The need for improved forest plantation data

Jim Carle[1)], Alberto Del Lungo[1)] and Martti Varmola[2)]

1) FAO, Forest Resources Development Service, Viale delle Terme di Caracalla, 00100 Rome, Italy, +39 06 5705 5296, +39 06 5705 3889, jim.carle@fao.org, alberto.dellungo@fao.org, http://www.fao.org/forestry/index.jsp
2) Metla, Rovaniemi Research Station, P.O.Box 16, 96301 Rovaniemi, Finland, +358 10 211 4410, martti.varmola@metla.fi, http://mesi.metla.fi/index.htm

Abstract

Based upon current outlook studies, forest plantations constitute only five percent of global forest cover but already supply up to 35 percent of global roundwood. FAO established a new forest plantation database to complement and supplement the Global Forest Resources Assessment, 2000 and previous assessments. The new data includes by country by species details purpose, growth rate, rotation length and rates of planting additional to the existing database for forest plantations to allow more sound forest plantation outlook analysis.

Examples of planting trends and strategies in different countries and regions are given. In some countries no new planting occurs while especially in Asia high new planting rates increase plantation area considerably. Significant new resources are recognized including *Populus* and *Hevea*. *Eucalyptus spp*. are generally the most productive but they too have modest growing rates on certain sites. More than 490 tree species, both exotic and native, are reported in tropical and sub-tropical plantations.

The question of plantation definition applied to temperate and boreal countries and to tropical and subtropical countries is discussed. Limited data is available for some developed countries, partly because of forest plantation definitions and concepts.

In both developed and developing countries there remain gaps in reliable and accurate plantation areas, purpose and ownership, survival rates, new planting/replanting rates, tree species, age class distributions, growth rates, rotation lengths and yields of raw material supply. The database for outlook studies to gauge the potential of forest plantations in global roundwood, fibre, fuelwood and non-wood forest products supply remain weak.

New procedures are presented to improve the collection, storage and access to plantation data. Efficient use of the internet is seen as a key tool. It is suggested that forest plantations should have a more central role both in country wise forest resources assessments and consolidation at the regional and global level in the future. A reviewed outlook study analysis is planned based upon the new forest plantation data.

Key words: plantation, planted forest, afforestation, reforestation, outlook study, wood supply, forest resource assessment

The importance of forest plantations in roundwood supply

Plantations make up a sustainable, energy efficient and environmentally and socially friendly source of world roundwood, fibre, fuelwood and non-wood forest products and provide social and environmental benefits. Reported plantations accounted for less than 5 percent of global forest cover, of which, those planted for industrial purposes made up 3 percent and those for non-industrial purposes (fuelwood, protection and conservation) made up 2 percent of global forest cover (FAO, 2001a; Carle et al., 2002). According to FAO (2000), based on the data from 1995 when plantation area was estimated to be 3.5 percent (or 103 million ha) of global forest area, 22 percent of industrial roundwood was estimated from plantations at the year 2000 with extrapolations to the year 2050 at extremes varying from 19.7 to 64.0 percent.

ABARE – Jaakko Pöyry (1999) estimated roundwood supply from plantations to be 35 percent in 2000, 44 percent in 2020 and 46 percent in 2040. These scenarios were made on the assumption that industrial plantation area was 116 million ha and total effective area 94 million ha in 1995. Thomberlin and Buongiorno (2002) estimated that the production of roundwood from industrial plantations compared to world total (not including Canada, Western Europe and former Soviet Union) would increase from 33 percent in 1995 to 42 percent in 2010.

In New Zealand and South Africa 99 percent of industrial roundwood is produced from plantations (FAO, 1997; Pandey and Ball, 1998); in Chile 84-95 percent and in Brazil 60-62 percent (Pandey and Ball, 1998; FAO, 1999).

From these figures it can be seen that:

- The importance of global forest plantation roundwood supply is higher than their share of forest area;
- The importance of forest plantations in global roundwood supply will increase in the future;
- Countries have different strategies in forest plantation development; and
- Outlook studies, databases and scenarios differ greatly from each other.

FAO forest plantation assessments

The objectives of forest plantation assessments and databases are to quantify the quantity and quality of forest plantation resources to allow policy and plan makers to make more soundly based decisions.

In the first global forest plantation assessment 1965 the area of "man-made planted forests" was estimated including European countries, USA and Canada but excluding e.g. former Soviet Union and China (FAO, 1967).

In 1980 FAO estimated the gross area of plantations for 76 tropical countries only (FAO, 1982) and added later non-tropical developing countries and small islands of Oceania into the 1980 data set (FAO, 1988). The 1990 Forest Resources Assessment net forest plantation areas (gross areas multiplied by a reduction factor of 0.7) were reported for both tropical and non-tropical developing countries to reflect losses after establishment (FAO, 1995a).

Reduction factors were further refined by countries and regions (FAO, 1995b, 2001b, 2002a) and results given for industrial and non-industrial plantations.

The Global Forest Resources Assessment (FRA 2000) definition of forest plantation was (FAO 2001, App. 2): "Forest stands established by planting and/or seeding in the process of afforestation or reforestation. They were either:

- Of introduced species (all planted stands); or
- Intensively managed stands of indigenous species, which meet all the following criteria: one or two species at planting, even age class, regular spacing."

In FRA 2000 gross forest plantation areas were reported for each country. In developing countries the maximum of eight classifications including *Acacia*, *Eucalyptus*, *Hevea*, *Tectona*, Other broadleaves, *Pinus*, Other coniferous and Unspecified were reported according to ownership (industrial or non-industrial) and ownership (public, private, other, unspecified). In industrialized countries of the temperate and boreal zones no tree species distributions, purpose or ownership was reported.

Features of current global forest plantation data

Although FRA 2000 forest plantation data was derived and validated in a comprehensive, transparent and participatory manner, the coverage remained incomplete. A summary is:

- Tropical and sub-tropical developing countries of Africa, Asia, Oceania, North and Central America and South America had the most comprehensive data coverage;
- The largest genera, *Pinus*, contained over 37 million ha (or 20 percent) globally and *Eucalyptus*, 18 million ha (10 percent) but consolidated data was not reported according to individual species;
- Globally, 108 million ha or 58 percent did not have a genus or species classification - 29 percent, unspecified; 18 percent, other broadleaves; and 11 percent, other coniferous;
- Temperate and boreal zone industrialized countries of Europe and the former Soviet Union accounted for 32 million ha and New Zealand, Australia, Japan and Turkey for a further 15 million ha of forest plantations without specified genera/species, purpose or ownership;
- Austria, Canada, Czech Republic, Finland, Germany and Liechtenstein reported no forest plantation areas;
- The purpose of plantations was classified according to industrial (timber, pulpwood, biomass production), non-industrial (fuelwood, environmental protection and other uses) but unspecified accounted for 49 million ha globally (26 percent);
- The differentiation between new plantings and replanting after harvesting was not always made in country reports;
- Failures in plantation establishment and management due to adverse weather conditions, forest fires, pests and diseases, desertification, harvesting, roading, infrastructure development, encroachment etc. were not always used to reduce gross to net areas;
- In some major developing countries, estimates of forest plantations were based upon distribution of nursery seedlings and average stocking rates at planting to derive gross planted area;

- Age class distribution data was weak, often expressed for total plantings, or totally lacking;
- Rotation lengths were rare or given only according to species groups, not tied to purpose (timber/pulp/fuelwood);
- Growth rates if reported, were expressed as mean annual increment (MAI) over the full rotation length on a country or species basis, with limited recognition of variations between individual species;
- There was no correlation of plantation data by ecological zones or sub-national units in which management and performance could vary considerably;
- Systematic collection of plantation area development for most of industrialized countries was weak;
- Comparisons between successive assessments was not strictly valid due to differences in definitions, classifications in plantation areas (gross/net), country borders and species coverage (e.g. *Hevea brasiliensis)*.

Plantation database (PDB)

In recognition of the need to improve the scope and reliability of forest plantation data FAO established a forest plantation database that allows better understanding of global, regional and national status and trends. Entries were made for four different database tables:

- Gross and net area: 3,869 observations
- Planting rate: 1,759 observations
- Productivity: 2,885 observations
- Taxa: 520 species, 48 genera, 4 species groups

The Global Forest Resources Assessments contained gross area information of forest plantations including:

Gross area	FRA 1980	FRA 1990	FRA 2000	PDB
Countries	104	109	173	141
Observations	214	237	1,411	2,388

The PDB was designed to complement and supplement the FRA 2000 forest plantation database status and trends between countries and regions.

Global plantation area development trends

Countries were divided according to gross plantation area: large (>1 million ha), medium (> 100,000 ha), small (> 10,000 ha) and minor (< 10,000 ha) and gross area developments assessed according to expanding, stable/constant or decreasing.

The following trends were observed:

- Most large plantation countries are in Asia;
- All large plantation countries are expanding in planting area development, i.e. gross area is increasing;
- In Africa many medium plantation countries are stable/constant (Algeria, Angola, Madagascar, Malawi, Morocco, Rwanda) or even decreasing (Ethiopia, Tanzania, Tunisia) in their planting developments;

- Among medium plantation countries on other continents only Colombia has decreasing planting development;
- Most of the small plantation countries are stable/constant or decreasing in their planting development;
- Many countries in which plantation area development is decreasing, have had serious economic or political problems or civil wars in recent decades; and
- Some countries in Asia lack plantation data (former Soviet Union, Republic of Korea, People's Democratic Republic of Korea).

Polarisation appears to be occurring in plantation development - large are becoming larger and small are becoming smaller.

There were 490 forest plantation species recorded in primarily tropical and sub-tropical countries. Most of the tree species were used, however, in very few countries: 262 in one country only and 90 in five or more countries. The most commonly distributed broadleaf species included *Eucalyptus camaldulensis* (67 countries), *Tectona grandis* (50), *Swietenia macrophylla* (38), *Eucalyptus grandis* (37), *Eucalyptus tereticornis* (36), *Gmelina arborea* (34), *Eucalyptus globulus* (26), *Eucalyptus saligna* (26), *Eucalyptus citriodora* (25), *Azadirachta indica* (22), *Eucalyptus robusta* (22) and *Acacia auriculiformis* (21). The most commonly distributed coniferous species recorded included *Pinus caribaea* var. *hondurensis* (49 countries), *Casuarina equisetifolia* (23), *Pinus patula* (23) and *Pinus radiata,* (17).

Reporting of species gross area data was very incomplete. From a preliminary analysis of a subset of 28.2 million ha in which specific species were reported the most common included: *Pinus radiata,* 14 percent; *Tectona grandis*, 9 percent; *Pinus merkusii*, 3 percent; *Acacia nilotica*, 3 percent; *Pinus halepensis*, 2 percent; *Acacia auriculiformis*, 2 percent; *Eucalyptus grandis*, 2 percent; *E. globulus*, 1 percent; *Pinus roxburghii,* 1 percent; and *Dalbergia sissoo*, 1 percent.

The global estimate for *Hevea* (rubberwood) plantations in 2000 was 9.9 million ha (FAO, 2001; Carle et al. 2002) and has become a significant source of wood and fibre particularly in Malaysia, Thailand, Indonesia and increasingly China, Viet Nam and India.

From 1992-2000 inventories poplar plantation gross areas in 25 countries were reported to be 7.1 million ha (Ball, 2000). China reported 6 million ha of poplar plantations, with 0.1-0.3 million ha in each of France, Iran, Argentina, Italy, Hungary and Spain. Poplar plantations in China and Europe have had a long tradition. Generally, the area and productivity of poplar plantations has increased.

Some forest plantation species predominate nationally, including 4.6 million ha of *Cryptomeria japonica* and 2.5 million ha of *Chamaecyparis obtusa* in Japan (Gaston et al., 2000) and 6 million ha of *Cunninghamia lanceolata* in China (Fung, 1994).

Productivity of plantations

According to the PDB references, *Paraserianthes falcataria* (formerly *Albizia falcataria*) had the highest average mean annual increment (MAI) of all species with 29 m^3 ha^{-1} yr^{-1}. Among the species with average MAI over 20 m^3 ha^{-1} yr^{-1} *Eucalyptus* and *Pinus* species were most common (*E. deglupta, E. grandis, E. urophylla, E. regnans, E. saligna, P. pseudostrobus, P. radiata, P. merkusii, P. elliottii* and *P. patula*). *Leucaena leucocephala, Acacia magnium,*

Maesopsis eminii and *Gmelina arborea* also exceeded the limit of 20 m^3 ha^{-1} yr^{-1}. The valuable hardwood species *Dalbergia sissoo* (9 m^3 ha^{-1} yr^{-1}), *Swietenia macrophylla* (9 m^3 ha^{-1} yr^{-1}) and *Tectona grandis* (8 m^3 ha^{-1} yr^{-1}) were among the least productive species when measuring productivity on volume growth only.

A comparison of MAIs between the PDB and previous FAO reports is given in Table 1. Other sources for extensive MAI estimates are Webb et al. (1984) and Wadsworth (1997).

Table 1. Mean annual increment (MAI) by species by different sources

Species	MAI - m^3 ha^{-1} yr^{-1}			
	FRA 2000 Carle	FAO 2000 Brown	FAO 1998 Pandey & Ball	FAO 2002 PDB
Acacia auriculiformis	6-20	6.5-10		9-18
Acacia magnium		8-19	10-15	15-37
Acacia mearnsii	14-25			12-24
Araucaria angustifolia	8-24			8-16
Araucaria cunninghamii	10-18			10-24
Casuarina equisetifolia	6-20	1.5-7.5		6-18
Casuarina junghuhniana	7-11			
Cordia alliodora	10-20			
Cryptomeria japonica			8	
Cupressus lusitanica	8-40			8-25
Dalbergia sissoo	5- 8	3- 5		4-10
Eucalyptus camaldulensis	15-30			10-21
Eucalyptus deglupta	14-50			17-35
Eucalyptus globulus	10-40			8-29
Eucalyptus grandis	15-50			14-35
Eucalyptus robusta	10-40			11-28
Eucalyptus saligna	10-55			13-48
Eucalyptus spp.		4-25	1-20	11-31
Eucalyptus urophylla	20-60			20-40
Gmelina arborea	12-50	12-19		16-28
Leucaena leucocephala	30-55			18-42
Pinus caribaea var. Caribaea	10-28			10-23
Pinus caribaea var. Hondurensis	20-50			15-22
Pinus elliottii			15-25	10-24
Pinus kesiya			6-10	11-21
Pinus oocarpa	10-40		11	10-32
Pinus patula	8-40		15-25	11-30
Pinus radiata	12-35		18-24	13-26
Pinus taeda			7	12-30
Swietenia macrophylla	7-11	5-7.5		8-13
Tectona grandis	6-18	4-18	2-6.3	7-13
Terminalia ivorensis	8-17	5-12.5		8-15
Terminalia superba	10-14	5-12.5		10-16

Conclusions and Recommendations

Forest plantations are assuming an importance in roundwood, fibre, fuelwood and non-wood forest products supply far in excess of their representation by forest area. Recommendation: There is an urgent and critical need to improve both the quantity and quality of plantation data on which sound policy, planning and monitoring can be based.

Data collection for developing countries was done by FAO in the past, with data from industrialized temperate and boreal zone countries collected by UN/ECE/FAO. This led to different procedures and levels of data collection. Recommendation: Greater harmonization of methods for plantation data collection and reporting must be implemented in the Global Forest Resources Assessment in close collaboration with countries.

The definition and concepts of plantations must be harmonized. The collaborative work undertaken between FAO, IPCC, IUFRO, CIFOR, UNEP and other experts in harmonization of forestry related definitions during meetings serves as an excellent avenue for harmonization of plantation definitions (FAO, 2002b). Up to now the planted forests of indigenous species in industrialized countries are poorly represented in the context of global planted forest resources.

It has not always been possible to distinguish forest plantations from natural forests in those countries where natural species were grown on long rotation, mixed-species, mixed age plantings in temperate and boreal regions. The distinction between natural forests and plantation forests was more clear-cut if plantings were of single species (indigenous or introduced), uniform planting densities, even age classes, shorter rotation, intensively managed, as often found in tropical and sub-tropical regions.

There is a need to recognize semi-natural forests which are neither strictly natural forests with minimal management nor plantation forests with intensive management, but which provide critical wood and non-wood forest product supplies and valuable social, cultural, environmental and economic values. Semi-natural forests may be selectively harvested for wood and non-wood forest products, receive enrichment planting and/or seeding or have silvicultural treatments to enhance growth and yield. The wider planted forest classification can potentially include indigenous species, particularly in Europe and North America which have been reported as natural forests in previous FAO Global Forest Resources Assessments, including FRA 2000. Recommendation: The type and intensity of management, particularly enrichment planting and/or seeding be used to assist countries to determine whether their semi-natural forests qualify as a type of planted forest.

During FRA 2000 there were generally poor responses by countries to questionnaires to determine plantation areas by species, planting rates, purpose, ownership, age class distributions, mean annual increments, rotation lengths and harvest yields. Recommendation: New mechanisms be explored to improve the collaboration and transparency between FAO and the countries, focal agencies and persons at country and regional levels and national and international consultants in updating and extending the plantation database.

In order, China, India, Russian Federation, United States, Japan, Indonesia, Brazil, Thailand, Ukraine and the Islamic Republic of Iran reported the top ten forest plantation areas, which

accounted for 79 percent of the global forest plantation resources (FRA, 2000). One province in these countries can contain more plantations than many other countries around the globe. Recommendation: Consideration be given to collection of sub-national plantation data in the major plantation countries.

For meaningful analysis, resolution of the problem of reporting gross rather than net forest plantation areas is critical. The reduction factors used in the 1990s were simplistic and could not effectively reflect the reality on the ground. Recommendation: Conduct samples in key countries using modern technology and ground proofing to derive more scientifically proven reduction factors taking advantage of FAO's launching of support to National Forest Assessments in developing countries to include forest plantation resource assessment.

The present plantation database was sourced from over 400 documents including FAO official forest resources assessments, outlook studies, project documents and case studies supplemented by country and consultant reports, books, journals, working papers, proceedings of scientific meetings, projects and questionnaires. Although the PDB contains over 8,000 observations it is only a first step to establishing a more comprehensive database to service FAO member countries, particularly policy makers and planners wishing to prepare outlook studies for future supplies of forest products from forest plantations. Further parameters can be added as more comprehensive data and links are received. Ultimately the PDB will be linked to other FAO databases including the global information system on forest genetic resources; forest fires; pest management and mangroves as appropriate.

The current PDB is available through the FAO website: www.fao.org/forestry/plantedforest in a simple, user friendly basis, including by region, country, species and parameter (purpose, MAI, planting rate, rotation length). Recommendation: User feedback be invited to supplement and validate the forest plantation data with new entries, links and references.

Literature

ABARE & J. Pöyry, 1999. Global Outlook for Plantations. ABARE, Canberra, Australia. 99 p.

Ball, J., 2000. Synthesis of National Reports on Activities related to Poplar and Willow Areas, Production, Consumption and the Functioning of National Poplar Commissions. FAO, IPC, Rome, Italy. 25 p.

Carle, J., P. Vuorinen & A. Del Lungo, 2002. Status and trends in global forest plantation development. *Forest Products Journal* 52(7/8): 12-23.

FAO, 1967. World Symposium on Man-Made Forests and their Industrial Importance. *Unasylva* 21(86-87). 116 p.

FAO, 1995a. Forest Resources Assessment 1990 - Global Synthesis. *FAO Forestry Paper* 124. FAO, Rome, Italy. 44 p.

FAO, 1995b. Forest Resources Assessment 1990. Tropical forest plantation resources by Devendra Pandey. *FAO Forestry Paper* 128. FAO, Rome, Italy. 81 p.

FAO, 1997. Asia-Pacific Forestry Sector Outlook Study: In-Depth Country Study - New Zealand by C. Brown. *Working Paper Series* APFSOS/WP/05. FAO, Rome, Italy. 54 p.

FAO, 1999. State of the World's Forests. FAO, Rome, Italy. 154 p.

FAO, 2000. The global outlook for future wood supply from forest plantations by C. Brown. *Working Paper* GFPOS/WP/03, Forest Policy & Planning Division. FAO, Rome, Italy.146 p.

FAO, 2001a. Global forest resources assessment 2000. Main report. *FAO Forestry Paper* 140. FAO, Rome, Italy. 479 p.

FAO, 2001b. Forest Plantation Resources, FAO Data-Sets 1980, 1990, 1995 and 2000. Based on work of A. Del Lungo. *Forest Plantations Working Paper* 14., Forest Resources Development Service, Forest Resources Division. FAO, Rome, Italy. 38 p.

FAO, 2002a. Tropical forest plantation areas 1995 data set by D. Pandey. *Forest Plantations, Working Paper* 18, Forest Resources Development Service, Forest Resources Division. FAO, Rome, Italy. 55 p.

FAO, 2002b. Second expert meeting on harmonizing forest-related definitions for use of various stakeholders. FAO, Rome, Italy. 354 p.

Fung, L.E., 1994. A literature review of *Cunninghamia lanceolata. Commonwealth Forestry Riview* 73(3): 172-192.

Gaston, C., D. Ciohen & D. Fell, 2000. Wood market trends. Japan. Forintek Canada Corp., Forest Renewal BC, Natural Resources Canada, Canadian Forest Service. 32 p.

Pandey, D. & J. Ball, 1998. The role of industrial plantations in future global fibre supplies. *Unasylva* 49(193): 37-43.

Thomberlin, D. & J. Buongiorno, 2001. Timber Plantations, Timber Supply and Forest Conservation. In: Palo, M., J. Uusivuori & G. Mery, (eds.). World Forests, Markets and Policies World Forests, Volume III. Kluwer Academic Publishers. p. 85-94.

Wadsworth, F.H., 1997. Forest production for Tropical America. United States Department of Agriculture, *Agriculture Handbook* 710. 563 p.

Webb, D.B., P.J. Wood, J.P. Smith & G.S. Henman, 1984. A guide to species selection for tropical and sub-tropical plantations. *Tropical Forestry Papers* 15. Unit of Tropical Silviculture, Commonwealth Forestry Institute, University of Oxford, Oxford, UK. 256 p.