Wood from Planted Forests

A Global Outlook 2005-2030

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Abstract

Planted forests constituted only 7 percent of the global forest area, or about 271 million hectares, in the year 2005, but they contributed a higher proportion of overall forest goods and services. In recent years, the broader significance and importance of planted forests have been recognized internationally, and standards for their responsible management have been established, relating to social and environmental as well as economic benefits. As one of the important provisions from planted forests, this study examined their future potential production of wood. From a baseline survey of 61 countries, 666 management schemes were established for planted forests, taking into account tree species, rotation lengths, production potential and end uses of wood. With an assumed average efficiency rate of 70 percent, the potential industrial wood production in 2005 from planted forests was estimated at 1.2 billion m^3 or about two-thirds of the overall wood production in that year. Scenarios until 2030 (detailed) and 2105 (simplified) were developed, indicating that wood production from planted forests may increase considerably. Results are provided with breakdowns by region, species groups and end-use categories. It is concluded that the significance of planted forests, and recognition of their contributions to a range of development goals, are likely to increase in coming decades.

Role of planted forests

The United Nations' Food and Agricultural Organization (FAO) World Symposium on Man-Made Forests and Their Industrial Importance, Canberra, Australia, 1967 established a global recognition of the potential importance of planted forests. Although primarily driven by the need for a sustainable supply of industrial roundwood, the social and environmental dimensions of planted forests were also emphasized (FAO 1967). Planted forests have an important role in providing economic and social benefits in eradicating poverty in developing countries and in industrialized countries where marginalized groups and indigenous peoples have previously been excluded from the benefits of development processes (IIED 2004).

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The International Experts Meeting on the Role of Planted Forests in Sustainable Forest Management in Chile, 1999 (Anon. 1999) and subsequent UNFF Intersessional Experts Meeting on the Role of Planted Forests in Sustainable Forest Management in New Zealand 2003 (Anon. 2003) noted the beginning of a new era for planted forests. It was recognized that planted forests needed to fulfill diverse roles depending upon local contexts and drivers, and that adaptive management systems were necessary to respond to changing social, cultural, environmental and economic expectations. It was also recognized that although the role of the market and globalization provided opportunities for investors in planted forests, responsible investors were required to take into account all dimensions as non-market values. To facilitate this, sound governance, institutional, policy, legal and regulatory frameworks supported by knowledge exchange and technology transfer to build capacity and capability were needed. These developments led to a multi-stakeholder process to define principles of responsible management of planted forests, as a basis for the dialogue at the international level and guide for strategic decision-making on planted forests (FAO 2006).

Scope, concepts and definitions

Planted forests is a broader concept than forest plantations. In the past, FAO has defined forest plantations as those forest stands established by planting and/or seeding in the process of afforestation or reforestation. Historically, the emphasis has been on intensively managed forest plantations of single species (native or introduced) stands, with uniform planting densities, even age classes and shorter rotation, as often found in tropical and subtropical regions. However, it was not always possible to distinguish between forest plantations and forest plantings of native species grown in long-rotation, mixed-species, mixed-age classes, particularly in temperate and boreal regions—previously classified as "semi-natural" forests. Recent international dialogue suggests that a more inclusive concept be used to better reflect overall investments and returns of planted forests, as well as related social and environmental concerns (e.g., Anon. 2003).

Prior Global Forest Resources Assessments undertaken by FAO reported forest plantation data that strongly reflected monocultures of primarily introduced species that did not adequately account for the significant resources and provision of goods and services that were provided by the planted semi-natural forests of mainly Europe and North America.

In recent years, a FAO coordinated expert consultation on harmonizing forest-related definitions, defined forest plantations as those forests of introduced species established through planting or seeding. It was also recognized that forest plantations were a sub-set of planted forests that included planted semi-natural forests (FAO 2002).

Planted forests are now defined as those forests predominantly composed of trees established through planting and/or deliberate seeding of native or introduced species (FAO 2006, FAO 2007). This definition specifically recognized the planted component of semi-natural forests comprised primarily of native species, and forest plantations of primarily introduced species. The scope of planted forests in the continuum of forest characteristics is outlined in **Figure 1**.

The broadening of the definition to include the planted semi-natural forests not previously reported doubles the area that will have a substantial impact on the yields of forest products and social and environmental services. According to FAO (2005), there were 140 million hectares of forest plantations globally, of which 78 percent were for productive purposes. According to the Global Planted

Figure 1. — Scope and concept of planted forests.

Continuum of Forest Characteristics						Non-forest
Primary	Modified natural	Semi-natural		Plantation		Trees outside forests
		Assisted natural regeneration	Planted	Productive	Protective	
Forest of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed	Forest of naturally regenerated native species where there are clearly visible indications of human activities	Silvicultural practices for intensive management (weeding, fertilizing, thinning, selective logging)	Forest of native species, established through planting, seeding or coppice of planted trees	Forest of introduced species and in some cases native species, established through planting or seeding mainly for *production of wood or non-wood goods*	Forest of native or introduced species, established through planting or seeding mainly for *provision of services*	Stands smaller than 0.5 ha; trees in agricultural land (agroforestry systems, home gardens, orchards); trees in urban environments; and scattered along roads and in landscapes
			← Planted Forests →			

Forest Thematic Study (Del Lungo et al. 2006), the global planted forest area was estimated at 271 million hectares, of which 76 percent was for productive purpose. Based on these results, this paper explores alternative global outlooks for the provision of wood from planted forests from 2005 to 2030.

Recent outlook studies

The global outlook for plantations (ABARE 1999) and the global outlook for future wood supply from forest plantations (FAO 2000) provide the most comprehensive and recent studies on forest plantation outlook. Both studies were based upon FAO's Forest Resources Assessment 1990 dataset, updated to 1995 in 1997. Both studies used prevailing forest plantation definitions as detailed by FAO (1998).

The ABARE (1999) study estimated that although the productive forest plantation area was 116 million hectares or about 3 percent of the global forest area in 2000, forest plantations were estimated to produce 35 percent of the global wood supply in 2000, 44 percent in 2020, and 46 percent in 2040.

The FAO (1998) outlook study detailed three scenarios of future forest plantation expansion and three different extrapolations for future industrial roundwood consumption to 2050. In 1995 it was estimated that 124 million hectares of forest plantations (3.5 percent of forest area) yielded more than 22 percent of industrial roundwood production and by 2010, between 31 and 34 percent, by 2020 up to 46 percent, and by 2050 up to 64 percent— depending upon the forest plantation production scenario and extrapolation of industrial roundwood consumption. These and other outlook studies (Solberg et al. 1996, Sedjo and Lyon 1996, IIED 1996, WRI 1998, ITTO 1999, Turner et al. 2006) assist policy- and decision-makers, investors, and managers to better understand the key role that planted resources play in provision of wood, nonwood, and social and environmental services.

Policy context

The United Nations Conference on Environment and Development (UNCED), Earth Summit in Rio, 1992 (UNCED 1992) recognized the significance of planted forests in sustainable forest management as reflected in the Forest Principles (UN 1992) and Chapter 11 of Agenda 21 (UN 1993). United Nations legally binding instruments, including the Convention to Combat Desertification (UNCCD 2008), Framework Convention on Climate Change (UNFCCC 2008), and the Convention on Biological Diversity (CBD 2008) strongly support afforestation and reforestation in rehabilitation of degraded forests and fragile ecosystems to restore the contribution of forests and trees in mitigating the effects of climate change, reversing loss of natural forests and restoring landscapes and increasingly a competitive source of bioenergy. From 1995, the Intergovernmental Panel on Forests and Intergovernmental Forum on Forests (UNFF 2008a, 2008b), subsequently supported by the United Nations Forum on Forests (UNFF 2008c), formulated a comprehensive set of proposals for action to achieve sustainable forest management, several of which related to enhancing the social, cultural, environmental and economic benefits of planted forests.

Planted forests are recognized as a valuable land use to realize the values and principles of the Millennium Development Goals (UN 2000), particularly to: eradicate extreme poverty and hunger (Goal 1); ensure environmental sustainability (Goal 7); and develop global partnerships for development (Goal 8). Despite being less than 2 percent of global land use, planted forests play an important role in the provision of a wide range of goods (roundwood [industrial and subsistence] and fiber, bioenergy, and nonwood forest products) and social and environmental services (conservation, protection of soil and water, rehabilitation of degraded lands, combating desertification, carbon sinks, recreation, diversification of urban and rural landscapes and employment). Responsible management of planted forests can reduce the pressure on the range of goods and services provided by native forests and enhance the livelihoods of local communities, including indigenous peoples. Recent standards (FAO 2006, ITTO 1993; CIFOR 2001, 2003; IUCN/ITTO 2006) and certification schemes have highlighted the need for policy makers, planners and forest managers to strive to balance the social, cultural, environmental and economic dimensions of planted forest investments

In recent years a diverse modern forest industries sector has been encouraged to adapt to the use of the "new wood" from planted forests. The range of industrial products from planted forests include: lumber, plywood and veneer, reconstituted panels (MDF, OSB, chipboard, etc.), modular components (laminated products, moulding, framing, floorings, etc.), pulp and paper, and increasingly bioenergy. Scientific research and development, particularly in genetic improvement and forest industries processing have revolutionized the productivities and the end use options for planted forests. Application of biotechnology has substantially improved site-species matching, growth, yields and financial benefits for planted forest investors, particularly in fast-growing, short-rotation crops. The development of forest industries technology has resulted in increasing end use options for raw materials from planted forests, improved efficiencies and reduced wood industries costs (Sutton 2003, Millennium Ecosystem Assessment 2005).

Industrial roundwood from planted forests is being recognized as a renewable resource and an energy efficient and environmentally friendly raw material for construction when compared to alternative products such as steel, aluminum, concrete and plastic (Sutton 2003). Planted forests can make significant positive contributions to rural economies through primary and secondary industry development, employment and development of rural infrastructure. Trees are increasingly being planted to support agricultural production systems, community livelihoods, poverty alleviation, and food security (FAO 2006).

Outlook objectives

This study attempts to estimate the wood supply from planted forests globally to provide policy and decision-makers data and information on anticipated outlook options. While recognizing the important social and

Table 1. — Summary of planted forest area in the 61 studied countries by region and major species group in 2005.

Region	Softwoods		Hardwoods			Total
	Pinus spp.	Other	Acacia spp.	Eucalyptus spp.	Other	
	Mha	Mha	Mha	Mha	Mha	Mha
Africa	1.2	0.5	5.2	1.2	1.4	9
Asia	18.9	15.3	3.8	7.6	79.2	125
North, Central & Eastern Europe	26.4	36.0	-	-	12.1	74
Southern Europe	0.0	4.6	-	0.0	4.7	9
North & Central America	18.9	7.2	-	-	1.7	28
South America	5.1	0.3	0.2	4.5	0.9	11
Oceania	2.7	0.2	0.0	0.5	0.2	4
Total	**73**	**64**	**9**	**14**	**100**	**261**

Note: Mha = millions of hectares

Figure 2. — The 61 study countries showing the percentage of planted forests area out of total forest area.

environmental services from planted forests, the outlook for these dimensions is beyond the scope of this study.

Material and methods

Country survey

The baseline data for the present outlook were obtained from a survey of the status of planted forests in 61 countries, representing about 95 percent of the estimated global planted forest area of 271 million hectares in 2005. The survey requested in-depth information about planted forests in each country, including species distribution, ownership, end use, rotation lengths, mean annual increment (MAI) and age class distribution. Of the 61 countries, 36 responded to a formal information request, and 25 were subject to a desk study (Del Lungo et al. 2006). The present outlook is limited to these 61 countries and thus provides slightly conservative results for global planted forests. A summary of the initial state is presented in **Table 1**. The countries and their proportion of planted forests over all forests are detailed in **Figure 2**.

Scenarios

Three scenarios were defined for the outlook, taking into consideration potential changes in the planted forest area (mainly through new plantings) as well as opportunities for increased productivity resulting from more efficient management practices, new technology and genetic improvements (**Table 2**).

Management schemes

The unit of analysis in the outlook is a "management scheme", defined by country, species/species group, purpose (protective or productive) and characteristic (plantation or semi-natural forest) of the planted forest

Table 2. — Description of the three scenarios applied in the outlook model.

Scenario 1 – Pessimistic scenario
Area changes are assumed to be half of the predicted ones for Scenario 2, and there are no productivity increases. This represents a scenario where the current increase of planted forest area will slow down.

Scenario 2 – Business as usual
Area changes have been predicted based on past trends and are assumed to continue at the same rate until 2030. However, there are no productivity increases in this scenario.

Scenario 3 – Higher productivity
Area changes have been predicted as in Scenario 2. In addition, an annual productivity increase has been applied for those management schemes where genetic, management or technological improvements are expected. As an example, a productivity increase of 2 percent annually equals an accumulated productivity increase of 64 percent for the 25 year period (2005–2030).

subset (Del Lungo et al. 2006). Parameters applied in the outlook model for each management scheme are listed in **Table 3**, together with one example management scheme: *Picea sitchensis* in Ireland. In total, 666 management schemes were identified for the 61 countries and applied in the modeling. Input data missing from the country survey and data for area efficiency and productivity changes were filled through expert estimates. All management scheme input data are given in Carle et al. (2008). A summary of the management scheme inputs is shown in **Table 4** and **Figure 3**.

Model

A deterministic model was developed using Excel (Microsoft Inc. 2007) for the outlook to predict future production of wood in each management scheme, for each of the five wood end use categories, following the process in **Figure 4**. The model was run for all 666 management schemes for each of the three scenarios for the period 2005–2030. **Table 5** shows model results for one example management scheme: *Picea sitchensis* on Ireland, using the input data from **Table 3**. To derive longer term projections

Table 3. — Model input parameters for each management scheme.

Parameter	Unit	Comment	Example: Ireland, *Picea sitchensis* - forest plantation - productive purpose
Area	ha	Total extent of the management scheme.	301,080 ha
Age class distribution	%	Distribution of the area across 12 age classes. The sum of the 12 proportions to be 100.	1-5: 10% 6-10: 10% 11-20: 23% 21-30: 24% 31-40: 20% 41-50: 9% 51-60: 2%
Rotation length	years	Average rotation length across the management scheme	50 years
Mean annual increment (MAI)	$m^3 ha^{-1} yr^{-1}$	Average growth in stem volume on bark as average over rotation cycle and across the management scheme.	18 $m^3 ha^{-1} yr^{-1}$
Area efficiency	%	An estimate of the relative performance (max 100%) of the management scheme, taking into account (a) reductions of overall area related to infrastructure or unsuccessful stand establishments, (b) reduced productivity due to stand health issues or suboptimal management practices, (c) influence of other management objectives, particularly related to protective functions, on the wood volume production.	90%
Volume end use for: - Fuel / Bioenergy - Pulp / Fiber - Wood products - Unspecified - Harvest losses	%	Distribution of expected end use of stem wood into five categories as listed in the left column. The sum of the five proportions should be 100.	Fuel / Bioenergy: 5% Pulp / Fiber: 30% Wood products: 60% Unspecified: 0% Harvest losses: 5%
Annual area change	%	The annual increase in area (net new establishments). The increase is applied in relation to the initial area throughout the studied time period, i.e., as a linear development. This parameter varies between the applied scenarios.	Scenario 1: 1.5% Scenarios 2 and 3: 3%
Annual productivity change	%	The annual increase in overall productivity, representing improved area efficiency (see above), better management practises, higher technology efficiency and genetic improvements. The increase is applied to the previous year throughout the studied time period, i.e., as an exponential development. This parameter was applied only in Scenario 3.	Scenarios 1 and 2: 0% Scenario 3: 1%

Table 4. — Summary of planted forest area and model input parameters for different rotation lengths at 2005 for the 666 agement schemes identified.

Rotation length	Area	MAI	Production potential area*MAI	Management schemes included	Average area efficiency	Average area expansion (Scenarios 2 and 3)	Average productivity increase (Scenario 3)	Proportion young stands[1]	Proportion aged stands[1]	Proportion over-aged stands[1]
years	Mha	$m^3\ ha^{-1}\ yr^{-1}$	$Mm^3\ yr^{-1}$	n	%	% yr^{-1}	% yr^{-1}	%	%	%
-10	13	23	288	43	76	1.46	1.89	53	30	17
11-20	25	10	240	60	63	2.85	1.41	43	30	27
21-30	64	10	615	90	72	0.84	0.52	55	36	8
31-40	38	7	251	71	58	2.40	0.34	58	25	17
41-50	16	8	129	48	67	1.11	0.55	44	39	17
51-60	23	8	187	60	69	1.44	0.74	63	31	6
61-70	39	7	278	60	77	0.54	0.13	57	39	4
71-80	15	7	100	44	70	0.52	0.28	80	20	0
81-90	11	5	53	36	93	1.81	0.80	81	17	2
91-100	2	6	15	31	68	0.74	0.12	78	20	2
101+	14	7	91	123	62	0.00	0.01	57	40	3
Total	**261**	**9**	**2246**	**666**	**70**	**1.29**	**0.58**	**58**	**31**	**11**

*1) Young stands defined as aged <0.5 * rotation length; aged stands defined as aged 0.5-1 * rotation length; over-aged stands defined as aged > rotation length.*

Figure 3. — Distributions of rotation lengths and maturity of stands in relation to rotation length by region in 2005.

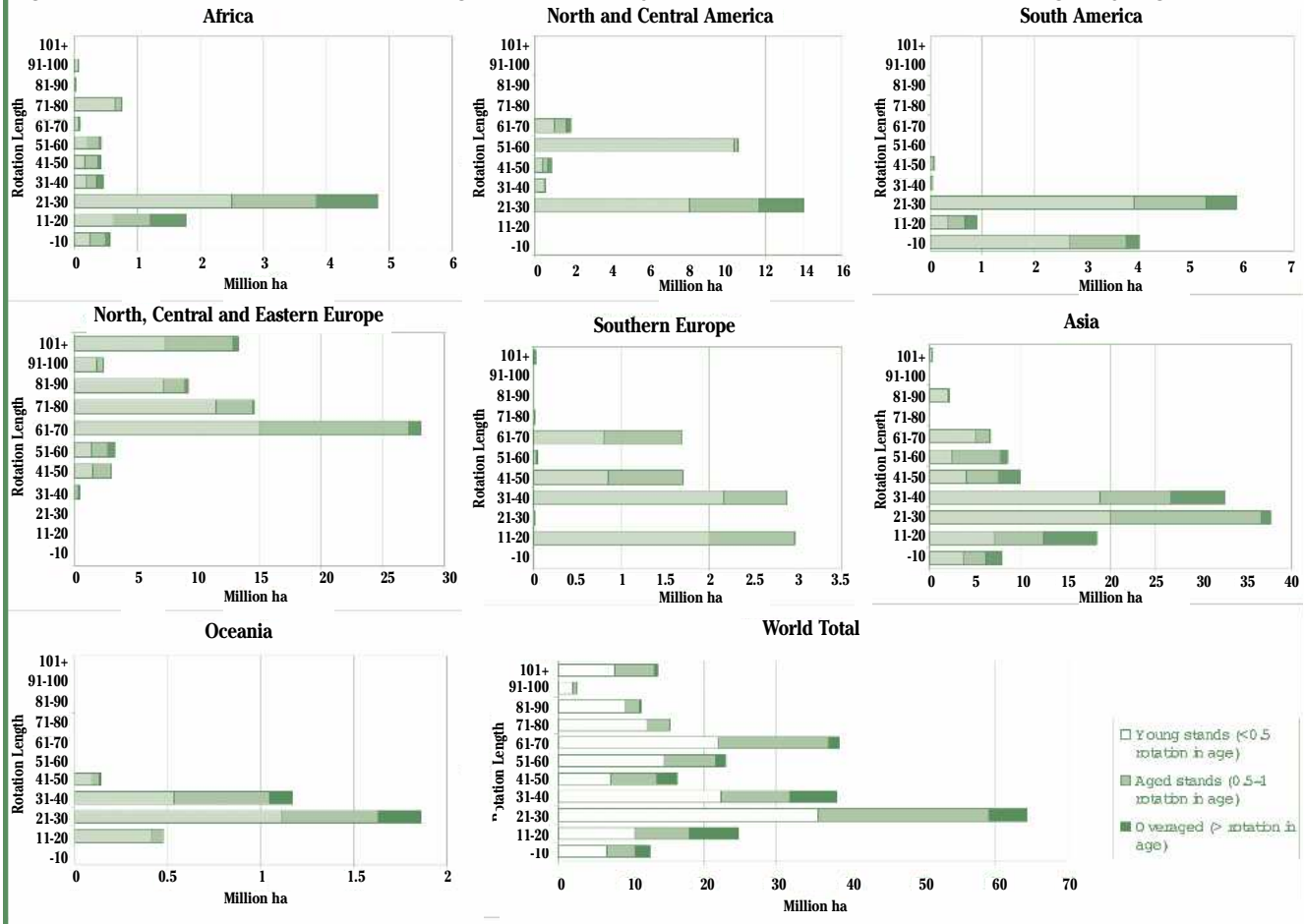


Figure 4. — Outlook model process applied to each identified management scheme for each scenario.

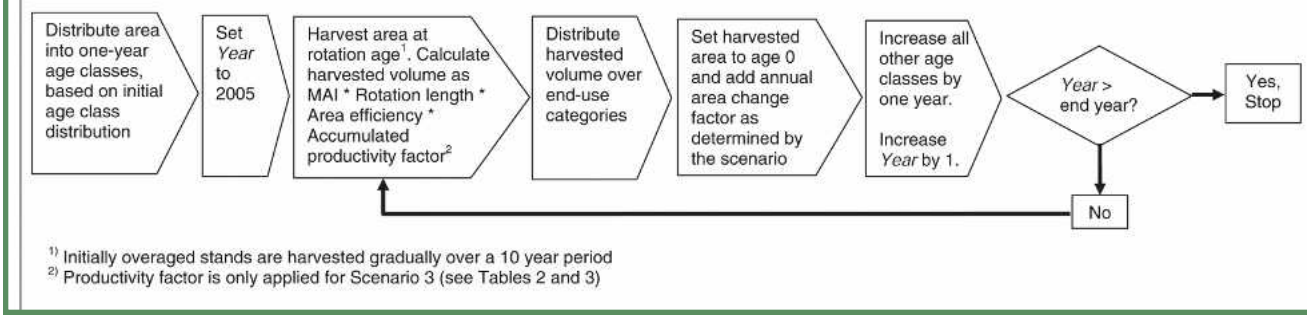


Table 5. — Example of model results for one of the 666 analyzed management schemes: Ireland, Picea sitchensis (see also model inputs in Table 3). Note similarities in wood outputs between Scenarios 1 and 2 as new plantings, in this case, will not generate wood before 2030.

		2005			2020			2030		
Category	**Unit**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 1**	**Scenario 2**	**Scenario 3**
Area	000 ha	301	301	301	369	437	437	414	527	527
Fuel / Bioenergy	000 m^3	110	110	110	244	244	283	293	293	375
Pulp / Fiber	000 m^3	658	658	658	1463	1463	1699	1756	1756	2252
Wood products	000 m^3	1317	1317	1317	2926	2926	3398	3512	3512	4504
Harvest losses	000 m^3	110	110	110	244	244	244	293	293	293
Total volume	**000 m^3**	**2195**	**2195**	**2195**	**4877**	**4877**	**5623**	**5853**	**5853**	**7423**

at a more general level, the rotation length distribution in **Table 4** was used to create a simplified set of 11 management schemes, for which the model was run for each of the three scenarios for the period 2005 to 2105.

Geographic presentation of findings

While the analysis was based on 61 countries, it is assumed that the results provide a global perspective of future wood production from planted forests, as they represent ca. 95 percent of the global area in 2005. Seven regions were identified for presenting the results as shown in **Table 6**.

Table 6. — Regions in this study and number of survey countries in each.

Region	**n survey countries**
Africa	7
Asia	11
North, Central & Eastern Europe	24
Southern Europe	11
North & Central America	2
South America	4
Oceania	2
World	**61**

Results

Area trends

Model results indicate that the area of planted forests will increase in all scenarios (**Table 7**). From an initial area of 261 million hectares, the area increase in Scenario 1 will be 16 percent to 303 million hectares, and in Scenarios 2 and 3 an increase of 32 percent to 345 million hectares in year 2030. Among regions, the highest absolute increase will be in Asia and the highest relative increase in Southern Europe. Among species groups, the highest absolute increase will be in pine forests.

Wood volume trends

The model provides estimates for wood production by species groups and regions for the period 2005–2030 as illustrated in **Figure 5** and **Table 8**. The total volume produced increases from 1.4 billion m^3 in 2005 to 1.6, 1.7 and 2.1 billion m^3, respectively, in the three scenarios. Most of the variation between scenarios are in Asia and South America where the higher productivity scenario gives a considerable increase in wood production. The differences between Scenarios 1 and 2 are very small, primarily as additional planted area in Scenario 2 may not generate wood within the studied period.

Figure 5 also illustrates that South America and Asia have a more dynamic future, compared with other regions, for Scenario 3, and that the volume increases in this scenario will mainly be in Eucalyptus and other hardwood species.

Table 8 illustrates that the proportion of wood for industrial use (comprised of the sum of the end use categories pulp/fiber and wood products) is about 85 percent of all wood from planted forests. The total volume of wood for industrial use increases from 1.2 billion m^3 yr^{-1} in 2005 to 1.9 billion m^3 yr^{-1} in 2030 according to Scenario 3.

Table 7. — Area of planted forests by region and major species groups at 2005 and 2030 for the three scenarios.

Region	Acacia	Eucalyptus	Pinus	Other softwood	Other hardwood	Total
			2005			
Africa	5.2	1.2	1.2	0.5	1.4	**9.4**
Asia	3.8	7.6	18.9	15.3	79.2	**124.8**
NCE Europe			26.4	36.0	12.1	**74.5**
S Europe				4.6	4.7	**9.3**
NC America			18.9	7.2	1.7	**27.8**
South America	0.2	4.5	5.1	0.3	0.9	**10.9**
Oceania		0.5	2.7	0.2	0.2	**3.6**
Total	**9.1**	**13.8**	**73.2**	**64.0**	**100.3**	***260.5***
			2030, Scenario 1			
Africa	4.7	1.2	1.4	0.5	1.6	**9.4**
Asia	4.6	10.6	23.3	16.9	92.8	**148.3**
NCE Europe			28.8	38.3	12.5	**79.6**
S Europe				7.5	7.6	**15.0**
NC America			21.9	9.8	2.0	**33.7**
South America	0.2	5.2	6.0	0.3	1.0	**12.7**
Oceania		0.7	2.8	0.2	0.3	**3.9**
Total	**9.5**	**17.7**	**84.2**	**73.5**	**117.8**	***302.7***
			2030, Scenarios 2 and 3			
Africa	4.2	1.2	1.6	0.5	1.8	**9.4**
Asia	5.4	13.6	27.6	18.5	106.4	**171.7**
NCE Europe			31.3	40.6	13.0	**84.9**
S Europe				10.3	10.4	**20.8**
NC America			25.0	12.5	2.4	**39.8**
South America	0.2	5.7	6.5	0.4	1.1	**13.9**
Oceania		0.8	2.9	0.2	0.3	**4.2**
Total	**9.9**	**21.4**	**94.9**	**83.0**	**135.5**	***344.6***

Long-term projection

In **Figure 6**, the continued linear increases of wood volumes in Scenarios 1 and 2 are confirmed. Scenario 1 leads to a volume production of about 2.5 billion m^3 yr^{-1} 100 years from now, and Scenario 2 results in a production of about 3.5 billion m^3 yr^{-1}. For Scenario 3, however, the assumed continued increased productivity gives a much more rapid development of wood production to about 9 billion m^3 yr^{-1} in year 2105.

Discussion

Methodology and data issues

The outlook model applied considers the development of wood production under current forest management regimes. It does not analyze consequences of eventual shifts in, e.g., wood markets, land-use competition, trade regulations or political decisions that may affect the development of planted forests. Further, the model does not apply any economic considerations to maximize the returns on investments, but assumes that the biological production potential combined with the estimated efficiency ration is a good measure of future wood output. The defined scenarios do, however, assume that there will be drivers that support an expanding investment in planted forests and improved productivity (in Scenario 3). The results should be interpreted in relation to these limitations and assumptions and could be used as input to further economic analyses.

Input data from the country survey were not complete for many of the management schemes, meaning that the analysts had to make estimates at the level of individual management schemes to fill these gaps. Further, data on productivity change and area efficiency were not included in the survey, but estimated by the analysts. These estimates were made in consultation with literature and expertise on the species/country in question. Carle et al. (2008) provides details on input data and estimates made.

Comparison with earlier studies

The results on planted forest areas and volumes correspond well to previous studies, considering that the scope was widened to include semi-natural planted forests. This study, consequently, provides a more complete picture of the extent and production of planted forests, particularly in the temperate region.

The present study has described the planted forest resources and their management in greater detail than

Figure 5. — Wood volume produced in planted forests 2005–2030 by major species group and region, for each of three scenarios (million m^3 yr^{-1}). The X-axis in each graph represents the time period 2005–2030.

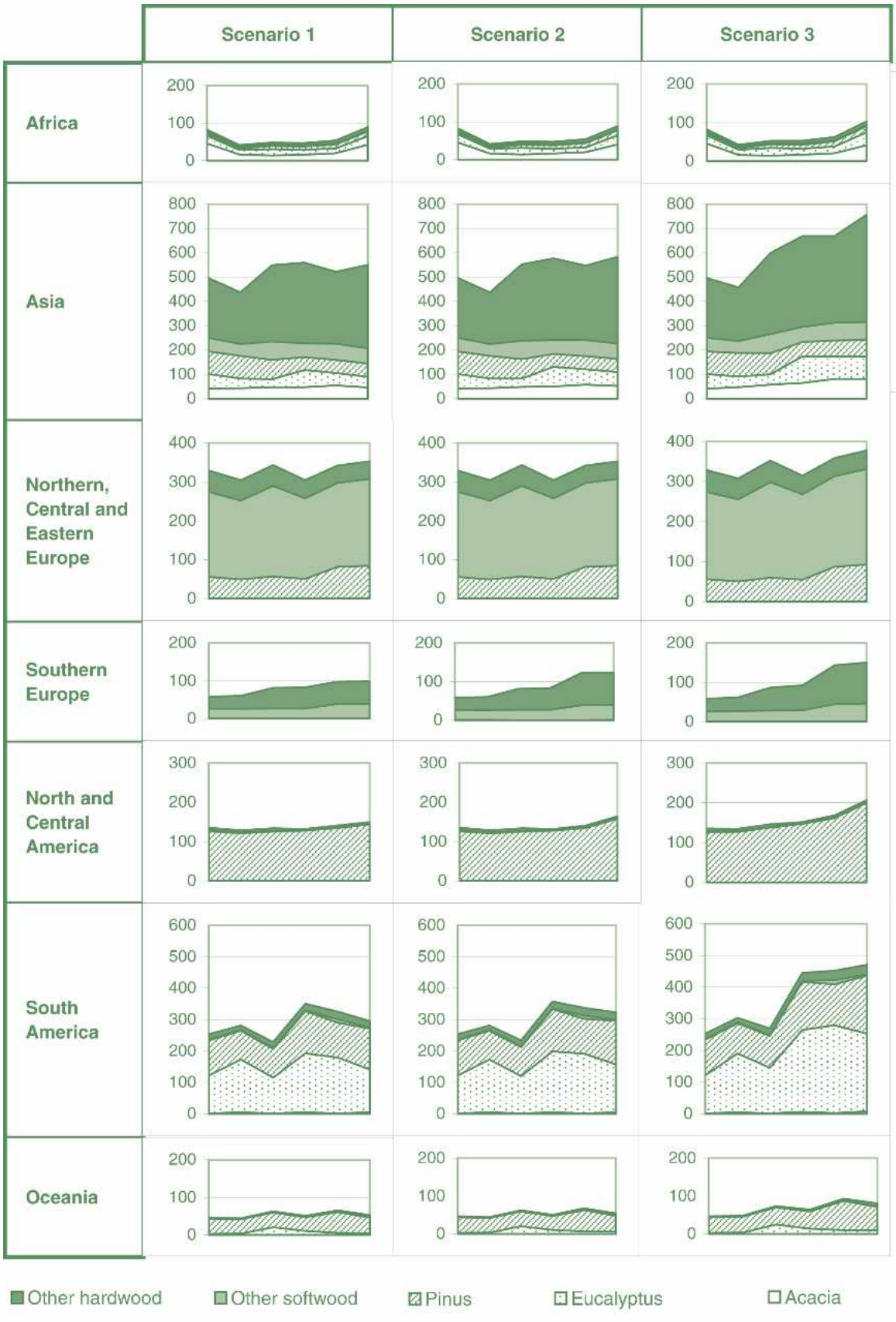


Table 8. — Wood volume produced in planted forests by region and use at 2005 and 2030 for the three scenarios (million m^3 yr^{-1}).

	Fuel/ Bioenergy	Pulp/Fiber	Wood products	Unspecified	Harvest losses	Total
			2005			
Africa	11	9	55	6	1	**82**
Asia	79	141	264	6	5	**495**
NCE Europe	17	123	166	8	15	**329**
Southern Europe	3	26	26	0	3	**58**
NC America	7	98	24	0	7	**135**
South America	19	133	91	0	10	**253**
Oceania	1	11	31	0	4	**47**
Total	**136**	**540**	**659**	**21**	**44**	***1400***
			2030			
Africa	10	14	57	6	2	**89**
Asia	83	132	311	18	6	**550**
NCE Europe	18	129	185	4	17	**353**
Southern Europe	5	44	45	0	5	**98**
NC America	7	106	29	0	7	**149**
South America	21	157	106	0	12	**295**
Oceania	1	12	35	0	4	**53**
Scenario 1, Total	**146**	**593**	**767**	**29**	**53**	***1589***
Africa	10	15	56	6	2	**89**
Asia	88	146	321	20	7	**582**
NCE Europe	18	129	185	4	17	**353**
Southern Europe	6	55	56	0	6	**123**
NC America	8	117	31	0	8	**164**
South America	23	173	115	0	13	**323**
Oceania	1	13	36	0	4	**55**
Scenario 2, Total	**155**	**647**	**800**	**30**	**57**	***1689***
Africa	10	22	63	6	2	**103**
Asia	107	204	417	22	7	**756**
NCE Europe	20	137	200	4	17	**378**
Southern Europe	8	67	69	0	6	**150**
NC America	10	149	38	0	8	**206**
South America	34	268	156	0	13	**471**
Oceania	2	19	55	0	4	**81**
Scenario 3, Total	**191**	**866**	**998**	**33**	**57**	***2145***

previous studies, through 666 management schemes in 61 countries representing about 95 percent of the global planted forest area. The results are, therefore, possible to break down into regions, rotation lengths, species and age class distribution and projected end uses of the produced wood. This provides important perspectives as to the types and geographic distribution of planted forests that were previously not well documented.

Previous outlooks and assessments have, like this one, made assumptions as to the overall management efficiency of reported planted forests. On average, this study assumes a 70 percent management efficiency, which is in parity with previous studies. Previous outlooks have not, however, emphasized increases in productivity over time, following both increased forest management efficiency as well as genetic and other improvements. As productivity has increased considerably in past decades, it is reasonable to conclude that Scenario 3, applying continued positive productivity trend is the most probable scenario until 2030. It can, however, be argued whether it is realistic that this development continues until year 2105 as also modelled in this study.

Significance of planted forests

The rates of new planting and expansion of the global planted forest resource have continued in most regions of the world as the increasing role of planted forests as an investment and legitimate land use have been recognized. Land use conflicts with competing land uses are emerging as a threat that needs to be addressed by participatory planning with key stakeholder groups. However, planted forests account for less than 2 percent of land-cover globally.

The proportion of wood for industrial use from planted forests depends upon the accuracy of scenarios for planted forests as well as industrial roundwood consumption and production. In 2005 the global industrial roundwood produced was 1.8 billion m^3 (FAO 2005) with some variations between estimates (**Fig. 7**). The wood for industrial use available from planted forests in 2005, calculated as the sum of pulp/fiber and wood products in **Table 8**, was 1.2 billion m^3,

Figure 6. — Long-term (100 year) projection of total, global wood production from planted forests for the three studied scenarios.

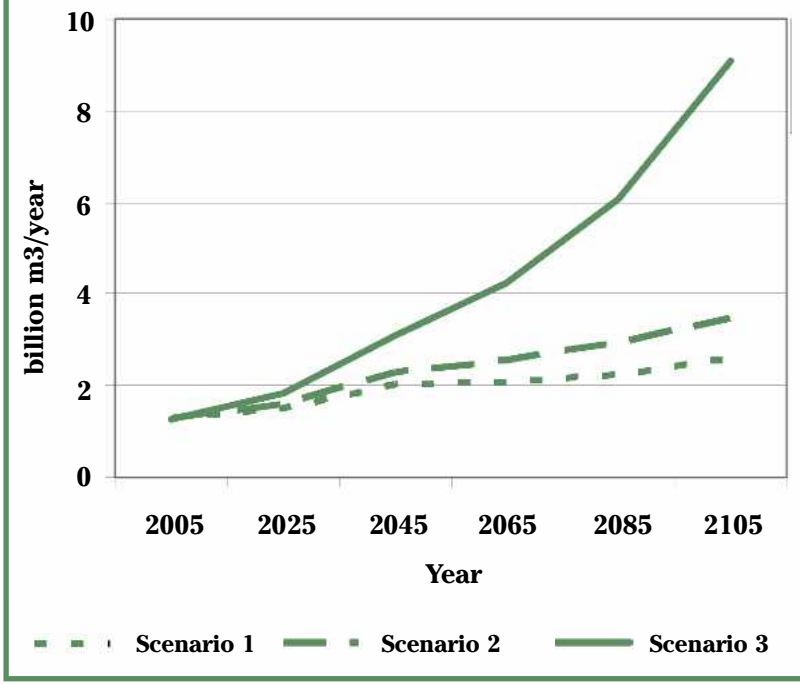
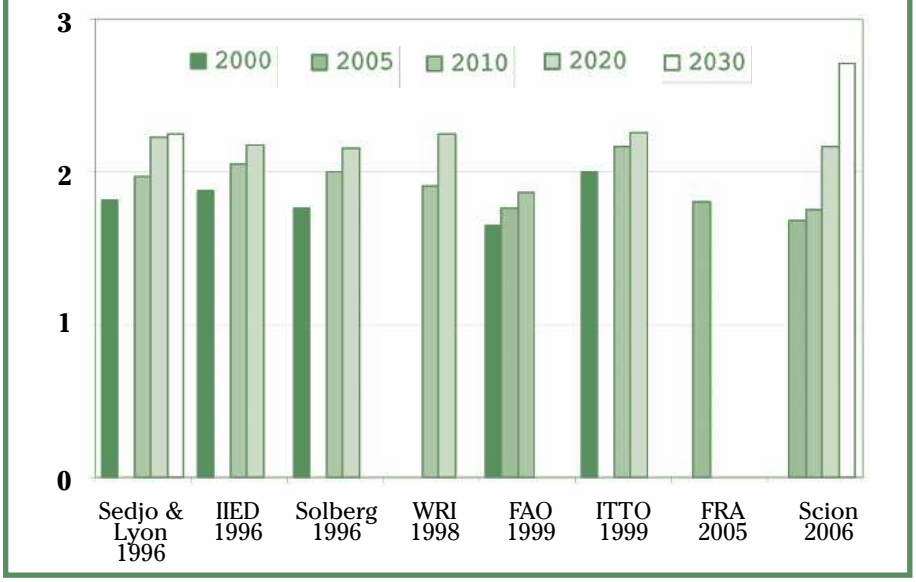


Figure 7. — Industrial roundwood supply (all forests) from various studies (billions m³).



or potentially 66 percent of global industrial roundwood production. Comparing Scenario 3 in this study with outlooks of industrial wood use (e.g., Sedjo and Lyons 1996, Turner et al. 2006), this proportion could rise to 69 to 80 percent.

According to this study, about 10 percent of wood yielded from planted forests is used for bioenergy. Only a small proportion of liquid biofuels are currently forest-based, but it is anticipated that within a decade the development of an economically viable process for producing lingo-cellulosic liquid biofuels will lead to the widespread use of forest biomass in the transport sector. Residues from the forest products industry and wood from planted forests provide the main sources of supply of commercial lingo-cellulosic biofuel production.

Although the role of the market and globalization provide opportunities for investors in planted forests for the marketing and trade of wood and nonwood forest products, responsible investors recognize the need to take into account all dimensions, including the non-market values. Planted forests have an increasingly important role in providing social, cultural and environmental benefits as well as the economic values. These include the recognition and the maintenance of social and cultural services, including the welfare and empowerment of adjacent communities, workers and other stakeholders and adopting planning, management, utilization and monitoring mechanisms to avoid adverse impacts. Planted forests also impact the provision of ecosystem services, so planning, management, and utilization and monitoring mechanisms should be adopted to maintain and enhance the conservation of environmental services by adopting watershed management, soil erosion protection and landscape approaches to maintain water, soil, forest health, nutrient and carbon balances and restore degraded landscapes. Furthermore, an indirect benefit of planted forests, if planned and managed responsibly, is to take some pressure for wood for industrial purposes away from native forests to allow them to be managed for conservation, protection and recreation purposes. Planted forests can make positive contributions towards meeting the objectives of the Millennium Development Goals, CBD, UNCCD, UNFCCC, UNFF and other legal and non-legally binding instruments.

The UN Convention on Climate Change and the Kyoto Protocol (UNFCCC 2008) provides for mechanisms to offset greenhouse gas emissions, including afforestation, reforestation and reduction in deforestation and forest degradation, to mitigate the impacts of climate change. Thus, planted forests, with their relatively high rates of growth and productivity, provide a high rate of annual carbon sequestration and provide a valuable carbon sink. In addition, the increasing wood products flows from planted forests provide long-term carbon storage. For the 271 million hectares of planted forests globally, and using average growth rates from this study and carbon expansion factors (IPCC 2004), planted forests sequester about 1.5 giga tonnes of carbon per year, which is in parity with calculated losses from deforestation. Additionally, an estimated 0.5 giga tonnes of carbon is

stored long-term in forest products from planted forests every year. Thus planted forests can play a critical role in sequestering carbon and providing carbon sinks.

Key drivers

Responsible management of planted forests can result in positive contributions being made towards meeting the objectives of the Millennium Development Goals, CBD, UNCCD, UNFCCC, UNFF/IPF/IFF and other legal and non-legally binding instruments. Major drivers that will influence planted forests development in the future include:

- Good governance and supportive policy, legal, regulatory, and institutional frameworks for long-term investments in planted forest developments.
- The impact of globalization on the nature of investment portfolios available for planted forest developments and access to global forest products markets.
- Availability of land suitable for planted forest developments that does not compete with existing land uses, including food and energy production through agricultural crops, livestock or naturally regenerating forests; native forests should not be cleared to establish planted forests, but they should benefit from the reduced harvesting pressure on them for forest products.
- Recognition that planted forests are a land use that provides, among other benefits, wood products that are renewable, energy efficient and environmentally friendly unlike competing construction industry products such as cement, steel, aluminium and plastic products.
- Recognition that climate change adaptation, but particularly mitigation can benefit from planted forest developments to sequester carbon and provide carbon sinks both in planted forest stands and in the forest products harvested and utilized.
- Advances in technology particularly in:
    - Commercially viable processes to convert lignocellulosic biomass to liquid biofuels from planted forests.
    - Biotechnology to produce high-quality reproductive materials that have high yields, are resistant to insects and diseases, and offer improved end-use qualities.
    - Silviculture, forest health, fire management, and invasive species
    - Harvesting and wood industries to utilize planted forests species, piece sizes and wood properties for a range of solid, panel and reconstituted products.

It is difficult to predict how the future for planted forests will unfold towards 2030 as the resources are subject to several major existing and emerging drivers. Planted forests can also be used in a flexible array of wood, non-wood and social and environmental services that are increasingly in demand. We would like to conclude, however, that the significance of planted forests for wood and other social, economic or environmental benefits are likely to continue to increase. However, if the full potential productivity and benefits of planted forests are to be achieved, responsible policies, plans and practices need to be adopted and applied to balance sustainable livelihoods and land use needs.

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