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# FOREST PRODUCTS

Status and Trends in  
Global Forest Plantation  
Development

THE NATURAL RESOURCE FOR THE FOREST PRODUCTS INDUSTRY





# **Status and Trends in Global Forest Plantation Development**

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Forest plantations are grown to supply raw material for industry and for other uses, such as fuelwood. Forest plantations also provide additional non-wood forest products and benefits, from the trees planted or from other elements of the ecosystem that they help to create. They contribute environmental, social, and economic benefits. Forest plantations are used in combating desertification, absorbing carbon to offset carbon emissions, protecting soil and water, rehabilitating lands exhausted from other land uses, providing rural employment, and, if planned effectively, diversifying the rural landscape and maintaining biodiversity. The potential for forest plantations to partially meet demand for wood and fiber for industrial uses is increasing. In several countries, a significant portion of the wood supply for industrial uses comes from plantations, rather than natural forest resources.

Not all forest plantation development has positive economic, environmental, social, or cultural impacts, however. Without adequate planning and without appropriate management, forest plantations may be grown in the wrong sites, with the wrong species/provenances, by the wrong growers, for the wrong reasons. Examples exist where natural forests have been cleared to establish forest plantation development or where customary owners of traditional lands may have been alienated from their sources of food, medicine, and livelihoods. In some instances, poor site/species matching and inadequate silviculture have resulted in poor growth, hygiene, volume yields, and economic returns. In other instances, changes in soil and water status have caused problems for local communities. Land use conflicts can occur between forest plantation development and other sectors, particularly the agricultural sector.

The negative impacts of forest plantations can draw the focus away from the fact that forest plantation resources are totally renewable and can be economically, socially, culturally, and environmentally sustainable with prudent planning, management, utilization, and marketing.

This article will describe the recent status of plantations worldwide. The data presented here were collected by the Food and Agriculture Organization (FAO) in the year 2000 and published in 2001 as the Global Forest Resources Assessment 2000 (FRA 2001f). New forest plantation areas are reported as being established globally at the rate of 4.5 million hectares per year, with Asia and South America accounting for more new plantations than the other regions. Of the new plantations established, about 3 million hectares per year are estimated as being successful. Of the estimated 187 million hectares of

plantations worldwide in 2000, Asia has by far the largest area. In terms of composition, *Pinus* spp. (20 percent) and *Eucalyptus* spp. (10 percent) remain dominant worldwide, although the overall diversity of species planted is shown to be increasing. Industrial plantations account for 48 percent, non-industrial plantations for 26 percent, and plantations for unspecified use for 26 percent of the global forest plantation estate.

The results of the FRA 2000 plantation assessment were the first global estimates with a uniform definition of forest plantations and can therefore not be directly compared to previous estimates. FRA 2000 country statistics on plantations may also differ from those reported in prior FAO publications (FAO 1981; FAO 1995), partly because of changes in definitions, countries included, and bases for formulating data sets (FAO 2001g.). Countries participated directly in the assessment, providing technical documentation and supporting analysis and validating the results generated by FAO. Several experts around the world were enlisted to provide detailed information on various aspects of the plantation situation in the form of special studies.

## Concepts and Definitions

Between the extremes of afforestation and unaided natural regeneration of natural forests, there is a range of forest conditions in which some human intervention occurs. European forests have long traditions of human intervention in site preparation, tree establishment, silviculture, and protection; yet these are not always defined as forest plantations. The term forest plantation tends to be applied to areas with single species, uniform planting densities, and even age classes. Terms such as “natural forest under management” or “assisted natural regeneration” are applied to stands of indigenous species in more heterogeneous management mechanisms in Europe and other industrialized temperate and boreal countries.

In FRA 2000, “forest plantations” are defined as those forest stands established by planting and/or seeding in the process of afforestation or reforestation. They are either of introduced or indigenous species that meet a minimum area requirement of 0.5 ha, tree crown cover of at least 10 percent of the land cover, and total height of adult trees above 5 m.

In country responses, terms such as “human made forest” or “artificial forest” were considered synonyms for forest plantations as defined in FRA 2000. Because of their increasing significance as a supply of fiber to the wood industries sector, rubber (*Hevea brasiliensis*) plantations were included as

forest plantation resources. Previously, rubberwood was categorized as an agricultural plantation rather than a forest plantation.

## Methods

It would be best if the reports of the area of existing forest plantations could be derived solely from statistically designed inventories of forest plantations or statistics for planted areas reported by planting agencies or appearing in national reports. But that is not feasible. Information also comes from many other sources, including nursery production, seedling distribution, and estimates derived from the goals of planting programs. The vast range of agencies, industries, and non-governmental organizations within countries engaged in planting programs made the comprehensive collection of all relevant source documents a major logistical exercise. For FRA 2000, over 800 source documents were analyzed to derive the forest plantation estimates. In most developing countries, a national clearinghouse for collecting information on plantations is either lacking or ineffective, owing to the enormity of the task and limited resources.

### Data collection

To retrieve the source documents for the plantation study, FAO made formal requests to all developing countries, some of which contributed the necessary materials. Most of the reports were collected directly by FAO staff during FRA 2000 workshops and visits to national ministries. For consistency, FRA 2000 prepared guidelines and questionnaires for the collection of forest plantation statistics in which the objectives, scope, definitions, sources of data, and templates for specific data collection were supplied to each country. Parameters requested included:

- \* total estimated forest plantation area, 2000;
- \* annual area of new plantations;
- \* species groups: broadleaf (including *Hevea* spp.); conifer; non-forest, e.g., African oil palm (*Elaeis guineensis*) and coconut palm (*Cocos nucifera*); bamboo; or unspecified;
- \* purpose and end-use objective of forest plantations: industrial (producing wood or fiber for supply to the wood-processing industries) or non-industrial (e.g., fuelwood, soil and water protection);
- \* ownership: public, private, other (e.g., traditional, customary), or unspecified.

Other data requested in the guidelines, which proved difficult for countries to provide by species group, included age class distribution; end-use by forest product (industrial plantations); growth and yield (mean annual increment); standing volumes; and rotation lengths. Despite the absence of these data,

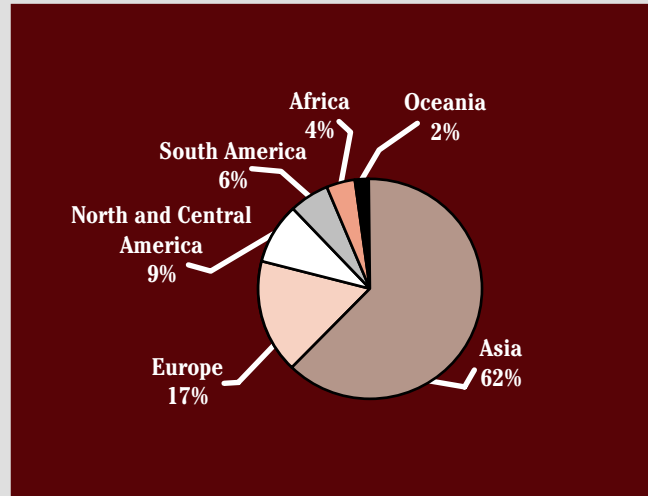


Figure 1. Distribution of forest plantation area by region.

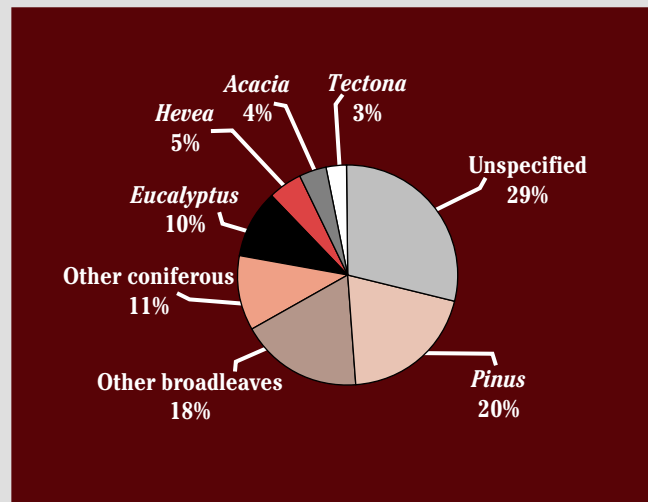


Figure 2. Distribution of plantation areas by genus.

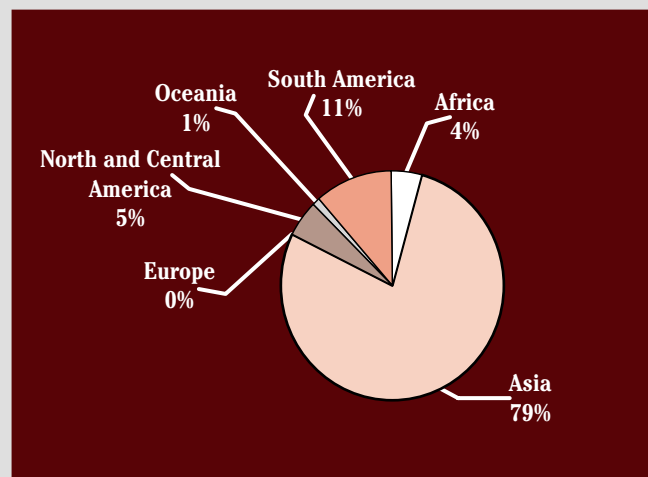


Figure 3. Distribution of annual planting area.



Region	Total area	Annual rate	Plantation areas by species groups							
			Acacia	Eucalyptus	Hevea	Tectona	Other broadleaf	Pinus	Other conifer	Unspecified
	(000 ha)	(000 ha/yr.)	(000 ha)							
Africa	8,036	194	345	1,799	573	207	902	1,648	578	1,985
Asia	115,847	3,500	7,964	10,994	9,058	5,409	31,556	15,532	19,968	15,365
Europe	32,015	5	-	-	-	-	15	-	-	32,000
North and Central America	17,533	234	-	198	52	76	383	15,440	88	1,297
Oceania	3,201	50	8	33	20	7	101	73	10	2,948
South America	10,455	509	-	4,836	183	18	599	4 699	98	23
<b>WORLD TOTAL</b>	<b>187,086</b>	<b>4,493</b>	<b>8,317</b>	<b>17,860</b>	<b>9,885</b>	<b>5,716</b>	<b>33,556</b>	<b>37,391</b>	<b>20,743</b>	<b>53,618</b>

Table 1. Annual plantation rates and plantation areas by region and species group.

Region	Total area	Industrial purpose					Non-industrial purpose					Purpose unspec.
		Public	Private	Other	Unspec.	Sub-total	Public	Private	Other	Unspec.	Subtotal	
		(000 ha)										
Africa	8,036	1,770	1,161	51	410	3,392	2,035	297	611	330	3,273	1,371
Asia	115,847	25,798	5,973	27,032	-	58,803	17,177	17,268	9,145	72	43,662	13,381
Europe	32,015	-	-	-	569	569	9	6	-	-	15	31,431
North and Central America	17,533	1,44	15,172	118	39	16,775	362	58	16	35	471	287
Oceania	3,201	151	14	-	24	189	2	3	-	19	24	2,987
South America	10,455	1,061	3,557	-	4,827	9,445	251	528	-	225	1,004	6
<b>WORLD TOTAL</b>	<b>187,086</b>	<b>30,226</b>	<b>25,876</b>	<b>27,202</b>	<b>5,871</b>	<b>89,175</b>	<b>19,836</b>	<b>18,161</b>	<b>9,772</b>	<b>680</b>	<b>48,449</b>	<b>49,463</b>

Source: FRA 2000

Table 2. Regional plantation areas by purpose and ownership.

FRA 2000 is the most comprehensive forest plantation resources assessment that has been carried out.

In previous assessments of forest plantation resources, plantation data were available up to the reference year for most countries, since the reporting followed the reference year. In FRA 2000, the reference year was 2000, so if data were not available to that date, then existing area and annual planting data were used to extrapolate the necessary information. For the few countries that have no data sets since 1990, the rate of planting in preceding years and future planting programs were considered in projections to the year 2000.

### Analysis and Interpretation

The quantity and quality of forest plantation data provided are dependent upon the capacity of the national forest inventory systems to collect and analyze data and to adjust the information to conform with global and regional reporting parameters. In many developing countries, there is a lack of institutional capacity to carry out periodic national forest

inventories, so data can be incomplete, inconsistent, outdated, and of variable reliability. Because of this, it was necessary to derive and in some instances to verify forest plantation statistics through desk research using available country reports. In addition, regional and national focal persons were appointed to assist in the forest plantation data collection to ensure that the latest data were available and to maintain coordination and communication between FRA 2000, FAO regional offices, and each participating country. On completion of the data sets, a formal verification process was undertaken with each participating country.

## Results

### Regional forest plantation areas, species, and annual plantings

The annual plantation rates and plantation areas by regions and species groups are summarized in Table 1.

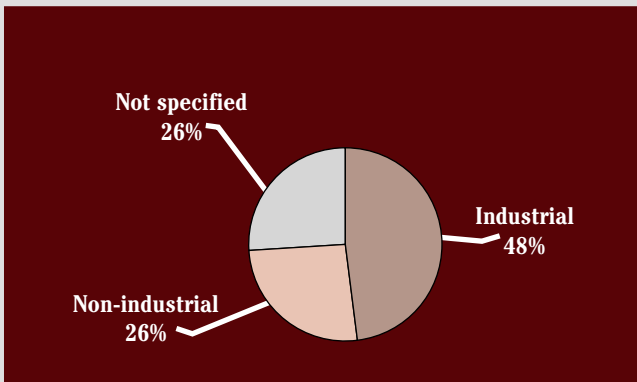


Figure 4. Distribution of forest plantations end-use, worldwide.

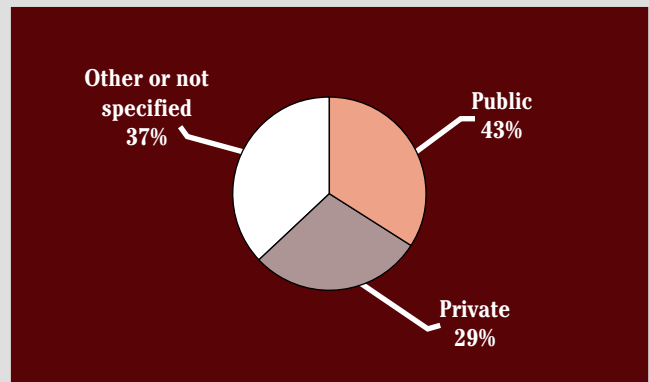


Figure 5. Ownership of industrial forest plantations, worldwide.

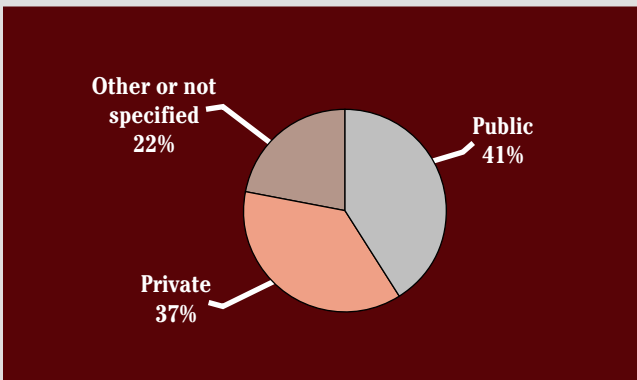


Figure 6. Ownership of non-industrial forest plantations, worldwide.

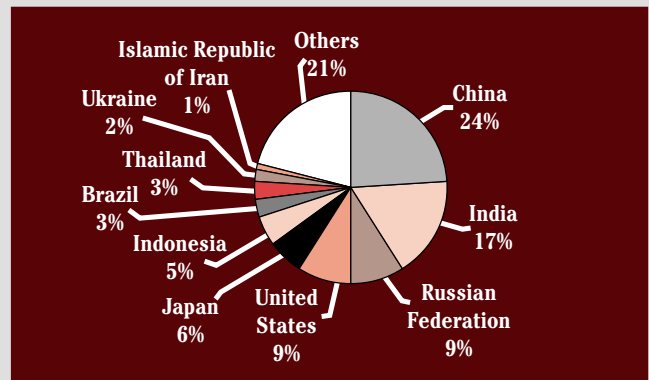


Figure 7. Leaders in forest plantation development, percentage of area.

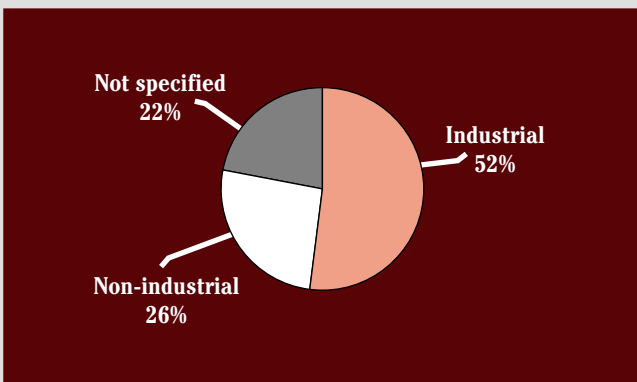


Figure 8. End-use of forest plantations, top 10 countries.

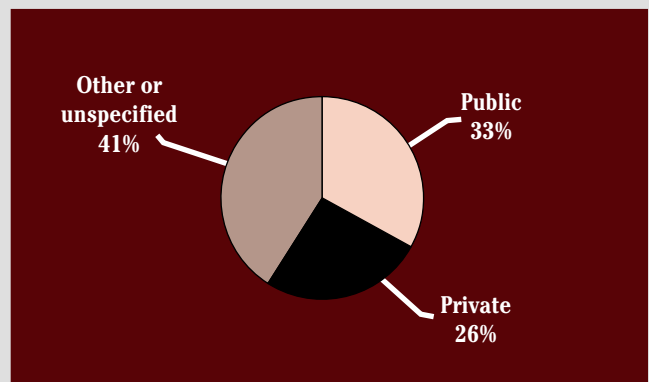


Figure 9. Ownership, industrial plantations, top 10 countries.

According to global forest plantation area distribution (Fig. 1), Asia accounts for 62 percent of the total; Europe, 17 percent; North and Central America, 9 percent; South America, 6 percent; Africa, 4 percent; and Oceania, 2 percent.

Globally, broadleaves make up 40 percent of forest plantation area with *Eucalyptus* the principal genus (Fig. 2). Coniferous species make up 31 percent, of which, *Pinus* is the principal genus.

In FRA 2000, the global rate of new planting is estimated at 4.5 million hectares per year. Asia accounts for 79 percent and South America for 11 percent (Fig. 3).

### **Purpose and ownership within the global forest plantation estate**

Purpose and ownership of forest plantations vary markedly among regions (Table 2). Industrial

Country	Total area	Industrial purpose					Non-industrial purpose					Unspecified purpose
		Public	Private	Other	Unspecified	Subtotal	Public	Private	Other	Unspecified	Subtotal	
	(000 ha)											
China	45,083	10,182	-	26,994	-	37,176	102	-	7,805	-	7,907	-
India	32,578	8,258	3,749	-	-	12,007	11,370	8,641	560	-	20,571	-
Russian Federation	17,340	n.a. <sup>a</sup>	n.a.	n.a.		n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	17,340
United States	16,238	1,185	15,053	-	-	16,238	-	-	-	-	-	-
Japan	10,682	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	10,682
Indonesia	9,871	4,531	1,228	-	-	5,759	358	3,754	-	-	4,112	-
Brazil	4,982	-	-	4,802	-	4,802	-	-	180	-	180	-
Thailand	4,920	850	314	-	-	1,164	1,219	2,537	-	-	3,756	-
Ukraine	4,425	n.a.	n.a.	n.a.	n.a.		n.a.	n.a.	n.a.	n.a.	n.a.	4,425
Islamic Republic of Iran	2,284	241	-	-	-	241	1,938	105	-	-	2,043	-
<b>Top 10 Total</b>	<b>148,403</b>	<b>25,247</b>	<b>20,344</b>	<b>31,796</b>	<b>-</b>	<b>77,387</b>	<b>14,987</b>	<b>15,037</b>	<b>8,545</b>	<b>-</b>	<b>38,569</b>	<b>32,447</b>
<b>Top 10 %</b>	<b>79%</b>					<b>87%</b>					<b>80%</b>	<b>66%</b>
<b>WORLD TOTAL</b>	<b>187,086</b>	<b>30,226</b>	<b>25,876</b>	<b>27,202</b>	<b>5 871</b>	<b>89,175</b>	<b>19,836</b>	<b>18,161</b>	<b>9,772</b>	<b>680</b>	<b>48,449</b>	<b>49,463</b>

<sup>a</sup> n.a. = not available.

Table 3. Plantation purpose and ownership by reported area for the 10 largest plantation development countries.

Region	Plantation area by purpose			
	Total	Industrial	Non-industrial	Unspecified
	(000 ha)			
<b>2000</b>				
Africa	8,036	3,392	3,273	1,371
Asia	115,847	58,803	43,662	13,381
Oceania	3,201	189	24	2,987
Europe	32,015	569	15	31,431
North and Central America	17,533	16,775	471	287
South America	10,455	9,446	1,004	6
<b>WORLD TOTAL</b>	<b>187,087</b>	<b>89,175</b>	<b>48,449</b>	<b>49,463</b>
<b>1990</b>				
Africa	2,990	1,366	1,623	
Asia	31,775	8,991	23,119	
Oceania	189	167	22	
Europe				
North and Central America	691	457	234	
South America	7,946	4,645	3,301	
<b>WORLD TOTAL</b>	<b>43,590</b>	<b>15,625</b>	<b>28,300</b>	
<b>1980</b>				
Africa	1,713	939	780	
Asia	11,088	3,487	7,601	
Oceania	88	41	47	
Europe				
North and Central America	287	272	15	
South America	4,604	2,261	2,348	
<b>WORLD TOTAL</b>	<b>17,779</b>	<b>7,000</b>	<b>10,791</b>	

Source: FAO 1981, 1995, 2000, 2001

Table 4. Forest plantation purpose trends by region, 1980-2000.

plantations provide the raw material for wood processing for commercial purposes, including timber for construction, panel products, and furniture, and pulpwood for paper. In contrast, non-industrial plantations are established to supply fuelwood and fodder; provide soil and water conservation, wind protection, and biological diversity conservation; combat desertification; rehabilitate degraded lands; and for other non-commercial purposes.

In many countries, particularly in the developing world, the end purpose of the plantations is not clearly defined at the outset. In some of these cases, valuable tree resources are established that coincidentally match future needs. However, in other cases, a lack of planning may result in plantations that have little commercial value and a low potential for local use.

Globally, 48 percent of the forest plantation estate is for industrial end-uses; 26 percent is for non-industrial uses; and 26 percent is not specified (Fig. 4). Industrial plantations are 34 percent publicly owned, 29 percent privately owned, and 37 percent other or unspecified (Fig. 5). Non-industrial plantations are 41 percent publicly owned, 37 percent privately owned, and 22 percent other or unspecified (Fig. 6).

### Leaders in forest plantation development

The 10 countries with the largest forest plantation development account for 79 percent of the global forest plantation development area (Table 3). Six of these countries, accounting for 56 percent of global forest plantations, are in Asia.

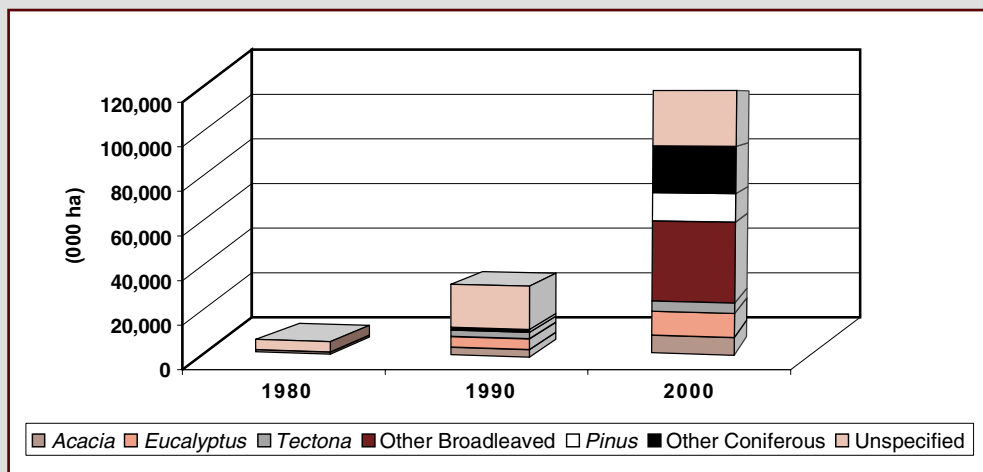


Figure 10. Plantation areas by genus, Asia. Countries not included in years 1980 and 1990: Japan.

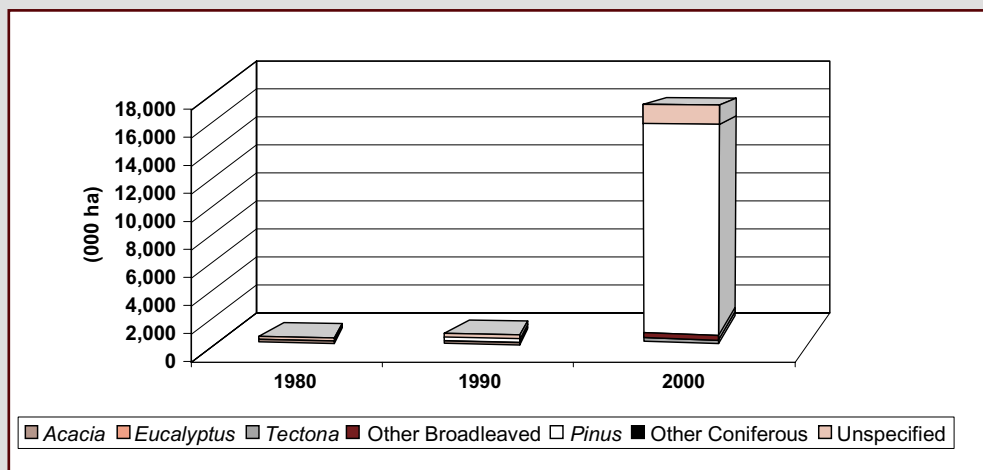


Figure 11. Plantation areas by genus, North and Central America. Countries not included in years 1980 and 1990: Canada and United States.

The top 10 countries according to area are: China, 24 percent; India, 17 percent; the Russian Federation, 9 percent; the United States, 9 percent; Japan, 6 percent; Indonesia, 5 percent; Brazil, 3 percent; Thailand, 3 percent; Ukraine, 2 percent, and the Islamic Republic of Iran, 1 percent (Fig. 7).

Within the top 10, an estimated 52 percent of forest plantations are grown for industrial purposes (to supply raw material for industry); 26 percent for non-industrial uses (fuelwood, soil and water protection, biodiversity conservation); and the purpose was not specified in 22 percent (Fig. 8). The industrial forest estate in these top 10 countries is 33 percent publicly owned, 26 percent privately owned, and 41 percent other or unspecified (Fig. 9).



## Selected Global Trends, 1980-2000

### Comparisons

FRA 2000 country statistics on plantations may differ from those reported in prior FAO publications (FAO 1981; FAO 1991), partly because of changes in definitions. For example, rubber (*Hevea* spp.) plantations were not previously considered as forest plantations, but they are included in FRA 2000 plantation data. Previous assessments also used regional reduction factors to indicate the successful proportion of plantations remaining after establishment. The FRA 2000 assessment applied reduction factors according to the best available data from each country independently. There have also been changes in the information base from which the estimates were derived. The statistics now include data from many industrialized countries, none of which were included in the prior global assessment reports. Despite these differences, comparison of FRA results from each decade allows analysis of some trends, including planting rates, genera, areas, and purpose (end-use).

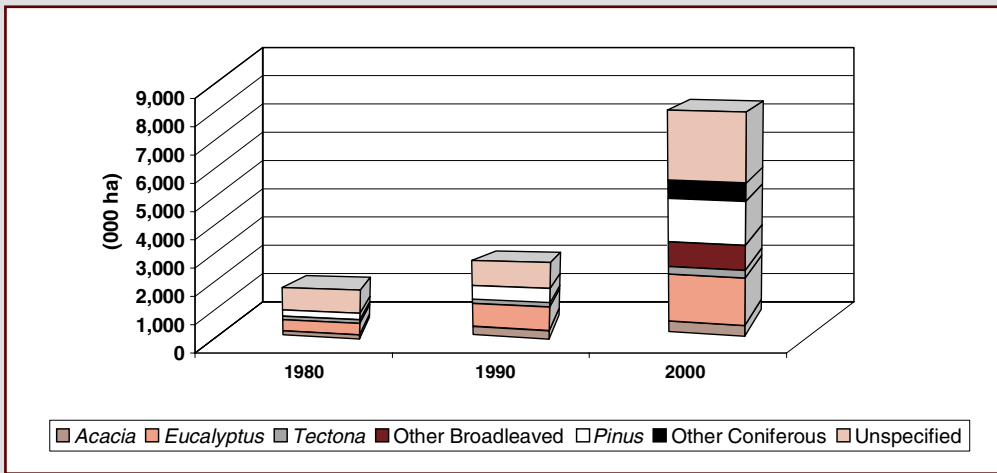


Figure 12. Plantation areas by genus, Africa.

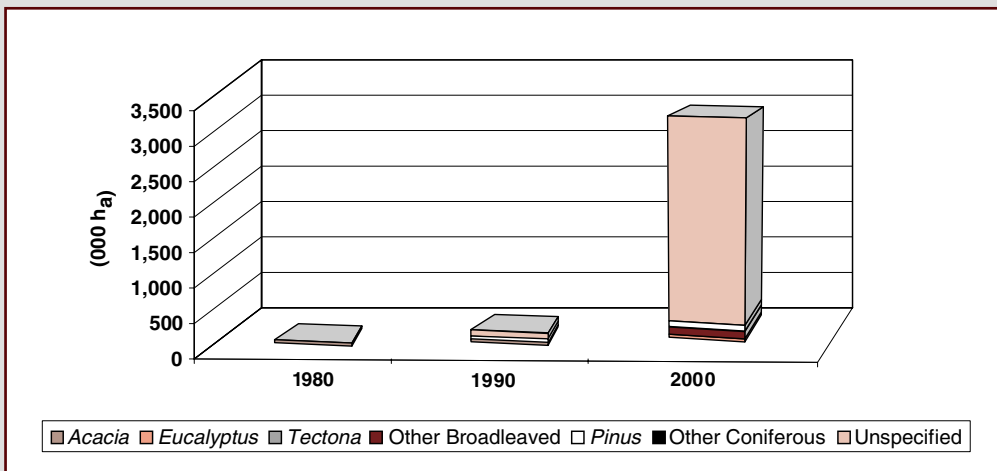


Figure 13. Plantation areas by genus, Oceania. Countries not included in years 1980 and 1990: Australia and New Zealand.

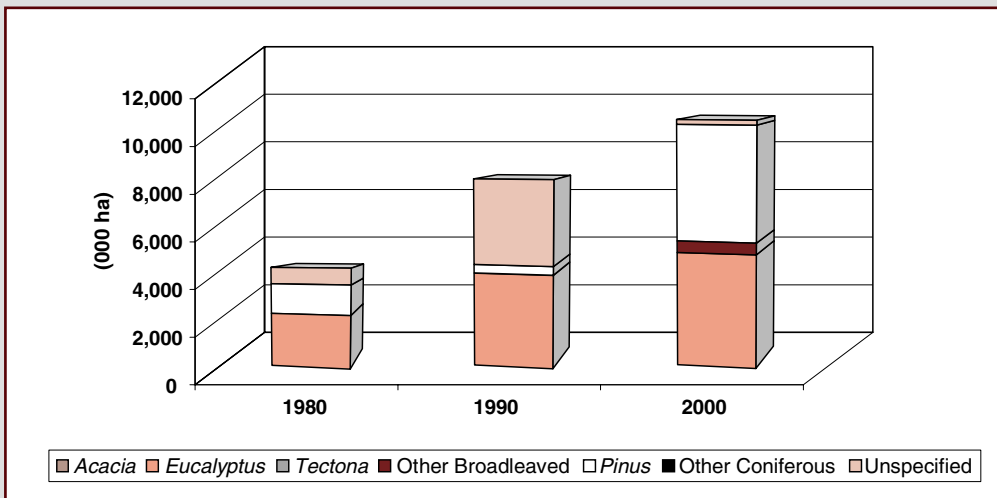


Figure 14. Plantation areas by genus, South America.

## Global forest plantation estate

The global forest plantation estate has increased from 17.8 million hectares in 1980 and 43.6 million hectares in 1990 to 187 million hectares in 2000 (Table 4).

Although in 2000, 26 percent of plantations continue to be for unspecified purpose, there was a sig-

nificant increase in plantations for industrial purposes in the past decade: from 39 percent in 1980 and 36 percent in 1990 to 48 percent in 2000. There has been a corresponding decrease in forest plantations for non-industrial purposes.

## Species trends by region

The direct comparison of trends for the period 1980 to 1990 to 2000 can only be done for the developing countries because as developed country inputs were not reported prior to FRA 2000. Species trends from FRA 1980, FRA 1990, and FRA 2000 are graphically illustrated by region in Figures 10 to 14 (FAO 1981; FAO 1995; FAO 2001f). The graphics are not to scale but illustrate relative growth within the region over the period and show trends in species used.

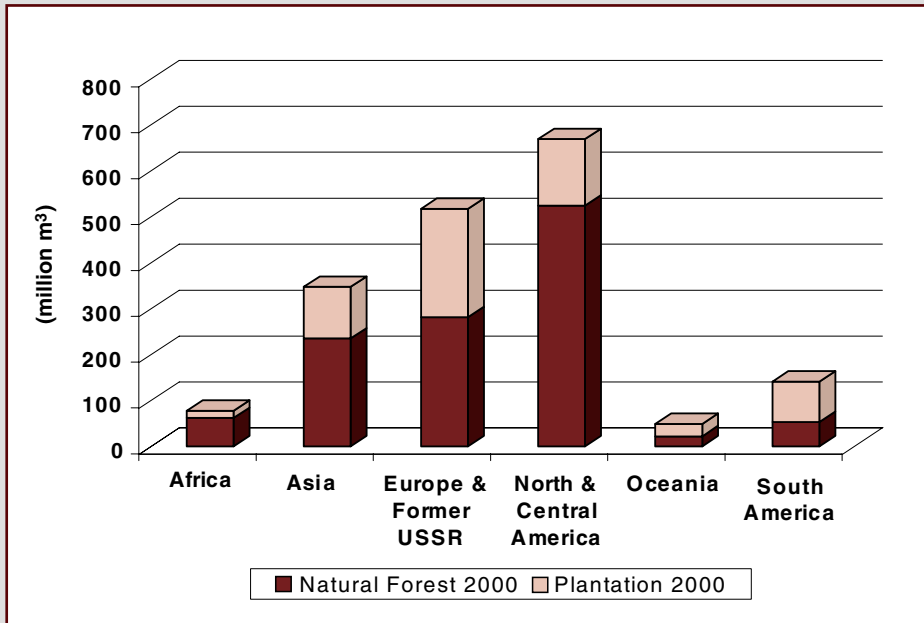


Figure 15. Predicted ratio of regional roundwood supply from natural forests and plantations at year 2000. (ABARE and Jaako Pöyry 1999)

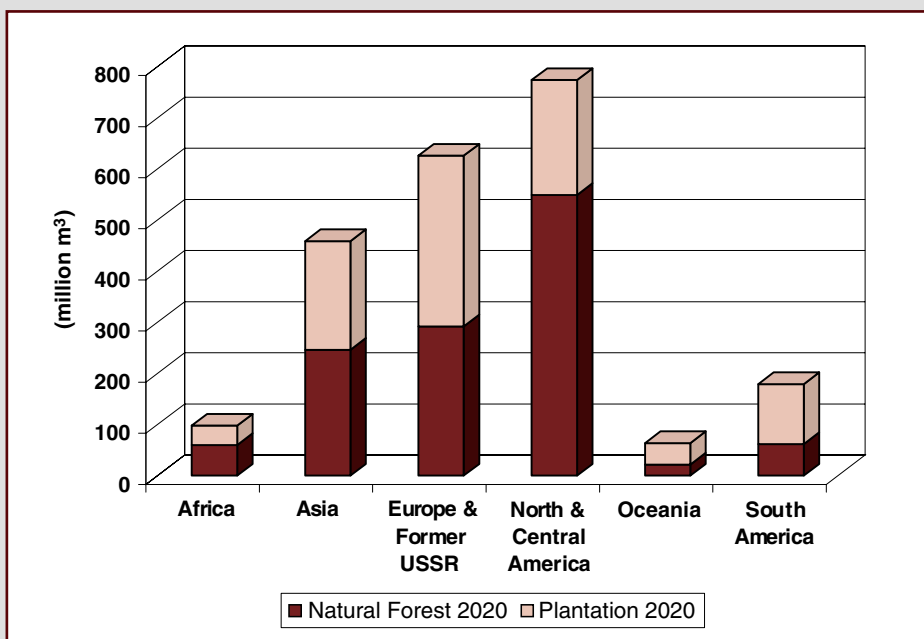


Figure 16. Predicted ratio of regional roundwood supply from natural forests and plantations at year 2020. (ABARE and Jaako Pöyry 1999)

## Industrial Roundwood

According to FRA 2000, the global forest plantation area accounts for only 5 percent of global forest cover and the industrial forest plantation estate for less than 3 percent. However, as an indication only, forest plantations were estimated in the year 2000 to supply about 35 percent of global roundwood and an increase to 44 percent is anticipated by 2020 (ABARE and Jaako Pöyry 1999) (Figs. 15 and 16). If plantation development is targeted at the most appropriate ecological zones and if sustainable forest management principles are applied, forest plantations can provide a critical substitute for natural forest raw material supply.

In several countries, industrial wood production from forest plantations has significantly substituted for wood supply from natural forest

resources. Forest plantations in New Zealand met 99 percent of the country's needs for industrial roundwood in 1997; the corresponding figure in Chile was 84 percent, Brazil 62 percent, and Zambia and Zimbabwe 50 percent each. This substitution by forest plantations may help reduce logging pressure on natural forests in areas in which unsustainable harvesting of wood is a major cause of forest degradation and where logging roads facilitate access that may lead to deforestation.

## Forest Plantation Issues

### *Data*

Reliable and consistent data are not available for certain aspects of the forest plantation resource, e.g. areas of natural forest cleared for forest plantation establishment; areas established with mixtures of tree species; total areas of forest plantations by species, purpose, ownership, age class distribution, growth, rotation, harvest yield, and forest products output. In addition to the lack of quantitative data, the poor quality of the available information is a major impediment to policymaking and monitoring. There is a need to improve the reliability and timeliness of forest plantation data.

FAO will continue to support developing countries in institutional strengthening and capacity building to provide increasingly accurate data on forest plantations at regional and global levels, to be used in national policymaking, in regional and global outlook studies, and in a range of other studies.

### *Land*

Land availability, land tenure, and crop ownership are important issues that determine confidence for forest plantation investment. In developed countries and in some countries with economies in transition, surplus or marginal agricultural land is becoming increasingly available for forest plantation development; however, such land may not be suitable for the establishment of all kinds of forest plantations, nor may the owner be willing to commit land for such a long-term investment to maturity. Land-use conflicts can occur where forest plantations are developed on land perceived as "wasteland" but that is actually used for grazing and for providing non-wood goods and services to landless people. In developing countries, land ownership, land-use, and crop ownership rights may not be clear or secure.

FAO is assisting developing countries to 1) review the role of forest plantations in reducing poverty and contributing to economic development; and 2) ensure that facilitating factors (legal, policy, regula-

tory, planning, and institutional frameworks and support systems) are put in place for secure investment in this land use.

### *Substitution*

While it is clear that plantations will have an increasingly significant role in substituting for wood and non-wood forest products from natural forests, the impact will be felt on a case-by-case basis as governments and investors determine where and how plantations can be technically, economically, and socially feasible as well as environmentally friendly. Globally, the current pace of industrial plantation development will barely keep pace with losses from deforestation and transfer of natural forests to protected status. While it would be theoretically possible, actual plantation development is, at present, not sufficient to offset both growing consumption and declining harvest from natural forests (FAO 2001a).

The FRA 2000 outlook studies can assist countries in developing national forest plans and provide policy and technical support, especially in developing countries.

### *Sustainability*

It is possible not only to sustain but also to increase productivity in successive rotations. This requires clear definition of the end-use objective for forest plantation development and a holistic management view. There is a need to integrate the following strategies into a prudent management plan: tree improvement programs, nursery practices, site and species/provenance matching, appropriate silviculture (site preparation, establishment, weeding, fertilizing, pruning, thinning), forest protection, and harvesting practices. New Zealand and the southern United States have shown that substantial gains can be made by adopting this holistic approach. In developing countries where resources may be constrained, highly technical solutions may not be essential but it is critical to get the fundamentals correct: careful species and provenance choice, good nursery stock, site preparation, planting techniques, weed control, and, less frequently, fertilizer inputs. Once healthy and uniform plantations have been established, later silvicultural tending may become increasingly important, depending on the end-use objective (FAO 2001e).

Burning and excessive cultivation in site preparation, soil compaction from mechanical operations, inappropriate harvesting techniques, and poor forest protection can contribute to loss of nutrients and soil erosion, with a resulting loss in productivity of the forest plantation sites. This can be addressed by the adoption of a whole range of

tree improvement, silviculture, protection, and harvesting techniques in an integrated forest management strategy. Additionally, forest plantations can help to conserve biological diversity if managed prudently.

FAO is assisting developing countries to establish and manage forest plantations according to sustainable forest management principles and practices, taking due regard of environmental, social, and economic factors.

### ***Carbon sequestration and climate change***

In the past 10 years, the development of forest plantations as carbon offsets or sinks has evolved towards a market mechanism, with carbon prices defined according to supply and demand forces. New tree planting results in the creation of new carbon sinks, i.e., carbon fixation during tree growth in afforestation, reforestation, forest rehabilitation, agroforestry, and other planting of trees outside forests. Carbon fixation can also be achieved by improving the growth rates of existing forests by applying silvicultural practices. The Kyoto Protocol, which was conceived in December 1997 at the third Conference of Parties to the United Nations Forum to Combat Climate Change, triggered a strong increase in investment in plantations as carbon sinks, although the legal and policy instruments and guidelines for management are still being debated. A number of countries have already prepared themselves for the additional funding from international investors who are emitting carbon and want to offset these emissions by investing in forest plantation development to sequester carbon. The 1997 Costa Rica national program was the first to establish tradeable securities of carbon sinks that could be used to offset emissions and the first to utilize independent certification insurance by authorized institutions.

To date, greenhouse gas mitigation funding (primarily from international investors and international development banks) covers about 4 million hectares of forest plantations worldwide (FAO 2001d). The recognition of afforestation and reforestation as the only eligible land use, land use change, and forestry activities under the Clean Development Mechanism of the Kyoto Protocol (as agreed in Bonn during the second part of the Sixth Conference of the Parties to UNFCCC in July 2001) will lead to a steep increase in forest plantation establishment in developing countries. If management of forest plantations is on a sustainable basis, harvesting will be permitted, but the technical instruments and standards for carbon accounting for forest plantation management and harvesting are still under development. The carbon sink

decision of the Bonn Agreement is expected to funnel additional funds into forest activities in developing countries and thus to strengthen the international efforts in this field. However, it will also require a monitoring and verification system to ensure that these plantations will not be established at the expense of the local population or hinder efforts to conserve biological diversity. Thus, the decisions made in Bonn to make the Kyoto Protocol ratifiable will also pose new opportunities and challenges for forest plantation development and management.

FAO has established an Inter-departmental Working Group on Climate in relation to Agriculture and Food Security that is active in international dialogue and in assisting in the development of standards.

### ***New sources of fiber***

Particularly in Southeast Asia, wood supply difficulties and advances in wood utilization technology have led to the utilization of woody or fibrous species that were not traditionally considered "forestry" species, such as rubberwood (9.7 million ha) and stems and leaves of African oil palm (6 million ha) and coconut palm (12 million ha). All grow in the humid tropics. This trend is expected to continue and consequences and implications will be monitored by FAO.

### ***Trees outside of forests***

Increasingly, trees are being planted to support agricultural production systems, community livelihoods, alleviate poverty, and to provide rural poor with access to a secure food supply. Communities and smallholder investors (including individual farmers) grow trees as shelterbelts, home gardens, woodlots, as well as a diverse range of agroforestry systems that provide a valuable supply of wood, non-wood forest products, fuelwood, fodder, and shelter. Joint forestry partnerships between large companies and smallholders (often called outgrower schemes) under various forms of contractual agreements are expanding rapidly on all continents and are becoming valuable sources of wood supply. Large companies experiencing land access constraints generally have sound technical expertise, processing capacity, and market access. Smallholders own small areas of land and furnish the labor to grow a forest crop under contract to the company, with technical (and possibly financial) assistance, in return for market access at prevailing prices. Pulp and paper companies have been the most active in these partnership arrangements; however, smallholder investors are also producing an increasing proportion of



decorative veneer species, especially teak, using such schemes.

FAO is collaborating with governments, the private sector (corporate and smallholder), international non-governmental organizations, and research institutions in a participatory process to derive practical field guides and disseminate information on experiences with outgrower and joint partnership schemes.

## Conclusion

Forest plantations can provide critical environmental, social, and economic benefits. Sound forest plantation management, tree improvement, and silviculture can sustain and/or enhance productivity of forest plantations. To do so, however, it is important that forest plantations be managed in accordance with a defined end-use objective and in compliance with sustainable forest management principles and practices.

Forest plantations provide a critical substitute for raw material supply from natural forests, including industrial roundwood and fuelwood. In addition, traditional non-forest species such as rubber (*Hevea brasiliensis*), coconut (*Cocos nucifera*), and oil palm (*Elaeis guineensis*) are becoming important sources of wood and fiber. Finally, there is increasing potential for forest plantation investment to offset carbon emissions and contribute significantly to the Clean Development Mechanism of the Kyoto Protocol.

Detailed FRA 2000 reports of forest resources are available at various web addresses: forest plantation descriptions and statistics by country are available at [www.fao.org/forestry/fo/country/nav\\_world.jsp](http://www.fao.org/forestry/fo/country/nav_world.jsp); the Main Report is available at [www.fao.org/forestry/fo/fra/main/index.jsp](http://www.fao.org/forestry/fo/fra/main/index.jsp), and can be provided in hard copy or CD-Rom on request. State of the World's Forests 2001 is available at [www.fao.org/forestry/fo/sofo/sofo-e.stm](http://www.fao.org/forestry/fo/sofo/sofo-e.stm). A forest plantations website is under construction.

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## Literature Cited

- Australian Bureau of Agriculture and Resource Economics (ABARE) and Jaakko Pöyry Consulting. 1999. Global outlook for plantations. ABARE Research Report 99.9. ABARE, Canberra, Australia.
- Evans, J. 1999. Sustainability of forest plantations - the evidence. Issues Paper. Dept. for International Development, London, UK.
- Food and Agriculture Organization (FAO). 1981. Forest Resources Assessment Project 1980. FAO, Rome, Italy.
- \_\_\_\_\_. 1995. Forest Resources Assessment 1990. Tropical forest plantation resources. FAO Forestry Paper No. 128. FAO, Rome, Italy.
- \_\_\_\_\_. 2001a. Role of forest plantations as substitutes for natural forests in wood supply - lessons learned from the Asia-Pacific region, by T. Waggener. Forest plantations thematic paper series. FAO, Rome, Italy. (unpublished)
- \_\_\_\_\_. 2001b. Biological sustainability of productivity in successive rotations, by J. Evans. Forest plantations thematic paper series. FAO, Rome, Italy. (unpublished).
- \_\_\_\_\_. 2001c. Non-forest tree plantations, by W. Killmann. Forest plantations thematic paper series. FAO, Rome, Italy. (unpublished).
- \_\_\_\_\_. 2001d. Plantations and greenhouse gas mitigation: a short review, by P. Moura Costa and L. Aukland. Forest plantations thematic paper series. FAO, Rome, Italy. (unpublished).
- \_\_\_\_\_. 2001e. Plantation productivity, by W. Libby. Forest plantations thematic paper series. FAO, Rome, Italy. (unpublished).
- \_\_\_\_\_. 2001f. Global Forest Resources Assessment 2000 - Main Report. Forestry Paper 140, FAO, Rome, Italy. ISSN 0258-6150.
- \_\_\_\_\_. 2001g. Forest Plantation Resources, FAO Data Sets 1980, 1990, 1995 and 2000 by A. Del Lungo. Edited by J. Carle. Forest plantations thematic paper series, FAO, Rome, Italy (unpublished).