

EXECUTIVE SUMMARY

INTRODUCTION

There is a strong need for a set of recent, reliable and internationally comparable data on the extent, location, nature, condition and productivity of, and changes to, the forest resource, at the global and regional level, as a vital input to any serious discussion of policy and decision-making relating to wood supply, industry location, protection of biodiversity, climate change, and a whole host of topics linked in one way or another to the forest resource. Since UNCED in 1992 and the second pan-European Ministerial Conference on the Protection of Forests in Europe (Helsinki, 1993), the international forest policy community has repeatedly stressed the need for more and better information on the forest resources of all parts of the world.

The global Forest Resources Assessment (FRA) is the response to those needs; and the publication *Forest Resources of Europe, CIS, North America, Australia, Japan and New Zealand* is a contribution to this global effort. This work has been carried out under the title of the Temperate and Boreal Forest Resources Assessment 2000 and is abbreviated throughout this publication as TBFRA-2000. FAO is responsible for leading this work at the global level, with the coverage of temperate and boreal forests in the UN/ECE region and some other industrialized countries entrusted to a team in Geneva formed by UN/ECE and FAO. TBFRA-2000 is the latest in a series of surveys of the temperate and boreal industrialized countries carried out from Geneva.

The main objective of TBFRA-2000 is to collect and make available the best possible information on the forest resources of the fifty-five countries it covers. It is intended to be useful, not only to governments and the international forest policy community, but also to a wide range of other groups, including the scientific community, forest industries, NGOs, the conventions on biodiversity and climate change, forestry teachers and students, and the general public.

The first step in the preparation of FAO's global Forest Resources Assessment (FRA) process, including TBFRA-2000, was an Expert Consultation on Global Forest Resources Assessment 2000 in Kotka, Finland in 1996 ("Kotka III"), which agreed on the terms and definitions to be applied in all parts of the global FRA. For the TBFRA-2000, data were collected from officially designated national correspondents by means of a questionnaire. The original country data, collected on the basis of national definitions and measuring and sampling techniques, have in many instances had to be adjusted to fit the international definitions for the sake of comparability. The country notes, including explanations of the adjustment process, are intended to provide transparency and to improve the credibility of the data set as a whole. There are quite large differences in data quality between different parts of TBFRA-2000. In general, quality is highest in the "traditional" areas, such as forest area, growing stock and increment, and lower in the "newer" parts, such as biodiversity, forest condition, etc. This is to be expected when the scope is widened to include areas not covered beforehand. The latter types of information are highly relevant to the policy debate and are considered to be good enough for publication (with explanations of their weak points).

Changes over time in the forest resource are at the heart of many of the recent forest policy debates. However, monitoring poses severe methodological problems, for instance separating changes due to changes in methods or in definitions from those arising from real changes in the parameter measured. For TBFRA-2000, national correspondents were asked to estimate change for only a very small number of key parameters.

The preparation of TBFRA-2000 has been an immense team effort involving the co-operation of hundreds of people, whose contributions are warmly acknowledged by the UN-ECE/FAO secretariat in Geneva.

REGIONAL AND TBFRA-2000 TOTALS

All the information which countries were able to provide in response to *Enquiry Tables 1 to 25* of the TBFRA-2000 is contained in the Main Tables 1 to 81 in the body of the report (with the exception of a few parameters, notably the detailed lists of tree species, which will be published in satellite documentation). It is a rather remarkable achievement that all countries provided data on quite a number of the key parameters, such as the area of forest and

TABLE S.1
Regional and TBFRA-2000 totals of selected parameters

<i>Parameter</i>	<i>Million units</i>	<i>Europe</i>	<i>CIS</i>	<i>North America</i>	<i>Other TBFRA</i>	<i>Grand Total</i>
Forest and other wooded land (FOWL)	ha	215	934	716	613	2478
of which: Forest	ha	176	856	462	189	1682
of which:	ha					
Predominantly coniferous	ha	91	426	252	16	785
Predominantly broadleaved	ha	57	82	133	168	440
Mixed	ha	25	345	78	5	452
Forest available for wood supply (FAWS)	ha	149	547	324	42	1061
Forest not available for wood supply (FNAWS)	ha	27	309	138	147	621
Undisturbed by man	ha	7	751	143	24	925
Semi-natural	ha	157	82	305	152	696
Plantations	ha	12	23	14	13	62
FOWL in public ownership	ha	101	934	516	426	1977
FOWL owned by indigenous peoples	ha	0	0	8	54	62
FOWL in private ownership	ha	115	0	191	132	437
Average annual change in FOWL	ha	+0.29	+1.18	+0.43	+0.05	+1.95
of which: In forest	ha	+0.50	-0.52	+0.59	+0.04	+0.61
of which:	ha					
In FAWS	ha	+0.11	-9.37	+0.51	+0.04	-8.72
In FNAWS	ha	+0.38	+8.86	+0.08	0	+9.33
Total woody biomass	m.t.(o-d)	16296	80754	61036	15497	173583
of which: Above stump biomass	m.t.(o-d)	13891	62036	53288	12843	142053
Total growing stock (GS)	m ³ (o.b.)	25854	90997	70046	14697	201594
of which: GS on FAWS	m ³ (o.b.)	21371	63528	44390	4382	133671
of which: Coniferous	m ³ (o.b.)	13570	45580	27647	493	87290
Average annual change in GS on forest	m ³ (o.b.)	+327	-23	+257	+81	+642
of which: On FAWS	m ³ (o.b.)	+252	-106	+207	+81	+435
Total net annual increment (NAI)	m ³ (o.b.)	772	1354	1486	192	3804
of which: NAI on FAWS	m ³ (o.b.)	662	793	921	138	2514
of which: Coniferous	m ³ (o.b.)	434	483	544	101	1562
Total annual fellings	m ³ (o.b.)	465	174	922	71	1633
of which: Annual fellings on FAWS	m ³ (o.b.)	431	146	737	71	1386
of which: Coniferous	m ³ (o.b.)	296	96	533	54	979
Total annual removals	m ³ u.b.	355	106	695	57	1213

N.B. Figures in **bold** are those where all countries have provided data. The others are *incomplete* regional or grand totals where some country data are missing or partly missing. Detail may not, for this reason or because of rounding, add to totals. For the totals on *areas*, missing data are negligible, in no case exceeding 2 per cent. For those on *volumes*, a few of the amounts not included in the totals are appreciable, for example for coniferous growing stock in "Other TBFRA", for fellings in North America, and for removals in the CIS and "Other TBFRA". None of the figures in plain type in the 'Grand total' column are likely to understate the true totals by more than 4 per cent.

other wooded land, of forest available and not available for wood supply, and of the pattern of ownership; and that a large majority of them could do so for a wider range of parameters. The result is that a rather comprehensive picture emerges of the forest resource situation in the 1990s in the TBFRA area and its component regions: Europe, the CIS countries, North America and the “Other TBFRA” countries, Australia, Japan and New Zealand.

This is summarized in Table S.1. The figures shown in bold type are those where all countries in the regions concerned were able to provide data. These totals are shown in the Main Tables. Thus, the area of 2,478 million hectares of forest and other wooded land includes data from all countries in the TBFRA area. On the other hand, figures that are in plain type indicate that data are missing from one or more countries. These incomplete totals are not shown in the Main Tables. The extent to which they fall short of the absolute totals may be gauged by comparing the sum of them, for example, the three categories of ‘naturalness’ of forest (925 + 696 + 62 = 1,683 million ha) with the full total for forest (1,682 million ha). This example shows, ignoring the slight discrepancy due to rounding of the figures to the nearest million, that the missing data are insignificant. Indeed, in most cases where the totals are incomplete, the discrepancy between them and what is probably the full total is small, usually a matter of a percent or two, and consequently they can be taken as providing reasonably accurate indications of the regional or grand totals.

In order not to overburden Table S.1 with figures, some important parameters are not shown, but in cases where the figures are in bold type they may be obtained by deduction. For example, the area of other wooded land (OWL) may be calculated by deducting forest (1,682 million ha for the total TBFRA area) from forest and other wooded land (2,478 million), resulting in an area of OWL of 796 million ha.

In several places in the full report there are discussions about the quality, reliability and comparability of the data. Suffice it to say here that particularly for the “traditional” types of information, such as that on area, growing stock, increment and fellings, the quality has been assessed as generally satisfactory. On the other hand, for some of the more recently introduced parameters, for example those concerned with forest condition, protection status, the provision of non-wood goods and services, and so on, some countries could not provide information from official sources and were thus obliged to make estimates or felt unable to provide any figures at all. A further difficulty for countries sometimes arose in interpreting and applying in their responses the definitions used in the TBFRA. This could affect not only the comparability between countries’ data, but also the actual statistics. Two cases, amongst others, where caution is merited in using the information are the ‘naturalness’ of forest and the average annual changes over a period of time in area and growing stock. In the latter case, the large changes shown for the CIS countries, largely accounted for by the Russian Federation, compared with most other countries in the TBFRA area, may be due to the way in which forest available for and not available for wood supply has been understood.

The main findings of TBFRA-2000 are summarized below under the six headings which correspond with the chapters.

AREA OF FOREST AND OTHER WOODED LAND

Information on the area of forest and other wooded land, species distribution, availability and non-availability of forest for wood supply and on silvicultural systems is relevant to all other parts of TBFRA-2000, including the assessment of the resource’s biological diversity, its ability to supply wood and to sequester carbon, its vulnerability to certain forms of damage and its ability to perform certain social, protection and other environmental functions. These questions are treated in greater depth in subsequent chapters.

General. The total area of forest and other wooded land (FOWL) in the 55 TBFRA-2000 countries in the late 1990s was nearly 2.5 billion ha or somewhat less than half the total land area. Nearly half of the forest was classified as predominantly coniferous, the remainder being predominantly broadleaved or mixed coniferous and broadleaved. Nearly two thirds of it was available for wood supply. With the main exception of the Russian Federation, net changes in the area of FOWL have not been very large. More specifically:

Area of forest and other wooded land. Of the 2,478 million hectares of forest and other wooded land (FOWL), 1,682 million (68 per cent) were classified as forest and 796 million (32 per cent) as other wooded land. (Figure S.1). Thirty-eight per cent of the total area of FOWL was located in the CIS countries, 29 per cent in North America, 25 per cent in “Other TBFRA” countries (Australia, Japan, New Zealand) and 9 per cent in Europe.

There was on average about 1.9 ha of FOWL per capita, of which 1.3 ha/cap of forest, the latter being about double the global average. At the country level, the range in forest area per head is very wide, from 31 ha of FOWL per capita in Australia and 14 ha/cap in Canada to virtually nil in Malta. On average in the TBFRA area FOWL covered 46 per cent of the total land area, ranging from 76 per cent in Australia, 75 per cent in Finland and 74 per cent in Sweden to little more than 1 per cent in Iceland and Malta. Australia’s area of other wooded land is remarkable in

FIGURE S.1
Area of forest and other wooded land in the TBFRA area

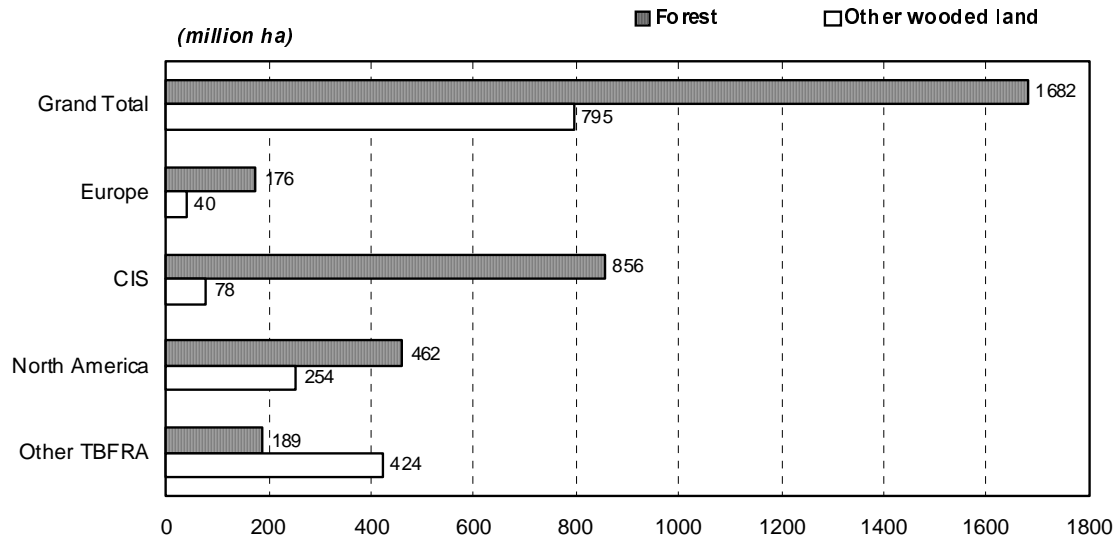


FIGURE S.2
Forest in the TBFRA area by species groups

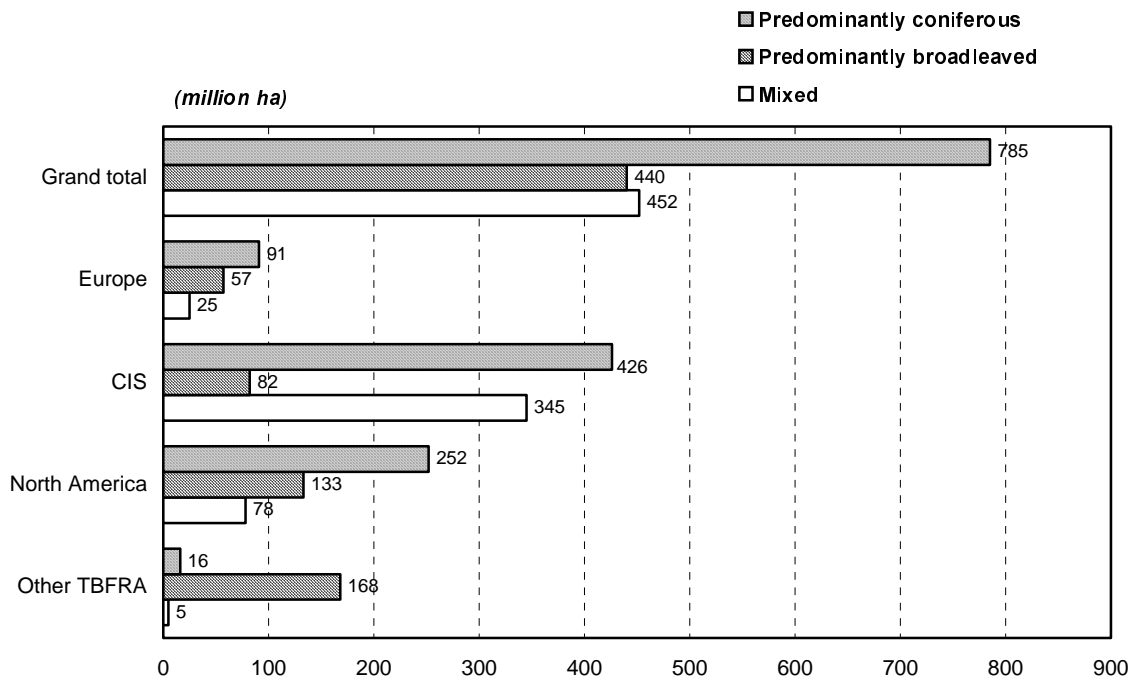


FIGURE S.3
Availability of forest for wood supply in the TBFRA area

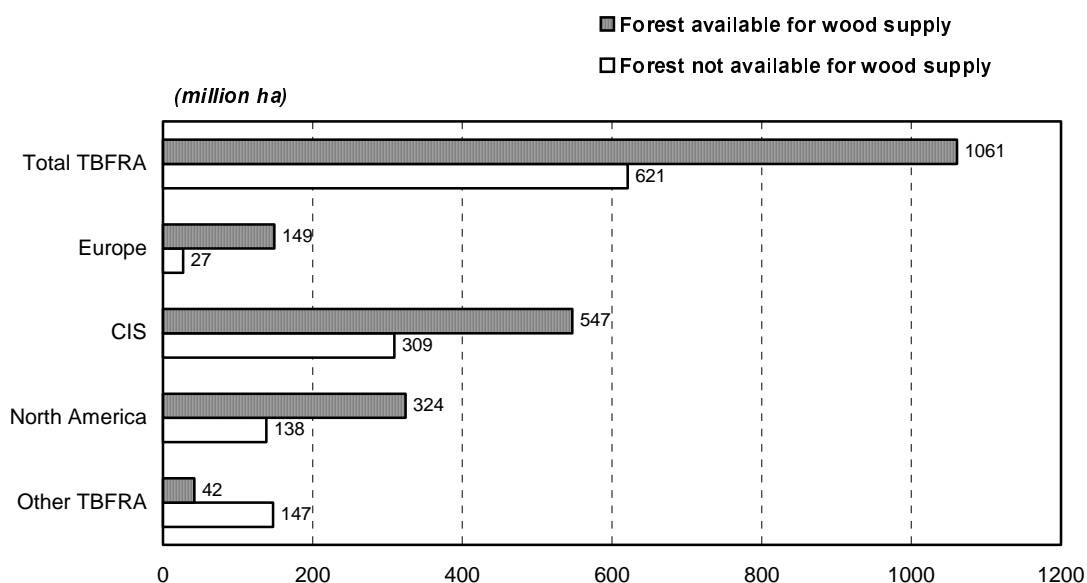
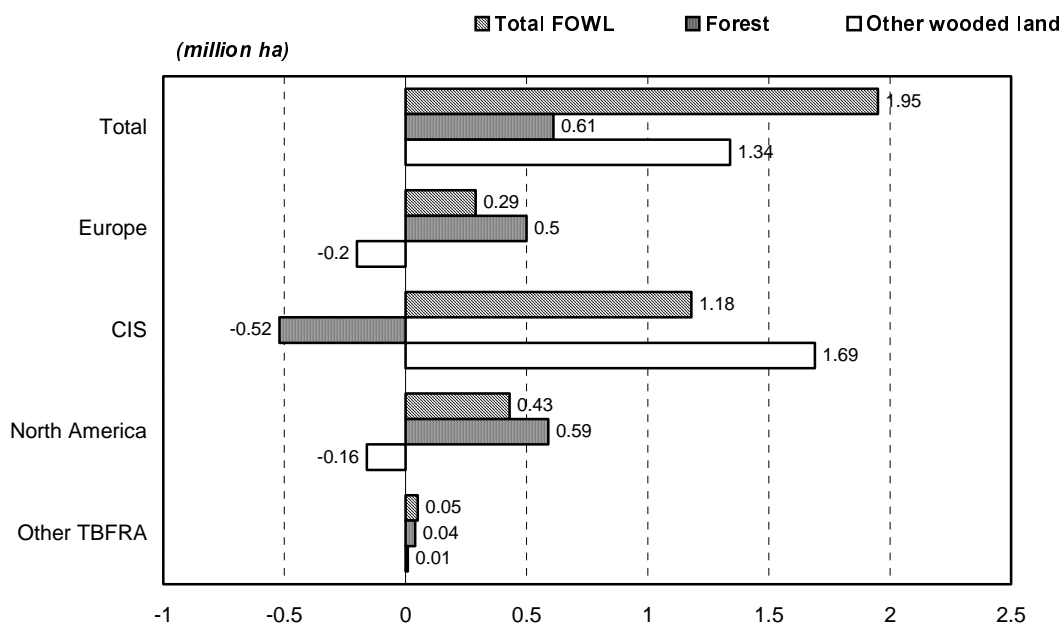


FIGURE S.4
Estimated average annual changes in area of forest and other wooded land (FOWL) in TBFRA area



absolute terms (422 million ha), and for its share of Australia’s total land area (55 per cent). It accounts for more than half the total of other wooded land in the TBFRA area.

Species composition and distribution. For the TBFRA countries in aggregate the species distribution in forest on an area basis was as follows: predominantly coniferous 47 per cent, predominantly broadleaved 26 per cent, mixed coniferous and broadleaved 27 per cent; with a small area (in Japan) of predominantly bamboos, palms, etc.

(Figure S.2). About three quarters of the coniferous area lies in the northern boreal belt, while broadleaved or mixed forests predominate in the temperate areas of the northern and southern hemispheres.

Forest available and not available for wood supply. About 63 per cent of the total area of forest in the TBFRA countries is classified as available for wood supply (FAWS) (Figure S.3). The proportion is high in Europe (85 per cent) and low in "Other TBFRA" (22 per cent). About 97 per cent of all FAWS is categorized as high forest; coppice and coppice with standards is of importance in a few countries, mainly in southern Europe. Approximately 80 per cent of the total area of forest not available for wood supply (FNAWS) is considered to fall into this category for economic reasons and 20 per cent for conservation/protection reasons. The importance of the "economic reasons" category is largely due to the figures for the Russian Federation and Canada with their vast areas of remote forest. For Europe nearly two-thirds of FNAWS come under 'conservation/protection reasons' and the USA and Japan put all their FNAWS into this category.

Changes in area over time. Not all countries could provide data on changes and there are doubts about the consistency of data between countries. Data from reporting countries show an average increase in area of about 1.95 million ha per year, of which over 600,000 ha of forest and over 1.3 million ha of OWL (Figure S.4). The largest reported changes were in the Russian Federation with an average annual decline in the area of forest of 1.1 million ha and a rise in that of other wooded land of 1.6 million.

For European countries in total the average annual increase in the area of forest is estimated at nearly 500,000 ha and a decrease in that of other wooded land of about 200,000, mainly due to conversion to forest. There were substantial increases in forest area in the USA and New Zealand; in Canada the area was assumed to remain more or less unchanged. From the available data, it is estimated that the average annual increase in the area of FNAWS in Europe was more than three times that of FAWS. Even though individual countries' trends were different, it appears that in many there was a transfer of areas of FAWS to FNAWS reflecting shifting policies in favour of non-wood goods and services, which was partly offset by afforestation and conversion of other wooded land to establish FAWS.

OWNERSHIP AND MANAGEMENT OF FOREST AND OTHER WOODED LAND

Information on the ownership and management status of forest and other wooded land is important as an indicator of the authority determining the uses to which the land may be put and the intensity of management and use. Designation of land ownership is dependent on a cadastral or legal system which clearly demarcates territory. Such a system exists in most of the countries of the boreal and temperate regions, although in some of them uncertainties about legal ownership still persist. For the purpose of the TBFRA-2000 enquiry ownership is divided into three broad categories: public ownership; private ownership; and owned by indigenous or tribal peoples. The ownership and management status of forest available for wood supply (FAWS) is further sub-divided: for public ownership into State ownership and ownership by other public institutions; and for private ownership into ownership by individuals, by forest industries and by other private institutions.

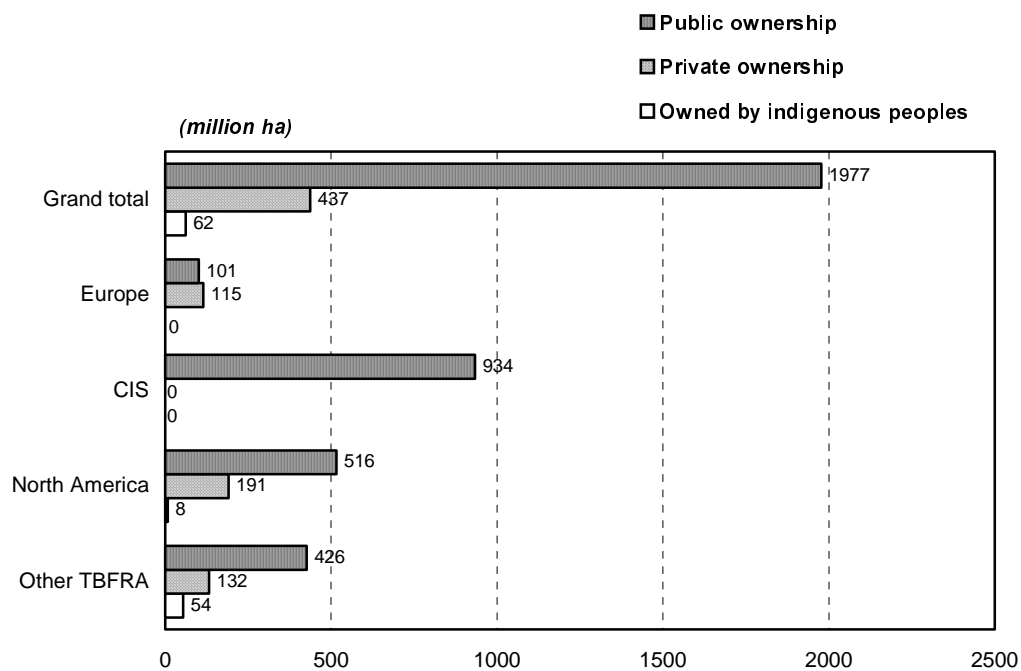
General. Public ownership accounted for nearly 80 per cent of the total area of forest and other wooded land in the TBFRA-2000 countries in aggregate: 100 per cent in the CIS countries and 68 per cent in the others. For forest available for wood supply in countries other than the CIS, State ownership and ownership by individuals each accounted for two fifths of the total and ownership by forest industries for nearly one tenth. Between 80 and 90 per cent of the area of forest and other wooded land in the TBFRA-2000 countries in aggregate is under management. More specifically:

Ownership status. Information about the ownership status of forest and other wooded land was available from virtually all TBFRA-2000 countries, apart from some missing data on ownership by indigenous or tribal peoples in a few countries, where claims are in process. The ownership pattern is changing in many of the countries of Europe and the Commonwealth of Independent States (CIS) whose economies are in transition to forms of market economy, where the process of privatization or restitution is continuing and where therefore the information provided may be partly out of date or may be expected to change significantly over the next decade. For the 55 TBFRA countries in aggregate, approximately 1.97 billion ha or 80 per cent of the area of FOWL was in public ownership, 437 million ha or 18 per cent in private ownership and approximately 62 million ha (between 2 and 3 per cent) owned by indigenous or tribal peoples (Figure S.5). In western Europe, i.e. excluding countries with economies in transition, the proportion in private ownership is 66 per cent and this part of Europe, together with the USA and Japan, differ from the other countries in the TBFRA area where public ownership predominates. Canada, USA, Australia and New Zealand have FOWL owned by indigenous or tribal peoples.

Ownership of forest available for wood supply. For the TBFRA countries in aggregate it is estimated that State ownership and ownership by individuals each account for two fifths of the total and ownership by forest industries for not quite one tenth. 96 per cent of FAWS in public ownership is owned by the State. In several European countries

FIGURE S.5

Forest and other wooded land in the TBFRA area by ownership categories



ownership by other public bodies, such as municipalities and communes, accounted for more than half the publicly owned area; this was the case in France, Italy, Spain and Sweden amongst the larger forest countries. Under private ownership, it is estimated that about 77 per cent of FAWS is owned by individuals, 17 per cent by forest industries and 6 per cent by other private institutions. Ownership by forest industries occurs mainly in North America, the Nordic countries, Portugal, Japan and New Zealand. Ownership by other private institutions is important in terms of area in the USA, Japan, France, Finland and New Zealand.

Management status. It is estimated that about 86 per cent of FOWL in the TBFRA countries in aggregate is managed; the proportion is higher for FOWL in public ownership (89 per cent) than in private (49 per cent). The CIS and “Other TBFRA” countries report that virtually all of their FOWL is being managed. In Canada 52 per cent of FOWL is managed. On average in the TBFRA countries the proportion of FAWS in public ownership that is managed is considerably higher (96 per cent) than that in private ownership (62 per cent). This is a result of, on the one hand, the almost 100 per cent management of public FAWS in the CIS countries and, on the other hand, the relatively low proportion of privately owned FAWS under management in the USA (40 per cent), which is the country with by far the largest area in this category. It would seem that the proportion of FNAWS that countries consider to be under management is about as high as that of FAWS.

Holdings of forest and other wooded land. In Europe, it is estimated that there are about 77,000 holdings in public ownership and 10.7 million in private ownership. The average size of public holdings is 1,200 ha and that of private holdings 10.6 ha. In the USA the number of public holdings is 64, according to the definition of public holdings used there, giving an average size of 1.99 million ha; the number of private holdings is 9.94 million with an average size of 17.2 ha. In most countries the size class distribution of private holdings results in a high proportion of owners owning a small proportion of the total area. There are several million private owners in Europe with holdings of less than 3 ha.

WOOD SUPPLY AND CARBON SEQUESTRATION

A. Growing stock, growth, drain and balance

Information on the volumes of growing stock, annual increment, annual fellings, removals and natural losses, as well as their changes over time, is important for the analysis of the utilization and wood production potential of forest and other wooded land, and the possibilities for maintaining the biodiversity of forests within given wood production scenarios.

Growing stock. The volume of growing stock in the TBFRA region is just over 200 billion m³ overbark (o.b.)–152 m³ for each inhabitant. Nearly 80 per cent of that volume is in three countries: the Russian Federation, the USA and Canada. Over 90 per cent of it is on land classified as forest and two thirds–134 billion m³ o.b.–on forest available for wood supply (FAWS) (Figure S.6). On average in the TBFRA region, two thirds of the growing stock is coniferous, but in the CIS the proportion is nearly 80 per cent while in the “Other TBFRA” group of countries it is just over 20 per cent.

On average, on FAWS the growing stock is between 105 and 145 m³ o.b./ha, but the variation between countries is very wide, from less than 50 m³/ha in Greece, Iceland, Spain and Turkmenistan, to over 250 m³/ha in Germany, Liechtenstein, Slovakia, Slovenia and Switzerland, all countries with a similar strong and conservative silvicultural tradition. New Zealand, with its large proportion of natural, predominantly broadleaved forests, also has a very high volume of growing stock per hectare. On average, the growing stock increased by approximately 640 million m³ o.b./year in the 1990s. The average annual increase for Europe was nearly 330 million m³ and for North America 260 million m³. In the CIS growing stock on forest decreased by an average of 23 million m³/year, and as much as 113 million m³/year in the Russian Federation alone, as forest was transferred to other land use categories. As will be seen below, fellings were well below increment, so total growing stock increased.

Increment and natural losses. Gross annual increment (GAI) on forest and other wooded land is over 4,670 million m³ o.b. 80 per cent of that GAI is on forest, where the mean annual increment is 2.1 m³ o.b./ha or 2.1 per cent of growing stock. Natural losses account for 8.7 per cent of GAI in Europe, 26.7 per cent in the CIS and 20.2 per cent in the USA.

Net annual increment (NAI, GAI less natural losses) of trees on forest and other wooded land in the TBFRA region was about 3,800 million m³ o.b., of which over 70 per cent was in three countries, the Russian Federation, the USA and Canada. NAI on forest available for wood supply in the TBFRA region is about 2,550 million m³ o.b., of which 700 million in Europe, 793 million in the CIS and 921 million in North America.

Fellings and removals. Total annual fellings in the TBFRA region were reported to be 1,632 million m³ o.b., of which over half in North America. The Russian Federation, which accounts for 30 per cent of the region’s increment, accounted for only 9 per cent of its fellings. Reported harvest losses accounted for about 12 per cent of total fellings.

FIGURE S.6

Growing stock on forest available for wood supply in the TBFRA area (Total: 133.7 billion m³ overbark)

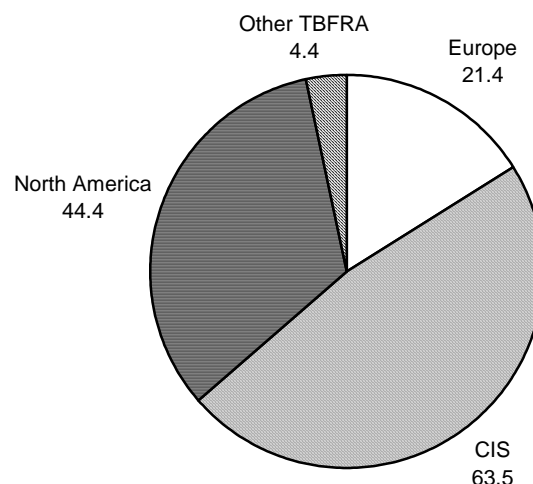
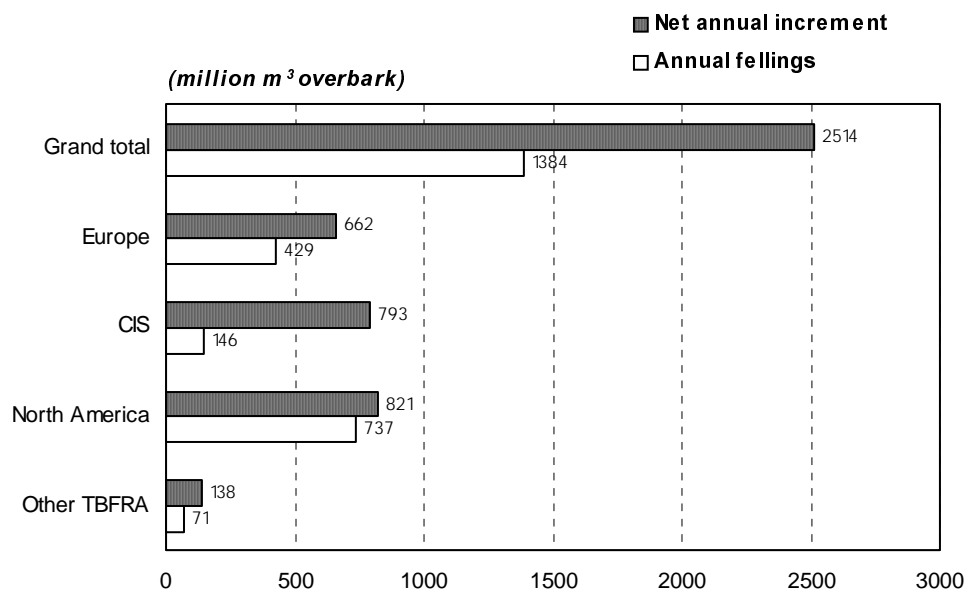


FIGURE S.7

Net annual increment and fellings on forest available for wood supply in the TBFRA area



Removals (fellings less harvesting losses) from the forests of the TBFRA region amounted to nearly 1,220 million m³ u.b. (underbark), of which 695 million (57 per cent) in North America and 360 million (30 per cent) in Europe.

Balance between increment and fellings. More than half the net growth on forest available for wood supply is harvested, when fellings are compared with NAI (Figure S.7). The sustainability of wood production can be more reliably determined by comparing NAI with fellings of growing stock (i.e. fellings of live trees, excluding fellings of natural losses). For the region as a whole, fellings of growing stock were 52.6 per cent of net annual increment. In North America this ratio is 78.6 per cent and in Europe 59.0 per cent, but in the CIS only 16.8 per cent. The increment of coniferous trees is more intensively used than of broadleaved: the fellings of growing stock/NAI ratio for the TBFRA region as a whole is 62.5 per cent for coniferous, 42.2 per cent for broadleaved.

B. Woody biomass and the carbon cycle

As a contribution to the improvement of knowledge about the role of woody biomass in the carbon cycle, it was decided to devote a special section of the TBFRA-2000 to the collection of relevant information. The rising concentration of carbon dioxide in the atmosphere has heightened interest in research on cycling of carbon at the global level. The atmospheric CO₂ concentration has increased 30 per cent from the preindustrial level of about 280 parts per million (ppm) to the present concentration of nearly 370 ppm. During recent years the concentration has been growing by some 1.5 ppm per year. The increase in the concentration of CO₂ in the atmosphere is predicted to reinforce the greenhouse effect of the atmosphere and consequently lead to worldwide changes in climate. This increase is caused by human activities, mainly by the combustion of fossil fuels and deforestation. Insight into the cycling of carbon is needed in order to predict the development of the concentration of CO₂ in the atmosphere and the potential climatic changes, and to combat the increase in the atmospheric CO₂ concentration by removing CO₂ from the atmosphere and binding it in other stores.

Forest statistics for studying carbon cycling in forests. Forest statistics provide a useful means to quantify the carbon stores and carbon cycles of the tree component of forest ecosystems. Converting stemwood volumes to biomass and carbon is one of the most critical steps in using forest statistics to quantify carbon cycling in trees; in particular the conversion from volume to biomass is considered as a serious source of uncertainty. Despite this, the use of forest statistics in studying carbon cycling in forests has advantages compared with other approaches. The conversion factors

employed by countries for the above-stump biomass vary appreciably but for conifers average 0.52 m.t. per m³ of stem wood, for broadleaved trees 0.66 m.t./m³, and for stumps and roots 0.12 m.t./per m³ of the stem volume. The carbon component of the woody biomass has been taken to be 50 per cent of the total mass.

Carbon store of woody biomass. The carbon store of woody biomass on forest and other wooded land in the TBFRA area at the time of the TBFRA-2000 assessment was estimated at 88 Pg. As much as 47 per cent of this total store was in the CIS countries, 35 per cent in North America, 10 per cent in Europe and 9 per cent in the “Other TBFRA” countries. Three countries, the Russian Federation, USA and Canada, account between them for 80 per cent of the total. The above-stump woody biomass contained 72 Pg of carbon, which was 82 per cent of the total store of woody biomass. The size of the carbon store of woody biomass on FOWL in the TBFRA area, 88 Pg, is about 14 per cent of the carbon store of global vegetation and 6 per cent compared with the store in soils worldwide. It is equivalent to 12 per cent of the amount of carbon in the atmosphere.

Carbon balance of woody biomass. In all TBFRA countries for which data are available, net annual increment has been larger than fellings and, consequently, the carbon store of woody biomass on FOWL has been increasing. The carbon balance of woody biomass, i.e. the rate of change in its carbon store, is calculated as

net annual increment – annual fellings + annual fellings of natural losses.

The increase in the carbon store of the woody biomass on FOWL is estimated at 0.88 Pg/ year or 1.0 per cent. Per unit area, the average increase in the TBFRA area was 0.35 m.t. of carbon/ha/year. The total increase, 0.88 Pg/year, is equivalent to about 16 per cent of the global anthropogenic emissions of CO₂ originating from the combustion of fossil fuels and cement production, to 55 per cent of the emissions resulting from deforestation in the tropics, and to 28 per cent of the present rate of increase in the amount of CO₂ in the atmosphere. In other words, without the increase in the carbon store in the woody biomass in the TBFRA area, the amount and concentration of CO₂ in the atmosphere would be increasing at a rate of 28 per cent more than they are.

BIOLOGICAL DIVERSITY AND ENVIRONMENTAL PROTECTION

The inclusion of questions in the TBFRA-2000 enquiry relating to biological diversity, the “naturalness” of forests and the extent and type of regeneration reflects the increasing interest amongst policy makers and the general public in biodiversity and environmental protection. Given the partly experimental nature of this part of the TBFRA and the difficulties encountered by some countries in providing information, the results should be treated with due caution.

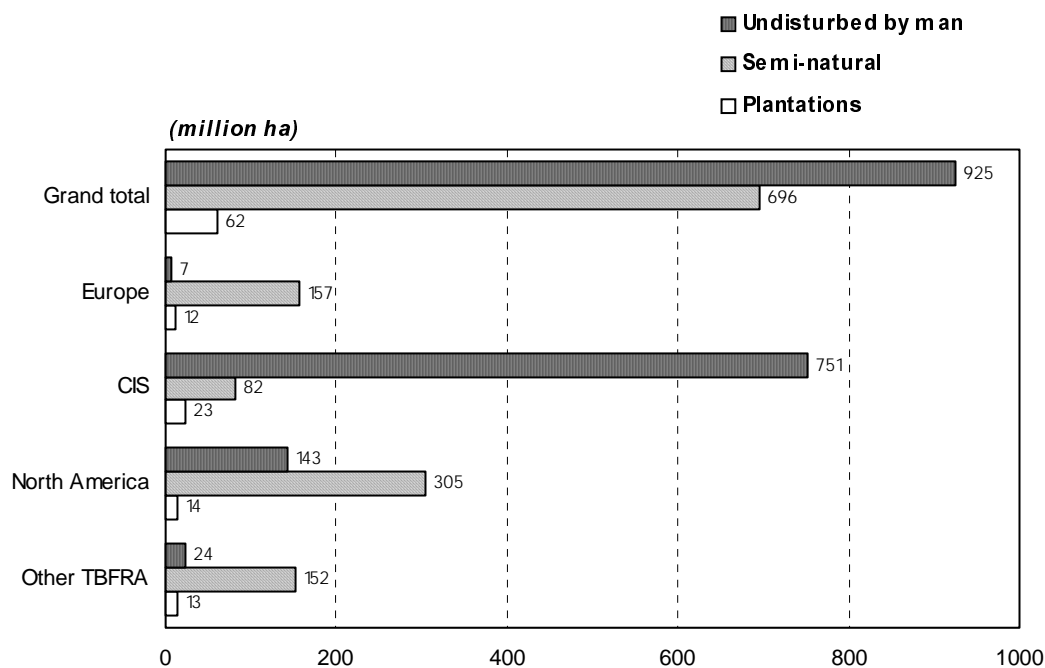
Forest and other wooded land by categories of naturalness. According to the countries’ replies, about 55 per cent of forests in the TBFRA area can be considered as undisturbed by man, about 41 per cent as semi-natural and 4 per cent as plantations (Figure S.8). These proportions are heavily influenced by the forest condition in the Russian Federation and Canada, with their huge areas of forest, much of it in remote areas. Excluding these two countries, the proportion of forest in the rest of the TBFRA area that is undisturbed by man is only about 7 per cent, with 89 per cent semi-natural and 4 per cent plantations. The United States and Australia account for much of the undisturbed forest in the rest of the TBFRA area with smaller areas in the Nordic countries, Japan and New Zealand. Concerns about the comparability of certain data mean that the figures for Canada and the Russian Federation should be treated with caution.

Tree species. The highest numbers of native tree species in the TBFRA area are found in New Zealand, Australia, Japan and the United States, and the lowest in the northern boreal regions. In Europe and central Asia, number of tree species increases towards the south and east.

Protection status. Fears about a decline in natural forest have created a political momentum for an increase in the area of protected forest in order to conserve biodiversity and also related ecological, social and cultural values. Several countries encountered difficulties in providing data according to the IUCN protected areas categories, but their replies were useful in revealing differences of opinion about the categorization of protected forest areas. With regard to IUCN Categories I and II (strict nature reserves, wilderness areas, national parks and natural monuments), replies on which were less ambiguous than on the other categories, about 87 per cent of all the protected forest area occurs in the four major forest countries, the Russian Federation, Canada, the USA and Australia, with the remaining TBFRA countries making up just 13 per cent of the total. These figures must be treated with caution: European countries have traditionally put greater focus on the less strictly protected area categories, particularly IUCN Category V–Protected landscapes, as well as having a large number of rather small protected areas

Reported number of species, including proportion endangered. The possibility of a large number of species of plants and animals disappearing, largely as a result of human actions, has gained official recognition, for example

FIGURE S.8
Forest in the TBFRA area by “naturalness



through the Convention on Biological Diversity. Whilst the majority of forest-occurring species exist in the tropics, concern has also been expressed about the status of some in temperate and boreal regions. Despite the incomplete nature of the data received in response to the TBFRA enquiry, a number of inferences can be drawn. There is a clear perception that significant numbers of wild plant and animal species are endangered, despite the existence of a relatively stable forest estate. Larger animals seem to be more endangered than smaller ones. In the case of plants, on the other hand, more lower plants (mosses and lichens) are listed as endangered than trees and other vascular plants. Invasive species are regarded as an important threat to biodiversity in New Zealand and Australia and as significant in Canada.

Regeneration and extension of forest. Throughout much of the TBFRA area, forest cover is expanding following deforestation in the past. The type of expansion varies from one country to another, for example, from the establishment of plantations of exotic species to natural recolonization of abandoned agricultural land. The largest areas of expansion are in the Russian Federation and the USA, which together account for about 87 per cent of the total in the TBFRA area, there is significant expansion in most European countries as well. At the same time, most countries appear to be regenerating forests. Of the estimated 1.5 million ha of natural colonization of non-forest land every year, over 90 per cent is in the Russian Federation. Other significant areas, including France, Norway and New Zealand, may reflect changing agricultural practices and abandonment of agricultural land. The small amount of recolonization, particularly in Europe, is significant when compared with claims made about the amount of land being removed from agriculture.

Origin of planting material used in the forest. Preliminary results of the enquiry on this issue, which must be treated with caution because of the limited nature of the data, suggest that the large majority of trees being planted in the TBFRA area are of local provenance.

FOREST CONDITION AND DAMAGE TO FOREST AND OTHER WOODED LAND

TBFRA-2000 differs from earlier assessments in that it has sought information not only on the extent of the resource, but also on its condition. There have been particular concerns over the issues of forest condition and forest damage, as the maintenance of forest condition is a clear prerequisite for the sustainable management of forest resources. Consequently, these issues have received considerable attention from both scientists and policy makers.

Information collected for the TBFRA-2000 provides a preliminary assessment, while at the same time highlighting the difficulties associated with making such an assessment.

Causes of damage. The most important reported causes of damage to forests in the boreal and temperate zones are insects and fire. For example, up to 205 million ha of forest were reported to have been damaged by insects and disease in Canada in the period 1986-1995, and almost 29 million ha of Canadian forests were damaged by fire in the same period. Damage caused by grazing and browsing was also widely reported and, in a number of European countries (e.g. Austria, Belgium, Bulgaria, Denmark, and Poland), the area of forest and other wooded land with such damage was greater than from any other identified cause.

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

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

The material presented in TBFRA-2000 represents a step forward in the assessment of forest condition at an international scale. It illustrates the diversity of methods used in individual countries to address this important issue, and highlight the gaps in our current understanding of the most important agents damaging forests.

The condition of a forest is best assessed in relation to its most important functions, and these vary from forest to forest. Consequently, any statement about the health of a forest in a country should take into account the functions of those forests. Currently, no methods exist which can be used to do this. Many of the difficulties associated with the identification of the condition of forests in the temperate and boreal zones stem from recent changes in the ways that forests are seen. Issues such as biodiversity, water quality and carbon sequestration have all become much more important than in previous years. However, forest inventory methods have primarily concentrated on the assessment of wood resources. This is still reflected in the data that have been collected for the TBFRA-2000.

PROTECTIVE AND SOCIO-ECONOMIC FUNCTIONS

The goods and services from forests provide a wide range of benefits. The TBFRA-2000 attempts to describe these goods and services more fully than previous assessments. The result is a sometimes bewildering array of products and services, some of which are touched on below.

Protective functions. The protective functions of forests are receiving increasing attention, at least partly in response to international attention to issues such as biodiversity, global climate change, and forest health. A number of countries are exploring approaches to alter or enhance forest inventory systems to better measure the protective functions of forests.

Use of the forest by indigenous or tribal peoples. Forests play an important role in many indigenous and tribal peoples' cultures. The information in response to the TBFRA enquiry was brief, and only begins to describe the importance of these lands to indigenous and tribal peoples. A more complete treatment would require consultation with the tribal peoples and other experts.

Public access. Most countries that responded to the enquiry indicated that the public has access to most public forest and other wooded land for the purposes of recreation and gathering of forest products for personal use. Any restrictions normally affect a small percentage of these lands. Commercial use of public forest and other wooded land normally requires special permits and some type of payment to the State, particularly for the harvest of wood products. The majority of countries in the TBFRA area with privately owned forest have a policy of open public access, sometimes with certain restrictions imposed. A minority of countries allow access only with the permission of the landowner, but even in these countries access is often allowed.

Non-wood goods. Data availability on the quantity of non-wood goods from forests varies widely among countries, but from countries' responses the general trend is clear: first, demand is increasing for most goods and services; second, the lack of supply information limits current ability to manage these resources; and third, existing and potential conflicts between users, combined with the increasing demand, are creating immediate challenges for managers. Commercial demand is the dominant force for wood products, but is less important for many of the non-

wood products. However, the growing demand for “natural” products has spurred commercial interest in products such as mushrooms and medicinal plants. Among the more important non-wood products supplied from the forest that are reported by countries are Christmas trees, cork (from only a few countries), mushrooms, berries, medicinal and herbal plants, decorative foliage, fodder and forage, and hunting and game products. Hunting is more closely regulated than most activities involving the forest and in some countries is considered as a form of utilization of natural resources on a sustained basis and as a means of wildlife management.

Leisure and recreational use. The importance of forests for leisure and recreational use is increasing across the TBFRA area. Forests are often the preferred environment for leisure activities such as picnicking, hiking, camping, horseback riding, and mountain biking. Several countries emphasize the importance of forest and other wooded land in proximity to population centres. Forest and other wooded land are also valued for social benefits not directly related to leisure, such as climate regulation, noise protection, aesthetics, and so on. Most countries report that demand for the cultural, historic, spiritual and scientific values of the forest is increasing.

At best, some countries collect data only on the most important goods and services, or have data on commercial production or exports. The measures of quantity were fairly standard across countries, although it was often not clear whether all types of production were included (particularly for personal use). Personal use often accounts for the largest share of use. However, since that use is not seen as economically important in many countries, there is little incentive to collect data. Additional attention may be directed to this topic in cases where personal use has the potential to harm the resource, or where personal and commercial collections are in conflict.

A number of the goods and services covered in TBFRA-2000 appear to have potential for future assessments. However, any significant progress beyond current information will probably require additional data collection, as well as coordination with organizations that may have data or expertise that is unavailable in the traditional agencies participating in forest assessments.

RELIABILITY AND COMPARABILITY OF THE TBFRA-2000 RESULTS

The systems of nomenclature applied in national forest resources assessments are characterized by tradition and by national information needs and are not standardized internationally. Even identically named attributes may mask different concepts and definitions. A major concern of the TBFRA-2000 was therefore the comparability of data between countries and the reliability of aggregated results. Studies were conducted that aimed at assessing the reliability of information obtained by the aggregation of data from national forest resources assessments. The results of these studies form the basis for analysis of the reliability and comparability of the TBFRA-2000 results.

The reliability of the TBFRA results is mainly affected by two error sources: (1) definition errors; and (2) non-response. In addition, the national reference periods may add some fuzziness to the results. The results of a study of the non-responses and reference periods and an analysis of the definition errors are summarized below.

Results of analysis of non-responses. The response rates by countries to the TBFRA enquiry are generally high, and with respect to non-response rates there is no reason to doubt the reliability of the TBFRA results.

Definition errors. The minimum crown cover threshold of 10 per cent specified by the TBFRA definition is not critical in closed forests. In open forests close to natural timberlines the minimum crown cover is decisive for forest area estimates. Most countries that have forests close to natural timberlines utilize crown cover thresholds of 10 per cent or define forest area in a way that matches approximately the TBFRA definition. A study carried out in Europe and covering EU member states and EFTA countries showed that the TBFRA definition results in an area of the European forest area roughly 1 per cent more than that assessed according to national definitions. The figures presented by TBFRA for forest area are reliable. Except for a few nations, diameter thresholds larger than 0 cm are defined for diameter breast height (d.b.h). However, even if the national figures are not converted towards the TBFRA definition only a small underestimation of standing volume will result. In conclusion, taking also into account the large unit of reference covered by the TBFRA and the primary use of the information provided by the TBFRA, the reliability of the results is more than sufficient.

Reference period. The reference periods of individual nations reporting to the TBFRA enquiry range from 1986 (Germany) to 1998 (Iceland). With the exception of two countries, all national data presented in TBFRA-2000 were assessed during the 1990s. The reported changes in area and growing stock can be utilized as an indicator for potential differences of the status at the reference period and the time when the TBFRA-2000 results were issued. If TBFRA-2000 results for individual nations are cross-checked with the assessment period and the reported changes, the information provided by TBFRA-2000 can be regarded as reliable and comparable with respect to the reference period.

The results from the four largest forest countries. Four countries, the Russian Federation, Canada, the United States of America and Australia, account between them for the predominant share of the TBFRA region's total forest resources. Their share of the area of forest, for example, is over 85 per cent, that of other wooded land nearly 94 per cent, and of most of the other main attributes more than three-fourths. Consequently, the reliability and comparability of their data have an important influence on the overall results of the TBFRA report. Given the very extensive nature of their forest resources, and the remoteness of and related difficulties of surveying a sizeable part of it, it is inevitable that they should have experienced certain problems in compiling as comprehensive and detailed a set of data as called for in the TBFRA enquiry. Without further analysis, it is impossible to assess whether there may be a number of areas where the data may possibly fall short of satisfactory reliability because of problems with definitions, sampling and survey methodologies, adjustment of national data, and so on. Generally speaking, there seems good reason to accept the figures in this report as the best available.