Chapter 3
Biological diversity

OVERVIEW

'Biological diversity' encompasses the variety of existing life forms, the ecological roles they perform and the genetic diversity they contain (FAO, 1989). In forests, biological diversity allows species to adapt continuously to dynamically evolving environmental conditions, to maintain the potential for tree breeding and improvement (to meet human needs for goods and services and changing end-use requirements), and to support their ecosystem functions.

While timber production often dominated the way in which forests were managed in the twentieth century, new pressures in the twenty-first century drive a more balanced approach, calling for delivery of multiple goods and services. The process towards sustainable forest management is now considered consistent with the conservation of biological diversity.

Assessing, monitoring and reporting on biological diversity are important activities aimed at guiding sustainable forest management. Monitoring of biological diversity and of the changes caused by forestry practices is important in assessing the effectiveness of management and the cumulative changes brought about by forest use. However, there are conceptual and practical difficulties in doing so. These are not unique to biological diversity *per se*, but are general inventory problems related to target parameters that are complex and highly variable.

The values derived from biological diversity are associated with different scales that require different assessment methodologies. These include ecosystems, landscapes, species, populations, individuals and genes. Varying and complex interactions exist among all these levels.

Because biological diversity encompasses the complexity of all life forms, assessment and monitoring are only possible for specific aspects or particular, defined goals. There is no single, objective measure of biological diversity, only proxy measures appropriate for specified and, by necessity, restricted purposes. Species richness, for example, has a very wide natural variation from boreal to tropical forests. For policy and monitoring purposes, it is the change in biodiversity that is important, which implies identifying a few relevant indicators and then monitoring them over time. So far this has not been achieved for forest ecosystems on a wide scale (i.e. national or continental), but FRA 2005 has attempted to establish a baseline for forest ecosystems worldwide, and to provide input into wider biodiversity monitoring work.

Most local forest inventories are conducted to estimate harvestable volumes of wood and sometimes non-wood forest products, rather than to monitor biological diversity. An immediate need exists to categorize and substantially improve the understanding of biological diversity with a view to measuring trends, particularly on regional scales. In this respect, the work carried out in the framework of criteria and indicators processes, which all address biological diversity, is an important contribution.

The variables measured in FRA 2005 with relevance to forest biological diversity include:

- area of primary forests;
- forest area designated for conservation of biodiversity;
- composition of forests;
- number of native tree species;
- threatened forest tree species.

These variables include measures both of policy response (e.g. areas designated for conservation of biodiversity) and of outcome (e.g. number of threatened species). Both are needed, but the fundamental difference between these two concepts should be borne in mind.

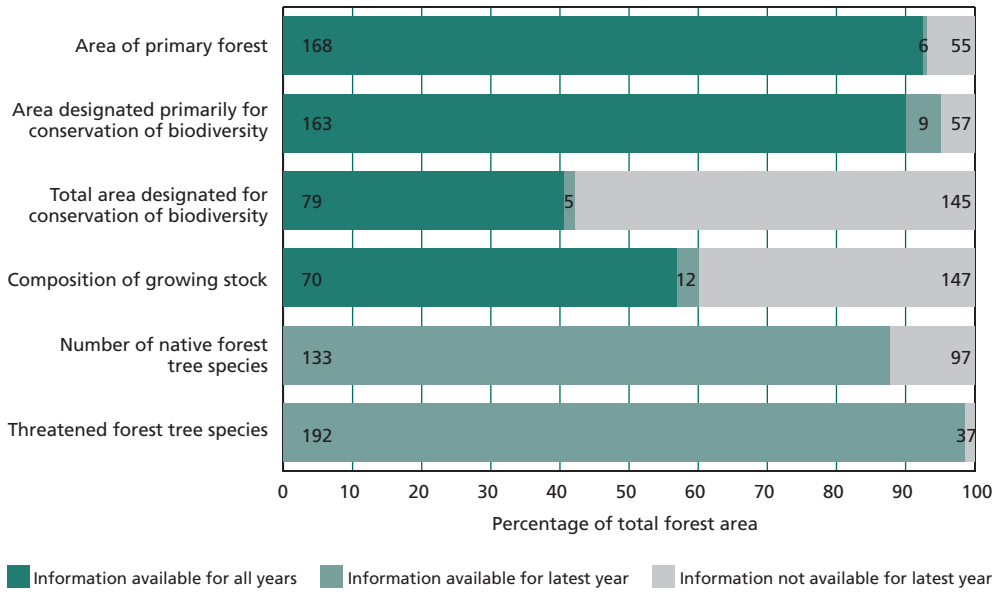
In recent years, the Global Forest Resources Assessments have increased their focus on forest biodiversity. FRA 2005 gathered and compiled relevant information at landscape and species levels, while addressing some structural and compositional aspects. At the ecosystem level, FRA 2005 provides information on the area of forests and – more specifically – on the area of primary and other forests managed for the conservation of biological diversity (including protected areas), thus complementing FRA 2000 data on the proportion of forests in protected areas. At the species level, FRA 2000 highlighted the global lack of estimates of the number of tree species by country, with the exception of endangered tree species. FRA 2005 thus focused on assessment of the number of both native and endangered forest tree species at the country level. In addition, country reports included lists of the ten most common tree species (measured by their share of total growing stock), thus providing important information on the tree species composition of forests.

Many countries lack the capacity to report on biological diversity. In particular, there is generally less knowledge with respect to biological diversity in tropical forests compared with the other biomes. In FRA 2005, countries were better able to report on the area of primary forest, on forest area designated for the conservation of biodiversity and on threatened tree species than on the other variables reported in this chapter (Figure 3.1). However, these data alone are insufficient to provide a reliable picture of broader trends in forest biological diversity.

KEY FINDINGS

Although a large number of countries have reported on the characteristics of their forests, information on the area of primary forest is not readily available. Proxy values have often been used, including the area of natural forest over a certain age or the area of forest with protected area status. This makes a detailed analysis of status and trends difficult. The

FIGURE 3.1
Information availability – biological diversity



Note: Figures present number of countries in each category.

results suggest, however, that the total area of primary forests exceeds 1.3 billion hectares or 36 percent of all forests, and that the ten countries with the largest area of primary forest account for 88.2 percent of the total area of primary forest in the world.

Information was unavailable for many of the countries in the Congo Basin, the second largest expanse of tropical forest, which should be kept in mind when analysing the findings.

Great variation exists in terms of the distribution of primary forest, with limited areas reported from the Caribbean, Eastern and Southern Africa, Europe (not including the Russian Federation), North Africa and the arid zones of Western and Central Asia. The largest expanse of primary forest is found in South America (the Amazon Basin). Countries in North and Central America and the Russian Federation have also classified a relatively high proportion of their forests as primary.

The estimated annual net decrease in primary forests of 6 million hectares is alarmingly high. This decrease reflects not only a complete loss of these forests, but also changes within the forest, for instance when primary forests move into the category of modified natural forests due to selective logging. Some countries, notably in Europe and Japan, are reporting an increase in their areas of primary forests, because natural forests have been set aside as 'no intervention' areas.

In 2005, globally, more than 400 million hectares of forests, or 11 percent of total forest area, were designated for the conservation of biological diversity as the primary function. The area of forest devoted to conservation of biodiversity has increased by at least 96 million hectares, or 32 percent, since 1990. This increasing trend is evident in all regions and subregions except Northern, Eastern and Southern Africa.

Information on the total area of forest that has conservation of biological diversity designated as *one* of the functions and management objectives is of considerable interest to the forest conservation community, but information was lacking from many countries. To improve the potential value of this variable, it would be worth refining and simplifying its estimation. This might improve the level of reporting, which was especially low in Africa and Oceania.

Forest composition is a valuable indicator of biological diversity. Although a significant number of countries reported on the composition of their forests in terms of growing stock, information was unavailable for many countries, which makes a detailed analysis of the value of the indicator difficult.

There is also great variation in terms of forest tree species diversity, from limited numbers of individual species in boreal ecosystems to high species richness per area unit in Central and South America, South and Southeast Asia, and Western and Central Africa. Boreal forests tend to harbour the lowest species diversity. On average, the ten most common tree species in a country account for 76 percent of total growing stock. The exceptions by region are found in Central America, South and Southeast Asia and Western and Central Africa, where percentages range from 22 to 47 percent. In Europe and Western and Central Asia, the ten most common tree species account for more than 90 percent of total growing stock.

Information was missing from many countries in South America (including Brazil) and from most of the countries in the Congo Basin, both areas of known high species diversity.

The combined list of the ten most common tree species from all countries contained 445 different species. Five genera (*Pinus, Quercus, Picea, Abies* and *Fagus*) make up almost one-third of the number of species reported as being most common. This may be influenced by the fact that Asia and Europe are over-represented, in terms of the number of countries that reported on this topic, relative to their total forest area. No change in the relative importance of different species was found between 1990 and 2000; nor were major changes noticed in the share of growing stock occupied by the three most common species.

In terms of the status of native tree species, South America displays a higher number of threatened tree species than other regions, with the lowest number being found in Europe. Countries in South and Southeast Asia also report a significantly higher number of endangered and critically endangered species. Forty-five countries report that they have no threatened tree species.

The overall high response rate on threatened species reflects the availability of the global *IUCN 2000 red list of threatened species* (IUCN, 2000) – although 53 countries and areas reported discrepancies with this list. It also demonstrates a clear perception that significant numbers of forest tree species are threatened.

On average, 5 percent of the tree species native to a country are either vulnerable, endangered or critically endangered.

In conclusion, FRA 2005 data confirm that forest biodiversity conservation concerns have encouraged significant policy responses and, in particular, the setting aside of increasing areas of forest for conservation purposes. FRA 2005 has established a tentative baseline for further monitoring work at landscape and species levels. The monitoring of a few selected outcome indicators, to be determined, should in the future help in reviewing the effectiveness, at the country level, of the implementation of policy decisions on biodiversity conservation.

PRIMARY FORESTS

Information on total forest area, forest characteristics and overall changes in both over time was presented in Chapter 2, Extent of forest resources. The present chapter focuses on primary forests, which are defined in FRA 2005 as forests of native species, in which there are no clearly visible indications of human activity and ecological processes are not significantly disturbed.

Primary forests are often equated with high levels of biodiversity, but this is not always the case. In the temperate and boreal zones, for example, they can be poor in terms of number of plant and animal species, while some modified natural or semi-natural forests and forests bordering agricultural areas may provide additional habitats and thus harbour more species. Nevertheless, the size of the area of primary forest is one of several important indicators of the state of forest ecosystems.

It should also be kept in mind that primary forests fulfil many essential functions other than the conservation of biological diversity: soil and water conservation, carbon sequestration and the preservation of aesthetic, cultural and religious values.

Information availability

The 174 countries reporting on area of primary forest account for 93.1 percent of total forest area. Information is missing, unfortunately, from many of the smaller islands and territories and from many of the countries in the Congo Basin, the second largest expanse of tropical forest (Figure 3.2).

Of the reporting countries, only 96 reported that they had any primary forest left in 2005. Several others reported that they had insufficient information on the area of primary forests. Few of those who did include an estimate had exact information. Many used the current area of forests in national parks and other protected areas as a proxy value or provided an expert estimate of the percentage of natural forests that could be considered primary according to the FRA 2005 definition.

These shortcomings should be kept in mind when referring to the findings below.

Status

Information on the current and past extent of primary forest in each of the countries reporting on this variable can be found in Table 9 in Annex 3. A regional summary follows.

An estimated 1.3 billion hectares of forest – or 36.4 percent of the combined forest area of the reporting countries – are considered primary forest (Table 3.1).

FIGURE 3.2
Information availability – area of primary forest

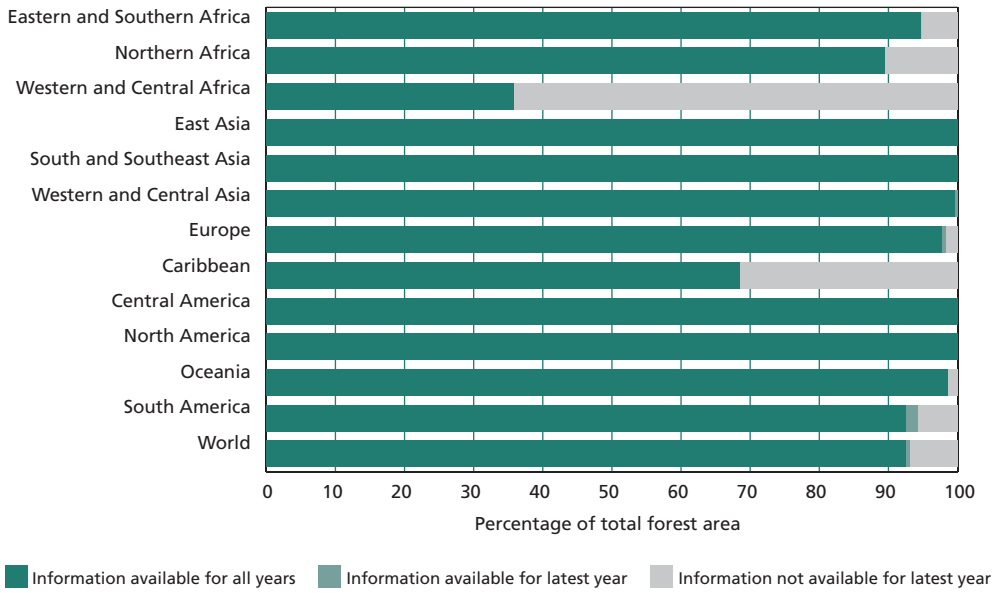


TABLE 3.1
Area of primary forest 2005

Region/subregion	Information availability			Area of primary forest *(1 000 ha)*	Primary forest as % of total forest area	
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area		Average	Range
Eastern and Southern Africa	18	214 589	94.7	12 241	5.7	0-81
Northern Africa	12	117 193	89.4	13 919	11.9	0-20
Western and Central Africa	17	99 566	35.8	11 510	11.6	0-45
Total Africa	**47**	**431 347**	**67.9**	**37 669**	**8.7**	**0-81**
East Asia	5	244 862	100.0	21 808	8.9	6-46
South and Southeast Asia	17	283 126	100.0	62 908	22.2	1-100
Western and Central Asia	23	43 579	100.0	2 810	6.4	0-72
Total Asia	**45**	**571 567**	**100.0**	**87 526**	**15.3**	**0-72**
Total Europe	**36**	**983 907**	**98.3**	**263 948**	**26.8**	**0-32**
Caribbean	12	4 090	68.5	60	1.5	6-59
Central America	7	22 411	100.0	9 139	40.8	2-70
North America	4	677 464	100.0	302 456	44.6	34-53
Total North and Central America	**23**	**703 965**	**99.7**	**311 656**	**44.3**	**2-70**
Total Oceania	**11**	**203 455**	**98.6**	**35 275**	**n.s.**	**n.s.-89**
Total South America	**12**	**783 827**	**94.3**	**601 689**	**76.8**	**10-96**
World	**174**	**3 678 069**	**93.1**	**1 337 763**	**36.4**	**0-100**

Forty-five percent of the total area of primary forest reported is found in South America, followed by North and Central America (23.3 percent) and Europe (19.7 percent – almost all of it in the Russian Federation).

The ten countries with the largest area of primary forest account for 89.1 percent of the total area of primary forest in the world (Figure 3.3).

Twenty countries report that their primary forest is at least 50 percent of their total forest area, and ten countries have classified more than 80 percent of their forests as primary (Table 3.2).

FIGURE 3.3
Ten countries with largest area of primary forest 2005
(%)

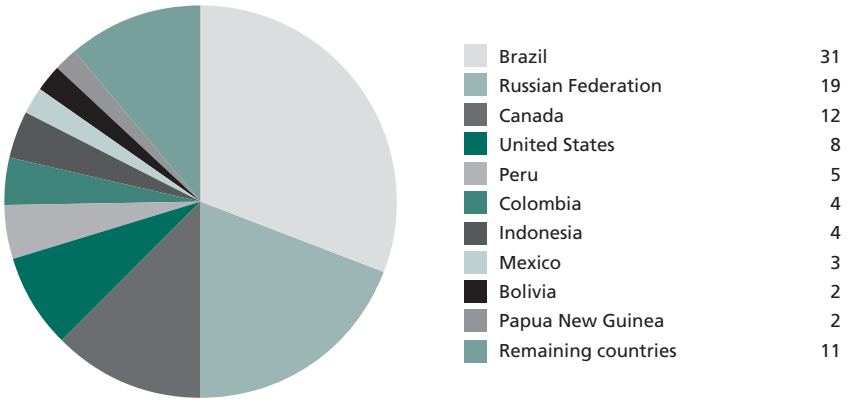


TABLE 3.2
Ten countries with highest percentage of primary forest 2005

Country	Primary forest as % of total forest
Brunei Darussalam	100
Singapore	100
French Guiana	96
Suriname	96
Fiji	89
Peru	89
Colombia	87
Brazil	87
Papua New Guinea	86
Madagascar	81

Of the reporting countries and areas, 28 countries, mostly in Europe and in the arid zones of Africa and Western Asia, reported that they have no primary forests left, and 50 provided no information on the area of primary forest. In some cases, this may be due to lack of data rather than complete lack of primary forest.

Trends

A trend analysis was generated based on those countries reporting for 2005, including those reporting that they had no primary forest. For eight countries for which information was missing for 1990 (Australia, Bosnia and Herzegovina, Burundi, Estonia, Guyana, Latvia, Lebanon and Samoa), FAO employed a linear extrapolation based on the estimates for 2005 and 2000. While the proportion of total forest classified as primary has remained fairly constant since 1990, indications are that primary forests were lost at an average rate of 6 million hectares per year over the last 15 years and that the rate of loss is slowing down in some regions, but is increasing in South America.

This estimated net loss excluded the Russian Federation, where a large difference in the change rate (from -1.6 million hectares per year in the 1990s to +0.5 million hectares per year in the last five years) is likely due to a modification in the methodology used rather than to actual changes.

Brazil and Indonesia alone accounted for an annual loss of primary forest of 4.9 million hectares during the period 2000–2005. The data received do not allow for an analysis of how large a proportion of this net loss is due to deforestation and conversion to other

uses and how much is due to the opening up of primary forests to selective logging and other human activities or to severe natural disasters, which could lead to some forests being classified as 'modified natural forests'.

A number of countries registered positive change rates in the area of primary forests (see Table 9 in Annex 3), including several western European countries and Japan. In most of these cases, the countries have been setting aside natural forest areas in which no intervention should take place. With time, these areas evolve into forests in which there are no clearly visible indications of human activity and ecological processes are not significantly disturbed, meeting the definition of primary forests used in FRA 2005. For example, Japan and some of the European countries classified all natural forests over a certain age or size as primary forests if no interventions had been conducted over the last 25 years.

FOREST AREA DESIGNATED FOR CONSERVATION OF BIODIVERSITY

The setting aside and management of land as protected areas is a key part of ongoing global efforts to conserve biological diversity. The amount of land set aside for conservation is an important indicator of progress, and the monitoring of this variable provides valuable information to conservation practitioners. The data on protected areas that were gathered, analysed and presented in FRA 1990 and 2000 are complemented by the data on area of forest designated for conservation in FRA 2005.

The primary global source of data is the World Database on Protected Areas (WDPA), which is managed by the World Conservation Monitoring Centre (WCMC) of the United Nations Environment Programme (UNEP) and funded by the WDPA Consortium. The WDPA and the analysis of the data it contains are useful in understanding global trends in protected areas.

FRA 1990 (FAO, 1993) presented data in a table entitled Distribution of protected areas. It documented the number of protected areas and the total area under protection in developing countries in Africa, Asia and Latin America and in developed countries in Asia, Europe, the former Union of Soviet Socialist Republics (USSR), North America and Oceania.

FRA 2000 (FAO, 2001b) presented regional and global data on forests in protected areas and on the proportion of forest in protected areas in tropical, subtropical, temperate and boreal zones. The estimate in FRA 2000 that 12.4 percent of total forest area was in protected areas was of obvious interest. The relatively low proportion of boreal forest in protected areas was also significant. These findings should be compared with the contemporary World Wide Fund for Nature (WWF)/IUCN goal of establishing an ecologically representative network of protected areas covering at least 10 percent of the world's forest area by the year 2000 (WWF and IUCN, 1998).

For FRA 2005, information was requested from countries and areas on two measures of the area designated for conservation of biodiversity:

- forest area designated primarily for conservation of biodiversity;
- total forest area designated for conservation of biodiversity.

Areas designated for conservation of biodiversity, whether as the primary or a subsidiary function, include areas outside protected areas. At the same time, some forests in protected areas may be designated for the conservation of soil and water resources or a cultural heritage. So the estimated area of forest designated for conservation of biodiversity is not necessarily equivalent to the area of forest in protected areas.

Information availability

For FRA 2005, Figures 3.4 and 3.5 show that there was a striking difference in all regions in the percentage of countries or areas that provided information on the two measures of the area of forest designated for conservation of biological diversity.

A plausible explanation for the large difference in response rates is that the calculation of the total area designated for conservation is rather complex and different methodologies

FIGURE 3.4
Information availability – area of forest designated primarily for conservation of biodiversity

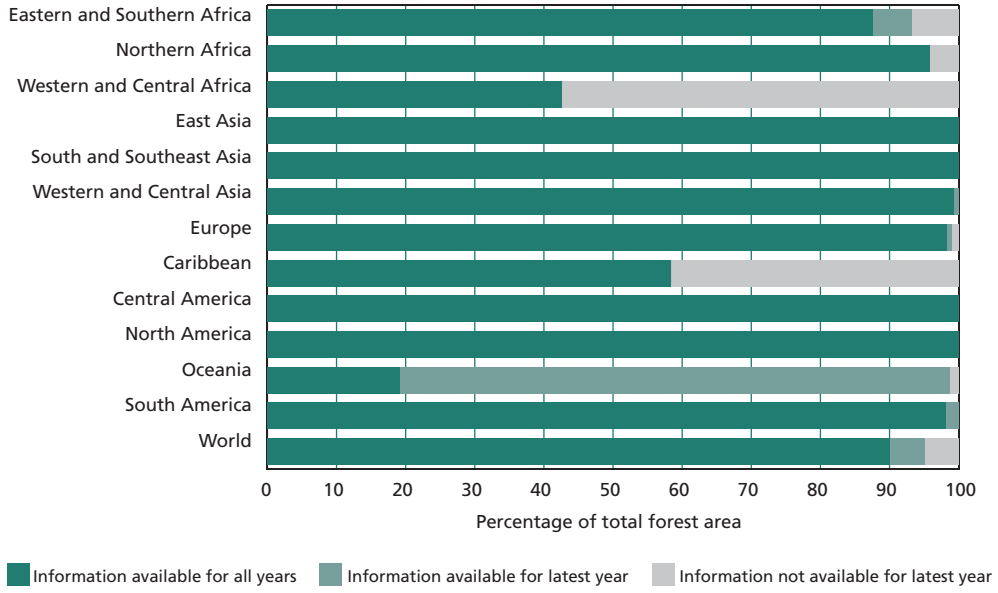
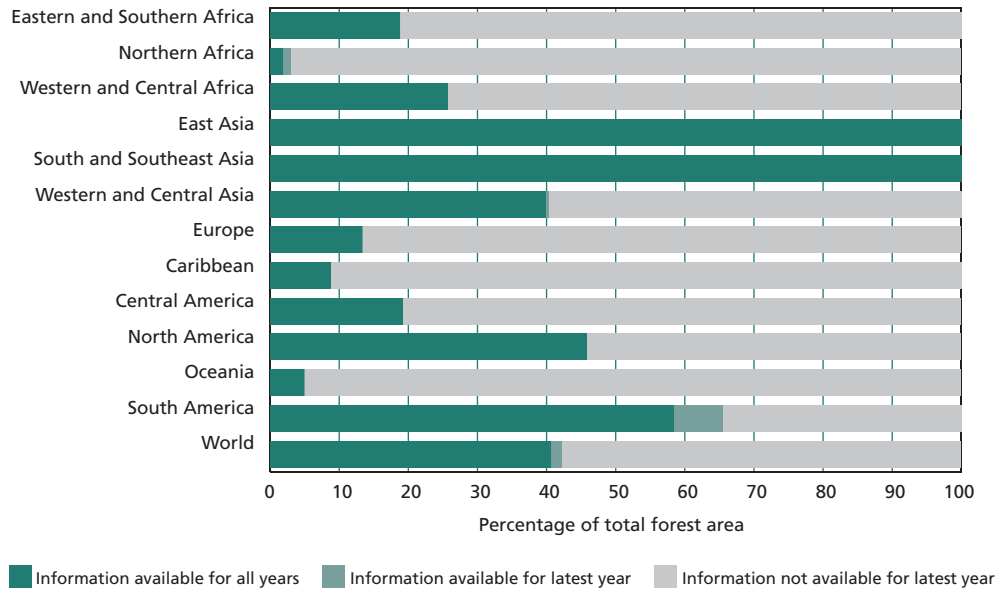


FIGURE 3.5
Information availability – total area of forest designated for conservation of biodiversity



are used at the national level. In Africa, eight forest-rich countries, accounting for 62 percent of the continent's total forest cover, did not report on this measure. As a result, the estimate of the total area designated for conservation was less than half that of the area with conservation as the primary function, which is an anomalous result.

In South America, on the other hand, although only three out of 15 countries and areas reported on this measure, they account for 69 percent of the continent's total forest

area. The estimate of the total area designated for conservation was nearly three times the area having conservation as the primary function, which is consistent with what would logically be expected.

Status

The data provided by countries on forest area designated primarily for biodiversity conservation show that, globally, more than 400 million hectares of forest – or 11.2 percent of total forest area of the reporting countries – are designated as having conservation of biodiversity as their primary function (Table 3.3).

The biggest area of forest designated for conservation of biodiversity is found in South America, followed by North America, while Central America and Western and Central Africa have the highest percentage of their forests designated primarily for conservation. Europe and Western and Central Asia have the lowest percentage of forests designated primarily for conservation.

Although the percentage of forest designated primarily for conservation is not exactly equal to the percentage of forest in protected areas, many countries used the area of forests in protected areas as a proxy value. It is thus not surprising to find that the global figure for this measure, 11.2 percent, is not significantly different from the estimate in FRA 2000 of the percentage of forest in protected areas, which was 12.4 percent.

The total area of forest designated for conservation is an interesting measure (Table 3.4) because it gives an indication of the area in which conservation is a consideration in land management, without necessarily being the priority, as might often be the case outside protected areas. It is logical to expect that this area will be larger than the area in which conservation is the primary function.

A comparison of Tables 3.3 and 3.4 confirms the expectation that the area designated for conservation would be larger than the area with conservation designated as the primary function. This comparison must be treated with caution, however, owing to the low response rates in Africa, Europe and Oceania for this variable.

Trends

For FRA 2005, countries were asked to make retrospective estimates for 1990 and 2000 for the two measures of forest area designated for conservation.

TABLE 3.3
Area of forest designated primarily for conservation of biodiversity 2005

Region/subregion	Information availability			Area designated primarily for conservation	
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	1 000 ha	% of forest area
Eastern and Southern Africa	16	211 181	93.2	20 158	9.5
Northern Africa	13	125 667	95.9	13 036	10.4
Western and Central Africa	15	118 280	42.6	41 390	35.0
Total Africa	**44**	**455 129**	**71.6**	**74 585**	**16.4**
East Asia	5	244 862	100.0	11 479	4.7
South and Southeast Asia	17	283 126	100.0	57 290	20.2
Western and Central Asia	23	43 579	100.0	2 772	6.4
Total Asia	**45**	**571 567**	**100.0**	**71 541**	**12.5**
Total Europe	**36**	**991 192**	**99.0**	**37 776**	**3.8**
Caribbean	9	3 489	58.4	704	20.2
Central America	7	22 411	100.0	8 482	37.8
North America	4	677 464	100.0	79 741	11.8
Total North and Central America	**20**	**703 364**	**99.6**	**88 927**	**12.6**
Total Oceania	**14**	**203 467**	**98.6**	**29 366**	**14.4**
Total South America	**13**	**831 540**	**100.0**	**119 742**	**14.4**
World	**172**	**3 756 260**	**95.0**	**421 936**	**11.2**

TABLE 3.4
Total area of forest designated for conservation of biodiversity 2005

Region/subregion	Information availability			Total area designated for conservation	
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	1 000 ha	% of forest area
Eastern and Southern Africa	3	42 529	18.8	10 272	24.2
Northern Africa	3	3 876	3.0	1 380	35.6
Western and Central Africa	6	71 350	25.7	27 150	38.1
Total Africa	**12**	**117 754**	**18.5**	**38 802**	**33.0**
East Asia	5	244 862	100.0	119 078	48.6
South and Southeast Asia	17	283 126	100.0	147 298	52.0
Western and Central Asia	12	17 507	40.2	8 580	49.0
Total Asia	**34**	**545 495**	**95.4**	**274 955**	**50.4**
Total Europe	**22**	**133 854**	**13.4**	**88 219**	**65.9**
Caribbean	3	524	8.8	130	24.9
Central America	1	4 294	19.2	2 827	65.8
North America	2	310 137	45.8	310 135	100.0
Total North and Central America	**6**	**314 955**	**44.6**	**313 092**	**99.4**
Total Oceania	**7**	**10 235**	**5.0**	**8 719**	**85.2**
Total South America	**3**	**544 501**	**65.5**	**318 335**	**58.5**
World	**84**	**1 666 795**	**42.2**	**1 042 122**	**62.5**

TABLE 3.5
Trends in area of forest designated primarily for conservation of biodiversity 1990–2005

Region/subregion	Information availability (all 3 years)			Area of forest designated *(1 000 ha)*			Annual change rate *(%)*	
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	1990	2000	2005	1990–2000	2000–2005
Eastern and Southern Africa	15	198 343	87.6	15 294	15 165	15 101	-0.08	-0.08
Northern Africa	13	125 667	95.9	14 441	13 515	13 036	-0.66	-0.72
Western and Central Africa	15	118 280	42.6	37 068	37 232	41 390	0.04	2.14
Total Africa	**43**	**442 291**	**69.6**	**66 803**	**65 912**	**69 528**	**-0.13**	**1.07**
East Asia	5	244 862	100.0	10 338	10 847	11 479	0.48	1.14
South and Southeast Asia	17	283 126	100.0	46 725	52 540	57 290	1.18	1.75
Western and Central Asia	21	43 272	99.3	1 744	2 126	2 761	2.00	5.37
Total Asia	**43**	**571 259**	**99.9**	**58 807**	**65 513**	**71 531**	**1.09**	**1.77**
Total Europe	**34**	**984 468**	**98.3**	**18 402**	**33 877**	**36 760**	**6.29**	**1.65**
Caribbean	9	3 489	58.4	622	675	704	0.83	0.83
Central America	7	22 411	100.0	7 873	8 660	8 482	0.96	-0.42
North America	4	677 464	100.0	69 745	70 384	79 741	0.09	2.53
Total North and Central America	**20**	**703 364**	**99.6**	**78 240**	**79 720**	**88 927**	**0.19**	**2.21**
Total Oceania	**11**	**39 593**	**19.2**	**6 709**	**7 968**	**7 948**	**1.73**	**-0.05**
Total South America	**12**	**816 436**	**98.2**	**69 463**	**108 103**	**119 591**	**4.52**	**2.04**
World	**163**	**3 557 412**	**90.0**	**298 424**	**361 092**	**394 283**	**1.92**	**1.77**

Note: As some countries did not report a complete series, figures for 2005 are slightly different from those presented in Table 3.3.

The estimates provided for the percentage of forest area designated primarily for conservation are summarized in Table 3.5. The figures in this table suggest that the area of forest devoted to biodiversity conservation has increased by at least 96 million hectares, or 32 percent, since 1990. This increasing trend is evident in all regions and subregions except Northern, Eastern and Southern Africa.

According to the 2003 *United Nations list of protected areas* (Chape *et al.*, 2003), which deals with all ecosystems, the area of land within protected areas grew by 53 percent from 1992 to 2003. The difference between this figure and the finding of FRA 2005 may be due to larger rates of increase in ecosystems other than forests.

TABLE 3.6
Trends in total area of forest designated for conservation of biodiversity 1990–2005

Region/subregion	Information availability (all 3 years)			Area of forest designated *(1 000 ha)*			Annual change rate *(%)*	
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	1990	2000	2005	1990–2000	2000–2005
Eastern and Southern Africa	3	42 529	18.8	10 273	10 273	10 272	0	n.s.
Northern Africa	2	2 322	1.8	863	1 179	1 276	3.17	1.59
Western and Central Africa	6	71 350	25.7	23 628	24 005	27 150	0.16	2.49
Total Africa	**11**	**116 200**	**18.3**	**34 764**	**35 457**	**38 698**	**0.20**	**1.76**
East Asia	5	244 862	100.0	81 185	105 727	119 078	2.68	2.41
South and Southeast Asia	17	283 126	100.0	130 606	148 547	147 298	1.30	-0.17
Western and Central Asia	11	17 371	39.9	8 186	8 138	8 576	-0.06	1.06
Total Asia	**33**	**545 358**	**95.4**	**219 978**	**262 411**	**274 952**	**1.78**	**0.94**
Total Europe	**21**	**133 187**	**13.3**	**78 529**	**89 304**	**88 010**	**1.29**	**-0.29**
Caribbean	3	524	8.8	138	130	130	-0.60	0
Central America	1	4 294	19.2	2 754	2 857	2 827	0.37	-0.21
North America	2	310 137	45.8	310 137	310 137	310 135	0	n.s.
Total North and Central America	**6**	**314 955**	**44.6**	**313 029**	**313 124**	**313 092**	**n.s.**	**n.s.**
Total Oceania	**6**	**10 064**	**4.9**	**8 024**	**8 561**	**8 644**	**0.65**	**0.19**
Total South America	**2**	**485 761**	**58.4**	**137 695**	**180 623**	**259 595**	**2.75**	**7.52**
World	**79**	**1 605 526**	**40.6**	**792 018**	**889 481**	**982 990**	**1.17**	**2.02**

Note: As some countries did not report a complete series, figures for 2005 are slightly different from those presented in Table 3.4.

The trends in the total area designated for conservation are summarized in Table 3.6. There was an estimated 24 percent increase in the world figure for total forest area designated for conservation between 1990 and 2005. However, the reliability of the estimate is reduced by the small areas reported for Africa, Europe and Oceania.

COMPOSITION OF FORESTS

Information on growing stock composition offers a proxy indicator that aids better understanding and monitoring of the dynamics of the relative abundance of forest tree species. The ten most common species in terms of growing stock have been listed and their contribution to total growing stock documented for 1990 and 2000. FRA 2005 attempts to estimate the rate of change of forest tree composition among the ten most abundant species, and to assess whether such information may be useful in documenting the factors implicated in these changes at the global level.

Information availability

Information on the species represented in growing stock is poor: only 82 countries and areas, accounting for 60 percent of total forest area, provided quantitative information on the ten most common species. Regions or subregions with the highest response rates were Asia, Europe and North America (Figure 3.6).

Status

Table 3.7 shows the percentage of growing stock of the three and the ten most common tree species.

The relative importance of growing stock of a species depends on many environmental and silvicultural factors. In natural and semi-natural forests, the percentage of growing stock represented by a given number of tree species is expected to be inversely correlated to tree species richness (and the number of tree species present in the area). Figure 3.7 shows that the percentage of growing stock occupied by the three most common tree species (native or introduced) is a reasonable predictor of the growing stock occupied by the ten most common (native or introduced) species at the country level.

FIGURE 3.6
Information availability – composition of growing stock

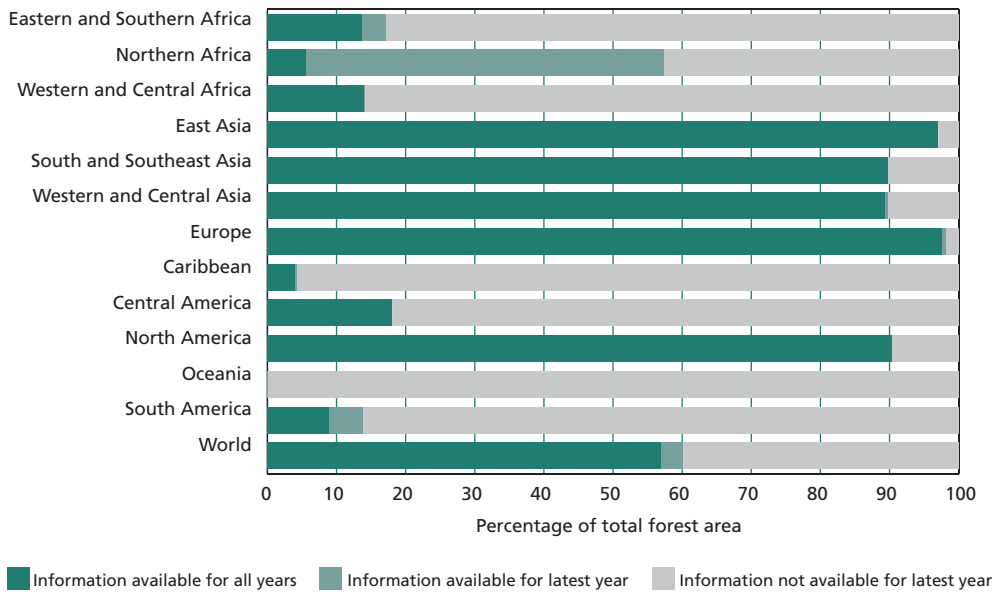
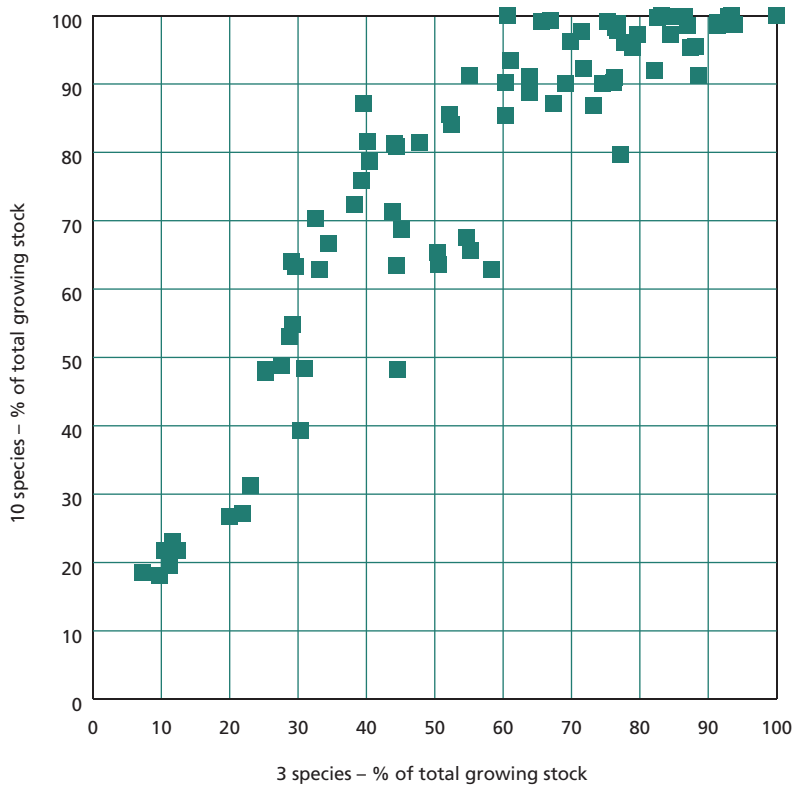


TABLE 3.7
Percentage of growing stock occupied by the most common tree species 2000

Region/subregion	Information availability			Three most common tree species			Ten most common tree species		
	Countries reporting	Forest area *(1 000 ha)*	% total forest area	Aver. % growing stock	Min. % growing stock	Max. % growing stock	Aver. % growing stock	Min. % growing stock	Max. % growing stock
Eastern and Southern Africa	6	40 294	17.1	54	12	100	69	23	100
Northern Africa	5	77 981	57.4	64	23	88	76	31	100
Western and Central Africa	5	40 129	14.1	24	10	44	43	18	71
Total Africa	**16**	**158 404**	**24.2**	**48**	**10**	**100**	**63**	**18**	**100**
East Asia	4	218 842	97.0	57	29	93	79	64	100
South and Southeast Asia	10	266 914	89.8	31	7	67	47	19	87
Western and Central Asia	11	39 062	89.7	77	60	94	94	80	99
Total Asia	**25**	**524 818**	**92.6**	**55**	**7**	**93**	**73**	**19**	**100**
Total Europe	**30**	**979210**	**98.1**	**70**	**34**	**93**	**92**	**65**	**100**
Caribbean	2	238	4.2	36	33	39	69	63	76
Central America	1	4 307	18.1	10	10	10	22	22	22
North America	2	612 428	90.3	29	25	33	59	48	70
Total North and Central America	**5**	**616 973**	**87.2**	**28**	**10**	**39**	**56**	**22**	**76**
Total Oceania	**2**	**44**	**0.0**	**41**	**38**	**44**	**77**	**72**	**81**
Total South America	**4**	**117 758**	**13.8**	**37**	**28**	**50**	**60**	**48**	**79**
World	**82**	**2 397 208**	**60.1**	**56**	**7**	**100**	**76**	**18**	**100**

Great variation exists in terms of species diversity, with limited numbers of individual species and high species richness per area unit in Central and South America, South and Southeast Asia and Western and Central Africa. Boreal forests of the Northern Hemisphere tend to harbour the lowest species diversity. At the country level, Congo, Viet Nam, Myanmar, Panama, Ghana, Madagascar, Indonesia and India (listed in ascending order) report that the ten most common tree species represent less

FIGURE 3.7
Average growing stock of the ten most common forest tree species as function of growing stock occupied by the three most common species[1]



[1] One square = one country/area.

than 30 percent of total growing stock, indicating high species diversity. Information was missing from many countries in South America (including Brazil) and from most countries in the Congo Basin, both areas of known high species diversity.

Figure 3.8 displays a loose relationship between two tree species diversity surrogates: total number of native tree species and growing stock composition. Introduced species are included in the data set for the growing stock composition.

Among the ten most common species, 445 different taxa have been reported by 88 countries. Asia and Europe are over-represented in the data set, which includes incomplete reports. A significant number of taxa were reported at the genus level without indication of species. Most countries provided Latin names. Five genera (*Pinus, Quercus, Picea, Abies* and *Fagus*) make up almost a third of the species reported. Figure 3.9 shows the distribution of the 25 most common genera, which represent 64 percent of all taxa reported.

Trends

Eighty-two countries provided time series (sometimes incomplete) on changes in the relative share of growing stock occupied by the ten main species from 1990 to 2000. No change in the relative ranking of tree species was observed in the data set. No significant change in the share of growing stock occupied by the three main species was seen in the data series from the 56 countries and areas providing complete series. In 1990 and 2000, this share accounted for 53 percent of growing stock, on average, although individual countries and areas varied by +/-5 percent.

FIGURE 3.8
Percentage of growing stock represented by the three most common forest tree species as function of number of native tree species

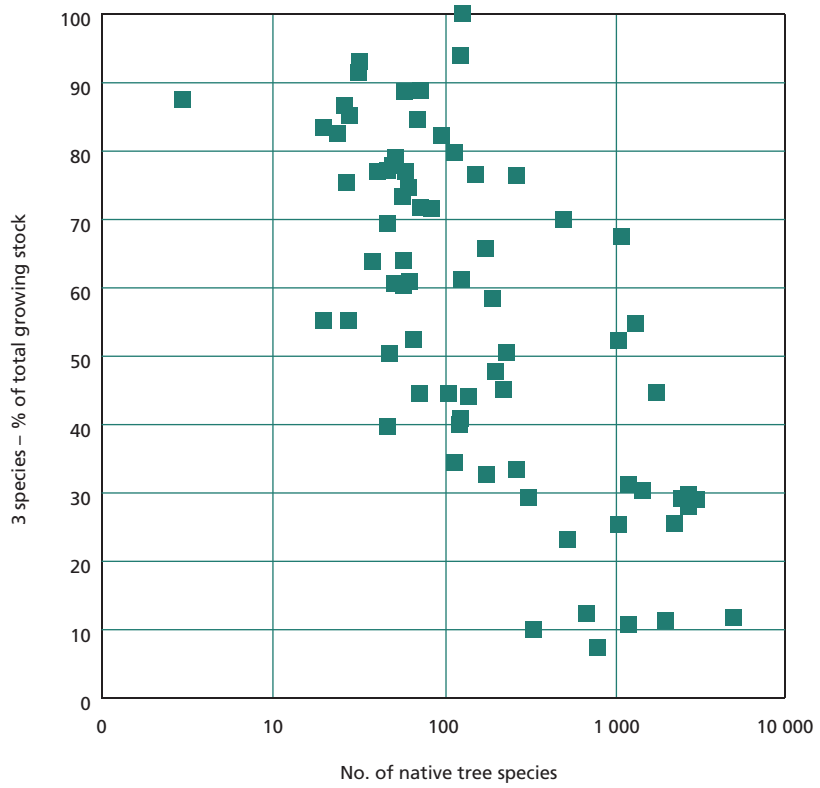
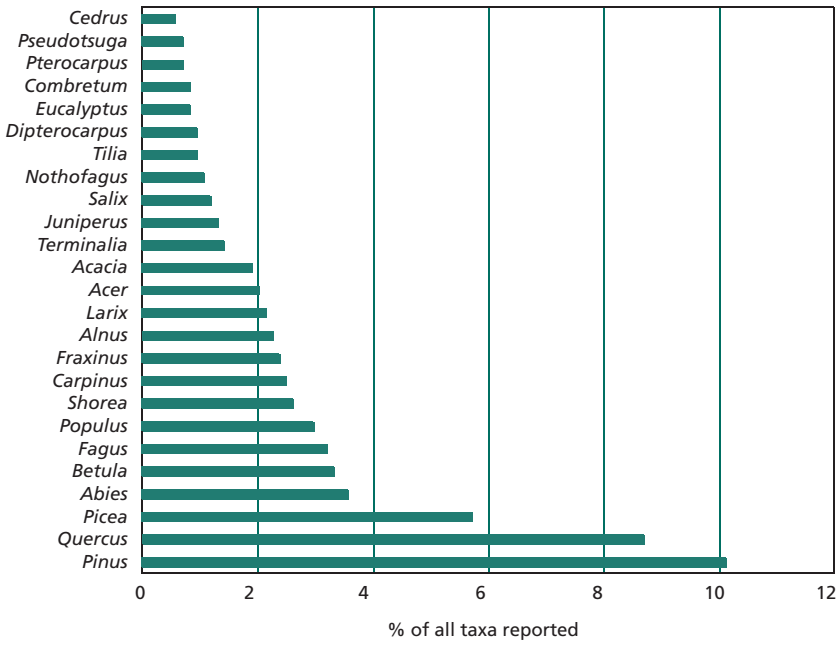


FIGURE 3.9
Twenty-five most common tree genera reported[1]



[1] Among the ten most common species reported by 88 countries.

NUMBER OF NATIVE TREE SPECIES

Estimates of number of species by taxonomic group, by country, are available in the literature, with the notable exception of trees. FRA 2005 is a first attempt to systematically record the number of native forest tree species by country and area at the global level. The definition of a tree is complex; for example there is no universally adopted relative classification of shrubs and trees. The definition of forests used for FRA 2005 includes bamboo, palm and other woody species. In addition, in some cases where a species has been present in a country for many centuries, it is impossible to ascertain whether it is native or was introduced.

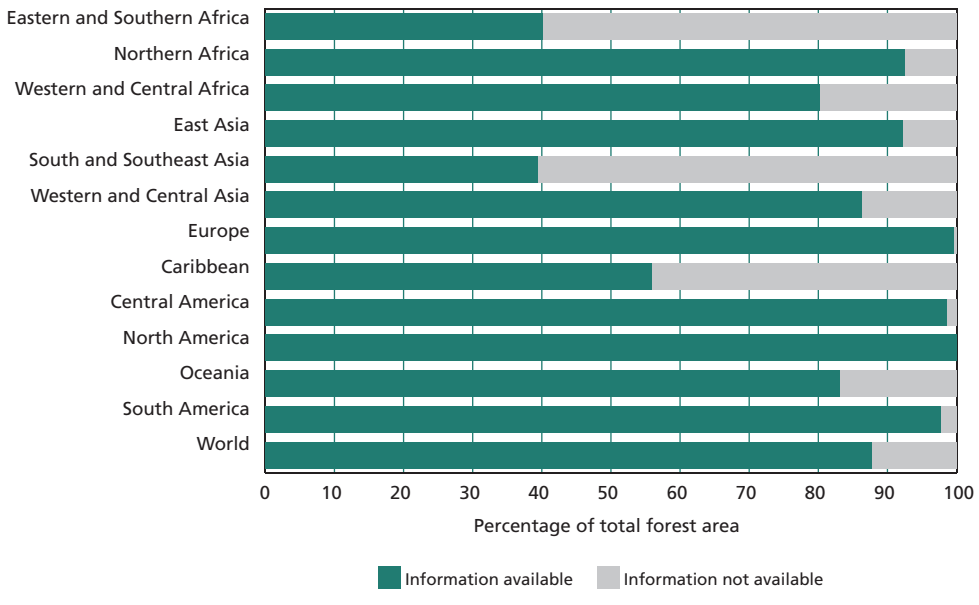
Information availability

Globally, 132 countries and areas accounting for 88 percent of total forest area provided data on the number of native tree species. High response rates were noted in Europe, East Asia, North America, Northern Africa and South America. The lowest response rates were in island states and territories of the Caribbean and Oceania (Figure 3.10).

National data were based on forest inventory lists, flora, national biodiversity reports and discussions with botanists and taxonomists. National forest inventories tend to group species according to their commercial value or to list genera rather than species, making species recording difficult and undervaluing species richness. Some countries reported that a number of native species were under identification or not identified. By default, some areas have reported the total number of plants in the country. A number of countries have undertaken desk studies of available literature and many synonyms were found, making cross-checking difficult.

None of these problems necessarily invalidate the results: identification of tree species present in a country, independently of unsolved taxonomic problems, is notoriously difficult, particularly in mega-diversity areas. The data set was incomplete and its significance in terms of biological diversity will be determined at a later stage. Once these methodological problems are resolved, there is considerable potential for useful information, for instance on the geographical range of species.

FIGURE 3.10
Information availability – number of native forest tree species



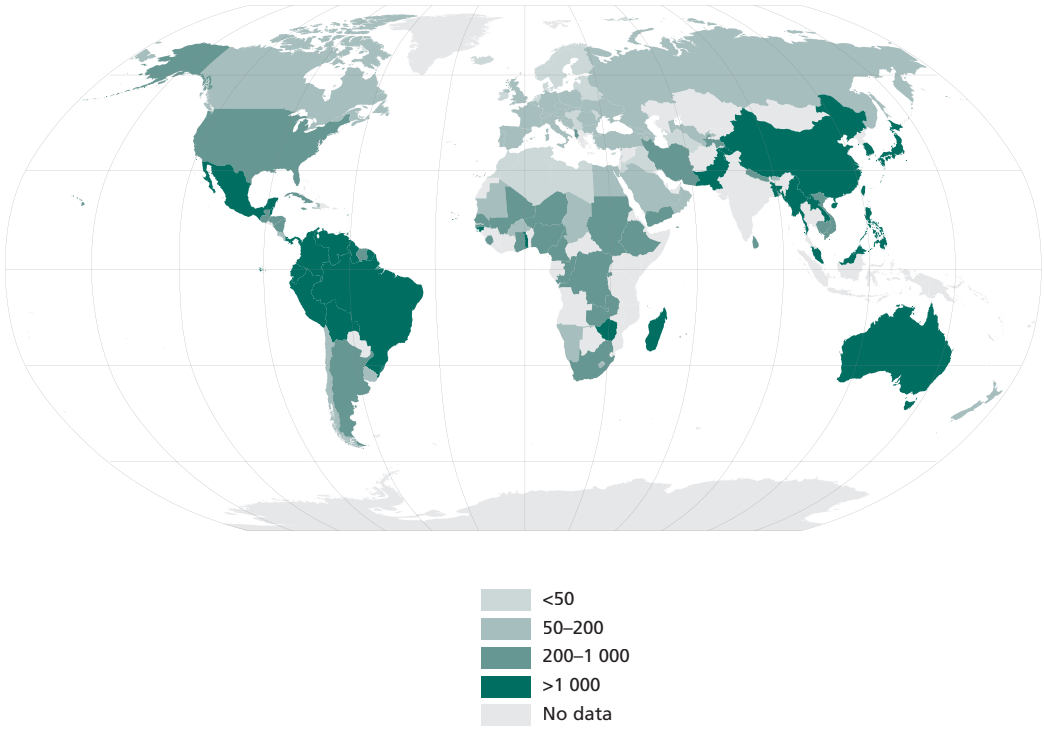
Status

Table 3.8 shows the average number of native tree species for the reporting countries and the range within each region. Individual countries reporting on this topic ranged from a minimum of three native species to a maximum of 7 780. Figure 3.11 illustrates the number of native forest tree species per country.

TABLE 3.8
Native forest tree species

Region/subregion	Information availability			No. of native tree species by country		
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	Aver.	Min.	Max.
Eastern and Southern Africa	10	94 220	40.1	1 076	60	5 000
Northern Africa	12	125 851	92.6	327	12	1 739
Western and Central Africa	11	211 730	74.4	703	140	2 243
Total Africa	**33**	**431 801**	**65.9**	**679**	**12**	**5 000**
East Asia	3	208 177	92.3	1 625	1 049	2 500
South and Southeast Asia	14	117 159	39.4	1 320	105	3 000
Western and Central Asia	16	37 563	86.2	146	20	534
Total Asia	**33**	**362 899**	**64.0**	**778**	**20**	**3 000**
Total Europe	**36**	**993 477**	**99.5**	**63**	**3**	**280**
Caribbean	5	3 194	56.0	409	76	722
Central America	6	23 513	98.6	1 236	117	4 000
North America	4	677 971	100.0	596	21	1 130
Total North and Central America	**15**	**704 678**	**99.6**	**790**	**21**	**4 000**
Total Oceania	**3**	**172 876**	**83.1**	**838**	**121**	**2 100**
Total South America	**12**	**833 428**	**97.7**	**1 994**	**123**	**7 880**
World	**132**	**3 499 159**	**87.7**	**671**	**3**	**7 880**

FIGURE 3.11
Number of native forest tree species



South America has the highest average number of native forest tree species per country. Brazil reported the highest number of forest trees in the world (7 880), with high species diversity in the Amazon basin and in the Atlantic coastal forest (Mata Atlantica). High species richness is also reported by countries in Central Africa, Central America, East Asia, Madagascar and South and Southeast Asia. The lowest average number of trees per country is found in Europe, where Iceland and Malta record the lowest number of native tree species – three – of any country with forests. Species diversity in boreal forests is usually relatively low, and vast expanses of such forests in the northern hemisphere are dominated by a small number of tree species. Countries with dry tropical forests tend to have lower species diversity than countries with moist tropical forests. More generally, it is often mentioned that tree species richness increases with decreasing latitude. Unfortunately, knowledge and documentation of species follow the opposite trend, and many native tropical tree species remain unidentified or unrecorded, especially in Central Africa.

FRA 2000 compiled information for temperate and boreal countries on all forest trees, not only native species. The broad regional trends it identified remain valid (Dudley and Solton, 2003). FRA 2000 found the highest levels of temperate and boreal tree diversity in the western part of the Pacific rim, while the lowest levels occured in the boreal regions. In Europe and Central Asia, tree diversity increased towards the south and east.

The absence of an authoritative world list of trees and shrubs is a serious impediment to assessing and monitoring one of the most basic components of forest biodiversity – tree species richness at the national level. Several ongoing global taxonomic initiatives are expected to ease this limitation in the years to come. At the country level, in addition to taxonomic issues, the development of flora and tree recognition guides will help species identification by foresters and conservationists. Lists of native tree species provide a useful background to lists of endangered tree species, as absolute numbers for the latter are of limited value without some indication of the total number of species.

THREATENED FOREST TREE SPECIES

For FRA 2005, countries were asked to report information on the number of forest tree species considered threatened. Precise status categories were suggested for the terms 'vulnerable', 'endangered' and 'critically endangered', using the ranking system of the *IUCN red list categories and criteria*. For countries and areas with an existing *IUCN red data book* of threatened plants, such information is accessible. The IUCN red list can be sorted by kingdom, genus and species. 'Tree' is not an easily definable group, and at the country level, data had to be gathered on a species by species (or genus by genus) basis. Although IUCN 2000 data are used in FRA 2005, some national reports contain complementary remarks or updates. This is particularly important in the case of discrepancies between IUCN data and national data sources, or when national classification systems are used.

Information availability

Information on vulnerable, endangered and critically endangered forest trees was provided by all regions, representing 192 countries and accounting for 99 percent of total forest area. Information was missing primarily from some of the smaller Pacific and Caribbean islands and some countries in Western and Central Africa (Figure 3.12). Fifty-three countries and areas reported discrepancies with the 2000 red list, while a few countries indicated that a national list of threatened trees was under revision. The availability of data is in line with findings from the UNEP-WCMC desk study for FRA 2000, which indicated that contrary to trees *per se*, for which no global data were available, the availability of global statistics on endangered trees was good.

FIGURE 3.12
Information availability – threatened forest tree species

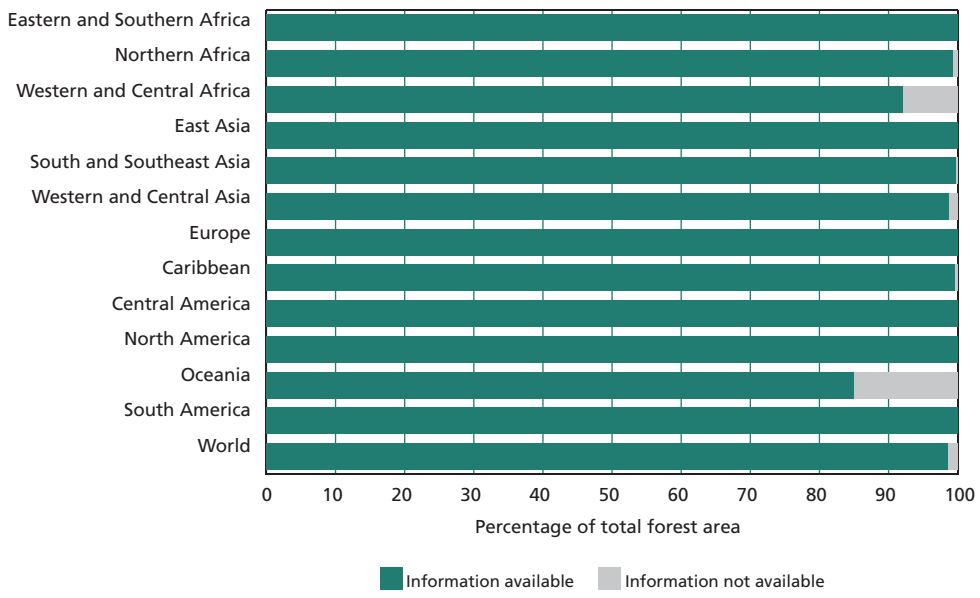


TABLE 3.9
Threatened tree species

Region/subregion	Information availability			No. of critically endangered tree species by country			No. of endangered tree species by country			No. of vulnerable tree species by country		
	Countries reporting	Forest area *(1 000 ha)*	% of total forest area	Aver.	Min.	Max.	Aver.	Min.	Max.	Aver.	Min.	Max.
Eastern and Southern Africa	18	235 039	100.0	6	0	41	10	0	65	21	0	63
Northern Africa	15	134 947	99.3	0	0	1	1	0	3	5	0	23
Western and Central Africa	20	262 050	92.1	4	0	50	5	0	27	34	0	138
Total Africa	**53**	**632 036**	**96.4**	**4**	**0**	**50**	**5**	**0**	**65**	**21**	**0**	**138**
East Asia	5	225 663	100.0	20	0	67	18	0	45	37	0	96
South and Southeast Asia	16	296 525	99.7	30	0	122	31	0	99	67	2	403
Western and Central Asia	20	42 995	98.7	0	0	1	0	0	2	1	0	5
Total Asia	**41**	**565 183**	**99.7**	**14**	**0**	**122**	**14**	**0**	**99**	**31**	**0**	**403**
Total Europe	**39**	**998 071**	**100.0**	**0**	**0**	**4**	**0**	**0**	**8**	**1**	**0**	**7**
Caribbean	20	5 683	99.6	4	0	23	7	0	50	10	0	62
Central America	7	23 837	100.0	10	0	43	29	6	71	45	18	106
North America	4	677 971	100.0	14	0	55	19	0	69	21	0	60
Total North and Central America	**31**	**707 491**	**100.0**	**7**	**0**	**55**	**14**	**0**	**71**	**20**	**0**	**106**
Total Oceania	**15**	**176 724**	**84.9**	**3**	**0**	**26**	**2**	**0**	**18**	**8**	**0**	**37**
Total South America	**13**	**852 796**	**100.0**	**9**	**0**	**34**	**17**	**0**	**100**	**48**	**0**	**187**
World	**192**	**3 932 299**	**98.6**	**6**	**0**	**122**	**8**	**0**	**100**	**20**	**0**	**403**

Status

Of the 192 reporting countries (Table 3.9), 146 countries and areas reported that one or more tree species are threatened in their jurisdiction. South America and South and Southeast Asia have the highest number of threatened trees, while the lower rates are found in Europe (Figure 3.13).

The overall high response rate is due to the availability of IUCN red lists. It also shows that there is a clear perception that significant numbers of forest trees are under threat and are found in all regions of the world.

FRA 2005 data on forest cover change, number of native forest trees and number of threatened trees were used to assess the links between loss of forest and number of threatened tree species. No simple relationship was found. Some countries, despite relatively high proportions of remaining natural forests and protected areas, also recorded high levels of risk to individual tree species.

Table 3.10 provides an additional perspective. The number of threatened tree species (the categories 'critically endangered', 'endangered' and 'vulnerable' added together by country) is expressed as a percentage of the total number of native species in individual countries and is then averaged by region and subregion. Representing 87 percent of the global forest area, 126 countries provided data on both native tree species and threatened

FIGURE 3.13
Average number of threatened forest tree species by region

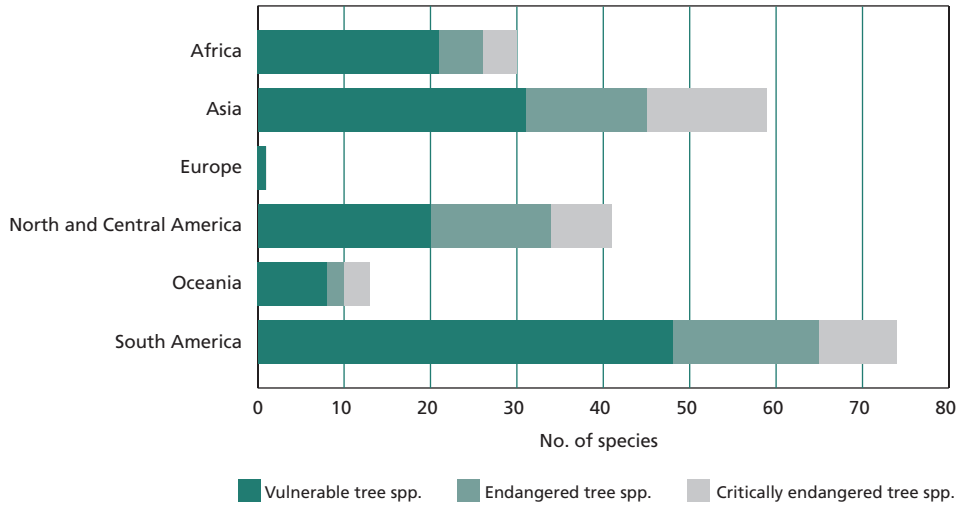


TABLE 3.10
Threatened tree species as percentage of number of native tree species in individual countries

Region/subregion	% of native tree species
Eastern and Southern Africa	11
Northern Africa	3
Western and Central Africa	9
Total Africa	**7**
East Asia	7
South and Southeast Asia	8
Western and Central Asia	1
Total Asia	**4**
Total Europe	**2**
Caribbean	18
Central America	12
North America	5
Total North and Central America	**12**
Total Oceania	**3**
Total South America	**6**
World	**5**

forest species. Globally, approximately 5 percent of the world's native tree species, on average, are reported threatened in their country or territory of origin.

The often-quoted primary direct causes of loss of biodiversity include habitat loss due to land conversion and fragmentation of habitats, alien species invasions and overharvesting of forest resources. The relationship between these factors and biodiversity estimates and surrogates will require further analysis. It is recognized that the value of information on endangered species has some limitations in this regard, owing to the lack of basic data on the distribution and occurrence of most tree species.