PART II
KEY ISSUES IN THE FOREST SECTOR TODAY

The status of forests: the Global Forest Resources Assessment 2000

Demand has grown for a broad range of information on forests at the national and international levels. Reliable information on the status and trends of forest resources helps give decision-makers the perspective necessary for orienting forestry policies and programmes. Such information is useful for monitoring progress towards sustainable forest management and for framing international discussions and agreements on such vital issues as deforestation, biological diversity, desertification, global climate change, wood supply and sustainable development.

FAO has carried out periodic global forest assessments since 1947, at intervals of approximately ten years. This chapter summarizes the methodology and key findings on forest area and forest management of FAO's most recent and comprehensive forest assessment, the Global Forest Resources Assessment 2000 (FRA 2000). The text also refers to the two previous assessments: FRA 1990, which reported on forest cover in 1990 and forest cover change between 1980 and 1990 (FAO, 1995a, 1995b), and the interim 1995 assessment, which reported on forest cover in 1995 and change from 1990 to 1995 (FAO, 1997d). FRA 2000 forest resource data at country level are provided in Annex 2. Detailed country profiles, including baseline data, and material on all parameters covered by the assessment, are available on the FAO Forestry Department Web site.[1] The full report of FRA 2000 is due to be published by the end of 2001.

THE ASSESSMENT PROCESS

The Global Forest Resources Assessment 2000 was a joint endeavour carried out by FAO in cooperation with its member countries and many other partners. Detailed planning for FRA 2000 began in 1996. In that year, FAO convened an expert consultation in Kotka, Finland, where some of the world's leading forest inventory specialists provided technical advice on the scope and implementation of FRA 2000 as well as on a core set of forest-related definitions to be used in the assessment. In 1997, the FAO Committee on Forestry, FAO's highest-level forest policy forum for its member countries, and the fourth session of the Intergovernmental Panel on Forests (IPF) approved the consultation's findings and endorsed FAO's leadership of the assessment.

FRA 2000 was a five-year effort, consisting of a number of activities: a forest assessment based on country information; a remote sensing survey of forest cover change at the pan-tropical level; mapping of global forest cover and ecological zones; and the establishment of a forestry information system. FRA 2000 provided basic assessment information on forest area in 2000, change in forest area between 1990 and 2000, and wood volume and biomass. Moreover, in keeping with recommendations made at Kotka, it included a number of other parameters to provide a more holistic picture of forest resources worldwide. The new subjects included, among other things, forest area under protection status, trees outside forests, forest fires, non-wood forest products, timber removals and information on forest management.

Great effort was made to ensure that the FRA process was both participatory and transparent. National forestry agencies from nearly every

[1] The FAO Forestry Department Web site is the most up-to-date source of information on all aspects of the assessment and contains information on all countries (www.fao.org/forestry/fo/fra/index.jsp). The results of the assessment of temperate and boreal forests in industrialized countries are also available in UN-ECE/FAO (2000b).

country of the world, a large number of research centres and academic institutions and several international, regional and non-governmental organizations collaborated in the implementation of FRA 2000. Before publishing the FRA 2000 data, FAO formally invited countries to review the preliminary results of the assessment. Countries were given the opportunity to submit comments and supporting technical material that could improve the results compiled by FAO. Background information and analyses used in the forest resource calculations have been made available on the FAO Forestry Department Web site (www.fao.org/forestry/fo/country/index.jsp), making it possible to trace the final results back to the original source data.

Forest assessment based on country information

The central undertaking of FRA 2000 was the forest assessment based on country information. National-level data on forest resources were collected through an exhaustive survey of inventory reports and other information from countries. National forestry experts and other partners from around the world were involved in this effort. A major partner was the UN Economic Commission for Europe (UN-ECE). UN-ECE coordinated the assessment of temperate and tropical forests in the industrialized countries and countries in transition: Australia, the Commonwealth of Independent States (CIS), Europe,[2] Japan, New Zealand and North America. FAO coordinated the assessment of developing countries, in which almost all tropical and subtropical forests and some temperate forests are located, and was also responsible for the integration of all the information into the harmonized synthesis constituting the global assessment.

To collect data for the developing countries, FAO formally requested country representatives to supply the most recent forest inventory reports, and FAO staff and consultants visited countries and held workshops with concerned country representatives. FAO relied mainly on statistics from primary sources, rather than on quoted or secondary sources. In the countries where no applicable national forest inventories existed, it was necessary to piece together information from various partial inventories or to use secondary sources and reconnaissance surveys. In contrast, UN-ECE collected information on industrialized countries from questionnaires filled out by national correspondents, who used mainly national forest inventory data. All data provided to FAO and UN-ECE were checked and validated with the national correspondents in an intense dialogue over nearly two years.

Several major challenges had to be met in order to assemble country information and then integrate it to form a global picture of the status of forest area in 2000 and change in forest area between 1990 and 2000. After FAO and its partners made a major effort to amass all relevant inventory and related information, the information base for many countries was found to be limited. For example, over half of the developing countries had only one forest inventory, and more than one-fourth of them had never carried out an inventory (see Table 1). Most of the country data used for FRA 2000 spanned a period of about ten years (although a few inventories were even older). Only a handful of countries maintain continuous national forest inventories with comparable time series. As a result, it was difficult to calculate precise estimates of forest change at both the national and global levels. Projecting data forwards and backwards to the reference years 2000 and 1990 was a critical and difficult aspect of the assessment. In the absence of comparable multiple-date inventories, a trend line had to be derived for many countries by using a variation of the "convergence of evidence" method, in which countries' survey results were complemented with other information such as inventory statistics, economic information and policy studies. Finally, forest vegetation types and terminology varied widely among countries, compounding the problem of aggregating national data into harmonized global estimates.

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[2] The countries considered to be in the European region for the purposes of the assessment coordinated by the UN-ECE include all those listed under Europe in Annex 2 except members of the CIS, plus Cyprus, Israel and Turkey.

To make the highly variable country information useful for global reporting, FAO developed a set of protocols and standards for its harmonization. All country information had first to be classified according to a common set of terms and definitions. (See Annex 1 for some definitions used.) This was a difficult task owing to the sheer magnitude and variability of the information produced by countries and the wide range of forest formations, ecological conditions and cover types that exist worldwide. For example, FRA 2000 assembled more than 650 definitions of forest from 132 developing countries. Reducing this information into a highly compressed set of global forest classes (i.e. closed forest, open forest, and other wooded land) was a major task. For the definition of forest, FAO adopted the threshold of 10 percent crown cover. Recommended in the landmark study on worldwide vegetation classifications carried out by the United Nations Educational, Scientific and Cultural Organization (UNESCO, 1973), this threshold was used for developing countries in the Forest Resources Assessments of 1980 and 1990, but FRA 2000 was the first assessment to use it as the minimum canopy cover to describe forests in industrialized countries as well.

To make the comparison between forest area in 1990 and 2000 possible, the 1990 national forest area figures derived by the interim 1995 assessment were revised, using the same definitions, methodologies and new inventory data used for calculating the 2000 figures. This established a new baseline for forest cover in 1990. It should be noted that updating national forest area figures from a previous forest resources assessment by incorporating new data is a standard feature of all FAO forest assessments.

Pan-tropical remote sensing survey

An independent remote sensing survey was conducted for FRA 2000 to complement the survey based on country information. Controlled sampling of tropical forests combined with a uniform data source – satellite imagery – provided a comparable set of statistics for 1980-1990 and 1990-2000, making possible a direct comparison of forest area change over these two

TABLE 1
Forest inventories in developing countries

Regions	Number of countries/areas	Countries/areas with no forest inventory	Countries/areas with a partial forest inventory	Countries/areas with a national forest inventory:		
				Repeated[1]	Single shot[2]	
					After 1990	Before 1990
Africa	56	14	15	7	12	10
Near East	13	11	0	2	0	0
Asia and Oceania	22	2	2	3	13	3
Latin America	21	1	4	15	16	11
Caribbean	24	13	0	4	6	10
Totals	**136**	**39**	**21**	**32**	**47**	**34**

[1] The term “repeated” is used to refer to continuous monitoring or comparable inventories carried out at fixed intervals.
[2] The term “single shot” refers to countries that have carried out either one or multiple inventories that are not comparable with one another. The date (after or before 1990) refers to the most recent inventory.

assessment periods. The survey relied on statistical sampling (10 percent) of 87 percent of the world's tropical forests through 117 sample units to produce estimates of the status and change of tropical forest at regional, ecological and pan-tropical levels (but not at the national level).[3] The principal output of the remote sensing survey was an area change matrix, which illustrates and quantifies how the forest and other land use classes changed between 1980 and 2000. The forest and land cover classification scheme used by the remote sensing survey was linked closely to the FRA forest classes used for the country-based survey and for the low-resolution global forest map, so that data from these three sources are complementary.

FRA 2000 global maps

The production of global maps was a significant new undertaking for FRA 2000.[4] For the first time, a global forest map now exists that shows the location and distribution of forests according to FRA classifications. FRA 2000 also produced global maps on ecological zones and protected areas. The FRA 2000 maps are useful visual aids for understanding the location and extent of the major forest areas of the world. Each map is generated using computerized Geographic Information System (GIS) technology, which makes it possible to combine the maps with other spatial and statistical data.

The forest map has been printed at a scale of 1:40 000 000 and enlargements up to 1:10 000 000 are possible. A poster version of the forest map accompanies this publication (reproduced in Figure 2). Digital versions are available on the FAO Forestry Department Web site (www.fao.org/forestry/fo/fra/index.jsp).

The accuracy of the forest map is estimated at about 80 percent for all forest classes. Accuracy for closed forests is somewhat higher and accuracy for open/fragmented forests is somewhat lower. Other wooded lands has the lowest accuracy of the three woody vegetation classes represented.

The global ecological zoning map provided a means of differentiating forests globally by ecological zone. While most countries have appropriate means of compiling national information on forests according to ecological units, it was not possible to aggregate this information at the global level prior to the development of the ecological zoning map. A major reason for this was the absence of an internationally accepted global standard and classification system that is geometrically correct and registered to a map base.[5] In the past, few applications have required analysis and reporting according to ecological zone at the global scale, and until now, useful global maps have been slow to emerge. However, because certain environmental functions have international dimensions, global applications of ecological zoning are expected to become increasingly important.

FAO identified the Köppen system, as modified by Trewartha in 1968, as the most appropriate ecological zoning scheme for the FRA 2000 ecological zoning map. Slightly modifying this scheme, FAO identified 20 global ecological zones, ranging from evergreen tropical rain forest to boreal tundra (see Box 12). These were then mapped. The worldwide forest cover according to ecological zone was determined by overlaying the FRA 2000 global forest cover map on the global ecological zoning map in the GIS, and then extracting the statistics.

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[3] The Kotka expert consultation (referred to as Kotka III) advised FAO to consider conducting the remote sensing survey at the global level with about 350 sample units. Financial restrictions, however, limited the work to the tropics, except for some pilot activities.

[4] FAO developed a network of cooperators who were instrumental in the development of the maps. Major collaborators involved in the effort included EROS Data Center of the United States; the World Conservation Monitoring Centre, based in the United Kingdom; the Institute for Applied Research and Analysis, in Austria; the Laboratory of Terrestrial Ecology of France; the Canadian Center for Remote Sensing; the United States Forest Service; and the Australian Bureau of Rural Sciences.

[5] A small number of classification schemes have been developed for use at the global level, including Bailey, Holdridge, Köppen and Thornwaite, but none of these is available digitally or is registered to a geometrically correct map base. Köppen's classification scheme has been the most widespread and longest used.

BOX 12
FAO global ecological zoning

- Tropical rain forest
- Tropical moist deciduous forest
- Tropical dry forest
- Tropical shrubland
- Tropical desert
- Tropical mountain system
- Subtropical humid forest
- Subtropical dry forest
- Subtropical steppe
- Subtropical desert
- Subtropical mountain system
- Temperate oceanic forest
- Temperate continental forest
- Temperate steppe
- Temperate desert
- Temperate mountain system
- Boreal coniferous forest
- Boreal tundra woodland
- Boreal mountain system
- Polar

Disseminating the results

All of the country forest information, the remote sensing survey results and the reports from the special studies of FRA 2000 are archived in the Forestry Information System (FORIS), which links multiple references from each country to databases containing statistics, terms and definitions, contact information and other data. FORIS is accessible and easy to update, and a real-time link to the FAO Web site makes it possible to provide the latest statistics to the public as soon as they have been entered, analysed and cleared by countries and FAO. In addition to the findings, the background material used to calculate the FRA data is made available on the Web site, making it possible to trace the estimates to original source documents. This provides transparency in the FRA 2000 calculations.

GLOBAL FOREST RESOURCES IN 2000

FRA 2000 provides a wide range of information on the status and trends of forest resources. The text below focuses on the findings of FRA 2000 on forest area and change in forest area over the past decade. Information on other forest parameters (e.g. forest condition, forest fires and non-wood forest products) may be found on the FAO Forestry Department Web site (www.fao.org/forestry/fo/fra/index.jsp), in the report of the assessment for temperate and boreal forests in industrialized countries (UN-ECE/FAO, 2000b) and in the full report of FRA 2000, which is due to be published by the end of 2001.

Total forest area, 2000

The world has about 3 870 million ha of forests, of which 95 percent are natural forests[6] and 5 percent are forest plantations (see Table 2 in Annex 2). This global forest cover figure is higher than the forest cover estimates made by the previous two forest resources assessments (FRA 1990 and the interim 1995 assessment); this does not, however, indicate a real increase in forest area worldwide. Rather, it reflects a change in the definition of forest (i.e. the application of a uniform definition of forest for the first time) and the incorporation of new inventory data (see Box 13 for further explanation). FRA 2000 revised the 1990 forest cover figures, using the same definitions and methodologies used for calculating the 2000 figures, in order to make comparison between 1990 and 2000 possible. This set a new baseline for forest cover in 1990.

Table 2 provides FRA 2000 data on the distribution of forests by region. Europe (including the Russian Federation) and South

[6] Included in natural forests are semi-natural forests, the dominant forest type in many areas, particularly temperate and boreal forests in industrialized countries (see UN-ECE/FAO, 2000b).

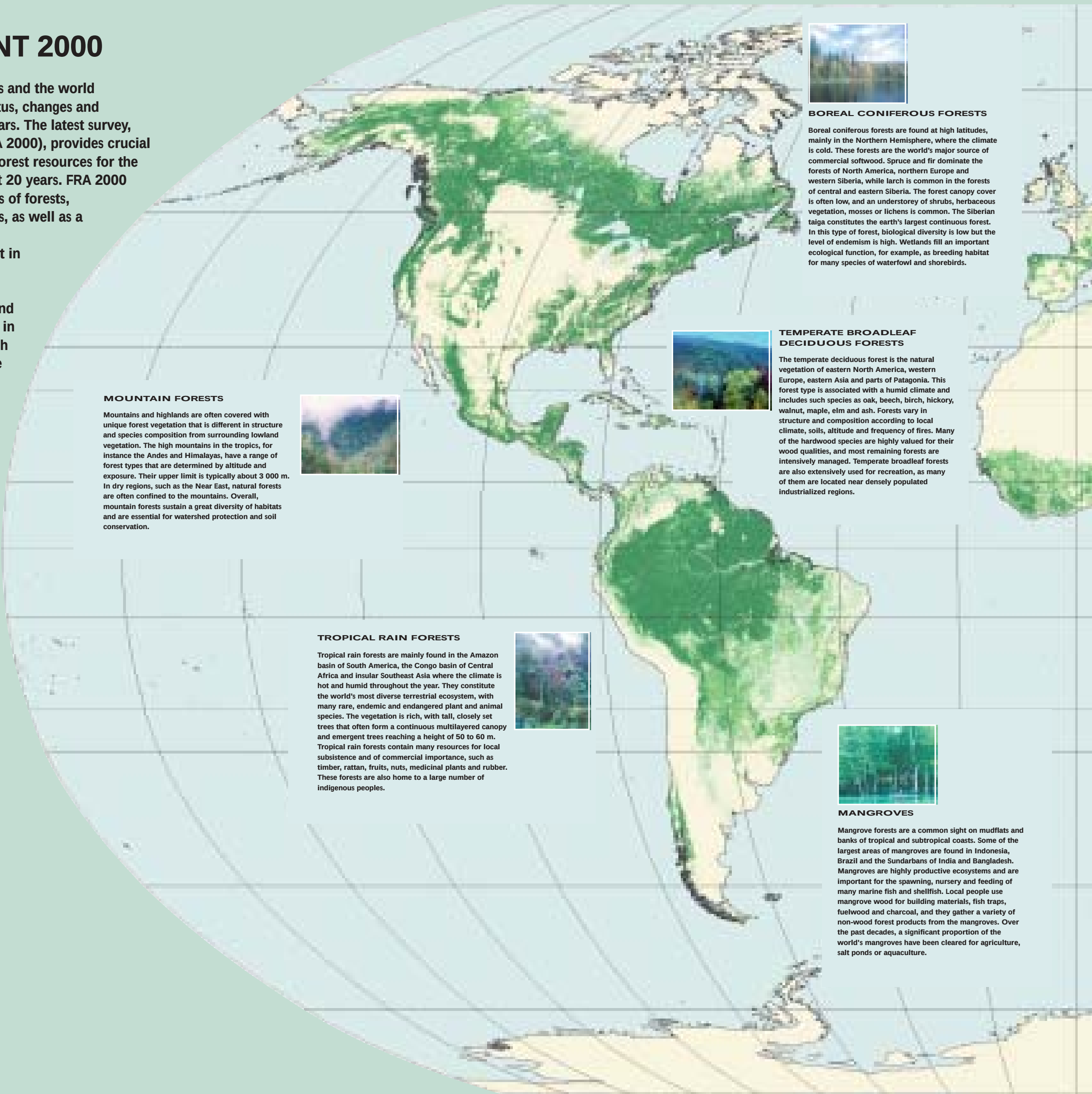
FIGURE 2
Global forests in 2000

GLOBAL FOREST RESOURCES ASSESSMENT 2000

Since 1947, at the request of its member countries and the world community, FAO has regularly reported on the status, changes and condition of the world's forests about every ten years. The latest survey, the Global Forest Resources Assessment 2000 (FRA 2000), provides crucial information describing the state and condition of forest resources for the year 2000, including changes undergone in the last 20 years. FRA 2000 also includes new parameters on ecological aspects of forests, protected forests and non-wood goods and services, as well as a set of global maps.

FRA 2000 is coordinated by FAO and carried out in cooperation with the United Nations Economic Commission for Europe, the United Nations Environment Programme, UN member countries and external partners, including the EROS Data Center in the United States, the Tropical Agriculture Research and Higher Education Center in Costa Rica and the World Conservation Monitoring Centre in the United Kingdom. Funding from the Governments of Finland, Sweden, Switzerland and the United Kingdom was instrumental in supporting the development of this global forest map, as were in-kind contributions from the United States Geological Survey and the United States Department of Agriculture Forest Service. Countries and regional cooperators were also involved in the mapping exercise.

This global forest map is one of the many outputs of FRA 2000, which has also produced several volumes of text and statistical information, available on the FAO Web site (www.fao.org/forestry) and in a series of printed volumes that may be obtained from authorized agents around the world.



BOREAL CONIFEROUS FORESTS

Boreal coniferous forests are found at high latitudes, mainly in the Northern Hemisphere, where the climate is cold. These forests are the world's major source of commercial softwood. Spruce and fir dominate the forests of North America, northern Europe and western Siberia, while larch is common in the forests of central and eastern Siberia. The forest canopy cover is often low, and an understorey of shrubs, herbaceous vegetation, mosses or lichens is common. The Siberian taiga constitutes the earth's largest continuous forest. In this type of forest, biological diversity is low but the level of endemism is high. Wetlands fill an important ecological function, for example, as breeding habitat for many species of waterfowl and shorebirds.

TEMPERATE BROADLEAF DECIDUOUS FORESTS

The temperate deciduous forest is the natural vegetation of eastern North America, western Europe, eastern Asia and parts of Patagonia. This forest type is associated with a humid climate and includes such species as oak, beech, birch, hickory, walnut, maple, elm and ash. Forests vary in structure and composition according to local climate, soils, altitude and frequency of fires. Many of the hardwood species are highly valued for their wood qualities, and most remaining forests are intensively managed. Temperate broadleaf forests are also extensively used for recreation, as many of them are located near densely populated industrialized regions.

MOUNTAIN FORESTS

Mountains and highlands are often covered with unique forest vegetation that is different in structure and species composition from surrounding lowland vegetation. The high mountains in the tropics, for instance the Andes and Himalayas, have a range of forest types that are determined by altitude and exposure. Their upper limit is typically about 3 000 m. In dry regions, such as the Near East, natural forests are often confined to the mountains. Overall, mountain forests sustain a great diversity of habitats and are essential for watershed protection and soil conservation.

TROPICAL RAIN FORESTS

Tropical rain forests are mainly found in the Amazon basin of South America, the Congo basin of Central Africa and insular Southeast Asia where the climate is hot and humid throughout the year. They constitute the world's most diverse terrestrial ecosystem, with many rare, endemic and endangered plant and animal species. The vegetation is rich, with tall, closely set trees that often form a continuous multilayered canopy and emergent trees reaching a height of 50 to 60 m. Tropical rain forests contain many resources for local subsistence and of commercial importance, such as timber, rattan, fruits, nuts, medicinal plants and rubber. These forests are also home to a large number of indigenous peoples.

MANGROVES

Mangrove forests are a common sight on mudflats and banks of tropical and subtropical coasts. Some of the largest areas of mangroves are found in Indonesia, Brazil and the Sundarbans of India and Bangladesh. Mangroves are highly productive ecosystems and are important for the spawning, nursery and feeding of many marine fish and shellfish. Local people use mangrove wood for building materials, fish traps, fuelwood and charcoal, and they gather a variety of non-wood forest products from the mangroves. Over the past decades, a significant proportion of the world's mangroves have been cleared for agriculture, salt ponds or aquaculture.

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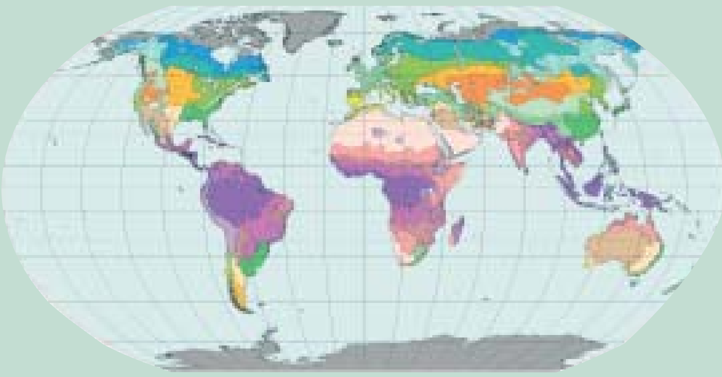
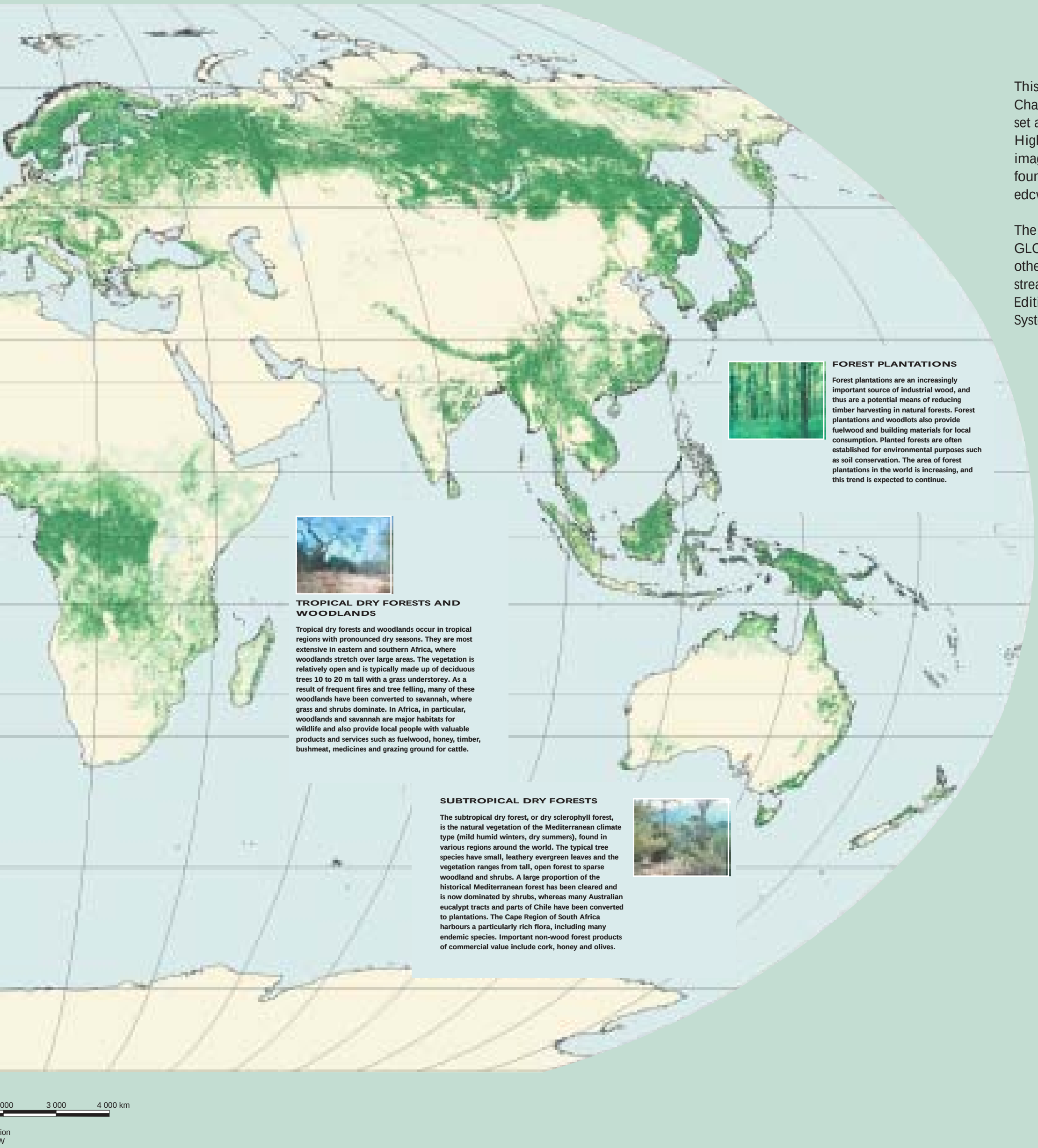
GLOBAL ECOLOGICAL ZONES



TAr	Tropical rain forest
TAwa	Tropical moist deciduous forest
TAwb	Tropical dry forest
TBSh	Tropical shrubland
TBWh	Tropical desert
TM	Tropical mountain system
SCf	Subtropical humid forest
SCs	Subtropical dry forest
SBSh	Subtropical steppe
SBWh	Subtropical desert
SM	Subtropical mountain system
TeDo	Temperate oceanic forest
TeDc	Temperate continental forest
TeBSk	Temperate steppe
TeBWk	Temperate desert
TeM	Temperate mountain system
Ba	Boreal coniferous forest
Bb	Boreal tundra woodland
BM	Boreal mountain system
P	Polar
Water	Water
n.d.	No data



This map was produced from the Global Land Cover Characteristics (GLCC) Database, a land cover data set at 1 km resolution, derived from Advanced Very High Resolution Radiometer (AVHRR) satellite images. Details on GLCC data characteristics may be found at:
edcwww.cr.usgs.gov/landdaac/glcc/globdoc1_2.html

The land cover classes were derived by aggregating GLCC classes with additional criteria drawn from other data sets. Coastlines, country boundaries, streams and lakes were derived from ArcWorld Edition 1 (December 1994) of the Environmental Systems Research Institute.

This map was produced by the
Food and Agriculture Organization
of the United Nations
and the
United States Geological Survey
EROS Data Center

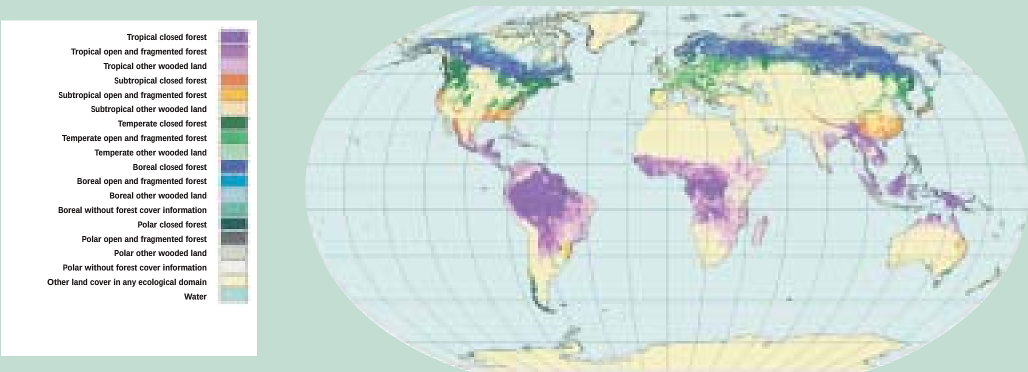
CLOSED FOREST
Land covered by trees with a canopy cover greater than 40 percent and a height exceeding 5 m.
It includes natural forests and forest plantations.

OPEN AND FRAGMENTED FOREST
Land covered by trees with a canopy cover of between 10 and 40 percent and a height exceeding 5 m (open forest), or mosaics of forest and non-forest land (fragmented forest). It includes natural forests and forest plantations

OTHER WOODED LAND
Land with a 5 to 10 percent canopy cover of trees exceeding 5 m in height, or with a shrub or bush cover of more than 10 percent and a height of less than 5 m.

OTHER LAND COVER
All other land, including grassland, agricultural land, barren land, urban areas, etc.

FORESTS BY MAJOR ECOLOGICAL DOMAINS



BOX 13
Global forest area figure for 2000

FRA 2000 was the first global forest assessment to use a common definition for all forests worldwide. Previous assessments used a canopy cover threshold of 10 percent for developing countries and 20 percent for industrialized countries to define forests. In FRA 2000 the uniform application of the 10 percent threshold for all countries has had a significant impact on the global forest area figure. The change in definition was the main reason why the estimated global forest area for 2000 is 400 million ha higher than the estimate for 1995 made by the interim 1995 assessment (FAO, 1997d). The effect is most significant for Australia and the Russian Federation. The estimate for Australia's forest area in 2000 is 155 million ha, compared with 41 million ha in 1995, in part because the 2000 estimate includes large expanses of sparsely stocked forests that previously had been classified as other wooded land. The estimate for the Russian Federation is 850 million ha in 2000, compared with 764 million ha in 1995.

In addition, forest inventories conducted after 1990 contain higher figures for some countries (e.g. Mozambique) than were previously reported, and the inclusion of these results has also contributed to the higher estimate for 2000. In other countries, such as Kenya, a more detailed breakdown of forest classes in national inventory reports has facilitated an improved reclassification of national results into the FRA 2000 forest classes; thus the new estimates include as forests some areas previously classified as other wooded lands.

America have the largest percentage of the world's forests (27 and 23 percent, respectively), and Oceania has the least (5 percent). A map showing the location of forests by region is provided in Figure 3.

Two-thirds of the world's forests are located in only ten countries: the Russian Federation, Brazil, Canada, the United States, China, Australia, the Democratic Republic of the Congo, Indonesia, Angola and Peru (Figure 4; see also Table 2 in Annex 2).

The world average of forest area per person is 0.6 ha. There are, however, large differences among countries. Asia has very little forest per capita, whereas Oceania and South America have a substantial area per person (see Figure 5). Only 22 countries have more than 3 ha of forest per capita, and only about 5 percent of the world's population lives in these countries – mostly in Brazil and the Russian Federation. Three-quarters of the world's population, on the other hand, lives in countries with less than 0.5 ha per capita, including most of the densely populated countries in Asia and Europe.

About 30 percent of the world's land area is under forest, as already seen in Table 2. The proportion of total land area under forest varies significantly by region and country. About half the land area of South America and Europe is covered by forest, but only one-sixth of Asia's land is forested. Africa, North and Central America and Oceania fall in between, each with about one-fourth of its land covered by forest. Fifty countries and two "areas" (e.g. territories, protectorates) are reported to have less than 10 percent of their land covered by forest. Twenty countries and two areas have more than 60 percent of their land under forest (Figure 6).

Worldwide forest cover according to ecological zones was determined by using the FRA 2000 global forest cover map and global ecological

TABLE 2
Forest area by region, 2000

Region	Land area (million ha)	Total forest (natural forests and forest plantations)			Natural forest (million ha)	Forest plantation (million ha)
		Area (million ha)	% of land area	% of world's forests		
Africa	2 978	650	22	17	642	8
Asia	3 085	548	18	14	432	116
Europe	2 260	1 039	46	27	1 007	32
North and Central America	2 137	549	26	14	532	18
Oceania	849	198	23	5	194	3
South America	1 755	886	51	23	875	10
World total	**13 064**	**3 869**	**30**	**100**	**3 682**	**187**

FIGURE 3
Location of forests, by region

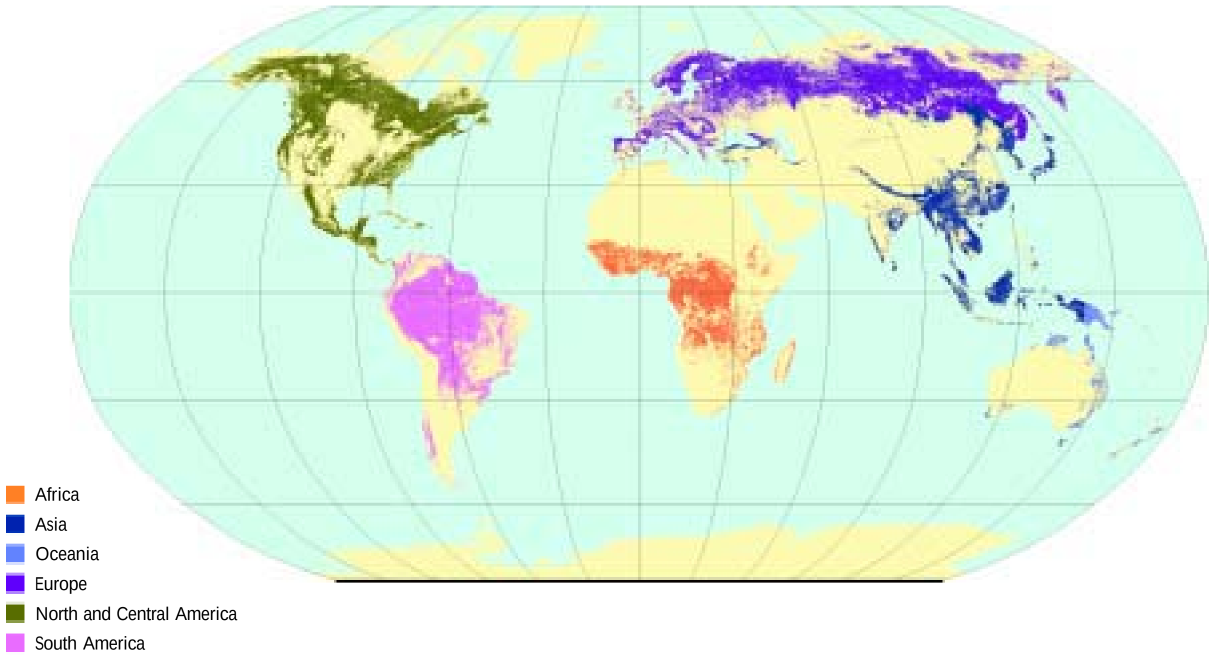
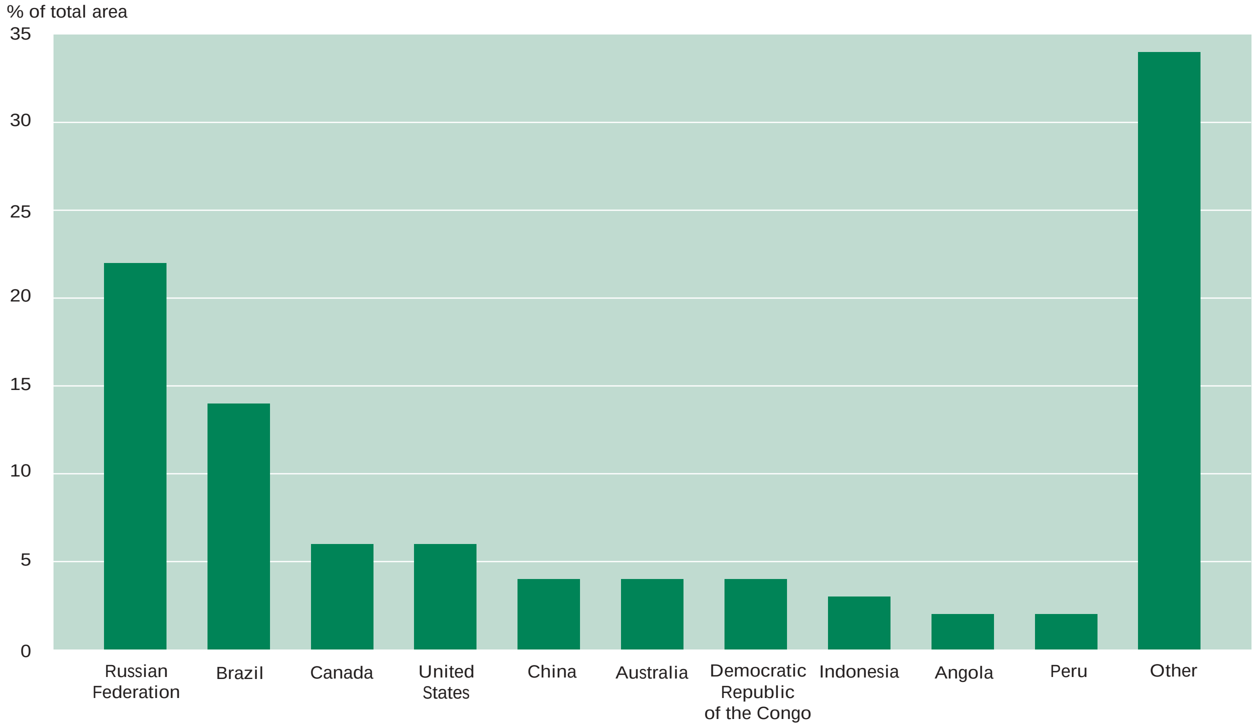


FIGURE 4
Countries with the largest percentage of the world's forests



Source: FRA 2000.

zoning map. The largest proportion of the world's forests is in the tropical zone (47 percent), followed by the boreal (33 percent), temperate (11 percent) and subtropical (9 percent) zones. Figure 7 shows the location of forests in these four broad ecological zones. The distribution of forests according to the more detailed ecological zoning classifications and by region is indicated in Table 3. Tropical and subtropical dry forests are concentrated in Africa (containing 36 percent of the world total), South America (30 percent) and Asia (21 percent). The majority of tropical rain forests are located in South America (58 percent), but a large proportion (24 percent) is also found in Africa; most of the rest is in Asia (17 percent). Nearly all temperate and boreal forests are located in Europe and North and Central America. Mountain forests are found mainly in Europe (40 percent) and North and Central America (34 percent).

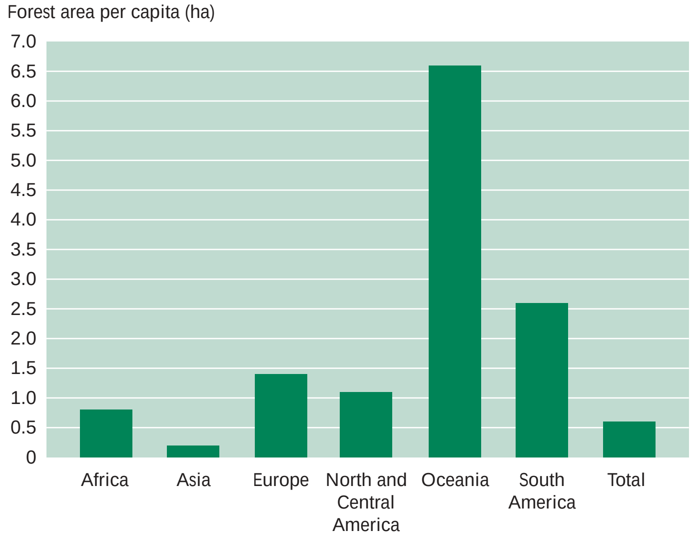
Forest plantation area, 2000

FRA 2000 provides a picture of the status of forest plantations worldwide. It is the first global assessment to have estimated forest plantation areas using a uniform definition and including data from all countries. Owing to changes in both definitions and methodologies used, the 2000 global and national plantation data cannot be directly compared with those of previous plantation assessments (e.g. FAO, 1995b). For example, rubberwood plantations were considered forest plantations in FRA 2000, whereas in previous assessments they were not.

The area of plantations in many industrialized countries, particularly in Europe, is less well defined than in developing countries. Many European countries make no distinction between planted and natural forests in their inventories, and the difference between the two is often not readily discernible in practice. In Europe, naturally occurring species are commonly planted, so that planted stands may have species compositions that are similar or identical to those of natural stands; in addition, planted stands generally have long rotation periods (in some cases more than 100 years), so they may become, over time, difficult to distinguish from natural forests.

According to FRA 2000 data, there are an estimated 187 million ha of plantations worldwide, representing 5 percent of the global forest area. Data on forest plantation area by region is indicated in Table 4. Asia has by far the largest forest plantation estate of any region, accounting

FIGURE 5
Forest area per capita, by region



Source: FRA 2000.

FIGURE 6
Forest area as percentage of country land area

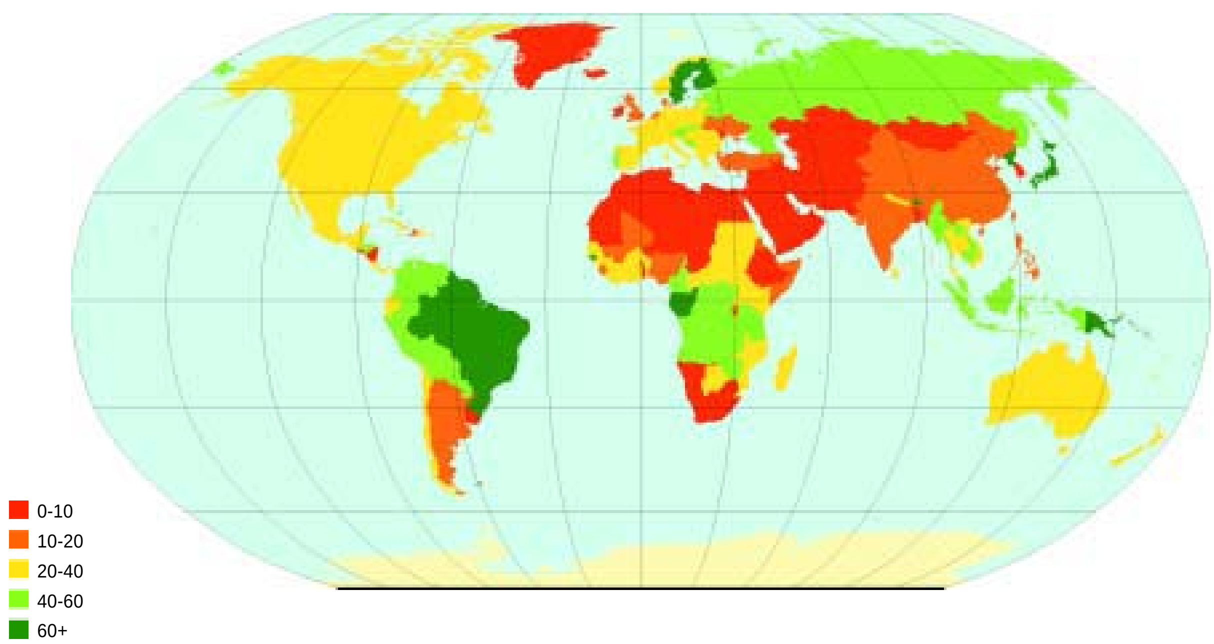
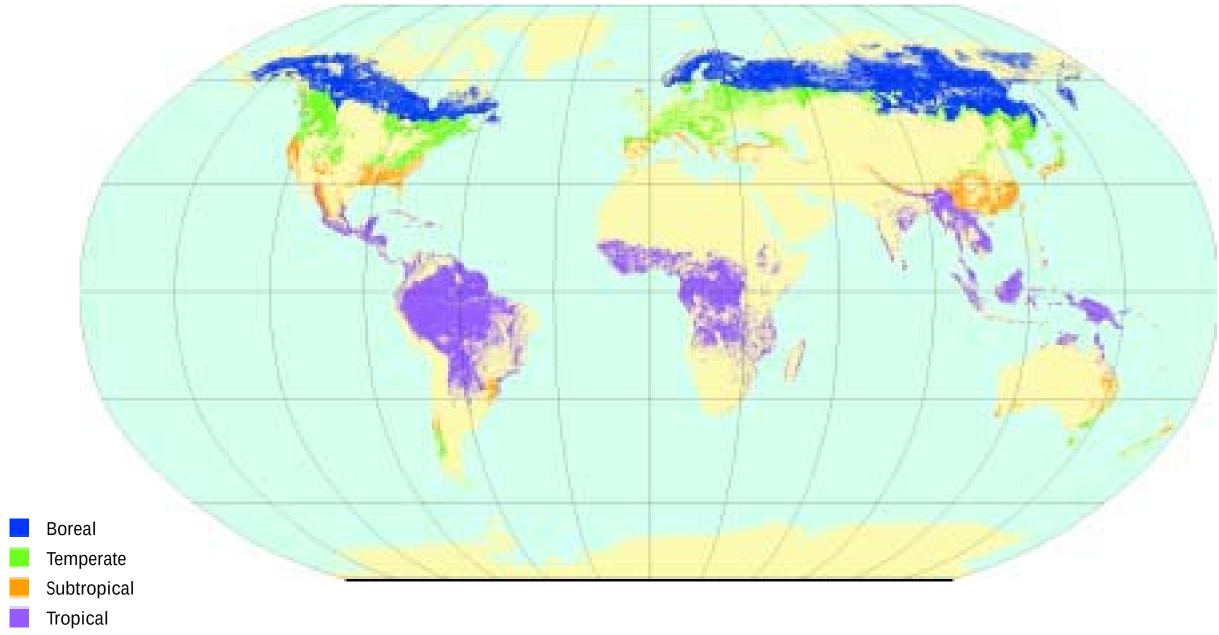


FIGURE 7
Distribution of the world's forests by major ecological zone



for 62 percent of the world's forest plantations. Plantations account for over one-fifth of all forests in Asia. The ten countries with the largest reported areas of forest plantation together account for 80 percent of the global forest plantation area (Figure 8). About 60 percent of forest plantations are located in only four countries: China, India, the Russian Federation and the United States.

Species in the genera *Pinus* and *Eucalyptus* continue to be the most commonly planted trees in forest plantations, accounting for 20 percent and 10 percent, respectively, of forest plantation area worldwide. However, comparison with the findings of the interim 1995 assessment suggests that the overall diversity of species planted is increasing.

Industrial plantations (i.e. those supplying raw material for industry) account for 48 percent of the global forest plantation estate, while non-industrial plantations (e.g. those grown for fuelwood, soil and water conservation and wind protection) account for 26 percent, and 26 percent are unspecified. The countries with major industrial plantation areas are China (37 million ha), the United States (16 million ha) and India (12 million ha). These three countries accounted for 73 percent of all industrial forest plantations globally in 2000. The countries with a significant proportion of non-industrial plantation areas are India (21 million ha), China (8 million ha), Indonesia and Thailand (4 million ha each), together accounting for 75 percent of all non-industrial forest plantations in the world.

Plantation ownership is of interest in light of various countries' efforts to privatize some of their forest plantations. The ownership of industrial plantations, where specified in the ten countries with the largest plantation estates, is 33 percent public, 26 percent private and 41 percent

TABLE 3
Distribution of forests by ecological zone, 2000

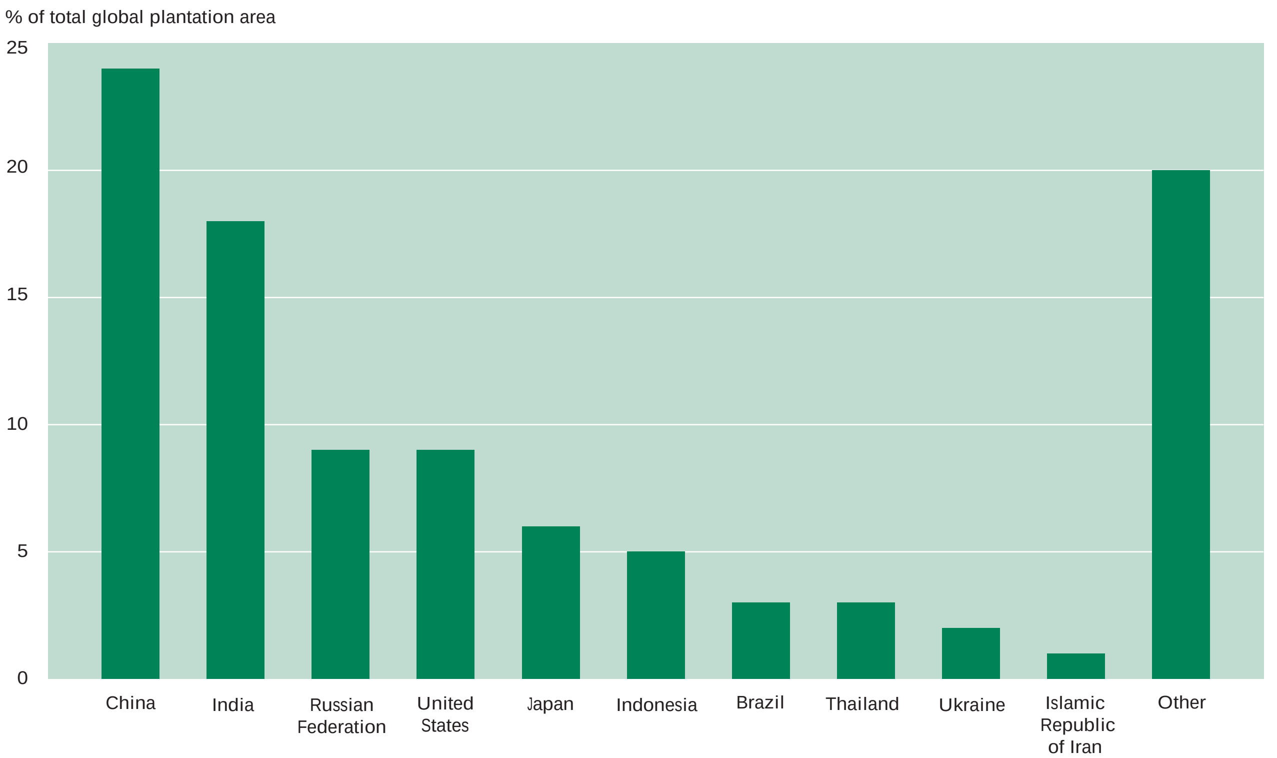
Ecological zone	Total forest (%)	Africa (%)	Asia (%)	Europe (%)	North and Central America (%)	Oceania (%)	South America (%)
Tropical rain forest	28	24	17	-	1	-	58
Tropical moist deciduous	11	40	14	-	9	6	31
Tropical dry	5	39	23	-	6	-	33
Tropical mountain	4	11	29	-	30	-	30
Total tropical forests	47	28	18	-	5	1	47
Subtropical humid forest	4		52	-	34	8	6
Subtropical dry forest	1	16	11	30	6	22	14
Subtropical mountain	3	1	47	13	38	-	1
Total subtropical forests	9	2	42	7	37	7	5
Temperate oceanic forest	1	-	-	33	9	33	25
Temperate continental forest	7	-	13	40	46	-	-
Temperate mountain	3	-	26	40	29	5	-
Total temperate forests	11	-	17	39	39	4	2
Boreal coniferous forest	19	-	2	74	24	-	-
Boreal tundra woodland	3	-	-	19	81	-	-
Boreal mountain	11	-	1	63	36	-	-
Total boreal forests	33	-	2	65	34	-	-
Total forests	**100**	**17**	**14**	**27**	**14**	**5**	**23**

Notes: Distribution of percentages does not exactly tally with other area statistics because of distortions in the remote sensing classification of forests in the global forest cover map. Only zones with forests are included.

TABLE 4
Forest plantation area by region, 2000

Region	Total forest area *(million ha)*	Natural forest area *(million ha)*	Forest plantation area *(million ha)*	Plantations as % of the region's total forest	% of total plantation area
Africa	650	642	8	1	4
Asia	548	432	116	21	62
Europe	1 039	1 007	32	3	17
North and Central America	549	532	18	3	9
Oceania	198	194	3	2	2
South America	886	875	10	1	6
World total	**3 869**	**3 682**	**187**	**5**	**100**

FIGURE 8
Countries with the largest proportion of the world's forest plantations, 2000



Source: FRA 2000.

other or unspecified. Of the non-industrial plantations, 39 percent are public, 39 percent are private and 22 percent are other or unspecified.

Forest area trends, 1990-2000

Perhaps the most sought-after result of a global forest resources assessment is the rate of change in forest area globally and by country. FAO's previous assessments have made major contributions to the world's understanding of the status of forest resources and patterns of tropical deforestation. They have also stimulated discussion in the international community concerning exact rates of change, methods used to capture the information, and the terms and definitions used to describe forests and forest changes.

FRA 2000 used two independent means to assess forest area change in the 1990s: data calculated from the information supplied by countries, and the findings of the pan-tropical remote sensing survey. The pan-tropical remote sensing survey provided directly comparable information on changes in tropical forests at the pan-tropical and regional levels over the 1980-1990 and 1990-2000 periods, and yielded information on the patterns of forest cover and related land use changes in the tropics. The country information represented a worldwide set of national assessments, which were harmonized according to global definitions and subjected to time series analysis to yield the FRA 2000 results.

The definitions of the forest change processes – reforestation, deforestation and afforestation – are central to the assessment of forest cover change. Box 14 provides an explanation of these processes and the relationships among them.

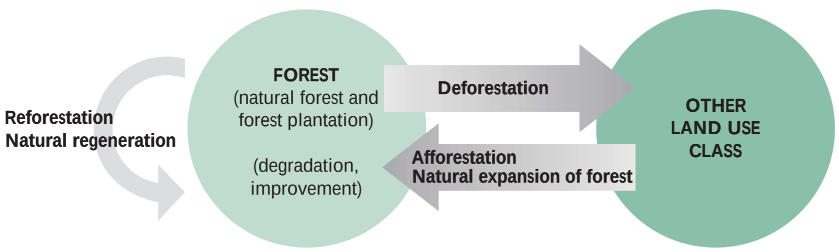
BOX 14

Definitions of forest cover change processes: deforestation, reforestation and afforestation

The figure below illustrates the relationships among forest change processes. Forest degradation and forest improvement occur within forests that continuously remain above the 10 percent canopy threshold that defines forests. Reforestation and natural regeneration on forest lands occur when forests are established or grow back, respectively, after their canopy cover has temporarily fallen below ten percent, but have been considered to be forests throughout that time (see next paragraph). Change in forest area is the result of transfers between forest and other land use classes. Gains are due to the expansion of natural forest (including succession of forests on abandoned agricultural land) and afforestation (i.e. the establishment of forest plantations on previously unforested land). Deforestation is defined as the removal of the forest and its replacement by another land use class (e.g. shifting or permanent agriculture, mining or water impoundments), or the long-term reduction of the canopy cover to less than 10 percent. In some cases, deforestation may contribute to such severe land degradation (e.g. in ecologically marginal areas, such as arid or mountain zones, and in the wet tropics) that little use can subsequently be made of the land without costly rehabilitation. By definition, timber harvesting does not, in itself, result in deforestation if the forest is allowed to regenerate.

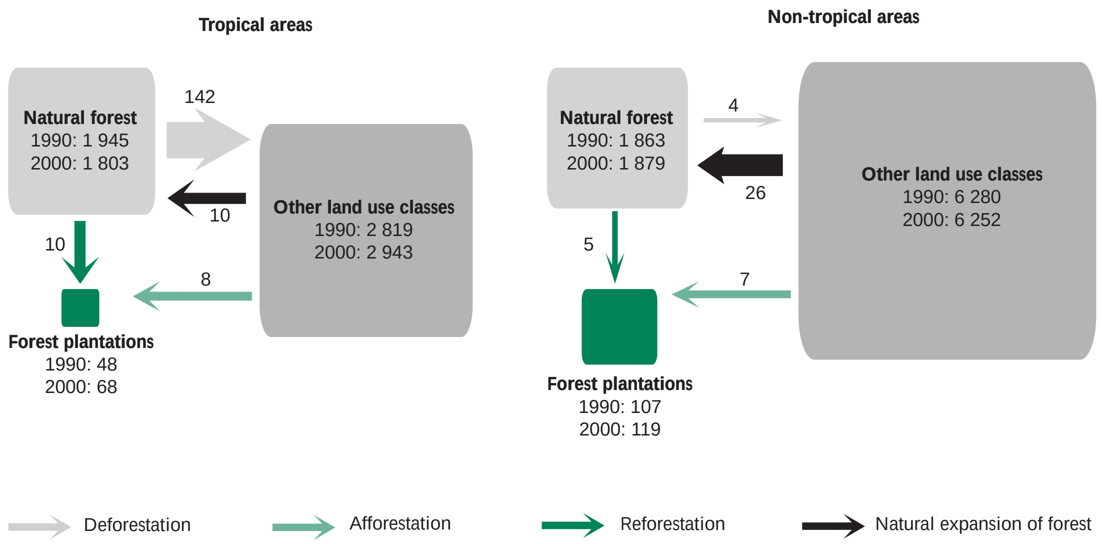
To determine whether the removal of trees from an area constitutes deforestation, it is necessary to take into account the likely development of the area. Land continues to be classified as forest if reforestation is to occur in the near future or is already under way, even if the 10 percent canopy cover threshold has not yet been reached. If, on the other hand, a sufficient density of trees is not likely to be established in the near future, or if land is converted to another land use, the area is considered to be deforested. The time frame is thus central to the forest change definitions. The suggested threshold period is ten years; "temporary" and "near future" in this context refer to less than ten years, whereas "long-term" refers to ten years or more. In some cases, the forest type, local climatic conditions, land use contexts or the purpose of the analysis may justify the use of a longer threshold period.

Relationships among forest change processes



Source: FRA 2000.

FIGURE 9
Forest area changes in the 1990s (million ha per year)



Notes: Sizes of the boxes and arrows are approximately in proportion to one another; natural regeneration within natural forests and reforestation within forest plantations are not shown; "other land use classes" include "other wooded land" and all other land uses; "tropical forests" are forests in countries covered by the FRA 2000 pan-tropical remote sensing survey.

Source: FRA 2000.

TABLE 5
Annual change in forest area, 1990-2000 (million ha)

Domain	Natural forest					Forest plantations			Total forest
	Loss			Gain	Net change	Gain		Net change	Net change
	Deforestation	Conversion to forest plantations	Total loss	Natural expansion of forest		Conversion from natural forest	Afforestation		
Tropical areas	-14.2	-1.0	-15.2	+1.0	- 14.2	+1.0	+0.9	+1.9	-12.3
Non-tropical areas	-0.4	-0.5	-0.9	+2.6	+ 1.7	+0.5	+0.7	+1.2	+2.9
World	-14.6	-1.5	-16.1	+3.6	-12.5	+1.5	+1.6	+3.1	-9.4

BOX 15

Increase in forest area in the industrialized countries

In contrast to the high deforestation rate in many tropical and subtropical countries, the rate of change in forest area in most industrialized temperate and boreal countries is low. In Europe, the area of forest is expanding, while that of "other wooded land" is decreasing, with a net expansion of forest and other wooded land of 0.3 million ha per year. Several developments are taking place in the region:

- Plantation programmes are being implemented (e.g. in France, Ireland, Turkey and Spain).
- Agricultural land or other wooded land is undergoing natural conversion to forest. (Forest is the climax ecosystem for most of Europe, so most land will revert to forest if human intervention is stopped. A probable major cause of the expansion of Europe's forest area is the depopulation of certain rural areas, owing in part to continuing changes in European agriculture.)
- At the same time, there is a contradictory trend of continuing conversion of forest and other wooded land to urban areas and other uses such as transport infrastructure and recreational facilities (e.g. ski slopes and trails).

In the United States as well, the forest area is expanding while other wooded land is decreasing; the net change is an increase of 0.4 million ha per year. Much of this increase is due to the natural transition, and reclassification, of other wooded land to forest. Most CIS countries report increases for both forest and other wooded land, with a net increase of 1.2 million ha per year for the region.

(See also Annex 1 for definitions of these and related terms.) Awareness of how these terms are defined in FRA 2000 is key to understanding the assessment's findings.

Changes in forest cover reflect transfers between forest and other land use classes (e.g. agriculture, infrastructure and mining). The net change in forest area equals the difference between the increase in forest area through both afforestation and the natural expansion of forest (e.g. through forest succession on abandoned agricultural lands), and the loss of forest through deforestation.

Figure 9 shows the changes in total forest area for 1990-2000 according to the FRA 2000 data, broken down into change in natural forests and change in forest plantations, for both tropical and non-tropical areas. Table 5 provides this information in terms of average annual change in forest area during the same period.

These data indicate that the world's natural forests continued to be converted to other land uses at a very high rate during the 1990s.

An estimated 16.1 million ha of natural forest worldwide were lost annually during the 1990s (14.6 million ha through deforestation and 1.5 million ha through conversion to forest plantations). Of the 15.2 million ha lost annually in the tropics, 14.2 million ha were converted to other land uses and 1.0 million ha were converted to forest plantations.

In non-tropical areas, 0.9 million ha of natural forest were lost per year, of which 0.5 million ha were converted to forest plantations and 0.4 million ha were converted to other land use classes.

Against the gross annual loss of 16.1 million ha of natural forests worldwide, there was a gain of 3.6 million ha as a result of the natural expansion of forest, giving a balance of -12.5 million ha as the annual net change of natural forest area globally. Of these 3.6 million ha, 2.6 million ha were in non-tropical areas, while 1.0 million ha were in the tropics. Much of the gain in natural forest area was the result of natural forest succession on abandoned agricultural land. Expansion of forest has been occurring for several decades in many industrialized countries, especially where agriculture is no longer an economically viable land use (Box 15). This has been the case, for example, in some countries in Europe.

Gains in forest area also occurred through the expansion of forest plantations. The average rate of successful plantation establishment over the decade was 3.1 million ha per year, of which 1.9 million ha were in tropical areas and 1.2 million ha were in non-tropical areas. As shown in Table 5, half of the new plantation area was on land converted from natural forest (i.e. representing reforestation on cleared natural forest land).

The net change in forest area during the 1990s (i.e. the sum of changes in natural forests and forest plantations) was an estimated -9.4 million ha per year. This represents the balance between the global deforestation rate of 14.6 million ha per year and the rate of forest area increase of 5.2 million ha per year (Table 6).

TABLE 6
Annual gross and net changes in forest area, 1990-2000
(million ha)

Domain	Deforestation	Increase in forest area[1]	Net change in forest area
Tropics	-14.2	+1.9	-12.3
Non-tropics	-0.4	+3.3	+2.9
World	-14.6	+5.2	-9.4

[1] Increase in forest area represents the sum of natural expansion of forest and afforestation (see Table 5).

The global figures obscure significant differences in forest cover change among regions and countries (Figure 10 and Table 3 of Annex 2). Net deforestation rates were highest in Africa and South America. The loss of natural forests in Asia was also high, but was significantly offset (in terms of area) by forest plantation establishment. This resulted in a more moderate rate of change of total forest area in the region. In contrast, the forest cover in the other regions, which are largely made up of industrialized countries, increased slightly. Figure 11 shows the areas of the world with the highest rates of net deforestation and the highest rates of forest area increase during the 1990-2000 period according to the FRA 2000 estimates. The countries with the highest net loss of forest area between 1990 and 2000 were Argentina, Brazil, the Democratic Republic of the Congo, Indonesia, Myanmar, Mexico, Nigeria, the Sudan, Zambia and Zimbabwe. Those with the highest net gain of forest during this period were China, Belarus, Kazakhstan, the Russian Federation and the United States.

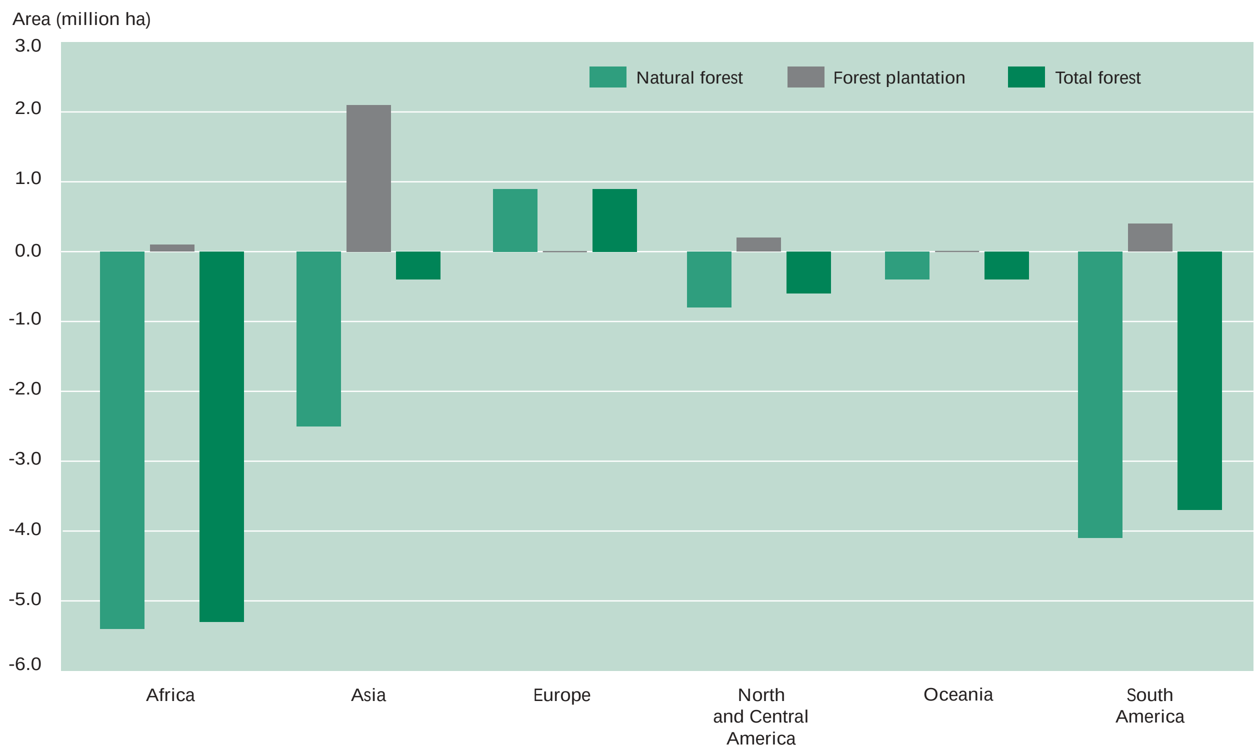
Comparison of forest area trends in 1990-2000, 1980-1990 and 1990-1995

For a longer-term picture of trends in forest area change, a comparison may be made of the rate of change in the global forest area (in million ha per year) calculated for the 1990-2000 period in FRA 2000, for 1990-1995 in the interim 1995 assessment, and for 1980-1990 in FRA 1990. In the following analysis, this comparison is made at the global level.

According to the reported numbers, the estimated net loss of forest (i.e. the balance of the loss of natural forest and the gain in forest area through afforestation and natural expansion of forest) was lower in the 1990s than in the 1980s. Net annual forest area change was estimated to be -9.4 million ha for the 1990-2000 period, -11.3 million ha in the 1990-1995 period and -13.0 million ha in 1980-1990.

However, the forest area change estimates from FRA 2000 are not directly comparable with those of the previous two assessments, owing to three factors: changes in definitions, changes in

FIGURE 10
Annual net change in forest area by region, 1990-2000



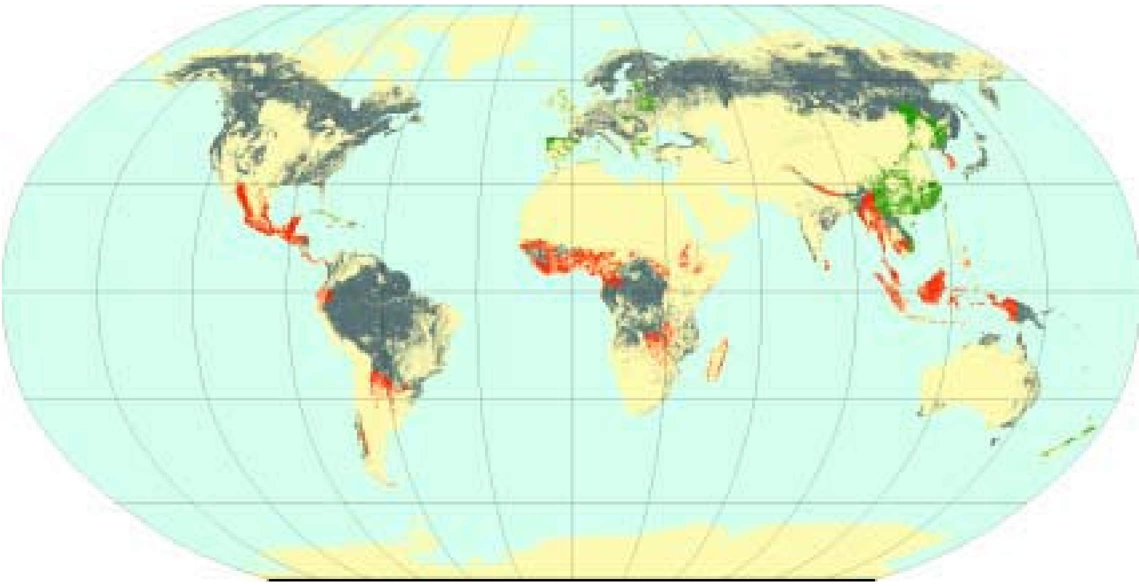
Source: FRA 2000.

methodology and updated inventory information. Nonetheless, if the effects of these three factors are taken into consideration, some general conclusions can safely be made regarding deforestation over the past 20 years.

The change of forest definition for industrialized countries, while notably increasing global estimates of forest cover, did not greatly affect the estimated rate of change of global forest area. This is because the change in definition had the greatest impact on the forest area of Australia and the Russian Federation, where conversions of forest to other land uses were relatively small on a global scale and thus did not significantly alter worldwide change rates. The revised 1990 national forest area figures (based on FRA 2000 definitions, methodologies and new data) for most other industrialized countries showed a high degree of consistency and comparability with the 1990 figures of the previous two assessments. The three assessments used essentially the same definition for natural forest for developing countries. The new definition for plantations (which allowed the inclusion of rubberwood plantations) affected the forest area figure for a few tropical countries, but without significant effect on the world forest area change rate.

The three assessments used the same methodology to assess forest area change in the industrialized countries. In the developing countries, however, FRA 1990 and the interim

FIGURE 11
Net change in forest area



>0.5% net decrease in forest area per year   >0.5% net increase in forest area per year

Note: Map shows the location of forests in countries that have the highest and lowest rates of net change in forests area. Other forests are shown in grey.

TABLE 7
Forest change matrix, 1980-2000 (% of area by land cover class)[1]

From 1980 / Into 2000	Closed forest	Open forest	Long fallow	Fragmented forest	Shrubs	Short fallow	Other land cover	Total 1980
Closed forest	88	1	1	2		2	6	100
Open forest		88		4	1	1	5	100
Long fallow	3		70	1		16	9	100
Fragmented forest	1	1		83	1	3	12	100
Shrubs					80	1	17	100
Short fallow	2	1	2	2		77	16	100
Other land cover					1	1	97	100
Total 2000 as % of 1980	88	91	98	101	88	122	118	

[1] Numbers relate to the area actually surveyed, which excludes tropical areas with low forest cover, but includes a representative sample of about 90 percent of tropical forests.

1995 assessment used regional models driven by demographic data to generate national change rates, whereas FRA 2000 relied directly on survey reports. Even so, an analysis has shown that this difference in the methodology used for developing countries does not significantly affect the estimates for global rates of change.

Updated inventory information for many countries led to new estimates at the national level. Although these were not always comparable with earlier assessments, they did not significantly affect the estimates of global change rates.

The findings of the FRA 2000 pan-tropical remote sensing survey supported the results of the country-based assessment. The survey indicated a net rate of change for tropical forests that was slightly lower in the 1990s than in the 1980s, but the difference was not statistically significant. The survey's findings on forest cover change in the 1980s and 1990s, which are completely compatible with one another, confirm a continued high rate of forest loss in the tropics during the 1990s. This result fits well with the results of the country assessment, as net gains in forest area are reported for the non-tropical countries as a whole while net losses are occurring in the tropics. The pan-tropical remote sensing survey also provided information on the patterns of forest cover change. The results show high levels of transition between various land cover classes over the 1980-2000 period (Table 7).

In conclusion, after analysis of the estimates of present and previous assessments, FRA 2000 points to a lower rate of net loss of forests worldwide in the 1990s than in the 1980s, owing mainly to a higher rate of natural expansion of forest area. At the same time, the worldwide loss of natural forests has continued at roughly comparable high levels over the past 20 years.

Forest volume and biomass

Wood supply and production are still the forest functions for which the most comprehensive data are available, as wood supply remains the focus of most forest inventories. This reflects the economic importance of wood to many forest owners, public and private. FRA 2000 estimated the biomass and volume of wood (growing stock) in forests worldwide.

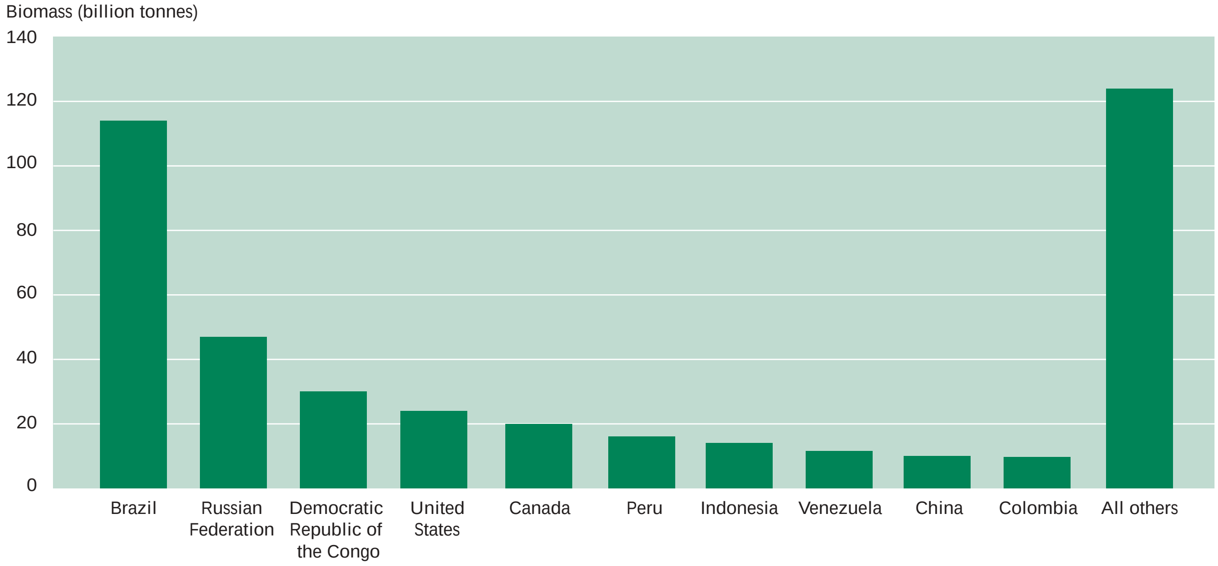
Total wood volume (m^3) and above-ground woody biomass (tonnes) in forests were estimated for 166 countries, representing 99 percent of the world's forest area. The world total of above-ground woody biomass in forests was 420 billion tonnes, of which more than one-third was located in South America (Table 8) and about 27 percent was in Brazil alone. Figure 12 shows the countries with the highest total forest woody biomass. The worldwide average above-ground woody biomass in forests was 109 tonnes per hectare (Figure 13). South America had the highest average biomass per hectare, at 128 tonnes per hectare.

The countries with the highest standing volume per hectare include many Central American and Central European countries, the former having high-volume tropical rain forests and the latter having temperate forests managed to achieve high stocking levels.

TABLE 8
Distribution of above-ground woody biomass by region

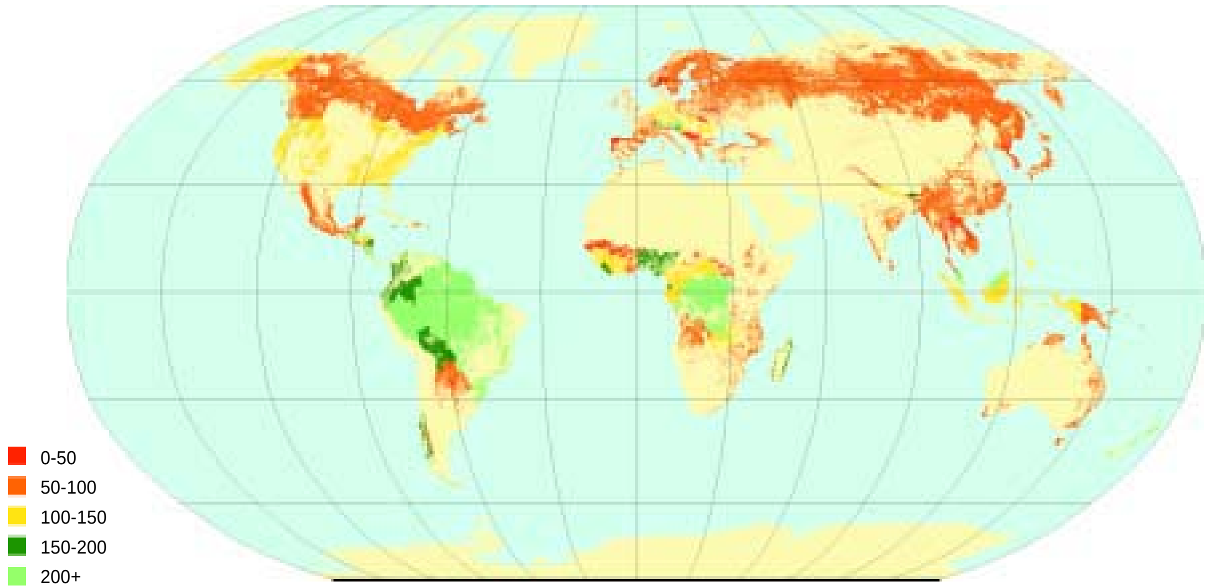
Region	Biomass *(million tonnes)*	%
Africa	70 916	16.8
Asia	45 036	10.7
Europe	61 070	14.5
North and Central America	51 895	12.3
Oceania	12 350	2.9
South America	179 947	42.7
Total world	**421 214**	

FIGURE 12
Countries with highest above-ground woody biomass



Source: FRA 2000.

FIGURE 13
Above-ground woody biomass



Note: Map shows the location of forests by the country's national average level of above-ground woody forest biomass (tonnes/ha).

FOREST MANAGEMENT IN 2000

Status and trends in forest management

Developments in forest management over the past decade have focused on progressing towards sustainable forest management in accordance with the "Forest Principles"[7] agreed at the United Nations Conference on Environment and Development (UNCED) in 1992. The sustainable forest management concept, which balances environmental, socio-cultural and economic objectives of management, has stimulated changes in forest policy and legislation and in forest management practices in many countries.

While FRA 2000 did not attempt to estimate the total area of forests under sustainable forest management worldwide, it included information on selected indicators demonstrating countries' commitment to working towards sustainable forest management (see Table 4 in Annex 2).

One measure of political commitment to the concept of sustainable forest management is the number of countries currently involved in international initiatives to develop and implement criteria and indicators for sustainable forest management. As of 2000, 149 countries were involved in a total of nine ecoregional criteria and indicator processes (Figure 14). All of these were established within the past ten years. (See also Part IV for more information on these processes.) A common indicator in all but one of these processes is the area of forest being managed according to a management plan.[8]

Information on the total area of forest being managed according to a forest management plan was collected for FRA 2000. Eighty-three countries, including all industrialized countries, provided this information for FRA 2000, and an additional 14 countries supplied comparable information to FAO's Latin American and Caribbean Forestry Commission in 2000. The findings from these countries indicate that 89 percent of forests in industrialized countries are being managed "according to a formal or informal management plan". National statistics on forest management plans were not, however, available for many developing countries, including several of the larger countries in Africa and some key countries in Asia. Nevertheless, preliminary results from developing countries showed that of a total forest area of 2 139 million ha, at least 123 million ha, or about 6 percent, were covered by a "formal, nationally approved forest management plan covering a period of at least five years".[9] It must be emphasized that the total area reported to be subject to a formal or informal forest management plan is not necessarily equivalent to the total area of forest under sustainable forest management. Some areas covered by a management plan may not be sustainably managed, while some areas not under a formal management plan may be.

Information on forest certification was also collected for FRA 2000. Forest certification is an instrument used to confirm the achievement of certain predefined minimum standards of forest management in a given forest area at a given point in time. Whereas certification implies that an area is well or sustainably managed for wood production, the total area of well-managed forest is not limited only to certified areas. Many uncertified forests, including both those managed primarily for wood production and those with other management objectives, may also be under sound management. (See Part I for more information on forest products certification.)
A number of international, regional and national forest certification schemes now exist, focusing primarily on forests managed for timber production purposes. Depending on how the

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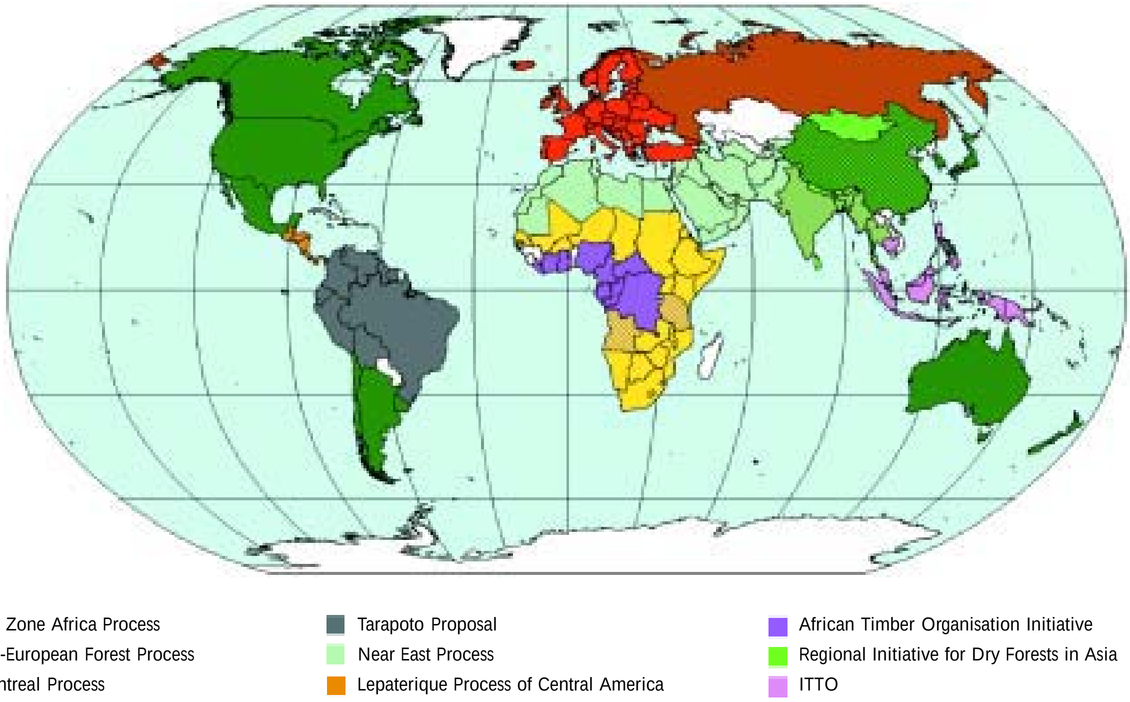
7 The full name is the Non-Legally Binding Authoritative Statement on Principles for a Global Consensus on the Management, Conservation and Sustainable Development of All Types of Forest.

8 The exception is the Montreal Process, which does not specify the area managed according to a management plan *per se*, but, rather, the percentage of forest area managed for specific objectives.

9 The use of two different definitions makes it difficult to compare the situation between industrialized countries and developing countries and to derive a global total of forests under management plans. In addition, some industrialized countries interpreted the definition in different ways. Moreover, many developing countries did not include forests in protected areas in the area under management, and some countries excluded plantations. This points to a need for further refinement and clarification of the definitions for future reporting on the area of forest under management plans.

FIGURE 14
International initiatives on criteria and indicators for sustainable forest management



term "area certified" is defined, the area of certified forests worldwide as of the end of 2000 has been estimated to be about 80 million ha, or about 2 percent of total forest area. While some important wood-producing countries in the tropics have forests certified under existing certification schemes or are in the process of developing new schemes, most certified forests are located in temperate, industrialized countries; at the end of 2000, about 92 percent of all certified forests worldwide were located in the United States, Finland, Sweden, Norway, Canada, Germany and Poland. At the same time, only four countries with tropical moist forests (Bolivia, Brazil, Guatemala and Mexico) were listed as having more than 100 000 ha of certified forests, for a combined total of 1.8 million ha.

Despite the indications above that there may be cause for cautious optimism with regard to increased implementation of sound forest management practices in at least some countries and regions, reliable information on the longer-term trends of forest management worldwide is not readily available. Very few attempts have been made in the past to estimate the extent of sustainable forest management worldwide. This is perhaps not surprising, given the number of countries and the wide variety of forest types, local conditions and management objectives. Previous attempts have, as a consequence, focused on specific regions and on specific management objectives and definitions of sustainable forest management, allowing for a partial analysis of trends. The FAO Forest Resources Assessments of 1980 and 1990 and a study undertaken by the International Tropical Timber Organization (Poore *et al.*, 1989) provide useful points of reference.

According to FRA 1980, an estimated 42 million ha of forest in 76 tropical countries were reported to be subject to "intensive management for wood production purposes" in 1980 (FAO/UNEP, 1982). In 2000, at least 117 million ha of forests in these countries were reported to be covered by a formal, nationally approved forest management plan of a duration of more than five years. Most, but not all, of these forests were managed for wood production. A reported 2.2 million ha of forests in these countries had obtained forest certification by third parties.

The ITTO study estimated that in 1988 a maximum of 1 million ha of forest in 17 tropical timber producing countries were being managed sustainably for wood production purposes. Judging from the area under management plans and/or certified in the same 17 countries in 2000, a considerably larger area may now be under sustainable management for wood production purposes. Currently more than 35 million ha of forests in these countries are covered by a formal forest management plan, and 1.7 million ha have been certified by third parties. A considerably larger area is likely to be eligible for certification or to be under sustainable management for purposes other than timber production. As a case in point, six tropical countries[10] with a combined forest area of 206 million ha, while not yet having all their forests under sustainable management, appear to have established all the conditions that make it likely that they can manage their forests sustainably in the near future (ITTO, 2000b).

The situation in temperate and boreal forests appears to have remained stable or to have improved over the past 20 years. In the early 1980s, all areas classified as closed forests in the former Soviet Union were reported as "managed according to a forest management plan", and in 2000 the Russian Federation and most of the States of the CIS reported that all forests were being "managed according to a formal or informal management plan", according to FRA 1980 and FRA 2000, respectively. Nineteen other countries in Europe provided information on the situation in the early 1980s, in 1990 and in 2000 for forest management assessments (UN-ECE/FAO, 1985; UN-ECE/FAO, 1992; UN-ECE/FAO, 2000b). For these countries, the proportion of closed forests "managed according to a forest management plan" in 1980 was 64 percent; in 1990, the proportion of forests "under active management" was 71 percent; and in 2000, 95 percent of the forest area was reported to be "managed in accordance with a formal or informal management plan". The proportion of the forest area reported to be under management in Canada and the United States increased from 60 and 41 percent, respectively, in 1990 to 71 and 56 percent, respectively, in 2000.

In summary, it appears that, overall, the situation as regards forest management has improved in most regions over the past 20 years.

Forests under protection status

Interest in the conservation of forests, particularly for biological diversity, has increased considerably during the past decade. FRA 2000 included an assessment of the area of forests worldwide under protection status, using the World Conservation Union (IUCN) classification system for protected areas (see Table 9).

FRA 2000 relied on two independent sets of statistics for assessment of forest area under protection status: data submitted by countries in response to the FRA 2000 questionnaire, and a spatial database on protected areas developed by the World Conservation Monitoring Centre (WCMC) of the United Nations Environment Programme (UNEP). Most of the FRA 2000 questionnaires were sent to national forestry agencies, while WCMC collected its information from national agencies involved in nature conservation, parks and protected areas. Comparison of these two data sources indicated that much work is still needed to harmonize national and international data, including data from different agencies in the same country. In addition, the interpretation of the concept of protected areas frequently differs substantially among countries, making the aggregation of statistics unreliable at the global level. For

[10] Cameroon, Ghana, Guyana, Indonesia, Malaysia and Myanmar.

TABLE 9
IUCN protected areas classification

Category	Definition
Category Ia	Strict nature reserve: protected area managed mainly for science
Category Ib	Wilderness area: protected area managed mainly for wilderness protection
Category II	National park: protected area managed mainly for ecosystem protection and recreation
Category III	Natural monument: protected area managed mainly for conservation of specific natural features
Category IV	Habitat/species management area: protected area managed mainly for conservation through management intervention
Category V	Protected landscape/seascape: protected area managed mainly for landscape/ seascape conservation and recreation
Category VI	Managed resource protected area: protected area managed mainly for the sustainable use of natural ecosystems

example, some countries consider that virtually all their forests fall under protected status according to IUCN Category V or VI, as a consequence of general forestry legislation that provides for management and sustainable use of forests.

Consistent global data, broken down by country, were established by overlaying the WCMC spatial database on the FRA 2000 global forest cover map. The results indicated that, worldwide, about 12 percent of forests are in IUCN Categories I to VI. The North and Central America region has the largest proportion (20 percent) of its forests under protected area status, followed by South America (19 percent). Europe is the region with the lowest proportion (5 percent), in part because the IUCN classification (particularly Categories V and VI) is not well adapted to European conditions. Figure 15 shows the location of the major areas of forest under protection status.

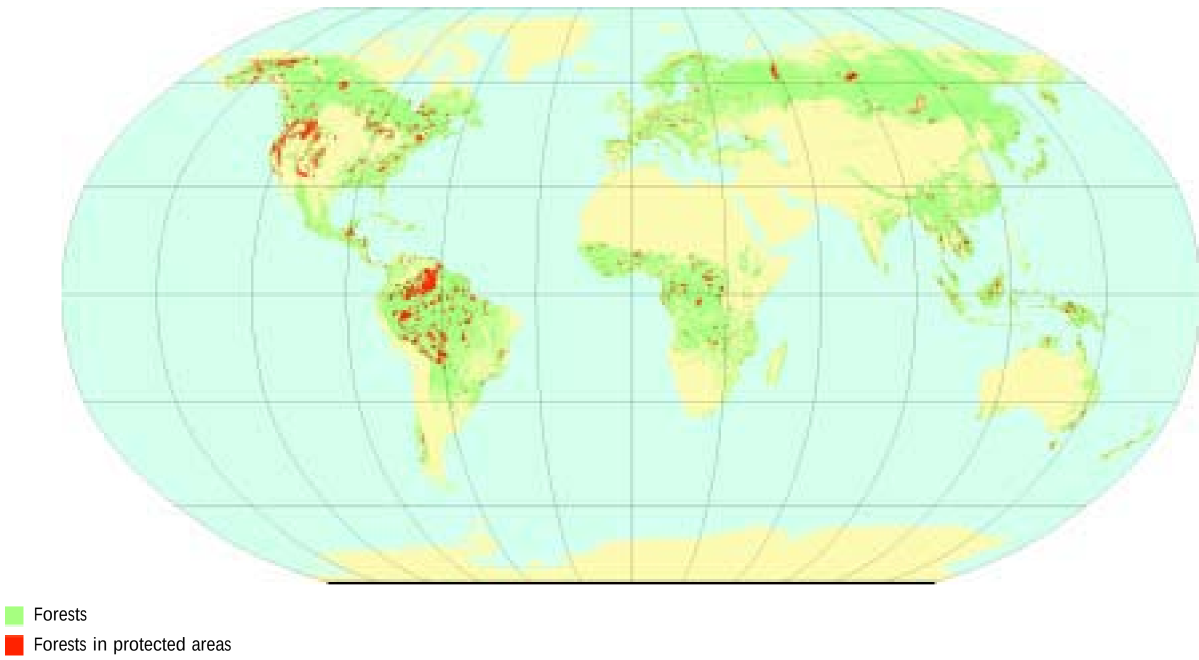
Additional parameters related to forest management in industrialized countries

The assessment process for industrialized countries, coordinated by UN-ECE, included a wider set of variables than the assessment for developing countries and yielded additional information on several important aspects of forestry. Some of these are highlighted below.

Changes in forest condition. Information was collected for FRA 2000 on factors that affect forest condition and, thus, forest management. In addition to the effort made to collect data on the extent and incidence of forest fires worldwide (see also discussion in Part I), information was collected from industrialized countries on the condition of the temperate and boreal forests and the extent of damage to them. The findings are briefly summarized as follows.

- Fire is a major problem throughout the temperate and boreal zones, although the causes and significance of fires vary from place to place.
- Insects and diseases are the most important causes of damage in many forests, although reporting is not done systematically in most countries and there are no standard ways of measuring this type of damage, which varies in severity and nature according to the cause and is often episodic.
- Damage by wildlife and livestock grazing, which mainly affects new regeneration, is significant in many countries.
- Damage by abiotic causes, such as storms or snow, is highly episodic and statistics are not usually kept. In Europe, two major storm events (in 1990 and 1999) were particularly notable. (See Part I for more information on the 1999 storm.)
- The reported figures indicate that defoliation is much more widespread in Europe than in North America. However, the comparability of defoliation figures over time and among countries is problematic, as is their significance. Pollution damage is often cited as a major contributory cause of defoliation, but there is no direct evidence for this – nor, indeed, any clear indication of what a "normal" level of defoliation should be.

FIGURE 15
Major areas of forest under protection status

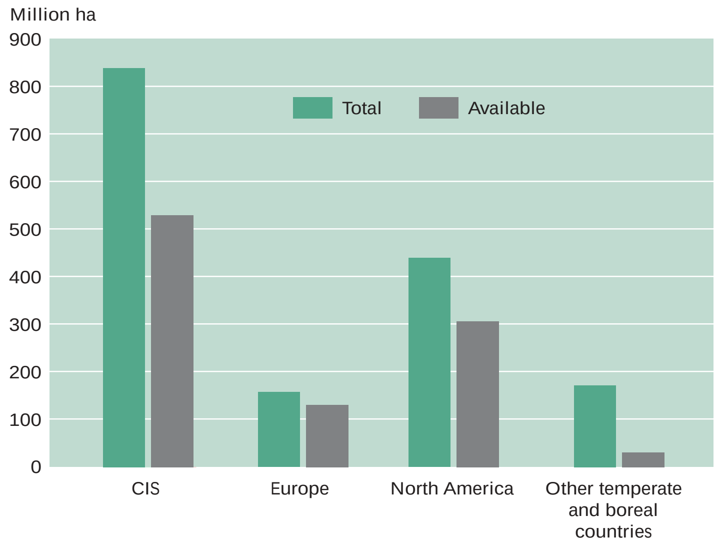


Although FRA 2000 provides information on certain types of forest damage, it is not yet possible to make an objective assessment of forest condition because of the different causes of damage and the lack of clarity as to what the condition of a "normal" or "healthy" forest would be. Forest condition should ideally be assessed in relation to forest function, but functions vary from forest to forest and over time. The advances in assessing forest condition made by FRA 2000 have raised further questions which will have to be addressed in the future.

Wood production. In many parts of the world, forests are still predominantly managed for wood supply and production. An effort was made in FRA 2000 to estimate the volume of wood, its rate of growth and how much is harvested. The results are given here for the industrialized countries.

Temperate and boreal forests of industrialized countries contain 188 billion m^3 of growing stock. Nearly half of this volume is in the Russian Federation. However, some forests are not "available for wood supply", either because they have been designated as protected or because harvesting would be uneconomical owing to their remoteness or difficult terrain (see Figure 16). In Europe, 85 percent of forest is available for wood supply, compared with 70 percent in North America and 64 percent in the CIS. In "other industrialized countries", notably Australia, many forests are considered unavailable because of their remoteness or because they are located in nature reserves. Two-thirds of the area that is not available for wood supply in Europe, and all of the area in this category in the United States and Japan, is so considered for reasons of conservation and forest protection. All unavailable forests in Japan and the United States are reported to be unavailable

FIGURE 16
Area of forest available for wood supply



Source: FRA 2000.

for these reasons. However, in Canada and the Russian Federation, economic reasons (mainly remoteness) predominate. In a context of increasing total forest area, both the areas available and those unavailable for wood supply have been growing in most countries, but the areas considered unavailable for wood supply have been growing faster. It appears that some of the "available" forest is being reclassified as "unavailable" as the area of forest under protection status grows.

The economics of wood supply are also strongly influenced by the concentration of the resource, i.e. growing stock per hectare, which in turn is influenced partly by climatic and site conditions and partly by the silvicultural practices of the present and previous forest managers. There are marked differences among countries.

Although the CIS region has by far the largest volume of growing stock of the temperate and boreal zones, its forests are less productive and are used less intensively than those in Europe and North America. Gross annual increment (GAI) in both the CIS and North America is just over 1 billion m^3, but when adjusted for natural losses (insects, mortality, fire, etc.), net annual increment (NAI) in North America is about 15 percent greater than in the CIS[11] (see Figure 17).

A salient feature of temperate and boreal forests is that in all but two countries (Cyprus and Armenia), fellings are less, often much less, than the NAI in forests available for wood supply. This results in a steady increase of the growing stock in nearly all countries. Only 59 percent of the NAI in Europe and 79 percent in North America is felled. In the CIS, only a very small part (17 percent) of the increment is felled. This is due in part to the remoteness and difficult conditions that make harvesting operations in areas of the Russian Federation very expensive, but it is also due to the widespread collapse of the forest sector institutions in the Russian Federation during the transition process. The level of fellings in 1999 was around 130 million m^3, compared with about 400 million m^3 (still lower than the increment) at the end of the 1980s.

For the temperate and boreal countries as a whole, the difference between NAI and fellings in forest available for wood supply is 1.2 billion m^3. Thus, the volume of wood in temperate and boreal forests is increasing by at least this volume every year, while the same forests are supplying a major part of the world's needs for industrial wood.

Ownership and management. Forest ownership patterns vary considerably. In Europe, Japan and the United States, well over half of the forest and other wooded land is privately owned, in almost all cases by individuals.[12] All forest land in the CIS, 93 percent in Canada, and 60 to 70

[11] This may be an overestimate, as Canada was not able to provide data on natural losses.
[12] Only in Canada, Finland, Japan, Sweden and the United States are more than 1 million ha owned by forest industries.

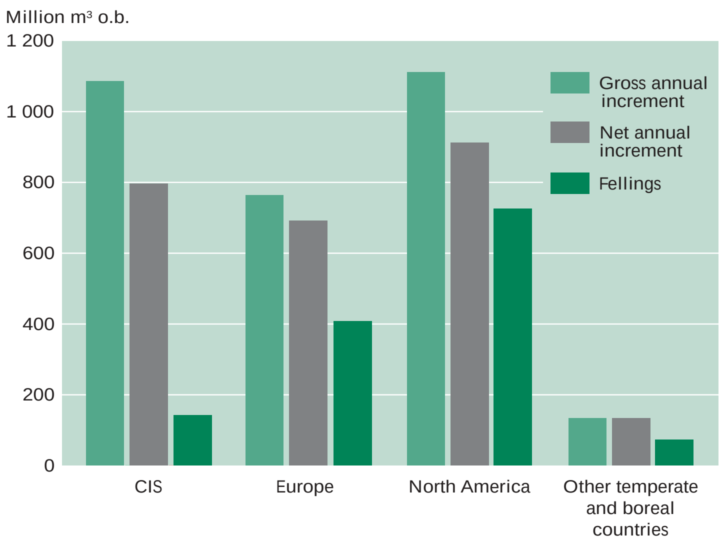
percent in Australia and New Zealand is publicly owned. Just over 2.5 percent of all forest and other wooded land – or 62 million ha – in industrialized countries belongs to indigenous and tribal peoples, as defined in the International Labour Organization's Indigenous and Tribal Peoples Convention. Most of this land is in Australia. There are, however, serious political discussions in a number of countries, including Canada and New Zealand, about giving or returning ownership of very large areas of land, much of which is forest, to indigenous peoples.

In many of the Central and Eastern European countries with economies in transition, the ownership pattern is undergoing substantial change as forest land is restituted to its former owners or is privatized. This is a long and complex process, involving major legal and practical issues.[13]

The size of a forest holding and its management are often linked. In Europe and the United States, there are many small, even minuscule, holdings, as well as some large ones. In Europe, there are about 10.7 million private forest holdings with an average size of 10.6 ha and several million private owners with holdings of less than 3 ha. There is an increasing number of absentee owners who live and work away from their forests and do not rely on them for income. This situation clearly influences the forest management objectives. Helping these owners manage their forests properly has become one of the main objectives of forest policies in many European countries.

Recreation and access. Most industrialized countries indicated that the public has access to government-owned forest for recreation and gathering of forest products for personal use. Commercial use normally requires a permit.

FIGURE 17
Gross annual increment, net annual increment and fellings



Source: FRA 2000.

Most countries have a policy of open access to privately owned forests as well, but sometimes with restrictions. A minority of countries allow access only with permission of the landowner. In general, there have been no recent significant changes in access to forests, although the increase of privately owned forests in Eastern and Central Europe as well as the increase in protected areas may slightly reduce the areas open to public access.

The importance of forests for leisure and recreational use is increasing across the temperate and boreal zones. Forests are frequently used for picnicking, hiking, camping, riding and mountain biking. Many countries emphasize the importance of forests for recreation near population centres. Forests are also valued for social benefits not directly related to leisure, such as microclimate, noise reduction and aesthetics. Most countries report that demand for the cultural, historic, spiritual and scientific values of their forests is increasing.

[13] The issues include the difficulty of finding and accurately identifying the former owners or their heirs 50 years after expropriation, setting out property boundaries on the ground, and providing support and guidance to thousands of new forest owners, many of whom retain a suspicion of central authority.

CONCLUSIONS

The Forest Resources Assessment 2000, a joint endeavour carried out by FAO in cooperation with its member countries and other partners, particularly UN-ECE, collected and synthesized a vast amount of information on the status and trends in forest area worldwide, on forest management and on additional forest-related variables. It also provided important findings on the status of forest inventories and of other information needed for policy-making and forest management decisions that underpin countries' efforts to work towards sustainable forest management. Despite the acknowledged limitations in the available information on which the assessment is based, FRA 2000 represents the most comprehensive, reliable and authoritative baseline survey of forest resources at the global level, and provides an excellent basis for future improvement of the information on the world's forests.

The major conclusions of FRA 2000 related to the subjects presented in this chapter are as follows.

- The total forest area in 2000 was 3.9 billion ha, of which 95 percent was natural forest and 5 percent was forest plantation.
- For the first time, a uniform definition of forest was used in FAO's global forest assessment. The application of a uniform definition resulted in forest cover figures for some countries that were significantly higher than those of previous assessments. This does not indicate a real increase in forest area. FRA 2000 recalculated the 1990 forest cover figures, using the same definitions and methodologies used for calculating the 2000 figures, to make the comparison between 1990 and 2000 possible. This sets a new baseline for forest cover in 1990.
- About 47 percent of forests worldwide are tropical, 9 percent subtropical, 11 percent temperate and 33 percent boreal.
- The world's natural forests have continued to be converted to other land uses at a very high rate. During the 1990s, the total loss of natural forests (i.e. deforestation plus the conversion of natural forests to forest plantations) was 16.1 million ha per year, of which 15.2 million ha occurred in the tropics.
- The area of forest plantations increased by an average of 3.1 million ha per year during the 1990s. Half of this increase was the result of afforestation on land previously under non-forest land use, whereas the other half resulted from conversion of natural forest.
- At the global level, the net change in forest area for the 1990s was an estimated -9.4 million ha per year (equivalent to 0.2 percent of total forests). This was the combined effect of a deforestation rate of 14.6 million ha per year and a rate of forest increase of 5.2 million ha per year.
- According to reported numbers, the estimated net loss of forest (i.e. the balance of the loss of forest area by deforestation and the gain through afforestation and the natural expansion of forest) was lower in the 1990s than in the 1980s. Although the rate of change figures for the two decades are not directly comparable because of changes in definitions and methodologies and updated inventory information, there is reasonable evidence that the net rate of forest loss has decreased.
- The above-ground woody biomass in forests amounts to 420 billion tonnes (dry), of which 27 percent is in Brazil alone. The standing volume of forests is highest in Central America and Central Europe.
- The concept of sustainable forest management – and efforts to achieve it – continued to gain momentum around the world during the past decade. As of 2000, 149 countries were involved in international initiatives to develop and implement criteria and indicators for sustainable forest management, although the degree of implementation varies considerably. The area of forests worldwide under formal or informal management plans, another indicator of efforts to improve forest management, increased. Furthermore, interest in forest certification increased; a number of forest certification schemes were

established during the past decade and the total global area of certified forests grew to 80 million ha by the end of 2000.
- An estimated 12 percent of the world's forests are under protected area status (as defined by IUCN Categories I to VI).
- FAO used the best available and most relevant information on forest resources for FRA 2000. Although some countries had notably improved their inventories over the past decade and the number of reports on forest resources increased in the 1990s, many countries still lack the basic data needed to assess accurately the state and changes of their forests. Most countries updated their forest cover estimates during the 1990s, often through remote sensing mapping approaches, but in many cases the methodology was not directly compatible with previous surveys, making change estimates difficult. There is a scarcity of comparable multiple-date inventories and a need to improve both the accuracy and depth of information provided in forest inventories.

Lessons learned from global forest assessments provide the basis for the development of new and better ways of generating reliable information on the world's forests. There is a pressing need, however, to continue to seek more accurate and objective information for future global surveys, and to strengthen countries' capacity to carry out forest inventories and monitor changes in their forest resources. An improved information base on forest resources is critical for the development and implementation of policies and programmes in sustainable forest management. FAO will seek to further its work with countries and other partners in this field through the development of new techniques and the training of professionals in forest inventory. ◆

Climate change and forests

The mitigation of global climate change through forestry was first proposed in the 1970s (Dyson, 1977). It was not until the late 1990s, however, that international negotiations considered this potential at a global level, calling for a definition and quantification of the role of forests and proposing a mechanism for international collaboration.

In 1992, the Framework Convention on Climate Change (FCCC) was adopted as a consequence of worldwide concern about global warming. The Convention aims at stabilizing the concentration of greenhouse gases in the atmosphere in an effort to reduce human-induced disturbances to the global climate system. The industrialized countries and countries in transition that are parties to the FCCC (Annex 1 Parties) committed themselves to carrying out national inventories of greenhouse gas emissions and carbon sinks, and to working towards voluntary goals in the reduction of emissions. At the third meeting of the Conference of the Parties, held in Kyoto, Japan in December 1997, an additional legally binding instrument was adopted: the Kyoto Protocol to the Framework Convention on Climate Change. Thirty-nine developed countries (comprising a slightly modified list of Annex 1 Parties) committed themselves to reducing their greenhouse gas emissions between 2008 and 2012 by at least 5 percent compared with 1990 levels. Parties can meet this commitment by reducing sources or protecting or enhancing sinks of greenhouse gases. The Kyoto Protocol foresees the inclusion of changes resulting from direct human-induced land use change and forest activities, limited to afforestation, reforestation and avoidance of deforestation.

The Kyoto Protocol also sets up a framework for the transfer of emission credits between parties. Three flexible mechanisms were introduced that permit signatory countries to meet their commitments partially or fully: projects undertaken jointly by Annex I Parties (Joint Implementation), projects between Annex I and non-Annex I Parties (Clean Development Mechanism) and emissions trading. Although the Kyoto Protocol has not entered into force and it is as yet[14] undecided whether forests will be included as sinks within the ambit of the flexible mechanisms, the role of forests in the context of climate change merits a close look because of the impact that the outcome of related decisions could have.

GLOBAL CARBON CYCLE

The International Panel on Climate Change (IPCC)[15] estimates that the global mean temperature of the earth's surface has increased by 0.3 to 0.6ºC over the past 100 years (IPCC, 2000). Predictions are that global warming will cause significant variations in climatic patterns over the next century that may have negative impacts on regional and global biomes. It is now generally accepted that this change in global temperature is caused primarily by rising atmospheric concentrations of greenhouse gases, principally carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The most important of these greenhouse gases, CO_2, accounts for some 65 percent of the "greenhouse effect". The rise of atmospheric CO_2 concentrations since the beginning of the industrial revolution has been caused by anthropogenic activity, in particular the

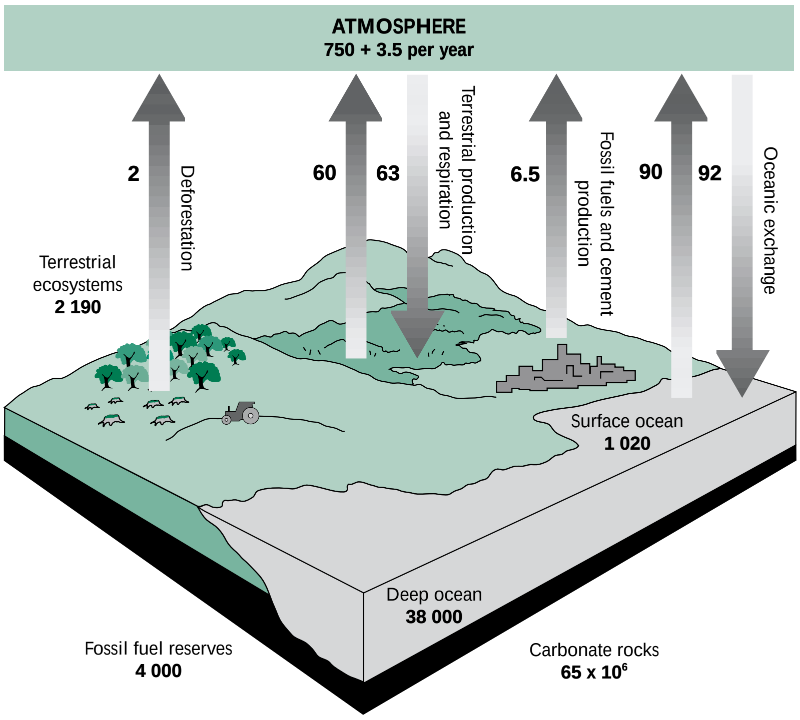
[14] As of June 2001.

[15] IPCC was set up in 1988 by the World Meteorological Organization and the United Nations Environment Programme. It provides the world community, but in particular the Parties to the FCCC, with scientific, technical and socio-economic information and advice related to human-induced climate change.

combustion of fossil fuels, cement manufacture and deforestation.

Terrestrial ecosystems play a significant role in the global carbon cycle. An estimated 125 gigatonnes (Gt)[16] of carbon are exchanged annually between vegetation, soils and the atmosphere, accounting for two-fifths of the total exchange of carbon between the earth and the atmosphere (see Figure 18). Forests account for some 80 percent of this exchange. While the world's forests are absorbing carbon, they are also releasing it. Deforestation is a significant source of carbon emissions; evidence suggests that deforestation in the 1980s may have accounted for one-fourth of all anthropogenic carbon emissions (Houghton, 1999).[17] However, it has been suggested that the terrestrial biosphere could be managed over the next 50 years to conserve or sequester 60 to 87 Gt of carbon in forests and another 23 to 44 Gt of carbon in agricultural soils (Brown *et al*., 1996).

FIGURE 18
An estimate of the current global carbon cycle[1]



[1]All numbers are in gigatonnes (Gt) of carbon (1 Gt = 1 billion tonnes).

Note: The magnitude of the fluxes between the atmosphere and the oceans and terrestrial biosphere is still uncertain and is the subject of ongoing research.

THE ROLE OF FORESTS IN THE GLOBAL CARBON BUDGET

Carbon stocks in forest ecosystems

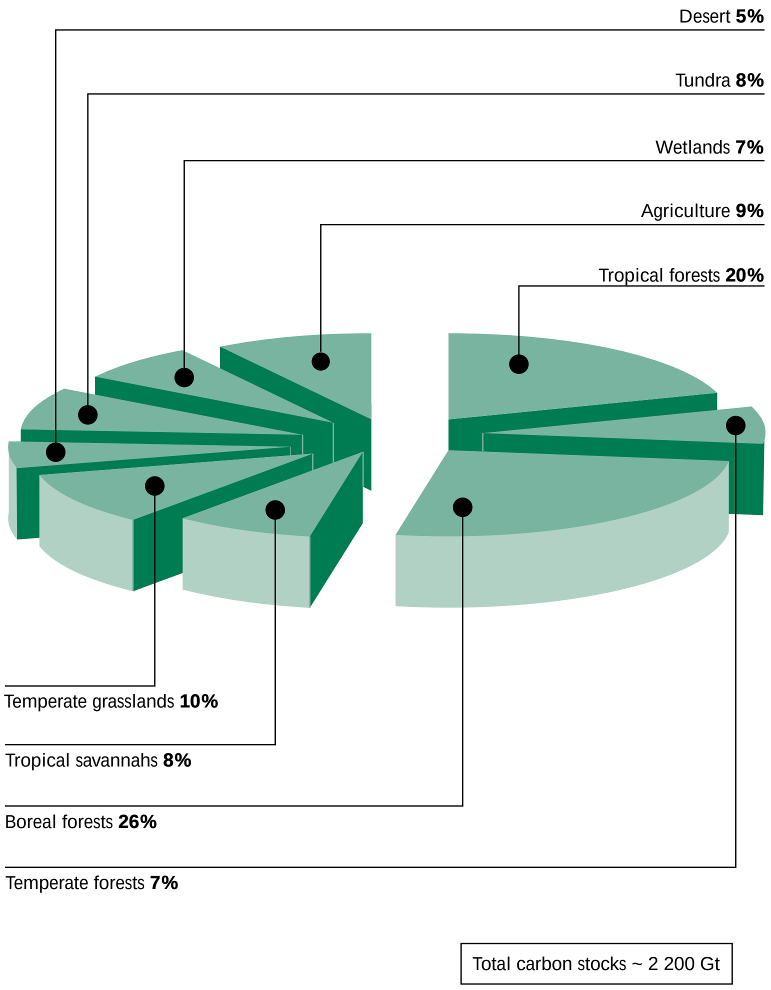
Carbon accumulates in forest ecosystems through the absorption of atmospheric CO_2 and its assimilation into biomass. Carbon is stored in living biomass, including standing timber, branches, foliage and roots; and in dead biomass, including litter, woody debris, soil organic matter and forest products. Any activity that affects the amount of biomass in vegetation and soil has potential to sequester carbon from, or release carbon into, the atmosphere.

Overall, forests contain just over half of the carbon residing in terrestrial vegetation and soil, amounting to some 1 200 Gt of carbon (see Figure 19). Boreal forests account for more carbon than any other terrestrial ecosystem (26 percent of total terrestrial carbon stocks), while tropical and temperate forests account for 20 and 7 percent, respectively (Dixon *et al*., 1994). In comparison with other vegetation in other terrestrial ecosystems, forest vegetation has a very high carbon density (see Figure 20).

The carbon stored in the soil and litter of forest ecosystems also makes up a significant proportion of the total carbon pool. Globally, soil carbon represents more than half of the stock of carbon

[16] 1 Gt is equivalent to 1 billion tonnes.
[17] Data for carbon emissions resulting from land use change in the 1990s are not yet available.

FIGURE 19
Terrestrial carbon stocks by ecosystem



Note: 1 gigatonne (Gt) = 1 billion tonnes.
Source: Dixon *et al*., 1994; Schlesinger, 1997.

in forests. There are, however, considerable variations among ecosystem and forest types. Between 80 and 90 percent of the carbon in boreal ecosystems is stored in the form of soil organic matter, whereas in tropical forests the carbon is fairly equally distributed between vegetation and soil (see Table 10). The primary reason for this difference is the influence of temperature on the relative rates of production and decay of organic matter. At high latitudes (i.e. in cooler climates), soil organic matter accumulates because it is produced faster than it can be decomposed. At low latitudes, however, warmer temperatures encourage the rapid decomposition of soil organic matter and subsequent recycling of nutrients.

Carbon fluxes from forest ecosystems

All forest biomes have undergone major changes in distribution since the height of the last ice age (18 000 years ago), when the climate was both cooler and more arid than it is today. Boreal and northern temperate forests were squeezed between advancing ice sheets and steppe tundra from the north and expanding semi-desert and steppe tundra from the south, while tropical rain forests retreated into small pockets as savannah expanded. The amount of carbon stored in terrestrial biomes was 25 to 50 percent lower than at present. Terrestrial carbon storage peaked in the warm, moist early Holocene period about 10 000 years ago and subsequently declined by about 200 Gt to reach today's level (2 200 Gt of carbon), probably because of a gradual cooling and aridification of the climate.

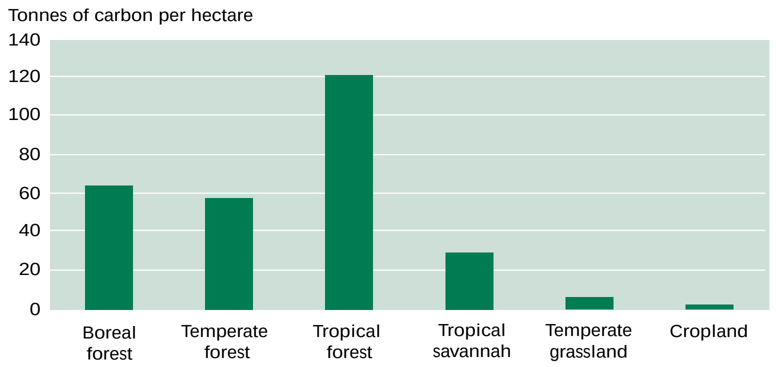
Prior to the nineteenth century, humans exerted only a modest influence on terrestrial carbon storage through fire, fuel use and deforestation, but since the outset of the industrial revolution, human activities have had a major effect on the global carbon cycle. Between 1850 and 1980, more than 100 Gt of carbon were released into the atmosphere as a result of land use changes, representing about one-third of the total anthropogenic carbon emissions over this period (Houghton, 1996).

Until the late nineteenth century, most forest clearing and degradation took place in temperate regions. In the twentieth century, the area of temperate forest largely stabilized and tropical forests became the primary source of carbon emissions from terrestrial ecosystems (Houghton, 1996). Today, forest cover in developed countries is increasing slightly: between 1980 and 1995 there was an average increase of 1.3 million ha per year (FAO, 1999d). In recent decades, many temperate forest regions (such as Europe and eastern North America) have become moderate carbon sinks through the establishment of plantations, the regrowth of forests on abandoned agricultural lands, and increased growing stock in forests. In contrast, tropical forests have become a major source of carbon emissions; the rate of tropical deforestation is estimated to have been 15.5 million ha per year in the period 1980-1995 (FAO, 1999d).

Net carbon emissions resulting from land use change in the 1980s are estimated to be between 2 and 2.4 Gt per year (see

FIGURE 20

Above-ground carbon density for selected vegetation types



Source: IPCC, 2000.

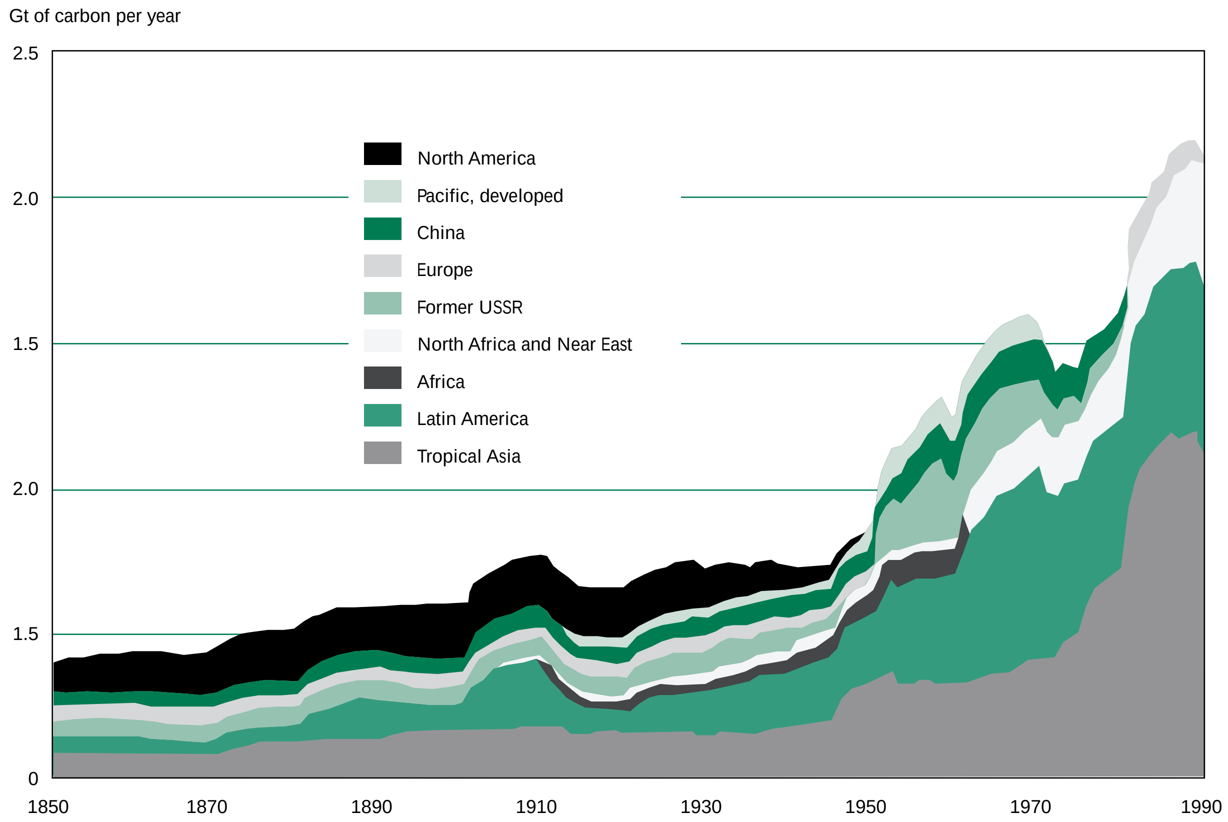
TABLE 10

Carbon density and stock of vegetation and soils for different ecosystems

Ecosystem	Country/region	Vegetation carbon density *(tonnes/ha)*	Soil carbon density *(tonnes/ha)*	Vegetation carbon stock *(Gt)*	Soil carbon stock *(Gt)*	Total carbon stock *(Gt)*
Boreal	Russian Federation	83	281	74	249	323
	Canada	28	484	12	211	223
	Alaska	39	212	2	11	13
Temperate	United States	62	108	15	26	41
	Europe	32	90	9	25	34
	China	114	136	17	16	33
	Australia	45	83	18	33	51
Tropical	Asia	132-174	139	41-54	43	84-97
	Africa	99	120	52	63	115
	Americas	130	120	119	110	229

Note: 1 gigatonne (Gt) = 1 billion tonnes.
Source: Dixon *et al*., 1994.

FIGURE 21
Carbon emissions from land use change



Source: Houghton, 1999.

Figure 21), equivalent to between 23 and 27 percent of all anthropogenic emissions (Houghton, 1999; Fearnside, 2000). Tropical deforestation accounts for most of the carbon emissions from land use change. The burning of biomass also releases other greenhouse gases, including methane and nitrous oxide. Burning of forest biomass accounts for 10 percent of global methane emissions. Forest degradation also results in carbon loss. An estimated net annual emission of 0.6 Gt of carbon was due to the degradation of forests in the tropics during the 1980s (Houghton, 1996). In tropical Asia, the loss of carbon resulting from forest degradation almost equals that caused by deforestation.

There is accumulating evidence that human-induced changes in concentrations of atmospheric gases are affecting the carbon cycle in forests. Global atmospheric CO_2 concentrations have risen from 280 ppm before the industrial revolution to 370 ppm in 2000, and nitrogen deposition rates in forests near industrial regions have increased substantially. Both these effects are likely to lead to an increase in plant growth and productivity. Permanent forest sample plots in climax forests of North and South America have shown significant increases in forest biomass in recent years. Other evidence for enhanced carbon uptake in forest regions comes from micrometeorological measurements of CO_2 fluxes above forests and assessments of atmospheric CO_2 distributions at continental scales. Studies suggest that, through the combined effects of reforestation, regrowth of degraded forests and enhanced growth of existing forests, between 1 and 3 Gt of carbon are absorbed per year, approximately offsetting the global emissions from deforestation (Malhi, Baldocchi and Jarvis, 1999).

CLIMATE CHANGE AND FORESTS[18]

If the temperature at the earth's surface increases during the twenty-first century as predicted, all ecosystems will experience the most rapid period of climate change since the end of the last ice age. The distribution and composition of forests will be affected by this change, and management strategies will need to accommodate the prospect of rapidly shifting climate zones and ecosystem margins.

Box 16 presents the predicted impacts on major forest types under climate change scenarios as indicated by IPCC models of global climate change in the twenty-first century. The models show a fair degree of consistency in their predictions of global warming, with less agreement on changes in precipitation. All these model scenarios assume that no big "surprises" will occur.[19] Using IPCC climate prediction scenarios, the key changes expected towards the end of the twenty-first century are:

- the atmospheric concentration of CO_2 will approximately double;
- the mean global temperature will increase by 1.5 to 4.5°C;
- precipitation will increase globally by 3 to 5 percent;
- the sea level will rise by about 45 cm.

Regional climate predictions are needed to determine the impacts on forests. There is a fair degree of confidence in most regional temperature predictions. The largest increases in temperature will be in the northern high latitudes, with lower increases nearer the tropics and in regions with a strong oceanic influence. Although precipitation will increase globally, regional predictions are less reliable. Overall, the key climatic changes controlling forest growth responses will be temperature increases at high latitudes and changes in rainfall at low latitudes. Any regions with increased temperature and unchanged or reduced rainfall will experience significant reductions in soil moisture, which will constrain plant growth and increase the likelihood of fire. Large outbreaks of fire may lead to significant losses of forest cover.

Existing forest stands may persist for some time under a changed climate, but long-term responses to climate change will depend on the capability of species to adapt to the new conditions or to change their geographic distributions. This capability will be determined by the variation within and between species in their physiological responses to changes in temperature, CO_2 concentration, soil moisture and, in some areas, increased nitrogen deposition. It will also depend on soil types and the ecological relationships between species that affect pollination, dispersal and damage through herbivory or pest and pathogen attacks. The nature of the landscape and the intensity of human activities will also be determining factors. For example, habitat fragmentation will affect how effectively species can change their geographic range in response to ecosystem shifts. Mountains may be particularly important refugia in a warming climate because many species will find it easier to shift their range upwards in altitude, to a cooler climate, than upwards in latitude over large distances. Changes in species distribution may lead to new species assemblages and may involve species losses.

Changes in forest cover could induce feedback effects on the climate by modifying surface temperatures and by influencing atmospheric CO_2 concentrations. Forests have a lower albedo (i.e. they reflect less light) than other ecosystems and, through their extensive root systems, have more access to soil water than other types of

[18] This section is based on WCMC (in press). The information is reproduced here with the permission of the World Conservation Monitoring Centre.

[19] Such changes could include the sudden release of methane from ocean deposits or the oxidation of northern forest soil carbon reserves, either of which would lead to accelerated warming or the slowing down of the North Atlantic thermohaline circulation, which could possibly lead to climate cooling.

BOX 16

Impacts of climate change on different forest types

Boreal forests will experience the largest temperature increases of all forests. The warming effect is expected to be greater in winter (4°C above the levels of the 1970s by the middle of the twenty-first century) and slightly lower in summer (2.5 to 3°C above the levels of the 1970s). Reduced moisture in the soil during summer will increase drought stress and the frequency and extent of wildfires. Climate zones are expected to shift northwards by as much as 5 km per year. Boreal forests will make gains in areas to the north, but will experience dieback and replacement at their southerly extremes. Changes in the frequency, intensity and extent of wildfires in response to increased heat stress will play a critical role in determining the dynamics of the changes at the southern fringe of the boreal forests. Models used to predict the long-term potential changes in the distribution of vegetation suggest that the overall response may be either a reduction (by up to 36 percent) or an expansion (by up to 16 percent) in boreal forest area, although a reduction is more likely. Few tree species are likely to become extinct, but local species loss may be significant.

Temperate forests will be most affected by climate warming at higher latitudes (2.6°C above the levels of the 1970s by the middle of the twenty-first century) and by changes in rainfall at lower latitudes. Drought stress at certain low-latitude margins (such as the Mediterranean and southwestern United States) may lead to significant dieback, while increased temperatures may enhance growth at higher latitudes. Climate zones will shift towards the poles at rates of up to 5 km per year. The potential area available for temperate forest growth is likely to expand by between 7 and 58 percent. The high level of fragmentation of many temperate forests is likely to limit effective dispersal of some tree species (and have an impact on forest-based wildlife). This may lead to significant species losses locally.

Tropical forests are expected to warm by 2°C above the levels of the 1970s by the middle of the twenty-first century, with larger increases in continental interiors. Changes in rainfall regime, however, are likely to be more important than changes in temperature, although model predictions of regional rainfall patterns vary substantially. Where there are reductions in rainfall and higher temperatures, reduced soil moisture is expected to be the most significant threat to tropical forests. These effects may increase vulnerability to fire or lead to significant dieback or changes in vegetation types in marginal areas. Interannual variability as a result of large-scale climatic events (such as those caused by the El Niño phenomenon) may exacerbate rainfall extremes. Depending on future climate scenarios, the potential tropical forest area could shrink by as much as 30 percent or expand by up to 38 percent. In most tropical regions, however, the impact of human activities such as deforestation or burning will be more important than climate change in determining forest cover. A shrinking of the area of tropical forests, particularly of moist tropical forests, would be likely to result in significant species losses.

Tropical montane cloud forests are expected to warm by 1 to 2°C by the middle of the twenty-first century, but they are most threatened by changes in the height of the cloud base, on which they depend for dry season water supply. Cloud base heights are likely to rise by as much as 2 m per year – which would affect the species in these forests. Where mountains are isolated and insufficiently high to accommodate upward changes in cloud height, climate change may lead to the local, if not total, extinction of some montane vegetation species (many of which are endemics). There is evidence from cloud forest in Monteverde, Costa Rica that such changes are already occurring. Cloud forests may be harbingers of climate change effects on global forest ecosystems.

Mangrove forests are expected to be able to adapt to rising temperatures but may be threatened by rising sea levels. This threat will be particularly acute for sediment-poor coasts, such as those found on small islands, and in areas where inland dispersal of forest species is constrained by human land use.

Source: WCMC, in press.

vegetation. In consequence, they absorb more solar energy, which can lead to heating, and lose more water through evaporation, which can lead to cooling. In tropical zones, evaporation processes tend to dominate and the net effect of forests is to cool and moisten the atmosphere. At higher latitudes, albedo effects are more important, thereby leading to local warming.

CARBON MANAGEMENT STRATEGIES

There are three possible strategies for the management of forest carbon (see Table 11). The first is to increase the amount or rate of carbon accumulation by creating or enhancing carbon sinks (carbon sequestration). The second is to prevent or reduce the rate of release of carbon already fixed in existing carbon sinks (carbon conservation). The third strategy is to reduce the demand for fossil fuels by increasing the use of wood, either for durable wood products (i.e. substitution of energy-intensive materials such as steel and concrete) or for biofuel (carbon substitution). These strategies are not mutually exclusive. A number of carbon sequestration and carbon conservation initiatives have already been developed, including Activities Implemented Jointly (AIJ)[20] under the FCCC and Land Use Change and Forestry (LUCF) carbon projects.

Carbon sequestration

The carbon sequestration potential of afforestation / reforestation is specific to the species, site and management involved, and it is therefore very variable. Typical sequestration rates for afforestation / reforestation, in tonnes of carbon per hectare per year, are: 0.8 to 2.4 tonnes in boreal forests, 0.7 to 7.5 tonnes in temperate regions and 3.2 to 10 tonnes in the tropics (Brown *et al.*, 1996). The sequestration potential for agroforestry practices is even more variable, depending on the planting density and production objectives of the system.

Assuming a global land availability of 345 million ha for afforestation / reforestation and agroforestry activities, Brown *et al.* (1996) estimate that approximately 38 Gt of carbon could be sequestered over the next 50 years – i.e. 30.6 Gt by afforestation / reforestation and 7 Gt through the increased adoption of agroforestry practices

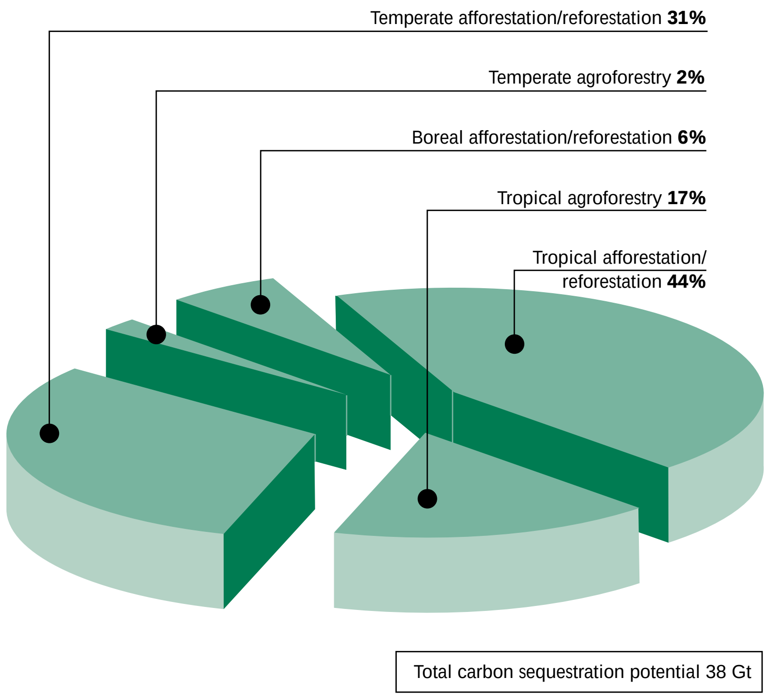
[20] AIJ projects are pilot projects carried out under the FCCC for testing and evaluating the feasibility of achieving the Convention's objectives through cooperative efforts between Parties to avoid, sequester or reduce greenhouse gas emissions.

TABLE 11
Overview of terrestrial carbon management strategies and potential land use and forest activities

Carbon management strategy	Type of land use and forest activity
Carbon sequestration	• Afforestation, reforestation and restoration of degraded lands • Improved silvicultural techniques to increase growth rates • Implementation of agroforestry practices on agricultural lands
Carbon conservation	• Conservation of biomass and soil carbon in existing forests • Improved harvesting practices (e.g. reduced impact logging) • Improved efficiency of wood processing • Fire protection and more effective use of burning in both forest and agricultural systems
Carbon substitution	• Increased conversion of forest biomass into durable wood products for use in place of energy-intensive materials • Increased use of biofuels (e.g. introduction of bioenergy plantations) • Enhanced utilization of harvesting waste as feedstock (e.g. sawdust) for biofuel

Source: Bass *et al.*, 2000.

FIGURE 22
Potential contribution of afforestation/reforestation and agroforestry activities to global carbon sequestration, 1995-2050



Source: Data from Brown *et al*., 1996.

(see Figure 22). Studies of tropical regions indicate that an additional 11.5 to 28.7 Gt of carbon may be sequestered through the assisted regeneration of about 217 million ha of degraded land.

However, the actual availability of land for forest activities may be considerably less when full account is taken of social and economic factors. Only one-third of ecologically suitable land may actually be available for afforestation/ reforestation activities (Houghton, Unruh and Lefebvre, 1991). Under this scenario, afforestation/reforestation and agroforestry activities would absorb about 0.25 Gt and the restoration of degraded lands a further 0.13 Gt of carbon per year.

Silvicultural activities that increase the productivity of forest ecosystems, such as timely thinning, can increase forest carbon stocks to some extent. However, compared with afforestation/reforestation, the effect of varying silvicultural systems on total carbon stocks is relatively low (Dixon *et al*., 1993).

Carbon conservation

While the most effective means to reduce atmospheric concentrations of CO_2 is the reduction of emissions from fossil fuel combustion, in terms of land use change and forestry the conservation of existing forest carbon stocks has technically the greatest potential for rapid mitigation of climate change. As the majority of carbon emissions from deforestation occur within a few years of forest clearance, reducing the rate of deforestation will produce a more immediate effect on global atmospheric CO_2 levels than will afforestation/ reforestation measures, in which similar volumes of carbon may be removed from the atmosphere but over a much longer period.

The potential for carbon conservation through the maintenance of forest cover is dependent on the assumed baseline for non-project deforestation (i.e. "business as usual"). In principle, 1.2 to 2.2 Gt of carbon could be conserved annually if deforestation were stopped completely (Dixon *et al*., 1993). However, while carbon revenues could improve the economics of forest land, projects will also have to address the underlying causes of deforestation and unsustainable forest use to achieve effective carbon conservation. Brown *et al*. (1996) estimate that a reduction in deforestation in tropical regions could feasibly conserve 10 to 20 Gt of carbon by 2050 (0.2 to 0.4 Gt per year).

The conservation of carbon stocks in existing forest may be achieved through improved management practices. Potentially, the most important is the use of reduced impact logging (RIL) in the tropics. Conventional logging practices may result in a high level of damage to the residual stand, with up to 50 percent of remaining trees damaged or killed (Kurpick,

Kurpick and Huth, 1997). The application of RIL techniques can reduce the level of damage to the residual stand by 50 percent (Sist *et al.*, 1998) and hence reduce the level of carbon emissions associated with logging. Nabuurs and Mohren (1993) calculated that long-term carbon conservation resulting from RIL in tropical rain forest may be between 73 and 97 tonnes per hectare. Given that an estimated 15 million ha of tropical forest is logged each year (Singh, 1993), the majority of which is considered to be unsustainable (Poore *et al.*, 1989), the potential for increased carbon storage is large. The additionality of carbon conserved through RIL techniques is dependent on the assumption that conventional logging would continue in the absence of intervention, and there is concern about how to quantify the changes in carbon stocks associated with changes in harvesting practices (IPCC, 2000, Chap. 4).

Wildfires result in large losses of carbon from forests every year. Weather conditions brought on by climate change, such as the enhanced El Niño phenomenon, increase the potential risk of wildfires. Fire management practices have the potential to conserve carbon stocks in forests. However, if fire management is to be effective, fire prevention and firefighting efforts must be combined with land use policy changes and measures to address the needs of rural populations. There could also be problems in assessing the baseline for fire prevention projects, which will be dependent on interactions between human factors and stochastic factors such as weather.

Carbon substitution

Biofuels currently provide 14 percent of the global primary energy supply. In developing countries, biofuels account for one-third of the total energy supply. If current biofuel use were to be replaced by fossil fuel-derived energy, an additional 1.1 Gt of carbon per year would be released into the atmosphere (IPCC, 2000, Chap. 5). In contrast to the combustion of fossil fuel, the use of sustainably produced biofuels does not result in a net release of CO_2 into the atmosphere, since the CO_2 released through the combustion of biofuels is taken up by regrowing biomass. The substitution of fossil fuels by sustainable biofuels will therefore result in a reduction of CO_2 emissions that is directly proportional to the volume of fossil fuel replaced. Predictions of the future contribution of biofuels in meeting energy requirements range from 59 to 145 x 10^{18} J for 2025 and 94 to 280 x 10^{18} J for 2050 (Bass *et al.*, 2000). The future usage will depend to a large extent on the development of technologies that permit an efficient use of biofuels, such as the gasification of wood products.

New biofuel plantations will also have a long-term positive sequestration effect if they replace a land use with a lower sequestration rate. Although the long-term average carbon density of a forest managed for biofuels (particularly for short-rotation coppice) will be lower than an unharvested forest or long-rotation plantation, this forest use stores more carbon than most non-forest land uses. Conversely, if natural forests are replaced with short-rotation coppice for biofuel production, the beneficial effect of fossil fuel substitution will be lost because of the emissions resulting from forest conversion.

The use of wood products in place of materials that are associated with the release of large volumes of carbon dioxide (either during processing – such as cement – or through energy consumption – such as steel) could also lead to significant net reductions in CO_2 emissions.

Experiences in Land Use Change and Forestry (LUCF) project-based activities

There are currently 16 approved international AIJ projects involving Land Use Change and Forestry (FCCC, 2000). Table 12 provides a summary of a representative set of LUCF projects currently under implementation, covering about 3.5 million ha (IPCC, 2000, Chap. 5). Eighty-three percent of this area is managed for the conservation of carbon in existing forests, either through forest protection (zero harvesting) or forest management (sustained production). Long-term carbon conservation by these projects varies from 40 to 108 tonnes per hectare from forest management and from 4 to 252 tonnes per hectare from forest protection. The estimated total lifetime sequestration effect of these projects is 5.7 million

TABLE 12
Comparison of selected LUCF projects

Project type	Number of projects	Area *(million ha)*	Carbon stored *(million tonnes)*	Carbon stored *(tonnes/ha)*	Costs *(US$/tonne of carbon)*
Sequestration					
Afforestation/ reforestation	8	0.18	21.7	26-328	1-28
Agroforestry	2	0.20	10.8	56-165	0.2-10
Conservation					
Protection	7	2.90	40-108	4-252	0.1-15
Management	4	0.33	5.7	0.2-85	0.3-8

Source: IPCC, 2000, Chap. 5.

BOX 17
Accounting for carbon sequestration by forestry

The accounting of greenhouse gas emissions attributable to nations, companies and industrial processes has become an important component of international agreements and national policies to address climate change.

The accounting of carbon benefits attributable to forest activities is of significant interest because of the forest sector's potential to contribute to the achievement of national emissions reduction targets negotiated under the FCCC, and also because of the potential value of forestry projects in offsetting emissions from specific businesses or business activities.

NATIONAL CARBON ACCOUNTING

National emissions or uptake of carbon by forests are accounted on an annual basis and are expressed in tonnes of CO_2 released or sequestered. Advances towards the targets set under the Kyoto Protocol are measured in terms of emissions or uptake relative to 1990. Under Article 3.3 of the Protocol, only the uptake of carbon by afforestation, reforestation and avoided deforestation may be counted towards national emissions reduction targets. The precise definitions of afforestation, reforestation and avoided deforestation are still being discussed.

PROJECT CARBON ACCOUNTING

Additionality and baselines

While national emissions and uptake of carbon are measured in absolute terms within national boundaries, the effect of forestry projects is measured relative to a hypothetical "without project scenario" or "baseline". The definition of a project baseline could be derived in a number of ways, including the extrapolation of previous trends in land use change, the expected impacts of current standard forestry practices, or by modelling of the social and economic pressures on forest resources. Standard methods have yet to be agreed on. When a project and a baseline case are compared, so-called "additionality" tests may be applied to ascertain whether carbon sequestration is attributable to the project or simply to incidental factors, including shifts in policy or socio-economic conditions outside the scope of the project.

Project boundaries and leakage

The setting of project boundaries will have an important effect on the emissions reductions attributed to project activities. If a project envisages the protection of a particular area of forest but involves the shifting of forest clearing to another area, there tonnes of carbon from forest management and 40 to 108 million tonnes from forest protection. A further 180 000 ha are managed for afforestation/reforestation activities and will offset[21] an estimated 21.7 million tonnes of carbon over project time scales. Two projects, covering 200 000 ha, involve agroforestry and are expected to offset an additional 10.8 million tonnes of carbon.

The cost per tonne of carbon for the projects described in Table 12 ranges from US$0.1 to US$15. However, it should be noted that the approaches for calculating the costs of carbon sequestration vary considerably between projects, and long-term estimates may need to be revised upwards. The eventual uptake of carbon sequestration potential will be dependent on the comparative costs of emissions reduction from the energy sector; some studies indicate that the market for carbon from the forest sector may be below 1 Gt.

Besides the question of how to calculate the costs of carbon sequestration, an important issue is the methodology for carrying out carbon accounting. Box 17 discusses carbon accounting at both the national and project levels.

Box 18 gives some examples of activities undertaken in LUCF projects.

[21] In this context, a carbon offset is the amount of carbon withdrawn from the atmosphere by storage in vegetation and soil over an agreed period (the convention used by IPCC to calculate warming potential is 100 years) to compensate for the radiative forcing of an emission of a specified quantity of CO_2 or another greenhouse gas.

is potential for a "leakage" of project benefits. Similarly, if an afforestation project leads to a reduction in timber prices and subsequent reduced investment in commercial plantations or increased clearance of forest land to fulfil subsistence food requirements, the net sequestration will be reduced. Project boundaries also need to be set to include all flows or stocks of carbon that might be significantly affected by project activities; this may include carbon stored in harvested timber products.

Project time scales and crediting

The long time scales associated with forest growth, particularly in temperate and boreal regions, and the potential reversibility of carbon gains through forest activities are key features of Land Use Change and Forestry (LUCF) projects. A number of alternative conventions for crediting the carbon sequestration or avoided emissions from forestry have been proposed:

- *Ex ante*, or upfront, crediting of future carbon sequestration, which would enable project developers to take credit for carbon uptake and storage that will occur in the future. This would make project development relatively easy but would require other mechanisms to guarantee fulfilment and long-term maintenance of carbon gains.
- Staged crediting, in which credit for carbon sequestration would be accrued in stages, so that project developers would have to demonstrate carbon gains before gaining recognition.
- *Ex post*, or delayed, crediting, in which credit for sequestration would only be given after carbon had been stored for a certain time, for example 40 or 50 years. This type of crediting would provide a strong measure of guarantee regarding the effectiveness of carbon offset projects but would provide little incentive for their development.

BOX 18

Examples of Joint Implementation (JI) projects currently in operation

RIO BRAVO CONSERVATION AND MANAGEMENT AREA, BELIZE

The Rio Bravo project involves the protection of 14 000 ha of "endangered" forest land and the development of a sustainable management programme for an additional 46 000 ha of forest. The project is managed by a Belizean NGO, called the Programme for Belize, and is financed in part by carbon offsets sold to a group of United States electricity utilities. In total, an estimated 2.5 million tonnes of carbon would be conserved over the 40-year life of the project, with an average potential of 36 tonnes of carbon per hectare at a cost of US$3 per tonne of carbon. The baseline case against which carbon benefits are calculated assumes that, without the project, the whole area of endangered forest would be deforested within five years. The land was previously privately owned and would probably have been sold to neighbouring farmers who had expressed interest in expanding their farms.

REDUCED IMPACT LOGGING (RIL) IN SABAH, MALAYSIA

Under this project, involving the forest concession Innoprise Corporation Sdn. Bhd. and New England Power of the United States, RIL techniques were adopted for use in 1 400 ha of dipterocarp forest in Malaysia for a period of two years. The resulting 50 percent reduction in damage to the forest vegetation (compared with conventional logging methods) conserved an estimated 40 tonnes of carbon per hectare at a cost of about US$8 per tonne. The calculation of carbon benefits assumes that the use of conventional logging methods would have continued if the project had not intervened. Thus, the carbon conserved is additional for only as long as conventional logging practices would have continued.

SCOLEL TE COMMUNITY FORESTRY PROJECT IN MEXICO

This project was set up by the University of Edinburgh and the Edinburgh Centre for Carbon Management in the United Kingdom and El Colegio de la Frontera Sur in Mexico, with funds from the United Kingdom's Department for International Development (DFID). The aim is to develop model planning and administrative systems by which small farmers can gain access to carbon markets. Under the project, small farmers and local communities identify reforestation, agroforestry and forest restoration activities that are both financially beneficial and intended to sequester or conserve carbon. The proposed activities are entered into a planning and evaluation system and the offsets are sold through a trust fund managed by a local NGO, Ambio. The systems are now well developed and carbon has been sold to various purchasers, including the International Automobile Federation. Around 300 farmers, with an average of about 1 ha of forest each, are currently involved. The average carbon sequestration potential is 26 tonnes per hectare at a cost of US$12 per tonne. The system applies a simple additionality criterion: carbon sequestration is deemed to be additional if one of the objectives of the planned afforestation is carbon sequestration. The baseline used is the mean carbon storage of the previous land use, the assumption being that the land use would have continued in the absence of project intervention.

CARBON SINK PROJECT IN MATO-GROSSO, BRAZIL

The project aims to sequester carbon in a plantation of native species established on degraded land. The plantation covers about 5 000 ha and is located on a private landholding of 15 000 ha. Only the plantation constitutes the carbon sink, but efforts are also being made to conserve the natural forest, even though it does not count towards the carbon balance. The project is funded by the French car manufacturer, Peugeot, as part of its environmental preservation policy. It is managed by ONF Brazil, a subsidiary of the Office National des Forêts of France, and the Instituto Pro Natura, a Brazilian NGO. The duration of the project is 40 years. Peugeot's contribution is US$10 million. The objective is to maximize carbon sequestration, while using local species and maintaining or enhancing biological diversity in the area. The project represents a first step towards re-establishing natural forest through the rehabilitation of pastures and the elimination of introduced grass species. The baseline is based on the continuation of the previous land use.

MANAGEMENT OF RESERVA FORESTAL MALLECO, CHILE

The project purchases the right to implement a management plan on 16 625 ha of natural, state-owned forest. Chilean regulations prohibit the transformation of this kind of forest to exotic species plantations. The purpose of the project is to promote sustainable management of the forest to prove its feasibility both in economic and carbon sequestration terms. The project is managed by the Corporación Nacional Forestal of Chile (CONAF) and the Office National des Forêts of France and it is sponsored by the French Fund for World Environment. The project involves adjustment of the methods of measuring carbon flux for this kind of ecosystem. The calculation of carbon benefits will be done from a "without project scenario" baseline.

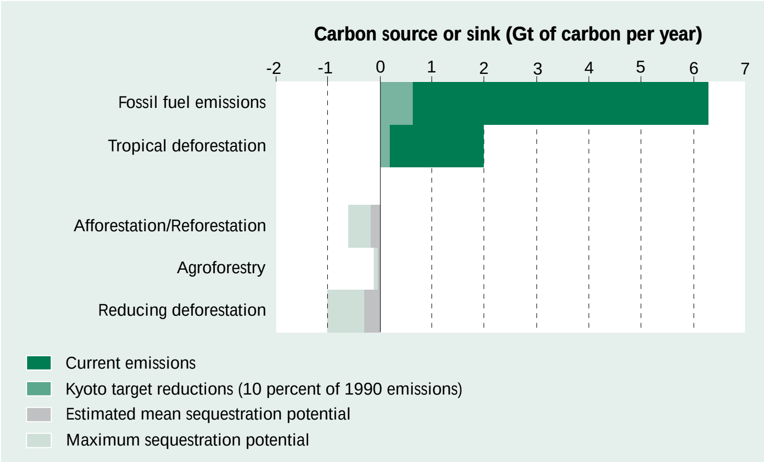
Sources: Stuart and Costa, 1998; IPCC, 2000, Chap. 5; Tipper *et al.*, in press; and Conseil Général du Genie Rural des Eaux et des Forêts, personal communication.

CONCLUSIONS AND FUTURE ISSUES

Forests are an important component of the global carbon cycle. They both influence and are influenced by climate change, and their management or destruction will have a significant impact on the course of global warming in the twenty-first century.

Forest ecosystems contain more than half of all terrestrial carbon. They account for about 80 percent of the exchange of carbon between terrestrial ecosystems and the atmosphere. Although forest ecosystems absorb between 1 and 3 Gt of carbon annually through regrowth in degraded forests, reforestation, and CO_2 and nitrogen fertilization effects, they release about the same amount (2 Gt) each year through deforestation. Deforestation in the 1980s may have accounted for one-quarter of all anthropogenic carbon emissions.

FIGURE 23
Estimates of carbon sources and the sink potential of various land use options



Note: For afforestation/reforestation, the potential rate assumes that 30 percent of suitable land is used; the maximum rate assumes that all available land is used. For reducing deforestation, the potential rate is based on the estimates of Brown *et al*., 1996; the maximum rate assumes a steady decline in tropical deforestation, with a complete halt after 50 years.

If predicted climate changes materialize, the impacts on forests are likely to be dramatic and long-lasting. Forest ecosystems may persist for some time under changed climatic conditions, but long-term responses will depend on the capability of species to continue to adapt to the new conditions or to change their geographic distribution.

Forest management can contribute towards emissions reductions and to carbon sequestration (see Figure 23). The conservation of existing carbon stocks in forests is potentially a more powerful tool than carbon sequestration. However, forestry measures alone will not be enough to halt the increase in atmospheric CO_2 concentrations. They can only complement efforts to reduce carbon emissions from the burning of fossil fuels. The Kyoto Protocol may have a profound influence on the forest sector, but its precise impacts will depend on which forest activities are included as eligible measures for climate change mitigation and what rules and standards are applied to potential projects.

Opinions about the role of forestry within the Protocol's Clean Development Mechanism (CDM) are divided.

Opponents of forestry's inclusion in the CDM argue that incentives for carbon sequestration are likely to lead to uncontrolled investment in industrial-scale forest activities, with negative social and biological diversity consequences. Some observers fear that the availability of forestry as a low-cost means of achieving emissions reduction targets will divert investment from efforts to reduce emissions at their source. There are also concerns about the sustainability and measurability of forestry project impacts.

Proponents, however, see potential social, economic and biological diversity benefits arising from investment in high-quality conservation, agroforestry and sustainable forest management initiatives.

They argue that the additional economic (or carbon) value given to forests may provide a useful impetus to sustainable forest management efforts. ◆

Forest biological diversity conservation: protected area management

The ever-increasing impact of human activities on the environment makes the conservation of natural resources, including biological diversity, an urgent and critical task. Two recently released publications add to the many warnings that the future of the world's biological diversity is severely threatened. The 2000 IUCN Red List of Threatened Species™ indicates that the number of critically endangered species has increased since the publication of the last list four years ago.[22] The World Conservation Union (IUCN) warns that 24 percent of mammal species and 12 percent of bird species face a "high risk of extinction in the near future". Habitat degradation is the major threat. The publication *World resources 2000-2001: people and ecosystems, the fraying web of life*, which reports on the results of a pilot assessment of the health of the world's ecosystems (forest, coastal, grassland, freshwater and agricultural), judges that their capacity to maintain biological diversity is decreasing (Rosen, 2000).

By virtue of their importance as habitats, forests – and especially tropical forests – figure prominently in efforts to conserve biological diversity. It has been estimated that half of the world's biological diversity is contained in forests and that probably more than four-fifths of many groups of plants and animals are found in tropical forests (CIFOR/Government of Indonesia/UNESCO, 1999).

Efforts to conserve biological diversity have become more active and widespread over the past 20 years. During this period, biological diversity conservation has moved from being a focus of a relatively small group of environmentalists and scientists to being a mainstreamed feature of national policy and planning throughout the world. Many countries have prepared national biological diversity action plans, and the topic has also become an important issue on the international agenda. The Convention on Biological Diversity, which was adopted in 1992, provides an international legal framework for biological diversity at the ecosystem level, complementing international protection offered at the species level by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (see Part III, p. 109). Biological diversity conservation is an important component of bilateral and multilateral assistance and is the focus of concerted efforts by NGOs around the world. It is recognized as one of the criteria of sustainable forest management as defined by regional and national processes (see Part III, p. 116). The Intergovernmental Forum on Forests (IFF) addressed biological diversity issues through special studies and government-sponsored intersessional meetings.[23]

Values provide much of the motivation for the conservation of biological diversity, which has a recognized ecological, economic, cultural and spiritual, aesthetic and recreational worth. It is

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[22] Available at: www.iucn.org/redlist/2000.

[23] In support of IFF, government-sponsored meetings on forest conservation and protected areas were held in Canberra, Australia in 1998 and in San Juan, Puerto Rico in 1999. The Canberra meeting produced a discussion paper, *International forest conservation: protected areas and beyond* (Kanowski *et al*., 1999).

also argued that biological diversity has an intrinsic value, independent of its usefulness to human beings (Wilson, 1992; Noss and Cooperrider, 1994; Redford and Richter, 1999). There has been a tendency to emphasize regional and local values but, increasingly, global values are driving efforts to conserve biological diversity. Efforts to articulate global social and environmental values, such as *The Earth Charter*[24] (published in March 2000), could serve as a positive model for social and environmental thinking in the same way that the Universal Declaration of Human Rights has done in the area of individual rights.

There are two major categories of strategies to conserve biological diversity: *in situ* and *ex situ* conservation. *Ex situ* conservation (e.g. gene banks, arboreta, zoos), although an effective strategy for conservation at the genetic and species level, is economically and logistically feasible for only a relatively small number of species. *In situ* strategies entail conservation both inside and outside protected areas. Protected areas have long been considered the cornerstone of conservation. However, they alone are not sufficient to achieve conservation goals and must be complemented by effective conservation management outside protected areas. There are four major reasons for this:

- most of the world's land area (an estimated 91 percent) falls outside terrestrial protected area networks;
- the establishment of protected areas is not a viable option in some places;
- if a protected area's size, shape or location limits its effectiveness, the management of the surrounding landscape becomes critical;
- if habitats shift geographically with climate change, as some predict, the effectiveness of protected areas as a conservation tool may decrease in the future.

The adoption of an integrated approach to conservation, involving management both within and outside protected areas, is therefore essential.

[24] See www.earthcharter.org/.

While recognizing the importance of all three conservation strategies and the need to consider them in conjunction with one another, the scope of this chapter is limited to conservation in forest protected areas. The past two decades have seen tremendous change in this field, so it is a useful moment to take stock of the situation and to highlight some of the major current issues. This chapter briefly discusses questions related to how much and what land should be protected; what the status of protection is; how the effectiveness of management should be assessed; which approaches are currently being used in protected area management; and how to pay for conservation.

THE STATUS OF PROTECTED FOREST AREAS: WHAT AND HOW MUCH SHOULD BE PROTECTED

FAO's Global Forest Resources Assessment 2000 estimates that 10 percent of the world's forests are located within protected areas[25] (see Part II, p. 54).

While this is a large area, for various reasons it is still generally not considered to be enough. The representation of different forest ecosystem types in the global protected area network and the effectiveness of different areas in conserving biological diversity vary widely (Miller, 1999). The designation of many protected areas was based on criteria other than their value in terms of biological diversity, such as their scenic, recreational, historical or cultural significance, or the simple fact that the land was of little value for alternative uses. In addition, the size, shape and location of many protected areas are not optimal for conservation. The size of many existing protected areas is too small to provide adequate habitat for some plant and animal species. The shape and location of many protected areas make them vulnerable to negative influences such as pollution, noise, illegal hunting and agricultural encroachment.

[25] The protected areas referred to are those in categories I-VI of the IUCN classification system (see Table 9, p. 54).

To enhance the conservation value of protected areas, efforts have been made both to increase the area of land in protected area systems and to make more strategic choices concerning the protection of additional areas. A major emphasis has also been placed on improving the effectiveness of conservation within existing protected areas, improving the conservation of biological diversity outside protected areas, and managing the two in an integrated way (this is discussed in the following section).

At an international conference convened by Conservation International in Pasadena, California in August 2000, conservation and corporate leaders highlighted the absolutely critical role of protected areas and emphasized that the top conservation priority should be to protect more of the planet's crucial ecosystems.

For the last two decades, international conservation groups that consider the global network of protected areas to be insufficient have called for at least 10 percent of the world's land area to be placed under protected area status. *Forests for life – the WWF/IUCN forest policy book* (WWF/IUCN, 1996) reiterated this goal for forests. It urged that a minimum of 10 percent of all forest types should be represented in protected area networks. There have been few challenges to this goal within the conservation community – that is, until recently.

Views on what land should be protected have been more varied than those on how much land should be protected. Myers *et al.* (2000) argue that species-rich "hotspots"[26] of biological diversity should be the priority of conservation efforts. Sites with high species numbers or high endemism, or areas with species of evolutionary significance (i.e. primitive species) are often selected for protection. Ecological representativeness is another important criterion used for identifying the choice of protected areas. Some people consider that areas threatened by degradation, or habitats of endangered species (including high-profile "charismatic megafauna") should be first on the list for protection, whereas others consider that areas that are not yet severely threatened may have the best chance of being protected effectively. The identification of conservation priorities has been complicated by weaknesses in the information base, owing to the fact that many areas are poorly known and many species are still unknown or undescribed by science.

Nonetheless, a considerable effort has been made to identify areas meriting protection, and there is beginning to be a considerable convergence of opinions regarding priorities, at least for certain groups of species. Global centres of plant diversity and areas that are important for bird conservation have been identified (WCMC, 1992). Several organizations, including the World Resources Institute (WRI), WWF, Conservation International, IUCN, WCMC and Birdlife International, have attempted to identify the most significant tropical forest sites in terms of biological diversity.

The most recent effort to indentify priority forest areas for conservation was made at a workshop held in Berestagi, Indonesia in February 1999. The purpose of the workshop, which drew on the results of the work carried out by the organizations just mentioned, was to examine the potential of the World Heritage Convention to serve as a mechanism for conserving tropical forest biological diversity. Given its unique position within the framework of international conservation agreements, the Convention is considered to play a potential key role in global biological diversity conservation. The workshop concluded that tropical forests are inadequately represented on the World Heritage List. Among the areas listed, there are now 33 tropical forest sites covering more than 26 million ha. The group of experts proposed a list of forest sites meriting protection under the World Heritage Convention (CIFOR/Government of Indonesia/UNESCO, 1999). The group noted that clusters, chains or corridors of protected areas

[26] Ecosystems that are rich in biological diversity and are under threat of destruction.

may provide the only feasible means of achieving forest biological diversity conservation goals in areas where the human population and other factors preclude the establishment of vast protected areas.

An alternative view on the optimal amount of land to include in protected areas emerged from the Berestagi workshop. Sayer *et al.* (in press) argue that about 100 sites – the existing World Heritage tropical forest sites in addition to the list proposed at Berestagi – representing 3 to 5 percent of the world's tropical forests, could be sufficient to conserve the majority of tropical biological diversity. The authors maintain that funds and political backing for the conservation of biological diversity could be more effective if they were focused on conservation efforts in this "élite" set of the earth's most biologically rich sites. It is too early to tell whether this concept, which differs from the long-held view that "more is better" and from the "10+ percent" goal, will be widely accepted. Nonetheless, it does illustrate that the fundamental questions of what and how much to conserve are still being debated.

EFFECTIVENESS OF PROTECTED AREA MANAGEMENT

The status of management

The quality of protected area management is even more important than the amount of area under protection status. The literature is full of references to serious threats to or inadequate management of protected areas. Although it is difficult to draw a coherent global picture of the situation, two recent studies attempt to assess the status of protected areas in some major forested countries around the world.

Van Schaik, Terborgh and Dugelby (1997) examined the susceptibility of protected areas to eight threats (agricultural encroachment, hunting/fishing, logging/fuelwood collection, livestock grazing, mining, fire, road building and hydropower) in important forest countries of Latin America, central and West Africa, South Asia, Southeast Asia and in Australia, Madagascar and Papua New Guinea. They found that threats to protected rain forest areas are pan-tropical phenomena and concluded that "the stark reality of the inadequacy of conservation measures" was true for all but one of the countries examined.

Dudley and Stolton (1999), in a survey of forest protected areas in ten forested countries,[27] concluded that only 1 percent of these sites could be regarded as safe from potential serious threats and that at least 22 percent were suffering from degradation. The study identified a daunting array of threats. It also discussed the severe constraints on the effectiveness of protected area management, including: a lack of funds, a shortage of trained staff, weak institutions, a lack of political support, a poor legal framework and weak enforcement, insufficient communication with and involvement of local residents in management planning, inadequate coordination among managing organizations, a lack of comprehensive land use plans and poor demarcation of boundaries. Despite the many constraints identified by this study, some hopeful conclusions were drawn. Among these was the finding that only 1 percent of the protected areas in these countries had been so badly degraded as to have lost completely the values for which they were established.

Threats to protected areas are apparent even in developed countries that spend considerable resources on conservation. The Panel on the Ecological Integrity of Canada's National Parks recently concluded that most Canadian National Parks are affected by ecological stresses (Parks Canada, 2000). Problems included habitat fragmentation or loss, air pollution, pesticide use, exotic species and overuse.

Measuring the effectiveness of protected areas

Methods for monitoring the effectiveness of protected areas are still relatively undeveloped. However, the situation has been the subject of

[27] Brazil, China, Gabon, Indonesia, Mexico, Papua New Guinea, Peru, the Russian Federation, the United Republic of Tanzania and Viet Nam.

growing concern and substantial efforts have been made in the past few years, owing in part to recognition of the importance of adaptive management. Managers can adjust and fine-tune management interventions in response to the detection of threats or changes in the status of plants and animals. Identifying areas of institutional weaknesses, policy failures or negative social impacts can also help managers make critical decisions.

The effectiveness of protected areas can be assessed in terms of the protection of biological diversity, institutional capacity, social impacts and legal status. Most monitoring efforts to date have been concentrated on assessing the first of these: the effectiveness of protected areas in terms of biological diversity conservation. This has proved to be a more difficult task than expected, as illustrated by the following statements:

> "Perhaps the biggest single defect of past programs to conserve biodiversity was that we never really knew whether we were succeeding or failing."
>
> **(Sayer and Iremonger, 1998)**

> "Biodiversity conservation was … the most critical variable that we had to monitor at each of our sites. If we have learned anything over the past few years, however, it is that conservation success is extremely difficult to define, let alone measure, in biological terms."
>
> **(Salafsky *et al.*, 1999)**

Challenges to monitoring are posed by the complexity of ecological systems, by the different levels of biological diversity, and by management objectives that are difficult to measure. It is possible to imagine the difficulties of monitoring progress towards the achievement of biological diversity conservation when considering the following two statements of objectives. A Forum on the Conservation of Wild Living Resources, held in the United States, concluded that: "The goal of conservation should be to secure present and future options by maintaining biological diversity at genetic, species, population and ecosystem levels" (Mangel *et al.*, 1996). A task force inquiring into the status of Canada's national parks recommended that the purpose of their management should be to "maintain ecological integrity" (Parks Canada, 2000).

Both inventory and monitoring are formidable challenges, given that a protected area may contain thousands or tens of thousands of species. Not all of them can be monitored and, even if they could, it would not be an optimal use of human and financial resources. This challenge is being addressed through various approaches, including:

- monitoring species for which the protected area was established or for which it is primarily managed (e.g. endemics, threatened species, or species of economic, popular or cultural value);
- using indicator species, which can serve as proxies for other species or groups of species and / or reflect changes in ecosystem processes;
- using rapid ecological assessment techniques, in which a team with expertise in an appropriate range of taxa conducts surveys over a period of weeks or months in the area of interest;
- monitoring threats to ecosystems.

Despite progress in this area, considerable work is still needed to develop effective monitoring methods. For example, the use of indicator species could greatly facilitate monitoring, but the relationships between possible indicator species and total biological diversity and ecosystem processes are not well established (Lindenmayer, Margules and Botkin, 2000). Furthermore, monitoring is unlikely to be adopted, particularly where human and financial resources for conservation are limited, until inexpensive and simple monitoring methods are available. Another challenge is to establish acceptable levels of change so that management action can be taken when thresholds are approached. Establishing useful threshold levels will require a greater understanding of ecological dynamics than exists now for most ecosystems.

Recent efforts have been made to develop tools to assess protected area effectiveness from a broader perspective, which includes institutional, social and legal factors as well as biological ones. IUCN's World Commission on Protected Areas (WCPA) established a task force on management effectiveness in 1998 and held two international workshops on this topic in 1999. A diversity of approaches will doubtless be necessary to accommodate the vast range of ecological and socio-economic conditions around the world, but WCPA's view is that the various approaches should be derived from a single, broad conceptual framework that can be used in a wide range of circumstances.

WCPA has proposed a framework for assessment (Hocking and Phillips, 1999). Five areas of evaluation are suggested:

- *design evaluation* to assess the planning or design of a protected area system, including its comprehensiveness, adequacy and representativeness;
- *input evaluation* to assess the adequacy and allocation of resources (funds, staff, equipment and infrastructure) devoted to managing the protected area or system;
- *process evaluation* to assess the standards of the management system and of the processes and functions used in administering the area;
- *output evaluation* to assess the extent to which the plans and intended targets or standards have been achieved;
- *outcome evaluation* to assess the extent to which management objectives are being achieved.

Other approaches to the assessment of management effectiveness are being tested and used. Two are discussed here – the first uses a participatory approach and the other allows for monitoring across a number of sites:

- Nature Conservancy, a United States-based conservation NGO, has used a participatory approach in Latin America for monitoring the effectiveness of protected area management (Courrau, 1999). The system is simple and low-cost. Five aspects of management – social, administrative, natural resource management, political-legal and economic-financial – are considered, and criteria and indicators are developed for each. Monitoring sessions, involving the protected area staff and representatives from interest groups (communities, associations, etc.), are conducted every six months. The status of the indicators reviewed and progress in each are ranked by the participants. Not only does this method provide a quantitative means of judging progress, but it also helps to establish a common vision of the objectives and future directions of management.
- In Wales, the United Kingdom, a system was designed that is simple, rigorous and effective in a situation where many sites have to be monitored (Alexander and Rowell, 1999). Only those features for which a site was selected are monitored, and the status of each feature is judged against a standard that has been set specifically for that feature. Recovery management is called for if a feature's condition is not considered satisfactory. This approach facilitates both reporting and management. Monitoring the situation across many sites is possible because the assessment and reporting system is standardized.

The field of monitoring protected area effectiveness is likely to continue to undergo important development in the future. Although considerable progress has been made, further refinement of approaches and tools for monitoring is needed. Until this happens and appropriate monitoring systems are in place and functioning well, effective adaptive management of protected areas globally will remain a goal rather than a reality.

CURRENT APPROACHES TO PROTECTED AREA MANAGEMENT

The changes that have occurred over the past decade have been described as a paradigm shift in the planning and management of protected areas (Dudley *et al.*, 1999). Attributes of the old paradigm included monopoly control by a central government, protectionist policies, the exclusion of local communities and, frequently, the prohibition of traditional uses of wildlife resources. Attributes of the new paradigm include a shift in the role of government from implementation to regulation; decentralization of decision-making; efforts to involve key stakeholders in protected area planning and management; and increasing recognition of the crucial role of policies, laws and institutions in creating an enabling environment for implementing necessary change and development.

In October 1999, FAO held an international technical consultation in Harare, Zimbabwe on how to reconcile protected area management and sustainable rural development. The meeting documented the complexity of achieving such a reconciliation, but there was also evidence of progress in collaborative management of protected areas and an improved understanding of issues such as institutional reform and the prerequisites for successful ecotourism enterprises.

Integrated conservation and development projects (ICDPs) and community-based conservation (CBC) are two ways in which recognition of the importance of making biological diversity relevant to rural people living in or near protected areas has been manifested.

A second major shift in protected areas planning and management that has emerged over the past decade is the visualization of protected areas as part of larger landscapes. The bioregional approach to protected areas planning is a concept developed by the conservation community to place protected areas into a wider geographic and land use context. It draws on some of the principles of ecosystem management, which has gained acceptance over the past decade among natural resource managers. The bioregional and ecosystem approaches recognize the complexity and dynamism of ecological and social systems. Both call for the involvement of local communities and stakeholders in decision-making and, thus, share some common elements of the paradigm shift described above. The following section discusses the new approaches: ICDPs, CBC, the bioregional approach and the ecosystem approach. Transboundary conservation areas are also discussed.

Integrated conservation and development projects

The reality is that many, if not most, protected areas have people living in or around them. Conservationists have responded to this by seeking to link conservation and development objectives to ensure that some of the benefits of protected areas accrue to local people. This concept is not new; it has simply become mainstreamed in conservation efforts over the last decade. It is an underlying principle for the nomination and management of biosphere reserves, an international protected areas designation under UNESCO's Man and the Biosphere Programme, which was established in 1972. The need for protected area management to regard local needs and rights was clearly articulated at the 1982 World Parks Congress in Bali, Indonesia. This was seen as an alternative to the more exclusionary protectionist policies of the past, which often resulted in the alienation of rural people from conservation efforts.

This view led to growing numbers of initiatives to link protected area management with local social and economic development, often by trying to provide incentives for park residents and neighbours to support conservation and sustainable use. Such initiatives are commonly known as integrated conservation and development projects. They have been strongly supported by governments, conservation NGOs and major donors. By the late 1990s, most plans or proposals for protected area management devoted substantial consideration to relations with local people. But now, more than a decade after the ICDP approach was vigorously promoted, there are still very few clearly successful cases in which local people's needs and aspirations have been reconciled with protected area management. There is growing recognition of the risk that ICDPs may not contribute effectively either to conservation or to development.

The Biodiversity Conservation Network, a large-scale experiment set up to examine the link between development opportunities and the conservation of biological diversity, documented some successful efforts and provides some useful lessons that may improve the success of such activities in the future (Salafsky *et al*., 1999). It concludes that a viable enterprise linked to biological diversity on a project site can result in the successful conservation of that resource. The conditions, however, have to be right. Marketing constraints and problems related to government regulations and bureaucracies have to be overcome. A large degree of local involvement in the enterprise is critical. The communities have to perceive that the enterprise depends on the maintenance of biological diversity. With these findings in mind, it is possible to surmise that some of the failures of ICDP projects may be attributed less to incompatibility between conservation and development than to flaws in project design and implementation or to the absence of the necessary preconditions for success.

The overall disappointment with conservation-development efforts, however, has added fuel to the debate about whether or not biological diversity conservation is synonymous with sustainable use, as illustrated by the following two opinions. Ntiamoa-Baidu *et al.* (2000) conclude that: "Interconnecting resource use with biodiversity conservation is considered critically important because rural people depend so much on natural resources for basic survival". Terborgh and van Schaik (1997), on the other hand, argue that: "Strictly protected areas must ... serve for the foreseeable future as the last bastions of nature. Rigorous protection of parks should thus become the priority of efforts to conserve nature."

Somewhere between these two opinions lies the view that conservation objectives are not best met by excluding people from protected areas, but by managing human activities to ensure that they do not compromise the values for which protected areas are established. Some contend that most biological diversity has always coexisted with significant human activities so, as long as extractive activities remain at a sufficiently low level, they should not threaten biological diversity. Linked with this view is a recognition of the need to involve local people in planning and management decisions related to protected area management.

This is consistent with a more general move towards decentralization and devolution in many countries. There is hope that, if local people are given more direct responsibility, they may have more success than efforts that have not involved them sufficiently in reconciling conservation and development.

Community-based conservation

The term community-based conservation refers to efforts that involve rural people as an integral part of conservation policy. The premise is that the participation of local communities in resource planning and management can both improve the effectiveness of conservation efforts and help ensure that local communities benefit from conservation.

The transfer of control over natural resources from the central to the local level, and community-based management systems that can build on science, information and traditional knowledge, are two aspects of the CBC approach that are being tried in various countries.

It is too early to be able to draw many conclusions about the success of CBC when applied to protected area management. Its long-term sustainability has yet to be demonstrated in many places, and the extent to which it conserves biological diversity values is uncertain.

Indications are that CBC may be a potentially viable model in developed countries where conservation can be given higher priority because basic economic needs are met. There are also examples, such as the CAMPFIRE in Zimbabwe and the Community Baboon Sanctuary in Belize, which show that CBC can work in developing countries. The model, however, may be less practicable in some other developing countries. There are many reasons for this. Rural people who face poverty, a lack of economic opportunities and conflicts over scarce resources are, understandably, more concerned with economic prospects than with the conservation of biological diversity. There is a vast disparity between the economic benefits that conservation can realistically be expected to deliver and the needs and aspirations of rural people. Consequently, poor rural people may reject conservation if they are presented with a more profitable option for using those resources (Hackel, 1999).

Economic, social and cultural diversity and power differentials existing within communities pose additional challenges. These have to be recognized, understood and factored into a conservation programme, which otherwise could easily fail to meet its objectives. Similarly, it must be recognized that indigenous peoples' groups and other forest-dependent people have varied attitudes about nature; mistakes have been made by simply assuming that they have a strong conservation ethic that will keep them from overusing resources, such as wildlife.

The means of reconciling the needs of poor rural people and biological diversity conservation are not yet clear. One option is to improve the design and implementation of programmes so that they effectively engage local people and provide them with tangible benefits linked directly to conservation. Brown (2000) offers another option: the formation of multisectoral, multistakeholder alliances, which bring communities together with profit-making interests and government. One thing is certain, however; understanding the local economic, social, ecological and political context is essential to the success of CBC efforts. There are no standard solutions that can simply be replicated; approaches must be carefully adjusted to each situation.

Bioregional approach

The bioregional approach is based on the concept that conservation and resource management programmes should encompass whole ecosystems or bioregions.[28] This approach helps maintain biological communities, habitats and ecosystems as well as ecological processes where the landscape has been fragmented by roads, settlements, dams and agricultural development (Miller and Hamilton, 1999).

The bioregional approach considers the conservation of biological diversity in four types of areas. The first are the core wild areas that sustain the wild flora and fauna in their native habitats. The second are buffer zones, or the areas surrounding the core areas, where private and communal landowners and land users are encouraged through legal and policy instruments and economic incentives to manage their resources in ways that minimize negative impacts on core areas. Third, the cores and their buffer zones are linked with other core and buffer zones by corridors that provide suitable habitats for plant and animal migration and dispersal. Fourth, the core areas, buffer zones and corridors are nested within areas dominated by human settlements and human activities. The goal of bioregional management is to establish cooperative programmes across the entire region that provide for the maintenance and restoration of biological diversity while supporting local livelihoods and lifestyles.

The successful deployment of the bioregional approach (Miller and Hamilton, 1999) is dependent on:

- compiling adequate information for identifying corridors and linkages;
- advocacy and education to convince all stakeholders of the advantages of the approach;
- effective communication between all stakeholders;
- the integration of all the units in the regional mosaic;
- coordination of the diverse activities and stakeholders;
- a long-term commitment to the process of bioregional management;

[28] A bioregion is a geographic area containing one or more nested ecosystems and whose boundaries are defined by the limits of ecological systems or human communities.

- habitat restoration and regeneration as the need becomes apparent.

The bioregional approach has been used in various areas throughout the world under varied ecological and socio-economic conditions. Many of these experiences are well documented and provide useful lessons (e.g. Miller, 1996; IUCN, 1999).

An ecosystem approach

There are various interpretations of the phrases "ecosystem approach" and "ecosystem management", but most share common elements, including systems thinking, recognition of the complexity and dynamism of ecological and social systems, ecologically derived boundaries, consideration of different time scales, adaptive management to deal with changes and uncertainty, and collaborative decision-making. Some people view the maintenance or restoration of ecosystem integrity or health as the overall goal of management, whereas others consider human needs to be equally or more important (Yaffee, 1999).

The Convention on Biological Diversity describes the ecosystem approach as follows:

> "The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way.... An ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential structure, processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems."[29]

Many countries are increasingly using an ecosystem approach for planning and managing natural resource use and development. In addition, Parties to the Convention on Biological Diversity agreed in the fifth Conference of the Parties in May 2000 to apply the principles of the ecosystem approach, as described above, in managing their natural resources. Two conferences held under the auspices of the Convention have generated 12 principles, commonly referred to as the Malawi Principles, and five operational guidelines for the use of this approach (see Box 19).

Implementing an ecosystem approach is a complex task, and more complicated than implementing traditional systems for managing protected areas and wildlife. The Director of the United States Fish and Wildlife Service points out that, by advocating an ecosystem approach, the wildlife manager is being called on to leave behind the time-tested single-species approach (Clark, 1999). He also makes the point that managers will need help from scientists in identifying the biological goals and objectives they are striving for.

Transboundary conservation areas

Although transboundary conservation areas are not new, they have recently attracted considerable attention (e.g. Biodiversity Support Program, 1999). They are important for both ecological and political reasons.

Zbicz (1999) has found 136 clusters of adjoining protected areas, or transboundary protected area complexes, covering at least 10 percent of the total protected area in the world. Existing and proposed complexes together offer 205 potential opportunities for transboundary biological diversity conservation.

These areas are important ecologically because many areas of biological diversity significance straddle two or more national borders. Effective management of transboundary ecosystems depends on compatible use by neighbouring countries and presents a potential for the creation of transboundary protected areas.

In a political context, it has been proposed that transboundary conservation areas could be

[29] www.biodiv.org/EcosysApproach/Description.html.

BOX 19

Principles and operational guidelines for the ecosystem approach: the Malawi Principles

PRINCIPLES

Principle 1: The objectives of management of land, water and living resources are a matter of societal choice.

Principle 2: Management should be decentralized to the lowest appropriate level.

Principle 3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.

Principle 4: Recognizing potential gains from management, there is a need to understand and manage the ecosystem in an economic context. Any such ecosystem management should:
a) reduce those market distortions that adversely affect biological diversity;
b) align incentives to promote biological diversity conservation and sustainable use;
c) internalize costs and benefits in the given ecosystem to the extent feasible.

Principle 5: A key feature of the ecosystem approach includes conservation of ecosystem structure and functioning.

Principle 6: Ecosystems must be managed within the limits of their functioning.

Principle 7: The ecosystem approach should be undertaken at the appropriate temporal scales.

Principle 8: Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for ecosystem management should be set for the long term.

Principle 9: Management must recognize that change is inevitable.

Principle 10: The ecosystem approach should seek the appropriate balance between conservation and use of biological diversity.

Principle 11: The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.

Principle 12: The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

OPERATIONAL GUIDELINES

1. Focus on the functions of biodiversity in ecosystems.
2. Promote the fair and equitable sharing of the benefits derived from the functions of biological diversity in ecosystems.
3. Use adaptive management practices.
4. Carry out management actions at the scale appropriate for the issue being addressed, with decentralization to the lowest level, as appropriate.
5. Ensure intersectoral cooperation.

developed as "peace parks" to serve as a mechanism for resolving international conflict along boundaries. The idea has attracted considerable interest and support, but is not without its critics. It is argued that the establishment and operation of transboundary parks is an inordinately complex undertaking and that resources would be better invested in upgrading the management of national protected area systems.

Whatever the political merits of transboundary protected areas, it is clear that the ecological reasons for concern about transboundary issues are valid and deserve further attention.

PAYING FOR PROTECTED AREA MANAGEMENT

A chronic lack of money to pay for conservation is one of the major constraints on effective biological diversity conservation in most developing countries. The need to improve national financing of protected area systems and to secure international sources of funding is the subject of ongoing discussion and innovation.

Apart from the problem of underfunding, a primary constraint for government agencies is their frequent inability to retain revenues raised in protected areas. There is little incentive for conservation agencies to implement revenue-raising programmes if they are obliged to return these revenues to the national treasury, which is often the case.

Their lack of financial autonomy often discourages initiatives to build links with the private sector (James, 1999). Reduced dependence on government funding, the development of innovative sources of financing and the retention by the agency of earned revenue, so that it can be rechannelled back into protected area management, would ease the situation.

The modification of institutional structures may be another option for bringing about significant changes in financial provision for protected area management. A comparison of traditional government conservation departments and financially and operationally autonomous parastatal conservation agencies in the African region revealed that parastatals spend 15 times more on protected area management than government departments (James, 1999). It reflects a different institutional culture. Parastatal protected area managers took steps to increase and diversify their funding sources. All of the financially autonomous agencies reported that they had initiated new revenue-generating programme fees, including raising visitors' entrance fees, setting up trust funds and soliciting donations from a wide variety of public and private organizations, inviting the private sector to bid on joint venture projects in ecotourism developments, and so forth.

Calls for increased international funds for conservation efforts argue that if biological diversity has global importance and provides global benefits, then the costs of its conservation should be borne globally. More pragmatically, some point out that, unless wealthier countries help cover the costs, conservation will remain weak because of the chronic lack of funds in poorer countries.

The Global Environment Facility (GEF) is the most important international funding mechanism for conservation in developing countries. It is also the financial mechanism for the Convention on Biological Diversity. Bilateral and multilateral support for conservation is another way in which the international community contributes to the cost of conservation in developing countries. Conservation NGOs, too, have long been active in raising funds for conservation efforts. Currently, support for international conservation from all these sources is provided on an unsystematic and unpredictable ad hoc basis. Securing systematic and sustained support for effective and sustainable conservation is clearly an important need. A medium- to long-term goal could be to establish a permanent international funding mechanism for biological diversity conservation. In the absence of this, new mechanisms for supporting conservation and new sources of financing have been emerging.

Conservation International recently devised a new mechanism for biological diversity conservation: a "conservation concession". In September 2000, it leased a large area of forest from the Government of Guyana at the market rate for a timber concession. It will manage the forest for the purpose of conserving biological diversity rather than using it for the extraction of timber. This market mechanism affords a measure of forest protection while at the same time guaranteeing a steady stream of hard currency to the country. Conservation International intends to work with other governments to use this mechanism for forest biological diversity conservation elsewhere.

Conservation NGOs are forming new alliances with non-traditional partners to support their work. The World Bank-WWF Forest Alliance, established in 1998, is one example. Two of the Alliance's goals are to work with governments and civil society to increase forest protected areas by 50 million ha and to secure effective management of the same amount of existing but highly threatened protected forest areas by the year 2005. Another example is the Critical Ecosystem Partnership Fund, established in mid-2000 by the World Bank, Conservation International and GEF to protect global hotspots of biological diversity. Each partner will contribute US$25 million and will work to raise another US$75 million for a total of US$150 million, which is to be spent on conservation activities.

Another recent development is the attraction of private funds for conservation. While individual and corporate donations for conservation efforts have a long history in some countries (e.g. the United States), new sources of funds are emerging for international conservation efforts.

The United Nations Foundation (UNF) is one such source of new funds. The portion of its funds currently designated for biological diversity conservation will be allocated to projects based on World Heritage Sites. One recent UNF grant of US$3 million was given for four World Heritage Sites in the Democratic Republic of the Congo, three of which are forest protected areas.

The electronic communications and Internet sector is becoming increasingly involved in funding conservation efforts, ranging from creating trust funds for managing individual protected areas to supporting NGO research and conservation activities. For example, the Nature Conservancy recently received US$5 million from the Internet community to assist its purchase of an area of prairie ecosystem in the northwestern United States. Another example includes a US$35 million donation, from a cofounder of the Intel Corporation, to Conservation International for the establishment of its Centre for Applied Biodiversity Science.

CONCLUSIONS

Conservation of forest biological diversity has become a much higher-profile concern over the past decade. At a time when many scientists with a long research experience conclude that the tropical forest reserves are in a state of crisis (van Schaik, Terborgh and Dugelby, 1997) and a highly respected conservation biologist writes of "the global onslaught on biodiversity" (Ehrenfeld, 2000), the issue is being addressed with a rising sense of urgency.

Concern has given rise to a wide range of national and international initiatives for the conservation of biological diversity and protected area management. There has been a significant evolution in thought about how to approach effective protected area management over the long term, manifested in efforts to reconcile conservation and development needs, to involve local communities and other stakeholders in conservation, and to manage protected areas as parts of larger geographic, ecological and social complexes.

Despite the changes that have taken place, important needs remain, including:

- improving the quality of protected area management;
- developing indicators and effective monitoring systems that can be used in adaptive management of protected areas;

- strategically locating new protected areas;
- reconciling the needs for sustainable development and biological diversity conservation and effectively involving local communities in decision-making related to protected area management;
- securing sustained sources of funding for conservation.

Making progress in these tasks will require research, experimentation, thought, discussion and commitment from the policy to the field level. Nevertheless, a measure of encouragement can be derived from the way in which problems, both inside and outside protected areas, are being addressed and by the innovative approaches that have emerged over the past few years. ◆

Illegal activities and corruption in the forest sector

Forest governance encompasses all aspects of the exercise of authority of formal and informal institutions in the management of a nation's forest resources.

Governance comprises activities by the government, the private sector and civil society and the relationships between them. Good governance translates into effective government institutions and an enabling framework (through policies, incentives, appropriate laws and strong enforcement, etc.) for these three sectors to operate in harmony to achieve national objectives, such as economic efficiency, economic and social equity, improved environmental quality and more sustainable forest management.

Weak governance in the forest sector, prevailing in many countries, has negative environmental, economic and social consequences. This chapter focuses on one of the most important aspects of weak governance: forest crime and corruption. In many countries, illegal operations proliferate and governments are unable to control their own bureaucracies or to enforce adherence to the "rules of the game" by commercial corporations and civil society entities. In extreme circumstances, private corporations or powerful groups are able to sway government and to "purchase" decrees, legislation and regulations for their own benefit.

Corruption – a subject that was until recently considered taboo – has come to the forefront of the international dialogue on forests. It has been openly discussed in major fora recently, and is being tackled by governments, NGOs, the private sector and international organizations through a range of initiatives. All this interest has been stimulated by an increasing awareness worldwide of the immense costs associated with corruption and other illegal activities. It has also become apparent that ongoing efforts to improve forest management will have limited value unless accompanied by measures to reduce forest crime. Finally, it is becoming much more difficult to keep illegal and corrupt activities hidden, owing to the efforts of the media and NGOs and to the rapid spread of information that has been made possible by new information technologies.

This chapter describes the effect of crime and corrupt activities in the forest sector and the efforts of various stakeholders to suppress them. The first section describes illegal forest activities and why the forest and forest industries sector may be more susceptible than other sectors to illegal activities. This is followed by a discussion of the magnitude and impacts of illegal and corrupt forest activities. The next section attempts to answer the questions: can illegal and corrupt activities be combated effectively? And if so, how? The final section describes efforts to combat forest crime.

ILLEGAL ACTIVITIES AFFECTING FOREST RESOURCES AND INDUSTRIES

Forest crimes and corruption defined

Individuals, groups of individuals and institutions may engage in illegal activities and undermine governance in the forest sector. There are many types of illegal forest practices (see Box 20 for some common examples). Public servants may approve illegal contracts with private enterprises. Private commercial corporations may harvest trees of species that are protected by law from timber exploitation. Individuals and communities may enter public forests and illegally take products that are public property. Illegal activities do not stop at the forest. They travel down the line to operations in transportation, processing and trade of forest products. Individuals or corporations

BOX 20
Examples of illegal practices in the forest and forest industries sector

ILLEGAL OCCUPATION OF FOREST LANDS

- Rural families, communities or private corporations invading public forested lands to convert them to agriculture or cattle ranching.
- Private corporations or individuals inducing landless peasant farmers to occupy forested areas illegally, in order to force governments to grant landownership rights to the peasant farmers, and then buying these lands from them.

ILLEGAL LOGGING

- Extracting more timber than authorized.
- Logging without authorization.
- Obtaining logging concessions through bribes.
- Duplicating felling licences.
- Girdling or ringbarking to kill trees so that they can be logged legally.
- Contracting with local entrepreneurs to buy logs from protected areas.
- Logging protected species.
- Logging in protected areas.
- Logging outside concession boundaries.
- Logging in prohibited areas such as steep slopes, riverbanks and water catchment areas.
- Removing under- or oversized trees from public forests.
- Reporting high volumes extracted in forest concessions to mask the fact that part of the volume declared is extracted from non-authorized areas outside the concession boundaries.

ILLEGAL TIMBER TRANSPORT, TRADE AND TIMBER SMUGGLING

- Transporting logs without authorization.
- Transporting illegally harvested timber.
- Smuggling timber.
- Exporting and importing tree species banned from trade under international law, such as the Convention on International Trade in Endangered Species of Wild Fauna and Flora.
- Exporting and importing timber in contravention of national bans.

TRANSFER PRICING AND OTHER ILLEGAL ACCOUNTING PRACTICES

- Declaring lower values and volumes than those actually exported.
- Declaring higher purchase prices than the prevailing market prices for inputs such as equipment or services from related companies.
- Manipulating debt cash flows to transfer money to a subsidiary or parent company, e.g. by inflating debt repayment to avoid taxes on profits.
- Undergrading, undervaluing, undermeasuring and misclassifying species exported or marketed locally.

ILLEGAL FOREST PROCESSING

- Operating without a processing licence.
- Ignoring environmental, social and labour laws and regulations.

Source: Based on Contreras-Hermosilla, 1997.

may smuggle forest products across international borders or process forest raw materials without a licence. Corporations with strong international links may artificially inflate the price of imported inputs or deflate the volume and prices of their exports to reduce their tax liability and to facilitate the illegal transfer of capital abroad.

Many illegal activities simply result from the inability of governments to enforce the law. Unfortunately, in many other cases, illegal activities are the result of corruption. Corruption is a complex concept that has many interpretations and different meanings. Here, corruption is defined as "the unlawful use of public office by politicians or civil servants for private gain".

According to this definition, corrupt acts are illegal acts that:

- *Involve public officials.* A private individual stealing wood from a public forest is performing a criminal act but, according to this definition, not a corrupt one. While corruption involves civil servants, most frequently a party from the private sector or civil society is also implicated.
- *Involve public property and power.* Public property may be tangible (e.g. timber) or intangible (e.g. selling knowledge about government negotiating positions on timber concessions). Frequently, private property is also involved. Thus, corrupt civil servants may use the power of their office to extract bribes from the private sector without strictly compromising public property. This form of corruption is better described as extortion.
- *Are perpetrated for private gain.* A public official who misuses public forests without deriving private gain may qualify as negligent and incompetent (and thus is not free from prosecution), but not as corrupt.
- *Are intentional acts.* A public official who unknowingly uses public forest resources illegally is also negligent and incompetent, but not corrupt.
- *Are surreptitious.*

Some authors distinguish between petty and grand corruption (Tanzi, 1998). In grand corruption, the bribes are large. Frequently, the attitude is that petty corruption is somehow more "acceptable" because it is generally committed by poorly paid officials and the assumption is that the scale is so small that it does not really have much overall effect on forest resources. However, this assumption may be faulty: the aggregate effect of widespread petty corruption may have an impact as substantial as a few instances of grand corruption (Callister, 1999).

In some cases, grand corruption may be easier to detect, but it may be more difficult to control and punish because of the greater political power wielded by the corrupt partners. Often, persistent and unchecked grand corruption indulged by people in high positions creates favourable conditions for petty corruption, thus altering social values and norms.

Susceptibility of the forest sector to crime and corruption

There are several reasons to believe that the forest and forest industry sector may be more susceptible than other sectors to illegalities and corruption. This seems to be the case at least in many tropical and subtropical countries, where forest ecosystems are very complex, access tends to be difficult and the visibility of illegal operations is lower because of generally insufficient monitoring systems and weak media. The reasons why these countries, in particular but not exclusively, are susceptible to forest crime and corruption are as follows:

- Forest activities in these countries often involve large areas and take place in remote places, far from public scrutiny, the media and official controlling agencies; independent checks are rare and the enforcement capacity of public controlling agencies over vast and remote areas is normally low.
- In forest-rich countries, forest resources are valuable but timber volumes and their quality are seldom known with precision.
- Most forestry departments must grant broad discretionary powers to local forestry officers to measure, classify and sometimes value forest products because these activities take place in the field, far from decision-making centres. Largely unsupervised officials are commonly empowered to certify volumes and qualities of wood extracted from forest concessions.
- Even when detailed forest inventories are available, logs are highly variable, voluminous and of different species. Commercial volumes are difficult to quantify when, for example, logs are affected by central rot, and sometimes the identification of species leaves latitude for "mistakes". If different prices are established for different species and qualities of logs in

different localities where concessionaires operate, possibilities to downgrade qualities and species emerge. Much must be left to interpretation and discretion rather than to objective and precise measurement (this is one of the reasons that impel governments to establish area-based uniform fees in forest concessions).

- Government officers, who are frequently on low pay and are largely unsupervised, oversee high-value products over large areas. Under these circumstances, the incentives to engage in corrupt acts are strong.
- The large number of regulations and permits that governments issue in their attempt to optimize the use of forest resources generate additional opportunities for corruption every time an unsupervised public official must approve those permits or enforce the regulations. Timber transit permits are notorious examples of well-intentioned, but widely circumvented, rules. Moreover, regulations are often poorly designed, constantly changing and open to interpretation, making them easier to bend.
- Penalties are commonly minimal in comparison with the potentially high returns from corruption. Furthermore, when corruption is systemic, it is difficult to identify and punish corrupt officials and partners in the private sector or civil society when so many others, possibly including the enforcers themselves, may also be corrupt.
- Finally, in numerous cases, comparatively powerless government forest controllers operating in isolated regions are forced to participate in illegal acts or risk physical harm. Violence is not foreign to attempts to monitor and control illegal operations by the forestry administration.

High timber values, low visibility, low pay, a far from standardized product, broad discretionary powers to decide on a number of highly subjective matters, poor objective information, uneven distribution of power among players and the improbability of harsh punishment, all create a favourable environment for illegal activities and corruption.

THE MAGNITUDE AND EFFECT OF ILLEGAL FOREST ACTIVITIES

Illegal forest activities and corruption happen virtually everywhere in the world: in industrialized societies, in developing countries and in countries with economies in transition.[30] Although countries with economies in transition have been receiving attention recently, the media tends to continue its focus on developing countries and, particularly, on forest-rich tropical countries. This is due partly to universal concerns about the importance of these forests in terms of biological diversity conservation and the fact that their degradation affects so many of the world's poorest people. However, countries with sparse forest resources, such as those in the drier regions of the world, are obviously not immune to crime and corruption. While individual corrupt acts and bribes in these countries may be small, their aggregate effect can be substantial, as can their negative impacts on large numbers of poor people. Nevertheless, forest crime in these countries attracts less attention from the media, environmental NGOs, development specialists and international assistance agencies.

In all these situations – in forest-rich and forest-poor countries, in industrialized, developing or transition economies – forest crime is difficult to quantify. No global or regional assessments of the magnitude of illegal and corrupt activities in the forest sector exist and it is difficult to know whether they are increasing in frequency or magnitude. However, available information, albeit partial, shows that illegal and corrupt activities are prevalent in many countries.

Studies have been carried out on corruption in the forest sector, some of which have been well publicized. One study, commissioned by WWF a few years ago, estimated that most of the timber exports from various countries in Asia were illegal (Dudley, Jeanrenaud and Sullivan, 1995). A recent

[30] The Transparency International Corruption Perceptions Index lists only one developing country among the 20 least corrupt countries, while there are 14 developing countries (including several forest-rich countries) in the group of the 20 most corrupt nations. See www.transparency.de/documents/cpi/2000/cpi2000.html.

joint report by WWF-Belgium, WRI and WWF International, sponsored by the European Commission, mentions cases of corruption in various countries of Africa, the Pacific and the Caribbean (Sizer and Plouvier, 2000). Research carried out by the Global Forest Watch initiative, recently launched by WRI, reveals that in one central African country, over half of all the active logging licences in 1999 were illegal (with offenders operating with expired licences or logging in parks and reserves) and that the legality of allocations of 23 other timber concessions was in doubt (WRI, 2000a). This research also showed that many of the offending companies and individuals that operated outside the law were never prosecuted because of the influence of a "higher authority". Several institutions such as the Environmental Investigation Agency, Global Witness and Friends of the Earth have researched forest crime in a number of other countries and shown that it is a critical problem facing the sustainable management of forest resources (see Environmental Investigation Agency, 1996; Global Witness, 2000; Glastra, 1999).

In a famous case of a detailed inquiry of forest crime and corrupt acts in the forest sector, a judge in a Pacific island nation concluded that:

> "It would be fair to say, of some of the companies, that they are now roaming the countryside with the reassurance of robber barons, bribing politicians and leaders, creating social disharmony and ignoring laws in order to gain access to, rip out, and export the last remnants of the province's valuable timber. These companies are fooling the landowners and making use of corrupt, gullible and unthinking politicians…. It is doubly outrageous that these foreign companies … have then transferred offshore secret and illegal funds … at the expense of the landowners and the government. There can be no doubt that the timber industry, by its very nature, is conducive to acts of a criminal nature contrary to law and proper government ministration."
>
> **(Marshall, 1990)**

A recent study of forest crime in a Southeast Asian country attempted to estimate the magnitude of illegal activities by comparing official figures of production of wood in the country during 1997/98 with the roundwood equivalent of domestic apparent consumption plus exports minus imports. This latter calculation produces a rough estimate of "apparent production". By comparing official production with apparent production, the analyst determined a gap of unexplained production reaching some 33 million m^3. This exceeds official production, which is declared at 29.5 million m^3. In other words, more than half of the forest extractions may be illegal in that country (DFID, 2000b).

Clearly, there is reason to believe that forest crime and corruption are serious problems that conspire against countries' efforts to establish systems of sustainable forest management.

Most people would agree that sound governance cannot be achieved without compliance with the law and that illegal acts should be combated. The remedy consists of better laws, and then effective monitoring, detection and harder punishment. Opinions are more mixed, however, in the case of corrupt acts. Ethical considerations aside, some argue that corrupt activities contribute to economic efficiency because they allow investors and entrepreneurs to avoid immensely complex and sometimes seemingly absurd bureaucratic regulations. In this view, corruption is the "grease" that keeps the wheels of forest development spinning. By avoiding government restrictions, corruption is tantamount to deregulation. The proponents of this line of reasoning also maintain that corruption contributes to economic efficiency because the most efficient firm – the firm with the lowest costs – will be able to pay the highest bribes and thus will win the contract, such as for a timber concession. Similarly, a company or individual that values time highly will be inclined to pay bribes to jump the line and have their papers or contracts processed faster. Thus, here too, corrupt behaviour would seem to increase economic efficiency.

However, there is much evidence to show that illegal activities and corrupt behaviour are economically inefficient and negatively affect the sustainability of forest management and social equity. Far from being an economic lubricant, corruption distorts the allocation of investments in the forest sector. Government officials accepting bribes may make decisions that only by chance coincide with those that are of most benefit to the country. For example, certain harvesting and transportation equipment may not be well suited to the conditions of a specific country, but they may be chosen because a supplier pays bribes to win the contract. Furthermore, inappropriate capital-intensive projects and technologies are sometimes preferred because they make it easier to "skim off" substantial sums.

Moreover, in corrupt environments, a vicious circle tends to come into effect. When corruption is tolerated, government officials have an incentive to create new rules that multiply the need for companies and individuals to pay bribes in order to have things done. For the same reason, corrupt officials may resist efforts to simplify regulations. Thus, recommendations to streamline timber concession systems, for example, may not be followed because reforms may close the door to opportunities for malfeasance. Corruption, therefore, may not be simply a reaction to cumbersome regulations, but may be a cause of them.

Similarly, payments to speed up bureaucratic procedures by "jumping the line" may act as a powerful incentive for bureaucrats to slow down such procedures. Bribes may secure an individual firm a higher position in the line (e.g. for obtaining export permits), but the average time of processing applications may slow down considerably. Corruption in these cases tends to feed itself in a downward spiral of economic inefficiency in which more corruption leads to increased inefficiencies, and so on.

Furthermore, when the discretionary power of government officials is high, they are able to customize bribe-seeking behaviour by charging higher bribes to the companies that are most able to pay. These are often the most efficient companies but sometimes they may be those supplying substandard products and services.

Several researchers have tested hypotheses that rationalize corruption based on its presumed economic benefits. Evidence from several sectors provides no support for the "efficient grease" concept (Kaufmann and Wei, 2000). Although none of these empirical studies has focused on the forest sector, there is no persuasive argument to believe that impacts would be different. In fact, when corruption is widespread, responsible companies tend to avoid investing in the corrupt country or sector (Kaufmann, 1997). This is because the costs of operating in corrupt environments can be very high. Research shows that the average added cost of corruption in the forest sector in a corrupt country is about 20 percent. This is equivalent to a very high corporate tax (Tanzi, 1998).

In addition, profits made by companies and proceeds accruing to corrupt government officials are generally sent abroad or hoarded as unproductive assets, thus negating the potentially productive use of capital.

Furthermore, corrupt behaviour tends to deter long-term forest investment because risks in corrupt environments are higher. While the "efficient grease" argument assumes that each side of the corrupt contract will adhere to the terms of that contract, this is frequently not the case. Promises tend to remain unfulfilled mainly because this opens the door to more bribes. Of course, there is no recourse to the courts to force compliance with the terms of a corrupt agreement. Furthermore, when changes in contracts depend on the whim of corrupt officials, who may be replaced in the next political reshuffle, the incentive to invest in long-term operations naturally fades away. All these factors tend to reduce the level of private forest investments.

So far, corrupt behaviour between government and the private commercial sector has been examined. Yet some of the same forces against economic efficiency also operate in the relations between government and institutions and individuals of civil society, such as rural communities or rural people in general. In these cases, corruption tends to be more violent ethically because some members of civil society are very weak. Public officials, abusing their power, are often able to extract money from some of the poorest and most disadvantaged people. Strictly speaking, and according to the definition of corruption, these are not corrupt acts because one of the partners does not carry them out voluntarily. These are criminal acts, better characterized as extortion. In extreme cases, the poor may have to pay for access to some forest goods and services already granted to them by law, such as the right to collect fuelwood from public forests. Refusal to pay bribes often results in the fabrication of cases against them, compelling people to "fall in line" and to be victims of corruption with no remedial action. Aside from their possible negative effects on economic efficiency, these illegal acts go against equity and the dignity of disadvantaged groups.

Furthermore, as public money is channelled into private pockets instead of into the state treasury, corruption reduces public revenue. As already indicated, the amounts involved are often likely to be substantial. Such diversion of funds is likely to be relatively more damaging in developing countries, where investment funds are very scarce and the need for national economic growth and improved conditions for the poor is more pressing.

In summary, contrary to the "efficient grease" theory, the impacts of corruption on forest governance, economic efficiency, forest management and equity are numerous and mostly negative. Corruption undermines the state's capacity to impose law and order in the sector. It undercuts economic efficiency because it leads to poor decisions and misallocation of scarce economic resources. It acts as a deterrent to private sector investment in the sector. It affects the quality of forest management because it favours the quick and wasteful utilization of public forests for private gain rather than for national benefit. As corruption disproportionately hurts the poorest segments of society, the poor perceive government to be unfair and in favour of those who already have plenty. This increases the possibilities for social unrest, if not violent conflict. For example, in 1994, Chiapas State in Mexico was the scene of an armed uprising against the federal government. The rebels were mainly impoverished Indians protesting against expulsion from their farmlands and forest tracts by large-scale cattle ranchers and loggers operating in collusion with corrupt public officials.

WHAT CAN BE DONE ABOUT ILLEGAL AND CORRUPT FOREST ACTIVITIES?

There is little doubt that illegal activities can be combated effectively by improving monitoring systems, passing simpler laws and ensuring strict enforcement. But when it comes to corrupt activities, sceptics question whether they can be fought effectively. Some argue that, when corruption is systemic, it becomes "part of the culture" accepted by all, and therefore any action to combat it is likely to be ineffective. Others point out that, under these circumstances, combating corruption in one group of activities – such as those related to forest resources and industries – is a losing proposition because one segment of government cannot be completely isolated from the total system of governance, and that the government as a whole therefore needs to be reformed before integrity in forest-related activities can be achieved.

These arguments are not supported by evidence. Recent cases reveal that even in societies where corruption is systemic, the majority almost invariably rejects it, thus refuting the argument that corruption is an integral part of the culture. This does not mean that its eradication is an easy task. When corruption permeates the whole government apparatus, is organized and faces no effective political challenge, it is extremely difficult to combat it in the forest sector (Johnston and Doig, 1999). In these cases, fighting corruption in the forest sector may perhaps produce short-term changes, but there is a real danger that these changes will not be sustained.

However, not all situations involve systemic corruption. When corruption is less entrenched, reforms in an individual ministry or line agency can render notable results. In the case of forest activities, installing more transparent mechanisms such as auctions in timber concessions, reducing the discretionary power of individuals in allocating subsidies, enlisting the help of stakeholders from the private sector and civil society, employing a third-party monitoring agency and promoting privatization, all contribute to reducing corruption. The case of Bolivia, described in Box 21, is an example of how actions in the forest sector can succeed.

National policy options to combat forest crime and corruption

Given the reality that policy actions against forest crime and corruption normally face stiff resistance from vested interests, their effectiveness will largely depend on the political will and determination of government officials to push for reforms. Illegal activities and corruption are symptoms of deeper problems in governance. Obviously, long-term solutions must attack the underlying causes of corruption rather than its immediate manifestations. This may take a long time – in fact, a very long time. The underlying causes are numerous and complex and include weak law enforcement, great inequalities in the distribution of economic power, a lack of protection of property rights, the prevalence of undemocratic decision-making processes, and so on.

Stricter enforcement, alone, is unlikely to suppress forest crime. Illegal and corrupt activities often provide the only employment and survival options for a number of people. Policies to fight corruption must consider that these people will only adopt legal alternatives to the extent that these exist. Alternatives must somehow be provided by government to generate monetary and other incentives for rural people to move away from the illegal use of forests.

In addition to tackling the fundamental causes of forest crime, measures that make it difficult to occur and increase can help. Prevention is a positive step, but so is deterrence. It may not be possible to eliminate forest crime, but at least some measures can be taken to achieve a second best, a situation where the environment is less favourable towards illegal acts.

The policy measures described in the following points are in line with this reasoning and are particularly appropriate in situations where corruption is not systemic and the government is determined to improve governance. However, a word of caution is in order: in most cases, measures to combat forest crime are not likely to have an effect unless they are implemented in packages, consisting of different measures that can be used to varying degrees depending on a country's specific circumstances. Individually, each measure would contribute to fighting forest crime but would be unlikely to solve the overall problem by itself. For example, the promotion of better forest resources monitoring may help in detecting illegal acts, but it will have little effect if the penalties for corrupt acts are not severe enough.

Increase the rewards for integrity. This is a policy aimed at *preventing* forest crime. If forestry officers are poorly paid or promotions are related more to patronage than to quality of service, there is little benefit in being honest. In such a context, the costs of losing a job are low and the propensity to accept bribes naturally increases. Granting higher salaries for forestry staff is an obvious and desirable reform because it would increase the pain of losing a desirable job but, although this may be a necessary condition, it is not sufficient in itself. The best-paid officials are often the most corrupt ones. In fact, in certain circumstances, a higher pay may only lead to more problems: an official with a good salary may demand higher bribes to offset the risk of losing the job if caught. Thus, higher salaries for forestry staff should only be part of a much more complex response. Another drawback to this policy measure is that, in many cases, it runs counter to the prescriptions of structural adjustment programmes, which normally insist on reductions in public sector spending. This potential obstacle can be eliminated if cuts in unnecessary jobs create enough savings to keep aggregate spending at a lower level, even if the remaining civil servants receive a higher pay.

Increase the probability of detection. This set of measures is also mainly oriented towards the *prevention* of forest crime and corruption. It includes better assessments of forest resources (including improved estimates of their commercial value) and the wide dissemination of the results, particularly to the media and watchdog NGOs. It may also include asking a third party (preferably

BOX 21

A strong push for reducing forest crime: the case of Bolivia

Policy and legal reforms in Bolivia's forest sector are some of the most far-reaching anywhere, and they contain specific strategies to combat forest crime and corruption. Legislation was approved after a lengthy period of political discussion involving different stakeholders from the private sector, civil society and the government. The development of the analytical framework was strongly supported by an international assistance project, which provided impartial and sound information and recommendations to decision-makers.

According to the country's Constitution, all natural forests are the property of the state. All forest harvesting is done by the private sector and, before the new law, was performed under short-term contracts with the government, based on volume charges. It is generally recognized that the old system provided a number of opportunities for forest crime and corruption to arise.

In 1996, a new law introduced drastic changes, including the introduction of a uniform area charge. While it may have some shortcomings, this method has the undeniable advantage of eliminating interpretation and the use of discretionary power in assigning timber concessions. The annual fee is US$1 per hectare of concession. Thus, a 100 000 ha concession pays US$100 000 per year, a clear and simple calculation with no room for alternative interpretations. At the same time, the responsibility for field-level forest operations was transferred to private firms. Management plans, following government guidelines, are now prepared by independent forest professionals, who are also legally responsible for their implementation. The private operators are required to produce five-year audits by a recognized independent body to prove that the prescriptions of the plans are being applied in practice. Concessions will be auctioned using transparent bidding processes and will last for a period of 40 years, subject to the approval of the five-year audits.

The head of the executive forestry agency, the *Superintendencia Forestal*, is selected from a list of three names provided to the President by a two-thirds majority of the senate. The Superintendent's assignment lasts for six years, thus straddling the presidential period, which is four years. Financing for the Superintendent is independent from the National Treasury, and the funds come largely from the direct collection of concession fees. The Superintendent holds annual public hearings to report to the public on the agency's progress and the use of financial, human and capital resources. An independent international third party controls the transit of wood, although the government carries out parallel verifications. All these measures have been designed to minimize political interference and the use of public office for private purposes as well as the incidence of corruption and forest crime in general.

The implementation of the reforms has not been without difficulties, but they have been widely recognized as having successfully reduced corruption.

an international institution of known reputation) to provide independent auditing, monitoring and reporting. The work of this outside institution should supplement the action of national forest institutions, and efforts must continue at the same time to strengthen government capabilities and foster an anticorruption culture. This is the model established in Cambodia, where a forest crime monitoring unit was created in 1999, composed of two separate government offices and an independent international monitor (Global Witness), to detect and contribute to suppressing illegal forest activities.

Increase penalties. This set of measures is oriented towards *punishing* parties for corrupt acts, and is thus aimed at deterring such action in the future. Penalties can act as deterrents if they are heavy enough and if they are commensurate with the economic value of the offence. In addition, penalties would be more effective if they were levied on both the government official and the private parties participating in the corrupt deal. Governments could also cancel all contracts with private firms or civil society groups involved in illegal activities, and they could blacklist corrupt private firms and other groups or individuals, thereby excluding them from future government contracts.

Reduce discretionary power of government officials. Because forest crime is more likely to occur if a few officials have considerable discretionary power over decisions that involve large values, reducing that discretionary power contributes to preventing corruption. For example, if only a few officials, unobstructed by controlling bodies, can award timber concessions or decide on the eligibility of firms to receive subsidies, the potential for corruption is increased. This potential can be reduced by simplifying norms, including export procedures, eliminating subsidies and making the awarding of concessions subject to transparent procedures such as open and independent bidding systems. These measures are also likely to improve economic efficiency. Certain operations can be privatized, thus replacing bribes with legal payments determined by market values. Furthermore, when the possibility exists, it may be advisable to promote overlapping institutional responsibilities, thus reducing the discretionary power of one single agency or individual. For example, forest guards may control permits for the transport of wood but this could also be done by the regular police force. Collusion in such circumstances is less likely. As with all the policy measures described, the application of this measure, alone, may not eliminate corruption, as a given operator may be forced to pay bribes twice. However, it would at least create incentives that reduce people's willingness to pay high bribes while also reducing the probability of corruption being undetected.

Streamline the policy, legislative and regulatory framework. Related to the previous measures, fewer, simpler and clearer government rules would reduce opportunities for their subjective interpretation and for malfeasance. For example, if a subsidy policy is cancelled, the associated opportunities to use the programme for personal gain disappear; and if procurement is based on standardized items, it provides a benchmark for judging decisions and spotting violations. In some cases, it is possible to introduce mechanisms for losers (e.g. of a government timber concession contract) to have a formal opportunity to challenge the government decision and sue the government if evidence of malfeasance is unearthed. Legal recognition of the customary rights of local populations would improve the possibility of their reporting misdoings. Rules should be established that stipulate clear responsibilities and procedures for granting concessions and other access and use permits in public forests.

Increase the use of market mechanisms. Markets can sometimes be used more intensely to avoid "command and control" policies and reduce opportunities for engaging in corrupt acts. If markets are reasonably competitive, administratively fixed prices (e.g. for awarding concession contracts) can be replaced by more open and transparent market mechanisms and the free play of demand and supply forces. Incentive and fiscal policies could be established to set market signals in the direction of more sustainable forest management.

Involve the media, NGOs and the public in combating forest crime. Various independent environmental NGOs, acting as "watchdogs", in collaboration with the media, have been instrumental in uncovering illegal operations in many countries and have frequently succeeded in forcing corrective action. These types of operations could be encouraged by government policy. The media can be a powerful instrument in unearthing and disseminating information about forest crime. The power of the Internet is already being used intensely to monitor and evaluate illegal activities and to provide an easy communication channel for "whistleblowers". Enhanced public awareness of the nature of forest resources and the way in which they are used usually helps in creating pressure for better governance. In contrast, secrecy creates "rents" for those who possess information.

Local people and NGOs can be engaged in fighting illegalities if, for example, they are informed about concessions granted and are provided with maps delineating concessions and areas affected by harvesting permits.

* * *

Committed governments and citizens are not alone in their concern about forest crime or in their efforts to implement preventive policies and punish offenders. With the increasing awareness that corruption in the forest sector is costly but can be combated effectively, a wide range of initiatives to reduce its impact are being undertaken by governments, NGOs, the private sector and international assistance agencies.

National responses

A number of developing countries are adopting legislation that incorporates some of these recommended policy elements to reduce forest crime and corruption. For example, the Malaysian Minister of Primary Industries has reportedly met with industry executives and demanded that they respect the laws of the countries in which they operate. Punishments in the form of fines and prison terms were increased for illegal loggers. Not long ago, the government fined 20 large companies involved in transfer pricing and forced them to pay back taxes.

In the Philippines, the Department of Environment and Natural Resources recently stepped up efforts to reduce illegal logging. The difficulty in combating entrenched logging syndicates in this country is illustrated by the fact that the enforcement efforts of the Department generated violent reactions, with the result that five of its staff investigating corrupt acts were killed in 2000 alone (Government of the Philippines, 2000).

At the beginning of the 1990s, Ghana faced a forestry crisis. Asia's timber demand and the operations of very aggressive corporations had caused a massive increase in illegal extractions. The Ministry of Forests took several steps to curtail the illegal traffic of wood; initially it imposed export taxes, and then an export ban. It also created a brigade to monitor forests. Unfortunately, these measures had little impact. In 1994, the Ministry renewed its efforts to combat illegal acts through several regulatory means, such as mandatory inspections by forest guards before exploitation, logging permits, transport permits and so on. These measures proved ineffective as well. At that point, the government took the critical step of making a genuine effort to involve other members of the private sector and civil society in the fight against the illegal use of forests, thus closing the triangle of good governance. The government involved farmers, forest owners, industrial operators, transporters and others. The main group concerned – forest owners – took the first step in supporting government efforts and, little by little, other private sector and civil society stakeholders joined in. As a result, illegal logging was substantially reduced, with the reduction in log supplies bringing about a fourfold increase in the value of marketed timber between 1994 and 1995 and, hence, an increase in government revenue (Bouderbala, 2000). Corruption has not disappeared in the forest sector; it is still reported to be a problem. Nevertheless, it is unquestionable that Ghana's efforts to fight corruption are a step in the right direction.

Bolivia is another country where the government has taken strong steps to fight forest crime (see Box 21). Most of the main actors, including the most sophisticated forest industrialists, support these measures, simply because the law introduces biases in favour of technologically advanced and innovative companies and against inefficient and technologically backward operators. As in all cases of reform, however, as long as the underlying causes of corruption persist, it is difficult to predict the course of future events.

NGO efforts

NGOs have been part of the vanguard in combating illegal acts and corruption in the forest sector. Here, it is possible to mention only a few of the many groups involved. A notable example is Global Witness, an NGO that organized effective anticorruption efforts in Cambodia. International exposure and worldwide awareness raising by Global Witness operations motivated government and international agencies, including the Asian Development Bank, the World Bank, the International Monetary Fund and several bilateral donors, to support actions against corruption in Cambodia's forest sector.

Transparency International, an NGO dedicated to combating international and national corruption, produces the now famous Corruption Perceptions Index,[31] which ranks countries according to degrees of perceived corruption among public officials and politicians. This NGO also helps committed countries to devise strategies for combating corruption. The main purpose of the Environmental Investigation Agency, an NGO based in the United Kingdom and the United States, is to investigate, expose and campaign against illegal trade in wildlife, illegal logging and trade in timber species as well as the destruction of the natural environment. The Environmental Investigation Agency has been instrumental in raising world awareness about the operations of unscrupulous corporations in illegal logging and trade. Environmental groups under the Friends of the Earth International Federation have carried out numerous studies and awareness-raising exercises in various countries, many of which have resulted in effective action against corruption in the forest sector.

The promotion and support of certification schemes by the Forest Stewardship Council provides a framework for companies and consumers to foster sustainable and "clean" forest management practices. While certification is not specifically focused on reducing forest crime, its sustainability requirements could help to eliminate forest crime that leads to unsustainable practices. Other NGOs are also helping to promote certification. For example, WWF's Global Forest and Trade Network brings together corporations interested in sourcing their wood from certified suppliers. While the global impact of certification is probably limited, because only a small fraction of the wood produced in developing countries is traded in international markets and only a small percentage of that is currently certified, certification provides an additional means of reducing forest crime. In early 2000, WRI launched Global Forest Watch, an initiative that uses satellite technology and the knowledge of partners to track developments such as mining, logging and other activities that may threaten forests if they are not properly regulated. It aims at introducing transparency and accountability in decisions by identifying the main actors behind these developments and the processes that lead to actions. Global Forest Watch is currently working in seven countries but, by 2005, it aims to expand its operation to 21 countries, covering 80 percent of the world's remaining large, undisturbed forest ecosystems. Its activities have already uncovered and documented several instances of illegal logging.

[31] See reference in footnote 30, p. 91.

Private sector initiatives

There are an increasing number of private sector initiatives to promote sustainable forest management and to avoid illegal and corrupt practices. These have been initiated by influential corporations that voluntarily adopt "codes of conduct" and lobby for transparent operations. Around the world, buyers' groups are proliferating. Formed by retailers and major users of wood with the aim of improving forest management worldwide, buyers' groups pledge to buy certified forest products.

An alliance of 42 timber companies committed to certification, *Compradores de Madeira Certificada*, was recently formed in Brazil with the assistance of WWF and Friends of the Earth Amazonia (WWF, 2000). The alliance helps to ensure that member companies' wood is not the product of illegal harvest. This is an example of private sector corporations and international and national NGOs joining forces in an effort that could help reduce corruption in forest operations.

International responses

Developed countries and their transnational corporations share a great part of the responsibility for the spread of corruption around the world. What is often overlooked is the fact that corruption in developing countries and economies in transition is frequently associated with companies from the industrialized world. The recognition that industrialized countries have a responsibility for reducing corruption connected with the operations of their international corporations has led to some corrective action. As early as 1977, the United States Foreign Corrupt Practices Act made it a crime for United States companies to bribe foreign officials. Unfortunately, this remained an isolated initiative for a long time. Until recently, corporations from other industrialized countries could conveniently deduct bribes to foreign officials from corporate taxes as "business expenses". In other words, bribing a foreign official was not only legal in industrialized countries, but openly encouraged through financial incentives.

Fortunately, this situation is rapidly changing. Following the lead of the United States, the Organisation for Economic Co-operation and Development's Convention on Combating Bribery of Foreign Public Officials in International Business Transactions went into effect in February 1999. Under the Convention, 34 countries, including all of the world's biggest economies, have made a commitment to adopt common rules to punish companies and individuals that engage in bribery. The Convention makes it a crime to offer, promise or give a bribe to a foreign public official in order to obtain favourable treatment in business deals (OECD, 2000a).

Many other international initiatives address forest crime and corruption directly or indirectly. The Libreville Action Plan 1998-2001 of the International Tropical Timber Organization (ITTO, 1998) contains several references to "undocumented" trade and forest activities, and "irregular" forest activities that evidently refer to illegal and corrupt actions in the forest sector. In 1997, the Organization of American States' Inter-American Convention against Corruption entered into force, with the aim of strengthening mechanisms to prevent, detect, punish and eradicate corruption in member countries. The Yaoundé Summit, held in March 1999 and involving five heads of African states, recognized problems of illegal poaching and logging and the need to combat these activities in countries participating in the Summit (for a discussion of the Yaoundé Summit, see Part III, p. 110). The extension of the Lomé Convention includes explicit provisions to support timber certification and thus, indirectly, actions to reduce illegal and corrupt activities.

The issue of corruption has been brought into the global debate on forests. The Intergovernmental Panel on Forests "invited countries to provide an assessment and share relevant information on the nature and extent of illegal trade in forest products and to consider measures to counteract such illegal trade". The Intergovernmental Forum on Forests included the "consideration of … market transparency and the related issue of illegal trade in wood and non-wood forest products".

Similarly, at their meeting in Birmingham, United Kingdom in 1998, the Group of 8 (G8) countries[32] reached an agreement on implementing an Action Programme on Forests that includes measures to combat illegal logging and trade. The G8 Summit in Okinawa, Japan, held in July 2000, reaffirmed these countries' commitment to fight illegal logging, with their pledge to "examine how best we can combat illegal logging, including export and procurement practices". In August 2000, the United Kingdom implemented this commitment with various initiatives, including the improvement of timber purchasing procedures by government agencies, action aimed at reducing consumption of illegal wood in the United Kingdom and cooperation with other countries to encourage good governance and to remove corruption.

In 1997, the World Bank launched a major initiative to address corruption. Its declared aims were to provide guidance in preventing fraud and corruption in Bank-financed projects, help countries that request Bank support to reduce corruption, take corruption issues into account in its analytical work and its dialogue in each country, and support international efforts to curb corruption. In 1998, the World Bank-WWF Alliance was launched. Within the framework of

[32] G8 comprises the world's seven most industrialized nations and the Russian Federation.

the Alliance, both institutions work with governments, the private sector and civil society in promoting improved forest management. Its targets include the increased protection, by 2005, of 50 million ha of forest areas under threat and of the 200 million ha under independently certified sustainable forest management. Although the aims of the Alliance do not explicitly include the fight against corruption, work to achieve its targets implies such action.

CONCLUSIONS

Illegal and corrupt activities threaten the world's forests, particularly but not exclusively in forest-rich developing countries. In some cases, and as a consequence of trade liberalization and globalization, illegal logging and trade appear to be growing. However, recent years have witnessed some encouraging developments. The subject is no longer ignored in major international conferences on forest sustainability. Arguments that attempt to rationalize corruption on the grounds of economic efficiency or as an excusable practice that is part of the culture of certain countries have been discredited by evidence. So have defeatist positions that suggest that corruption cannot be fought in isolated sectors or that corruption in poor countries is simply unavoidable.

Many NGOs and private sector institutions have launched campaigns that are directly aimed at stemming illegal activities and corruption in the forest sector. By exposing illegal and corrupt activities, these campaigns have effectively increased awareness of their economic, environmental and social consequences and have triggered action to combat them. In other initiatives, such as those concerning certification, the fight against illegal and corrupt acts is implicit but not less important.

In the fight against illegalities and corruption, words, rather than real action, frequently dominate. However, some governments have the necessary political will for translating words into action and reducing the incidence of illegal activities and corruption in the forest sector. The fight against crime and corruption includes such elements as the creation of stronger monitoring and enforcement systems; more transparent decision-making processes; simpler laws that reduce regulation and the discretionary power of individual government officers; much more severe punishments; and, above all, the effective involvement of civil society and of progressive private sector corporations. Such reforms need to overcome the resistance of entrenched and powerful vested interests. Some governments, with the support of NGOs and responsible private sector institutions, have made significant headway in overcoming this resistance. Keeping in mind the global values of forests, support from the international community should be secured for countries engaging in such an enterprise. ◆