 2005e; Kudoh, 2005; United Nations Economic Commission for Europe (UNECE) and FAO, 2001; UNECE *et al.*, 2000).

Most fires in forests and woodlands today are caused by humans. They are the result of a misuse of fire for conversion of forests to agricultural lands, maintenance of grazing lands, extraction of non-wood forest products, hunting, and clearing of land for mining, industrial development and resettlement. Forest fires may also be the result of personal or ownership conflicts.

Identification of the extent, causes and impacts of forest fires is a specialized technical area. The fire data in FRA 2005 indicate the overall extent, but in most cases provide minimal details of the underlying causes and impacts. Further information on fire disturbances is contained in a separate thematic report to be released during 2006 (Box 4.1).

BOX 4.1

FRA 2005 thematic study on forest fires

The study complements FRA 2005 through greater depth of data and information on the incidence, impact and management of forest fires and related issues in different regions around the globe. Data and information are being prepared by wildland fire specialists from each of the 12 regional wildland fire networks, which are supported by FAO, the United Nations International Strategy for Disaster Reduction (ISDR) and the Global Fire Monitoring Center (GFMC). FAO is publishing the regional reports early in 2006 as separate working papers under the Forest Fire Management Working Paper series. An in-depth analysis of these regional reports is being compiled as the global thematic study, to be published during 2006.

The study assesses the fire situation in each region, including the extent of forest area affected, number and types of fires and the causes. In recognition that not all fires are destructive, given that some ecosystems need fire-induced regeneration, both positive and negative social, economic and environmental impacts are outlined. An integrated approach to wildland fire management addresses: prediction, preparedness and prevention as key elements in the reduction of the negative impacts of fire; rapid response in extinguishing fires; and restoration after the fact. These elements constitute the rationale for voluntary guidelines for wildland fire management, which are currently being drafted.

The thematic study also addresses key issues in the institutional aspects of wildland fire management, including the roles and responsibilities of diverse stakeholders and their capacities and capabilities for prevention and suppression – particularly the role of community-based fire management. Based on these issues, a global strategy is being prepared for enhancing collaboration at international, regional, national and subnational levels in order to implement the voluntary guidelines.

Selected findings of the thematic report include:

- Some 80 to 90 percent of wildland fires are caused by human activities, primarily through the uncontrolled use of fire for: clearing forest and woodland for agriculture, maintaining grasslands for livestock management, extraction of NWFPs, industrial development, resettlement, hunting and arson. Thus proactive fire management must involve all these stakeholders.
- Legislation and expensive equipment alone are insufficient to prevent and suppress wildland fires. Given that their livelihoods are at stake, local communities and populations need to be actively involved in fire prevention and suppression.
- It is not only the biological and physiological effects of fire that must be understood in fire management strategies, but also the underlying socio-economic and cultural reasons for the use of fire, including poverty, food security and livelihood issues.
- Data on both destructive and beneficial fires are needed, including their overall economic and ecological impacts.
- To prevent and respond to fire emergencies, greater collaboration and agreement are increasingly required at international, regional, national and subnational levels.

Further information is available at: www.fao.org/forestry/site/fire-alerts/.

Although fire is one of the primary agents of forest degradation, as a natural process it serves an important function in maintaining the health of certain ecosystems. The conventional view of fire as a destructive agent requiring immediate suppression has given way to the view that fire can and should be used to meet land management goals and certain ecological conditions.

The impact of fires will vary significantly depending not only on the intensity and extent of the fire, but also on whether the ecosystem is fire sensitive, fire dependent/influenced or fire independent. Fire-dependent ecosystems are those that have evolved in the presence of fire; fire-sensitive ecosystems are those that have not evolved in its presence and thus its occurrence in these ecosystems has a negative impact; and fire-independent ecosystems are those that lack sufficient fuel to ignite fires, such as deserts and Antarctic tundra. According to The Nature Conservancy (2004), of the global area of major habitat types in important conservation ecoregions, 46 percent is fire dependent/influenced, 36 percent is fire sensitive and 18 percent fire independent.

To grasp the full impact and the roles of fire in forest ecosystems, an understanding is needed not only of the biological and physiological impacts, but also of the social sciences and the underlying socio-economic and cultural reasons for the use of fire. Thus the fields of sociology, community relations, public administration and food security should be involved when preparing fire management strategies.

However, technical and social fire management solutions are not enough. Legal and regulatory solutions in fire-dependent ecosystems and fire-prone forests need to be included as well.

Globally, the majority of forest fires stem from agricultural burning for land management – mostly adjacent to or outside the forest itself – that gets out of control (GBA-2000, 2000). Consequently, proactive fire management would include collaboration with the agricultural sector.

It is important that countries collect data on beneficial as well as detrimental fires. For an assessment of the overall economic impact of detrimental fires, both the direct economic damage and the ecological damage must be calculated.

A common understanding is needed regarding the basis for data collection on forest fires and the value that can be gained from data collection for management strategies. Other issues include the criteria for collecting and assessing national, regional and global wildland fire data and for streamlining the definitions used in forest fire management.

Additional research is needed on the ecological dynamics of forest fires and their underlying causes. Categorization of fire types should be undertaken, as well, so that the data collected can be used more effectively in fire management. Farmers, ecologists and forest staff need to be trained in the differences between beneficial and detrimental fires. This includes knowledge of how to use the right kind of fire in fire-adapted ecosystems and how to extinguish harmful fires in fire-sensitive ones.

Information availability

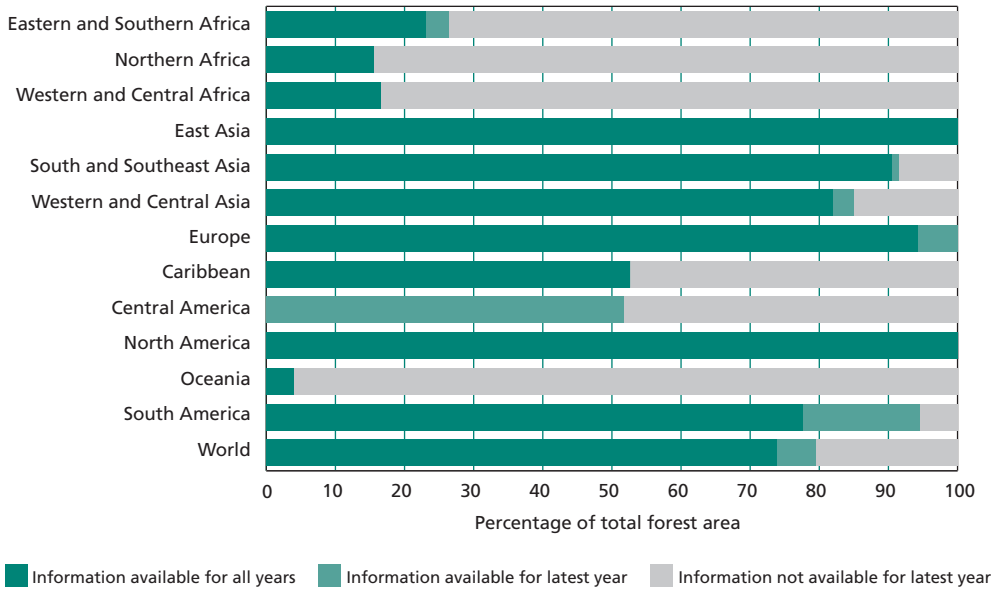
Classification of fires that occur in forests and other wooded land is complex. There is presently no global classification that distinguishes between beneficial and detrimental fires, and consequently no detailed global information on fire types in forests and other wooded land.

Of the 229 countries and areas included in FRA 2005, 91 provided data on the average annual area of forest adversely affected by fires for both the 1990 and 2000 reporting periods, while an additional 21 countries provided data for the 2000 reporting period only – for a total of 112 countries accounting for 80 percent of the total forest area. For the 2000 reporting period, eight regions or subregions provided data on more than 50 percent of their forested area, Oceania provided data on less than 5 percent of its forested area and information from Africa was largely missing (Figure 4.2).

Data were reported on 73, 65 and 35 percent of other wooded land in South America, Northern Africa and Western and Central Asia respectively, but on 25 percent or less of other wooded land in all other regions.

As a result of the different methodologies of data collection, data are not usually directly comparable among regions and countries except on a broad scale. Some countries do not separate forests and other wooded land when recording data, while others do so.

FIGURE 4.2
Information availability – forest fires



Research data are sparse on altered fire regimes and on historical and natural fire frequency and burning intensity. There is a relatively greater amount of data available on intensively managed semi-natural forests and forest plantations because of the higher investment in monitoring and control of fire. These intensively managed systems tend to be fire sensitive. As a result, the data provided for FRA 2005 primarily reflect fire impact in fire-sensitive ecosystems. In natural, fire-dependent forests, such as savannah forests, woodlands and boreal forests, it is more difficult to assess the true impact of fire.

Information is lacking for a number of countries in which forest fires are known to have occurred, including countries in Africa, Central Asia and Oceania. This is partly the result of a lack of capacity to collect and analyse data at the national level.

To improve the monitoring and assessment of fire damage to forests and other wooded land, it would be useful to have data-collection systems that are directly comparable. Thus there is a need to harmonize definitions and share information on methods of data collection and analysis.

Status

In the 2000 reporting period, the average area burned annually was at least 27.7 million hectares of forests, equivalent to 0.9 percent of the forest area of the reporting countries. An additional 5.1 million hectares of other wooded land were also reported as significantly affected by fire. The highest percentages were reported from Africa and Asia, while Europe reported the lowest. Two countries (Myanmar and Chad) reported that more than 6 million hectares of forests were affected by fires annually. Information on fire types, intensity and impact was not provided. Table 4.1 presents a regional/subregional summary.

The percentage of forest area affected by fires in Northern Africa is primarily due to high figures from Chad, where an estimated 50 percent of the Sudanian zone and 20 percent of the Sahelian zone are affected each year – down from 70 and 30 percent respectively in the 1990 reporting period.

The low figure for the total area of forest affected by fires in Oceania is the result of only two countries reporting (American Samoa and New Zealand). In South America, Brazil reported incomplete data.

TABLE 4.1
Average area of forest annually affected by fire 1998–2002

Region/subregion	Information availability			Area of forest affected by fire	
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	1 000 ha	% of forest area
Eastern and Southern Africa	8	62 129	26.4	483	0.8
Northern Africa	5	21 076	15.5	6 176	29.3
Western and Central Africa	7	47 558	16.7	519	1.1
Total Africa	**20**	**130 763**	**19.9**	**7 177**	**5.5**
East Asia	5	225 663	100.0	523	0.2
South and Southeast Asia	12	272 087	91.5	11 029	4.1
Western and Central Asia	16	36 994	85.0	218	0.6
Total Asia	**33**	**534 744**	**94.4**	**11 770**	**2.2**
Total Europe	**37**	**997 658**	**100.0**	**1 597**	**0.2**
Caribbean	3	3 004	52.6	13	0.4
Central America	4	12 338	51.8	130	1.1
North America	3	677 968	100.0	4 333	0.6
Total North and Central America	**10**	**693 310**	**98.0**	**4 476**	**0.6**
Total Oceania	**2**	**8 244**	**4.0**	**n.s.**	**n.s.**
Total South America	**10**	**806 483**	**94.6**	**2 719**	**0.3**
World	**112**	**3 171 203**	**79.5**	**27 740**	**0.9**

TABLE 4.2
Trends in area of forest annually affected by fire 1988–1992 and 1998–2002

Region/subregion	Information availability (both periods)			Average area of forest affected by fire *(1 000 ha)*		Annual change rate *(%)*
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	1990	2000	
Eastern and Southern Africa	7	54 096	23.0	76	45	-5.2
Northern Africa	5	21 076	15.5	9 191	6 176	-3.9
Western and Central Africa	6	47 214	16.6	477	514	0.8
Total Africa	**18**	**122 386**	**18.7**	**9 745**	**6 735**	**-3.6**
East Asia	5	225 663	100.0	319	523	5.1
South and Southeast Asia	11	268 946	90.4	10 095	11 020	0.9
Western and Central Asia	13	35 700	82.0	57	198	13.2
Total Asia	**29**	**530 309**	**93.6**	**10 471**	**11 742**	**1.2**
Total Europe	**31**	**941 240**	**94.3**	**1 043**	**1 584**	**4.3**
Caribbean	3	3 004	52.6	6	13	8.0
Central America	0					
North America	3	677 968	100.0	4 402	4 333	-0.2
Total North and Central America	**6**	**680 972**	**96.2**	**4 408**	**4 346**	**-0.1**
Total Oceania	**1**	**8 226**	**4.0**	**n.s.**	**n.s.**	**3.1**
Total South America	**6**	**662 062**	**77.6**	**139**	**154**	**1.0**
World	**91**	**2 945 145**	**73.8**	**25 806**	**24 561**	**-0.5**

Note: As some countries did not report a complete series, figures for 2000 are slightly different from those presented in the preceding table.

Trends

Data on forest fires are available for the 1990 and 2000 reporting periods. Table 4.2 presents a summary of this information.

The annual average area of forest fires was reported to have increased in 35 countries, decreased in 31 countries and remained almost constant in 25. From the data provided, it is difficult to discern any global trends. Africa reported a decrease in the 2000 period compared with the 1990 period, but this was due to the decrease in Chad referred to above and was based on data for less than 20 percent of the total forest area in the

subregion, with information missing from most of the sub-Saharan countries. All other regions reported a slight increase.

INSECTS AND DISEASES

Outbreaks of insects and diseases in forests have resulted in substantial economic losses and environmental damage, even though they may be less visible and less dramatic than fires and ice storms. For the purposes of this report insects and diseases are analysed together, as they are often co-dependent.

Insects and diseases are integral components of forest ecosystems and normally are present at a relatively low density, causing little damage and having negligible impact on tree growth and vigour. From time to time, however, some species may quickly reach damaging numbers, spatial distribution may increase and the outbreak may persist for a variable time before subsiding. Such large populations may have adverse effects on many aspects of forests, such as tree growth, survival, yield and quality of wood and non-wood forest products, and soil and water conservation. Such outbreaks are costly to control and may cause considerable damage, compromise national economies, local livelihoods and food security, and result in trade restrictions on forest products.

The types of problems caused by introduced insects and diseases have changed rapidly in recent years. Movement of insects and diseases has been facilitated by intensified long-range air travel and reduced travel time, increased international trade of agricultural and forest products and the exchange of plant material. Local climatic fluctuations may facilitate the establishment of introduced insects in previously hostile environments. Introduced forest pests can be extremely destructive, as seen in recent years in the impact of the cypress aphid (*Cinara cupressivora*) in Eastern and Southern Africa and more recently in South America.

As mentioned, the International Plant Protection Convention (IPPC) is a major international treaty that aims to secure action to prevent the transboundary spread and introduction of plant and plant-product pests (FAO, 1999b). The International Standards for Phytosanitary Measures (ISPM) (FAO, 1995–2005), developed within the framework of the IPPC, include a basic framework for risk analysis and development of phytosanitary measures to minimize such transboundary movement. Particularly relevant to forestry are ISPM No. 15, *Guidelines for regulating wood packaging material in international trade* (FAO, 2002b), and the ISPMs relating to risk analysis and pest reporting and status. Data on the movement of and disturbances by introduced insects are essential in the development of risk management strategies for transboundary pests.

Despite the significant adverse impacts of forest insects and diseases, and indications that outbreaks are on the increase in some regions, insects and diseases are often not considered in the planning of forest and forest-conservation programmes. There has been no attempt to systematically gather and analyse comprehensive information on the type, scale and impact of such outbreaks at the global level.

Identification of insects and diseases as causal agents of damage to forests is a highly specialized technical area. The insect and disease data in FRA 2005 indicate the overall extent of forest affected, but offer minimal details in most cases on the underlying causes.

A system that enables data to be reported on a continuous as well as an ad hoc basis could encompass the complexity of information required – so as to have data useful to the development of risk management strategies for forests and other wooded land.

Insect and disease problems are often either cyclical or chronic. Thus they require long-term investment in data collection and technical resources in order to fully assess the complexity and extent of the issues. A chronic disturbance by insects and diseases may be caused by a complex of species rather than by a single entity. The complex can vary not only in the species involved but also in the impact of each individual

species within that particular disturbance. Thus defining the beginning and end of a disturbance event can be a challenge.

There are further complications in recording data: (i) some insect life cycles overlap or are significantly longer than one year (e.g. the Siberian caterpillar – *Dendrolimus sibiricus*); and (ii) other cyclical disturbance events caused by insects last more than a year. For example, gypsy moth (*Lymantria dispar*) outbreaks of several generations can be every 7–10 years. More recently, however, the period between outbreaks has apparently been becoming shorter. Capturing data for such long-term cyclical events is difficult, particularly when there is variability in the length of cycles. The information supplied by countries for insect disturbances has been reported for annual averages over five years. With long cyclical outbreaks, five-year reporting periods do not adequately reflect the status of these events.

Moreover, due to the longer duration of some disturbance events, it is difficult to accurately assess the area affected annually. Some countries appear to have reported the cumulative area affected in a given year, rather than the additional area of forest affected within that year. Thus the figures for the different types of disturbances are not directly comparable.

Information availability

The status of the data on insect and disease disturbances is poor, mainly owing to a lack of clarity in interpreting what constitutes a 'disturbance'. Globally, the quantifiable data on insect incidences and their effects on forests and forest products are limited. Insect and disease outbreaks in developing countries are primarily surveyed and reported for forest plantations and planted trees only, and corresponding surveys of forest decline and dieback are rare in these countries. Serious outbreak situations may be recorded, but details of causative agents and the quantifiable impact on forest resources often are not. In some instances, there may be a reluctance to record such severe outbreaks because management jobs or even forest products trade can be put at risk.

Data on insects and diseases are collected and reported in a variety of ways. In some instances, data provided on the area of forest affected by diseases and insects (and other biotic disturbances) are not separated.

For insect infestations, of the 229 countries included in FRA 2005, 48 countries provided data for both the 1990 and 2000 reporting periods; a further 18 countries provided data for the 2000 reporting period only. These 66 countries represent 65 percent of the world's forest area. Reports from East Asia, Europe and North America covered more than 90 percent of their forest areas, while those from Africa and Oceania covered less than 1 percent of the forest area in their respective regions (Figure 4.3).

For diseases, 42 countries provided data for both the 1990 and 2000 reporting periods. A further 15 countries provided data for the 2000 reporting period only.

For the 2000 reporting period, East Asia and Europe provided data for over 80 percent of the forest areas within the region, while North America, South America and South and Southeast Asia each provided information for more than 50 percent of the forest area in their respective region or subregion. Data from Africa, the Caribbean and Oceania were largely missing (Figure 4.4).

For some regions, more data exist but were not readily accessible for this report owing to a lack of information exchange among sectors, individuals and government agencies or a lack of awareness of the existence of data.

To complement existing information and facilitate documentation on forest health at the country level, FAO is compiling data, with the cooperation of experts from member countries, for a global information system on the impact of insect and disease outbreaks on natural and planted forests, other wooded land and trees outside forests. The system is intended for national forest services, research and academic institutions and technical

FIGURE 4.3
Information availability – forest insect pests

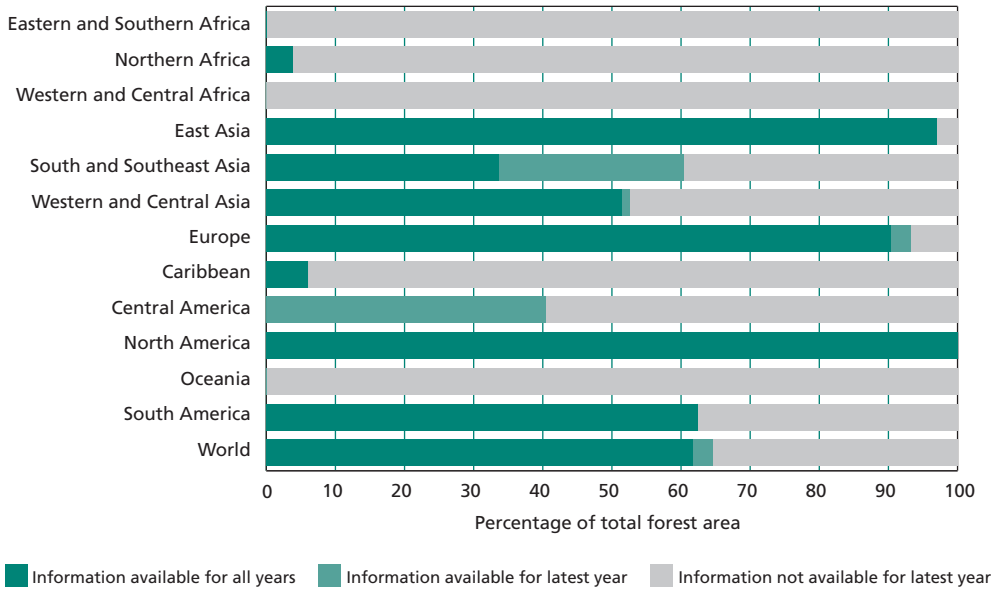
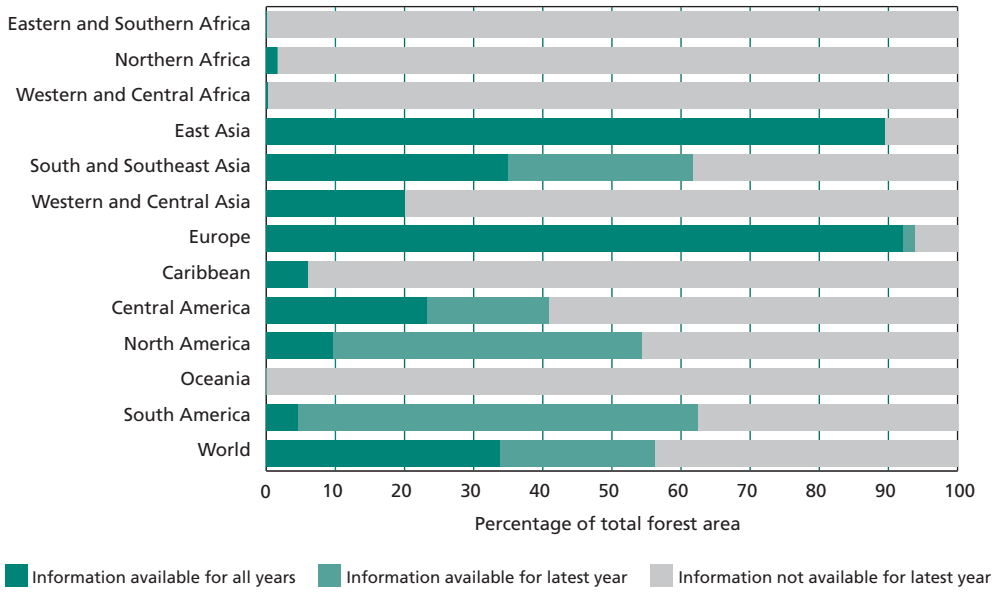


FIGURE 4.4
Information availability – diseases



officers dealing with forestry and pest management. It should help improve planning and decision-making, increase awareness of the severe problems related to forest insects and diseases worldwide, and provide up-to-date baseline information to support risk assessment and the design and implementation of effective forest protection strategies (www.fao.org/forestry/site/18748/en). A two-tiered questionnaire has been sent to in-country technical specialists in an attempt to obtain more detailed information. The results of this study are available in a separate thematic report (Box 4.2).

BOX 4.2

FRA 2005 thematic study on forest pests

Figures are rarely available on losses attributed directly to infestations of forests, trees and forest products by insects and diseases, particularly in developing countries and countries in transition. Thus, in addition to seeking quantitative information for FRA 2005, FAO compiles qualitative profiles of individual pest problems by country. Information is collated from many sources, through expert contacts in the countries, via the Internet and in literature searches. The study is ongoing and constantly updated.

Data are indexed, making it possible to highlight information on pest distribution that could indicate potential invasiveness between neighbouring countries. Information on the host preference of individual causative agents can be extracted, as well as breakdowns of pests at the country level.

The impact of pests on the forest sector is often underestimated, as illustrated in the following examples:

- Since an infestation of *Dendroctonus ponderosae* (mountain pine beetle) was first detected in interior British Columbia in 1994, an estimated 240 million m³ of timber on 11.3 million hectares have been lost, at an estimated cost of US$1.7 million per year. The beetle is spreading fast across Canada and threatens to move south into United States forests. Huge investments in control are now necessary, with more than US$82 million recently committed by the Canadian Government (Wilent, 2005).
- In eastern and southern Africa, three accidentally introduced aphids were the first specific conifer pests to invade the region, and they became the most damaging pests of these species. Since their initial introduction, the pine wooly aphid, *Pineus boerneri*, the pine needle aphid, *Eulachnus rileyi*, and the cypress aphid, *Cinara cupressivora*, have proliferated throughout southern and eastern Africa and continue to spread. It was conservatively estimated that, by 1990, *C. cupressivora* had killed trees worth approximately US$44 million and was causing a loss in annual growth increment of a further US$14.6 million per year. In addition, the two pine aphids were causing a further loss of approximately US$2.4 million per year to annual growth increment in pine forest plantations in the region. This economic data was instrumental in securing resources to mount a biological control programme, which led to substantial reductions of incidence of at least the cypress aphid (Murphy, 1996).
- In New Zealand it is estimated that the forest industry spends US$0.60/ha on the monitoring of diseases and pests, in comparison with US$3.50/ha on fire defence. Yet average annual losses to disease amount to some US$137 million, whereas losses to fire are just US$682 000 (Hocking, 2003).

At this time, 19 profiles have been completed from four regions. As more countries are included, there will be more opportunities for comparison. This information should not only increase awareness of the importance of forest health, but also encourage countries to collect data that will enhance the accuracy of future global forest resources assessments.

Status

Globally, the combined forest area adversely affected by insects and diseases for the 2000 reporting period was approximately 68 million hectares. In most cases, there are no details indicating the causative agent(s), so the data provided may reflect combined insect and disease disturbances. The highest area of insect disturbance reported for a single country was 14.2 million hectares (Canada), and of disease disturbance, 17.4 million

TABLE 4.3
Average area of forest annually affected by insects 1998–2002

Region/subregion	Information availability			Area of forest affected by insects	
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	1 000 ha	% of forest area
Eastern and Southern Africa	2	48	n.s.	0	0
Northern Africa	3	5 346	3.9	83	1.5
Western and Central Africa	0				
Total Africa	**5**	**5 394**	**0.8**	**83**	**1.5**
East Asia	4	218 842	97.0	9 329	4.3
South and Southeast Asia	7	179 498	60.4	1 010	0.6
Western and Central Asia	11	22 841	52.5	464	2.0
Total Asia	**22**	**421 181**	**74.3**	**10 803**	**2.6**
Total Europe	**28**	**930 556**	**93.2**	**6 354**	**0.7**
Caribbean	1	341	6.0	0	0
Central America	2	9 638	40.4	2	n.s.
North America	3	677 968	100.0	19 332	2.9
Total North and Central America	**6**	**687 947**	**97.2**	**19 334**	**2.8**
Total Oceania	**1**	**18**	**n.s.**	**n.s.**	**0.1**
Total South America	**4**	**531 886**	**62.4**	**561**	**0.1**
World	**66**	**2 576 982**	**64.6**	**37 134**	**1.4**

TABLE 4.4
Average area of forest annually affected by diseases 1998–2002

Region/subregion	Information availability			Area of forest affected by diseases	
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	1 000 ha	% of forest area
Eastern and Southern Africa	2	48	n.s.	0	0
Northern Africa	2	2 203	1.6	130	5.9
Western and Central Africa	1	461	0.2	100	21.6
Total Africa	**5**	**2 712**	**0.4**	**229**	**8.5**
East Asia	2	201 877	89.5	883	0.4
South and Southeast Asia	8	183 398	61.7	8 471	4.6
Western and Central Asia	8	8 701	20.0	31	0.4
Total Asia	**18**	**393 976**	**69.5**	**9 386**	**2.4**
Total Europe	**24**	**936 300**	**93.8**	**3 135**	**0.3**
Caribbean	1	341	6.0	0	0
Central America	2	9 747	40.9	33	0.3
North America	2	367 834	54.3	17 382	4.7
Total North and Central America	**5**	**377 922**	**53.4**	**17 415**	**4.6**
Total Oceania	**1**	**18**	**n.s.**	**0**	**0**
Total South America	**4**	**531 886**	**62.4**	**830**	**0.2**
World	**57**	**2 242 814**	**56.2**	**30 995**	**1.4**

hectares (United States) – both countries within the top five in terms of forest area and with good data-collection systems. Tables 4.3 and 4.4 present a summary of results for the 2000 reporting period.

Trends

The data reflect differences in the two periods, but as only two reporting periods are compared, they should not be construed as trends. The raw data indicate a very large increase in the level of disease reported and a decrease in the level of insect damage reported between the 1990 and 2000 reporting periods. However, this is primarily because more countries reported for the 2000 period than for 1990.

Analysing data only for those countries that have provided information for two points in time, the area affected by diseases shows a slight increase globally (from 4.4 to 4.7 million hectares per year), despite a significant decrease reported by Africa and East Asia (Table 4.5). The increase in South America is particularly noticeable and is primarily due to the fact that Chile has reported a very large increase in the area of forest affected by diseases.

TABLE 4.5
Trends in area of forest annually affected by diseases 1988–1992 and 1998–2002

Region/subregion	Information availability (both periods)			Average area of forest affected by diseases *(1 000 ha)*		Annual change rate *(%)*
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	1990	2000	
Eastern and Southern Africa	2	48	n.s.	0	0	0
Northern Africa	1	2 144	1.6	241	130	-6.0
Western and Central Africa	1	461	0.2	179	100	-5.7
Total Africa	**4**	**2 653**	**0.4**	**420**	**229**	**-5.9**
East Asia	2	201 877	89.5	1 821	883	-7.0
South and Southeast Asia	4	103 870	34.9	51	70	3.2
Western and Central Asia	8	8 701	20.0	47	31	-3.8
Total Asia	**14**	**314 449**	**55.5**	**1 919**	**985**	**-6.5**
Total Europe	**18**	**919 309**	**92.1**	**2 059**	**2 631**	**2.5**
Caribbean	1	341	6.0	0	0	0
Central America	1	5 539	23.2	3	33	26.2
North America	1	65 540	9.7	11	2	-15.7
Total North and Central America	**3**	**71 420**	**10.1**	**14**	**35**	**9.4**
Total Oceania	**0**					
Total South America	**3**	**38 673**	**4.5**	**13**	**810**	**51.6**
World	**42**	**1 346 503**	**33.8**	**4 426**	**4 690**	**0.6**

Note: As some countries did not report a complete series, figures for 2000 are slightly different from those presented in Table 4.4.

TABLE 4.6
Trends in area of forest annually affected by insects 1988–1992 and 1998–2002

Region/subregion	Information availability (both periods)			Average area of forest affected by insects *(1 000 ha)*		Annual change rate *(%)*
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	1990	2000	
Eastern and Southern Africa	2	48	n.s.	0	0	0
Northern Africa	2	5 287	3.9	61	82	3.0
Western and Central Africa	0					
Total Africa	**4**	**5 335**	**0.8**	**61**	**82**	**3.0**
East Asia	4	218 842	97.0	8 306	9 329	1.2
South and Southeast Asia	3	99 970	33.6	8	10	2.6
Western and Central Asia	9	22 372	51.4	235	413	5.8
Total Asia	**16**	**341 185**	**60.2**	**8 549**	**9 752**	**1.3**
Total Europe	**20**	**901 989**	**90.4**	**2 536**	**5 945**	**8.9**
Caribbean	1	341	6.0	0	0	0
Central America	0					
North America	3	677 968	100.0	33 658	19 332	-5.4
Total North and Central America	**4**	**678 309**	**95.9**	**33 658**	**19 332**	**-5.4**
Total Oceania	**0**					
Total South America	**4**	**531 886**	**62.4**	**916**	**561**	**-4.8**
World	**48**	**2 458 703**	**61.6**	**45 721**	**35 672**	**-2.5**

Note: As some countries did not report a complete series, figures for 2000 are slightly different from those presented in Table 4.3.

The area affected by insects, on the other hand, shows a decrease (from 45.7 to 35.7 million hectares per year), owing to a substantial decrease in affected areas reported by Canada and the United States. Most other subregions and regions reported an increase in the area of forest affected by insects (Table 4.6). In Europe, the large increase in the area of forest affected by insects in the 1998–2002 period compared with the 1988–1992 period may be due to increased attacks following the storms of December 1999. This may also be the reason behind the increase in the area affected by diseases in this region.

It should be noted that this information is indicative as, again, there are only the two data points in time and data are missing for a large number of countries. Conclusions cannot be drawn from the data as to the causative agents or trees species involved and the effects on trees and the forest ecosystem as a whole.

OTHER DISTURBANCES

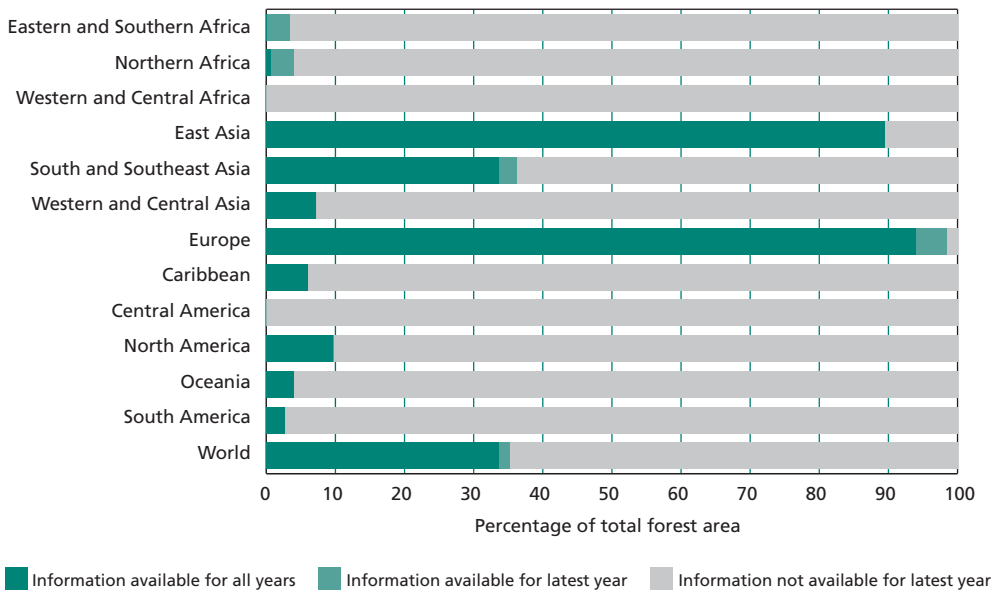
In the context of the FRA 2005 report, other disturbances include abiotic factors (e.g. wind, snow, ice, floods, tropical storms and drought) and damaging biotic agents other than insects and diseases (e.g. camels, beavers, deer and rodents). In general, information on disturbances attributed to these other biotic and abiotic factors is highly erratic, with a broad range of causative agents. Thus few of the data are comparable.

In Europe, a comprehensive overview of forest damage events is provided by the European Forest Institute's Database on Forest Disturbances in Europe. The effects on European forests of the severe storms of December 1999 and the floods of 2002 are well documented.

Information availability

Of the 229 countries involved in FRA 2005, 39 countries provided data on other disturbances for both the 1990 and 2000 reporting periods (33 percent of the total forest area). A further 16 countries provided data for the 2000 reporting period only. The reports were mainly from Europe and East Asia (Figure 4.5).

FIGURE 4.5
Information availability – other disturbances



Data for other wooded land were too limited to permit further analysis (less than 15 percent of the area of other wooded land in all regions).

Status

Total reported annual average area affected for the 2000 reporting period was 8.4 million hectares (Table 4.7). The highest area of other disturbances reported for a single country was 3.9 million hectares (Finland). However, this figure is the cumulative area affected rather than the average area newly affected in a given year. Overall, the data reflect a range of types of disturbances. First, there were single, major catastrophic events such as hurricanes, which cause widespread destruction and loss of trees, and which may weaken trees and make them susceptible to secondary infestations. Second, there were longer term, chronic pressures, such as consistent feeding by animals, that either cause significant, direct damage to trees or have indirect effects such as increased soil compaction beneath the trees, which may contribute to dieback and decline. Thus, collectively, without being broken down, the data are not particularly useful in the development of management strategies. However, detailed breakdowns into specific types of disturbances are given in most of the country reports for use at the national level.

Trends

Comparative data for the 1990 and 2000 reporting periods were provided by approximately 50 percent of the countries in the European region, together accounting for 94 percent of the total forest area in the region. The East Asia subregion provided comparative data on other disturbances for 89 percent of the forest area, and South and Southeast Asia for 34 percent. All other regions or subregions provided information for less than 10 percent of their combined forest area. Table 4.8 presents a regional summary.

The area of other disturbances almost doubled between the two reporting periods in Europe, primarily due to the effects of severe storms such as those in December 1999.

Wind, snow, drought and ice damage events have been reported, with wind being a significant factor in Europe and the tropical areas and islands for the 2000 reporting period. However, it should be noted that very little detail has been provided on other disturbances.

TABLE 4.7
Average area of forest annually affected by other disturbances 1998–2002

Region/subregion	Information availability			Area of forest affected by other disturbances	
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	1 000 ha	% of forest area
Eastern and Southern Africa	3	8 079	3.4	4	n.s.
Northern Africa	2	5 287	3.9	3	n.s.
Western and Central Africa	0				
Total Africa	**5**	**13 366**	**2.0**	**6**	**n.s.**
East Asia	2	201 877	89.5	847	0.4
South and Southeast Asia	4	107 885	36.3	3	n.s.
Western and Central Asia	3	3 121	7.2	4	0.1
Total Asia	**9**	**312 883**	**55.2**	**853**	**0.3**
Total Europe	**33**	**981 715**	**98.4**	**7 544**	**0.8**
Caribbean	1	341	6.0	0	0
Central America	0				
North America	2	65 543	9.7	3	n.s.
Total North and Central America	**3**	**65 884**	**9.3**	**3**	**n.s.**
Total Oceania	**3**	**8 270**	**4.0**	**11**	**0.1**
Total South America	**2**	**22 839**	**2.7**	**0**	**0**
World	**55**	**1 404 957**	**35.2**	**8 418**	**0.6**

TABLE 4.8
Trends in area of forest annually affected by other disturbances 1988–1992 and 1998–2002

Region/subregion	Information availability (both periods)			Average area of forest affected by other disturbances *(1 000 ha)*		Annual change rate *(%)*
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	1990	2000	
Eastern and Southern Africa	1	8	n.s.	0	0	0
Northern Africa	1	959	0.7	n.s.	n.s.	-9.9
Western and Central Africa	0					
Total Africa	**2**	**967**	**0.1**	**n.s.**	**n.s.**	**-9.9**
East Asia	2	201 877	89.5	790	847	0.7
South and Southeast Asia	3	99 936	33.6	n.s.	n.s.	-2.5
Western and Central Asia	3	3 121	7.2	3	4	1.2
Total Asia	**8**	**304 934**	**53.8**	**793**	**851**	**0.7**
Total Europe	**24**	**937 939**	**94.0**	**4 124**	**7 330**	**5.9**
Caribbean	1	341	6.0	1	0	-100.0
Central America	0					
North America	1	65 540	9.7	1	1	0
Total North and Central America	**2**	**65 881**	**9.3**	**2**	**1**	**-7.7**
Total Oceania	**1**	**8 226**	**4.0**	**5**	**7**	**3.4**
Total South America	**2**	**22 839**	**2.7**	**0**	**0**	**0**
World	**39**	**1 340 786**	**33.6**	**4 924**	**8 188**	**5.2**

Information on the impacts of these types of disturbances is important. At this point in time, there is insufficient quantitative information for a proper trend analysis. Some data have relevance to relatively isolated areas (specific animal species), whereas other types have much broader relevance (storms, wind). Countries have varying perceptions about what constitute 'other disturbances'.

Subdivision of the data would help provide more meaningful comparisons and conclusions at regional and global levels. Where feasible, consideration should be given to both direct and indirect effects (e.g. compaction of soils). A framework needs to be developed within which to capture information, prioritize types of disturbances and define data-collection methodologies from a global perspective.