



Forestry Department

Food and Agriculture Organization of the United Nations

Planted Forests and Trees Working Papers

Planted Forest Database: Analysis of Annual Planting Trends and Silvicultural Parameters for Commonly Planted Species

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Disclaimer

The Planted Forests and Trees Working Paper, report on issues and activities in planted forests. These working papers do not reflect any official position of FAO. Please refer to the FAO website (<http://www.fao.org/forestry>) for official information.

The purpose of these papers is to provide early release of information on on-going activities and programmes, and to stimulate discussion.

Comments and feedback are welcome.

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Note

The “Forest Plantation” series, available from Working Papers 1 to 24 has changed to the new series title, “Planted Forests and Trees Working Paper”, but numeration will not change.

Explanatory comment

The present study reviews and analyses a set of data contained in the Planted Forests DataBase (PFDB). The study is the result of a process that took three years and included the review of all accessible references on planted forests together with the existing FAO/FRA data sets to evaluate their compatibility when compared and compiled to produce reliable historical trends. The PFDB design in Microsoft Access was also important to compile, analyse and review the data collected.

The term “Forest Plantation” as defined in Forest Resources Assessment 1980 has been progressively refined. The definition used in the Global Forest Resources Assessment 2000 and State of the World's Forests 2003 was: *“Forest stands established by planting or/and seeding in the process of afforestation or reforestation. They are 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. New plantation forests are defined as afforestation for artificial establishment of forest on lands which previously did not carry forest within living memory or the past 10 years; and reforestation for artificial establishment of forest on lands which carried forest before”*.

FAO in collaboration with the Intergovernmental Panel on Climate Change (IPCC), the International Union of Forestry Research Organizations (IUFRO), the Centre for International Research (CIFOR), the United Nations Environment Programme (UNEP) are engaged in an expert process to harmonize forestry related definitions in which a wider concept/definition of “Planted Forests” is emerging to account for planting/seeding of indigenous species which may have been previously considered and reported as semi-natural forests or modified natural forests (e.g. Canada, Finland, Austria, Germany).

Increasingly the sub-set of “Planted Forests” using exotic species is referred to as “Forest Plantations” or “Plantation Forests” (with single or few species, even age class, uniform planting density). The other subset of “Planted Forests” with indigenous species is increasingly referred to as forms of semi-natural forest or modified natural forest (depending on degree of naturalness, including mixed species and age classes and variable planting density).

“Planted Forests” are often intensively managed for production purposes, but can also be established for protection, conservation or socio-economic purposes in which case the management may be less intensive. This distinction is important in global assessments that attempt to capture the extent of productive, protective, conservation of biological diversity, and socio-economic functions of forests, which are key criteria for sustainable forest management.

Working Papers FP/14 (Forest Plantation Resources, FAO Data Sets 1980, 1990, 1995 and 2000), FP/25 (Planted Forests Database (PFDB): Structure and Contents) and FP/26 (Planted Forest Database: analysis of annual planting trends and silvicultural parameters for commonly planted species) constitute an inter-related series on the PFDB.

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Acronyms

CIFOR	Centre for International Research
ECE	Economic Commission for Europe
FAO	Food and Agriculture Organization of the United Nations
FRA	Forest Resources Assessment
IPCC	Intergovernmental Panel on Climate Change
IUFRO	International Union of Forestry Research Organizations
MAI	Mean Annual Increment ($\text{m}^3 \text{ha}^{-1} \text{yr}^{-1}$)
PFDB	Planted Forests Data Base
RL	Rotation Length (yr)
SOFO	State of World's Forests
T14T	Top 14 Most Planted World's Trees
T30C	Top 30 Countries
UN	United Nations
UNEP	United Nations Environment Programme
USSR	Union of Soviet Socialist Republics

Chapter 1⁽¹⁾

ANNUAL PLANTING: ANALYSIS OF REGIONAL TRENDS

1 Introduction

Estimates on area planted by countries are based on estimates of annual or periodic planting collected by countries. Good trends in annual planting are essential to outlook studies, are useful to adjust estimates on area planted for a given year and provide dynamics on plantation developments in countries, sub-regions or regions.

Information and data on annual planting has been collected in the Planted Forest DataBase (PFDB) and detailed, where possible, for species, ownership, afforestation or reforestation and reliability of information.

Although the PFDB provides the opportunity to categorize the information found, the quality of data available remains insufficiently reliable, outdated, inconsistent and weak. Data on annual planting is still very difficult to collect and to estimate according to reliability. However this paper contains an analysis done on the most reliable data collected on annual planting by the PFDB and shows the main trends on planting derived at sub-regional and regional level. Although the quality of data is weak it is possible to provide indications on how trends vary according to different regions.

⁽¹⁾ Because of the large number of paragraphs, tables, graphs and pictures contained in the working paper, numbering in each Chapter begins from "1".

2 The “Top 30 countries”

The Global Forest Resources Assessment 2000 (FRA 2000) compiled information on total plantation area for 213 countries for a total area of 187 millions ha that correspond to 5% of the total area covered by forests. The 30 most planted countries which account 93% of the total planted area or 173 millions ha is referred to the “Top 30 countries” (T30C) on planted forests.

The T30C are located in all the world regions but thirteen of them are in Asia contributing to a total planted area of almost 118 million ha or 68% of the T30C total area and 63% of the overall total planted area in the world; four are located in Africa, four in South America, one in North and Central America, six in Europe and two in Oceania.

Annual planting data collected in the PFDB is only available for 21 countries of T30C. For the 9 remaining countries, highlighted below in table 1, reliable information on annual planting was not available however, the total planted area of countries collected in the PFDB corresponds to 144 millions of ha or 77% of the total FRA2000 plantation area.

Table 1: Top 30 countries on planted forests

Country	Total area of Planted forest (000 ha) source FRA 2000	Availability of annual planting data collected in PFDB
China	45083	yes
India	32578	yes
Russian Federation	17340	NO
United States	16238	yes
Japan	10682	yes
Indonesia	9871	yes
Brazil	4982	yes
Thailand	4920	yes
Ukraine	4425	NO
Iran, Islamic Rep.	2284	yes
Chile	2017	yes
United Kingdom	1928	NO
Spain	1904	yes
Turkey	1854	NO
Malaysia	1750	yes
Viet Nam	1711	yes
South Africa	1554	yes
New Zealand	1542	yes
Australia	1396	yes
Pakistan	980	NO
Bulgaria	969	yes
France	961	NO
Argentina	926	yes
Venezuela	863	yes
Portugal	834	NO
Myanmar	821	yes
Philippines	753	yes
Algeria	718	yes
Nigeria	693	NO
Sudan	641	NO
Total TOP 30 Planted area	173215	-

3 Annual planting

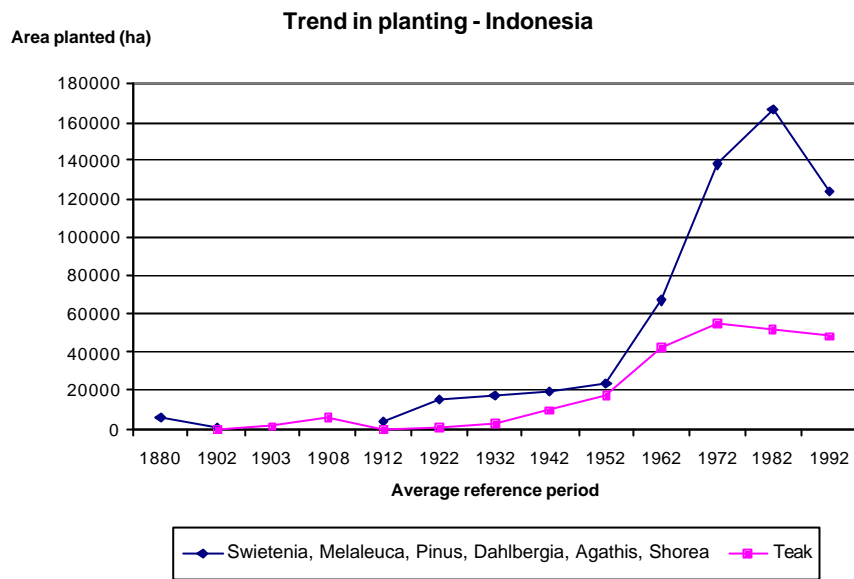
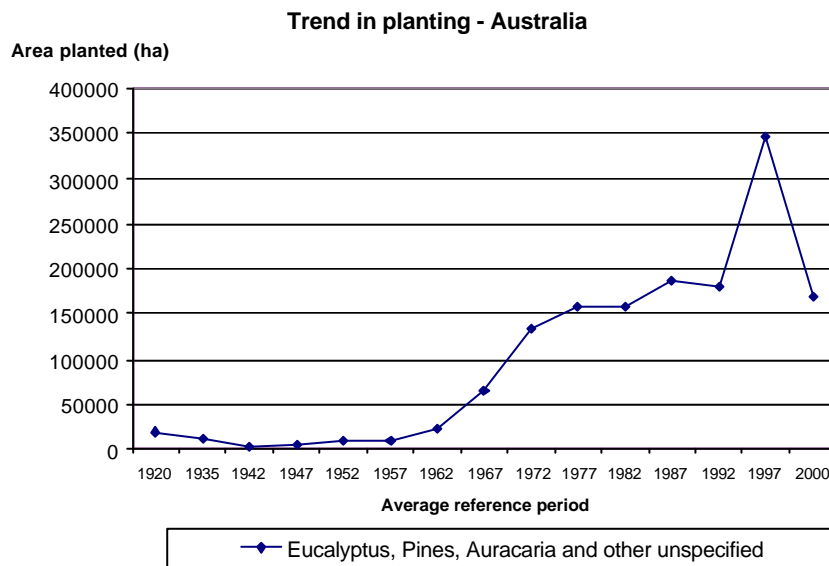
Annual planting data, or planting rates, have been defined as the amount of area yearly planted for a given country. In providing information on annual planting, each country should specify whether the data is afforestation or reforestation. Although PFDB has been designed to categorise annual planting in afforestation or reforestation, this information was seldom provided. However, data on annual planting carried out by countries have been collected and compiled in the PFDB in a table containing, at the moment, 1759 observations that only reports information on planting rates for 83 countries as overall national areas but more detailed information on planting areas broken-down by sub national units are provided only for Australia, India, Malaysia and Uruguay.

Detailed planting rates for periods longer than 1 year, and not necessary including all the species, are provided for 50 countries, 40 developing and 10 industrialised.

Despite the number of observations collected, information on planting rates remain incomplete due to the following weaknesses.

- It is impossible to specify whether annual planting is new planting for afforestation or replanting for reforestation.
- Almost all countries compiled do not provide details for all the species planted.
- Only few countries provide data to allow analysis of continuous trends.
- Not all the T30C with the largest area on planted forests assessed by FRA 2000 provide annual planting data.
- In many countries planting rates are provided by different sources that vary a lot among them. Therefore an evaluation of the sources found has to be carried out and more reliable information has to be derived.

However, annual planting data has been used for two main analyses: to analyse planting dynamics in the T30C, and in the sub-regions. Figures 1 and 2 show examples of trends for countries with reliable data.

Figure 1*Figure 2*

2.1 Trends in the “Top 30 countries”

Although data collected on annual planting are still under evaluation they have been used to derive interesting information.

It is possible to derive trends and regression lines for countries with reliable sets of data: Figures 3 and 4 below show different curves and lines that fit the same trends for Indonesia and Australia provided in the former paragraph.

Figure 3

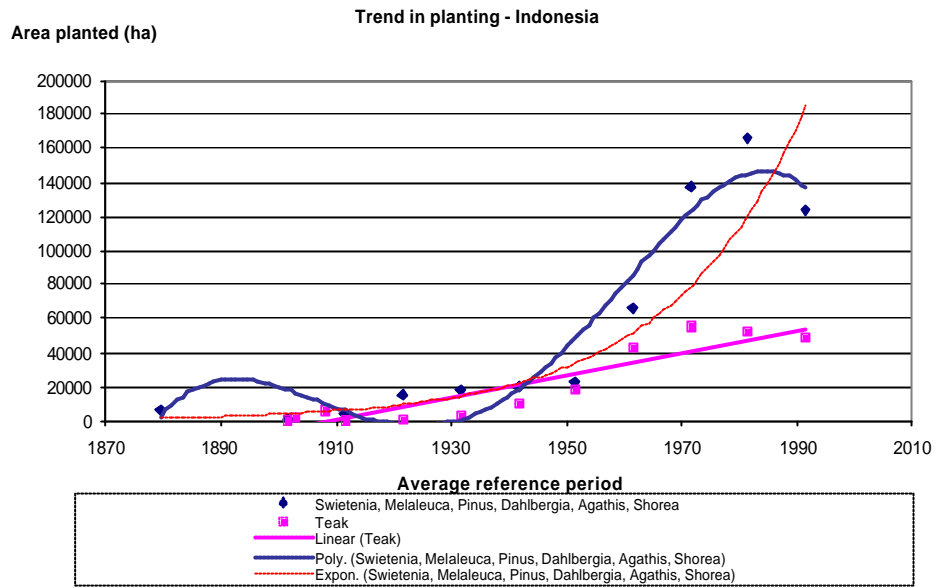
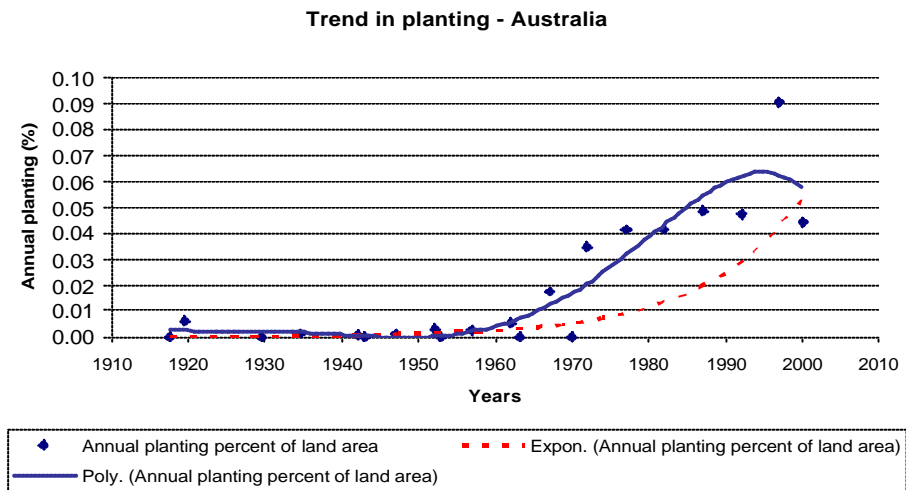


Figure 4

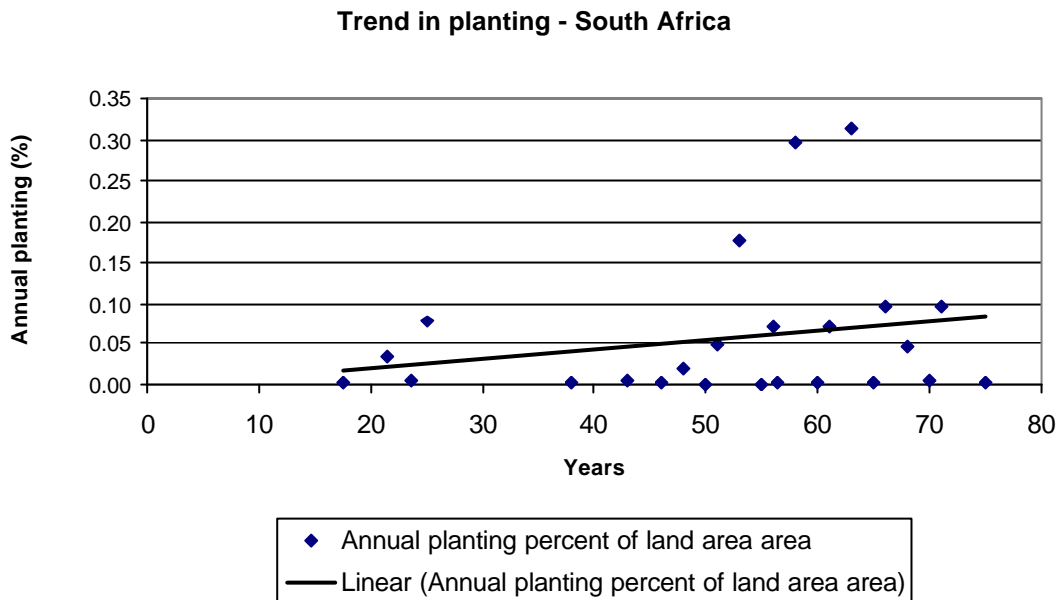


The proposed exercise shows the trend analysis done on the 21 available countries of T30C to describe their trends in new planting from the PFDB. In order to better understand the different planting trends adopted by countries, annual planting data were transformed into **percentage of total country land area** so that big countries like China can be compared with relatively small countries such as Viet Nam.

Africa

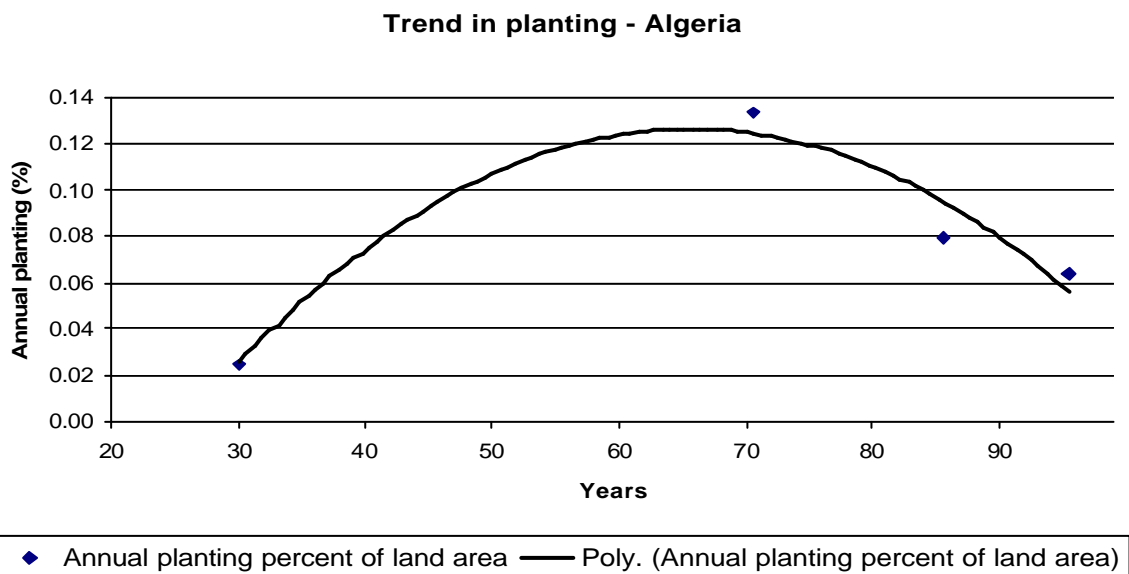
Although Africa is represented by 4 countries in the T30C list, data compiled in the PFBD is only available for South Africa and Algeria.

Figure 5



South Africa (Figure 5) is comprised of 24 reliable observations and shows a positive increasing trend on planting ranging from years 1920 to 1975. Unfortunately there are no new data available for years 80's and 90's that would better explain planting dynamics during the last 25 years.

Figure 6



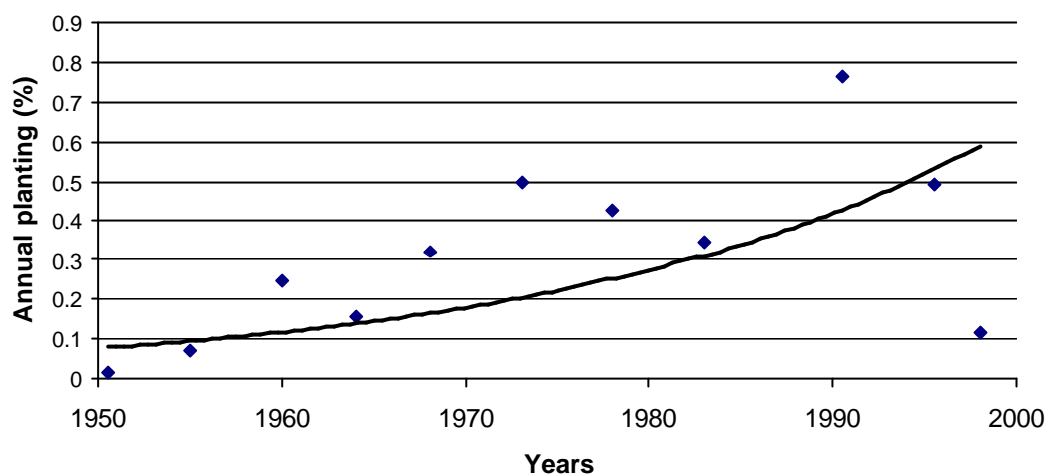
The PFDB reports for Algeria (Figure 6) only 4 observations that show a recent decreasing trend in planting however data are too few to be considered reliable.

Asia

Although Asia is represented by 13 countries in the T30C list, there are data compiled in PFBD for 10 countries reported as follow.

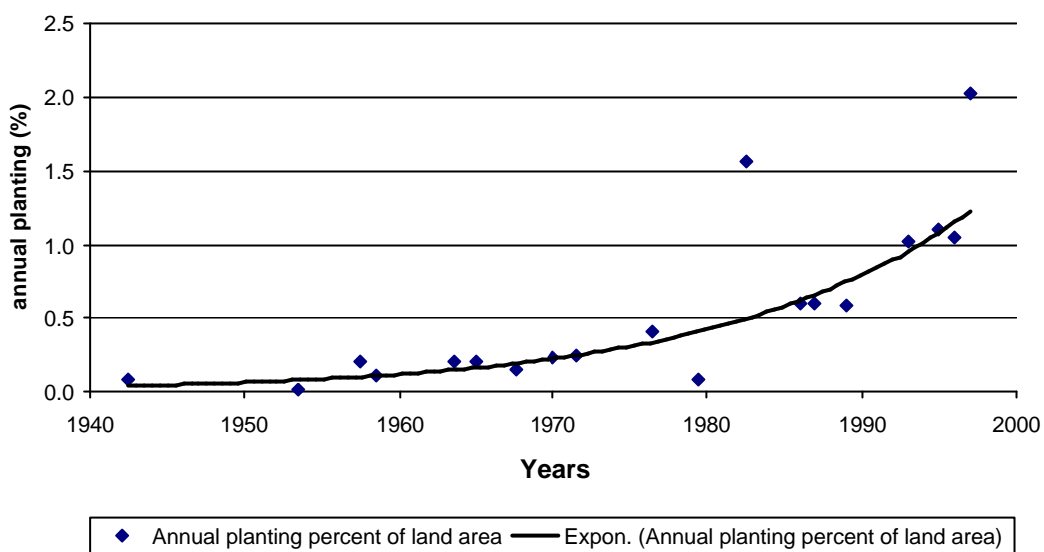
Figure 7

Trend in planting - China



◆ Annual planting percent of land area — Expon. (Annual planting percent of land area)

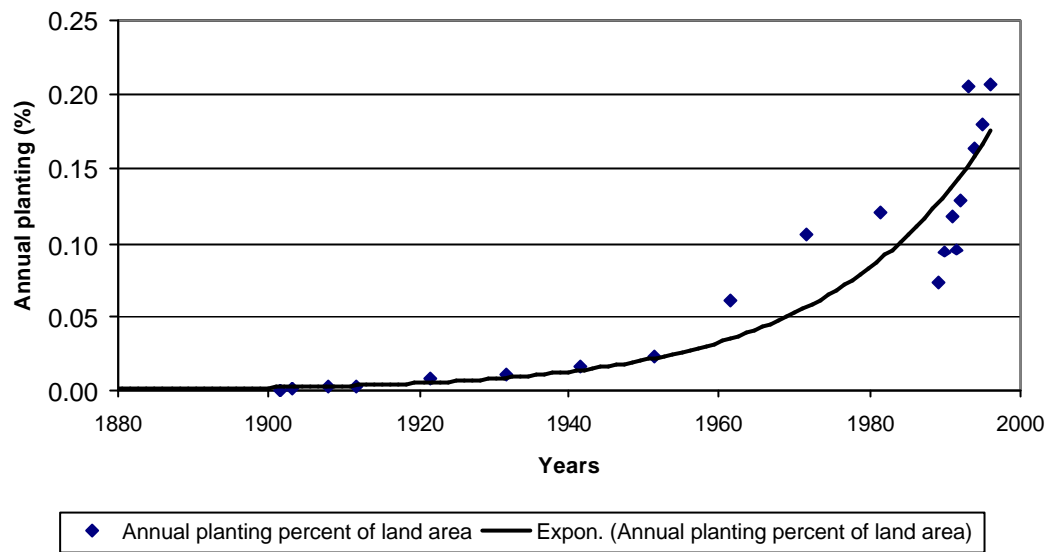
China (Figure 7) is the largest on planted forests area and shows a very positive, increasing trend since the 50's. The area annually planted is enormous; it is still increasing and corresponds to 0.6 % of the total land area or 5.6 millions ha per year with a total planted area at year 2000 of more than 45 million ha. Unfortunately this information is not classified according to afforestation and reforestation.

*Figure 8***Trend in planting - India**

India (Figure 8) has the second largest planted forest cover in the T30C. Planting rates are still increasing with positive trends corresponding to 3.6 million ha per year. Even though data are not classified according to afforestation and reforestation, most of this area should be due to reforestation. India remains very active on planted forests development.

Figure 9

Trend in planting - Indonesia



Indonesia (Figure 9) shows a very positive trend on annual planting corresponding respectively to 0.17% of the total land area or 308,000 ha per year.

An exponential line providing R^2 of 0.52 for Japan (Figure 10) does not sufficiently fit the new planting trend which peaked during the 1960's, but decreased over the last 30 years. The polynomial line better fits the trend.

Figure 10

Trend in planting - Japan

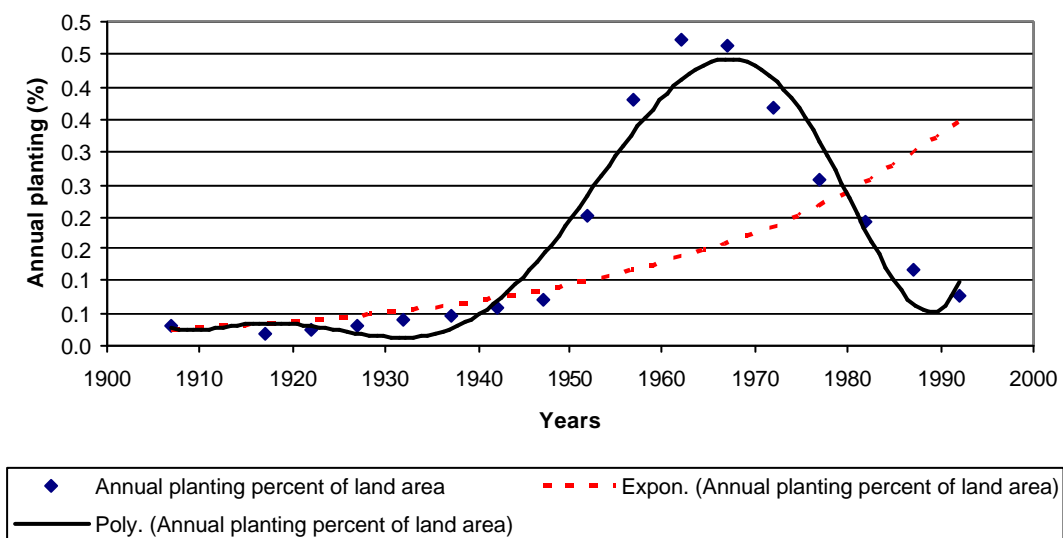
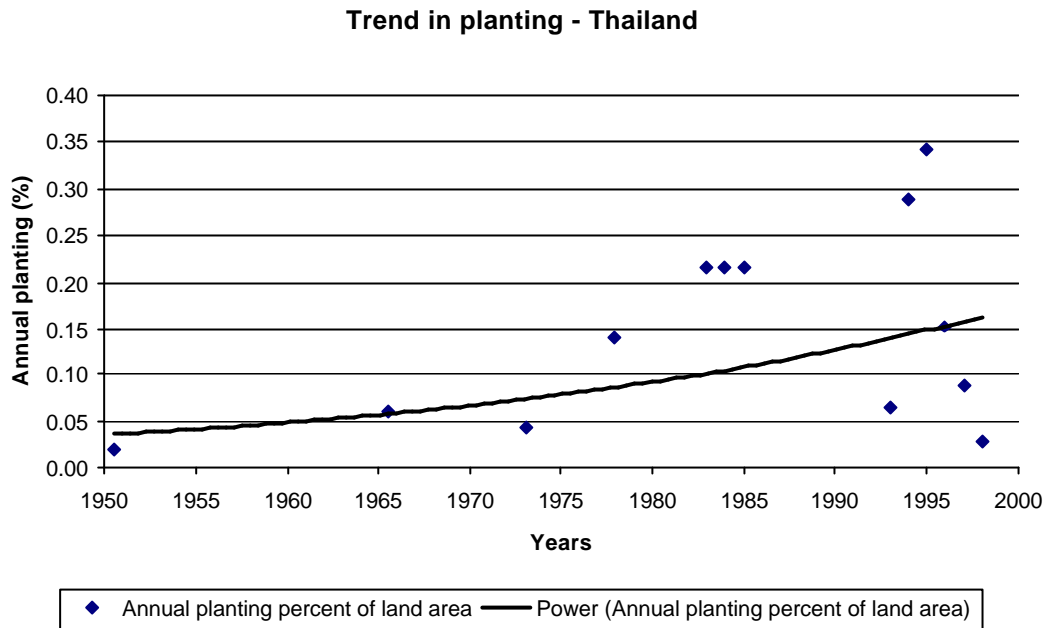
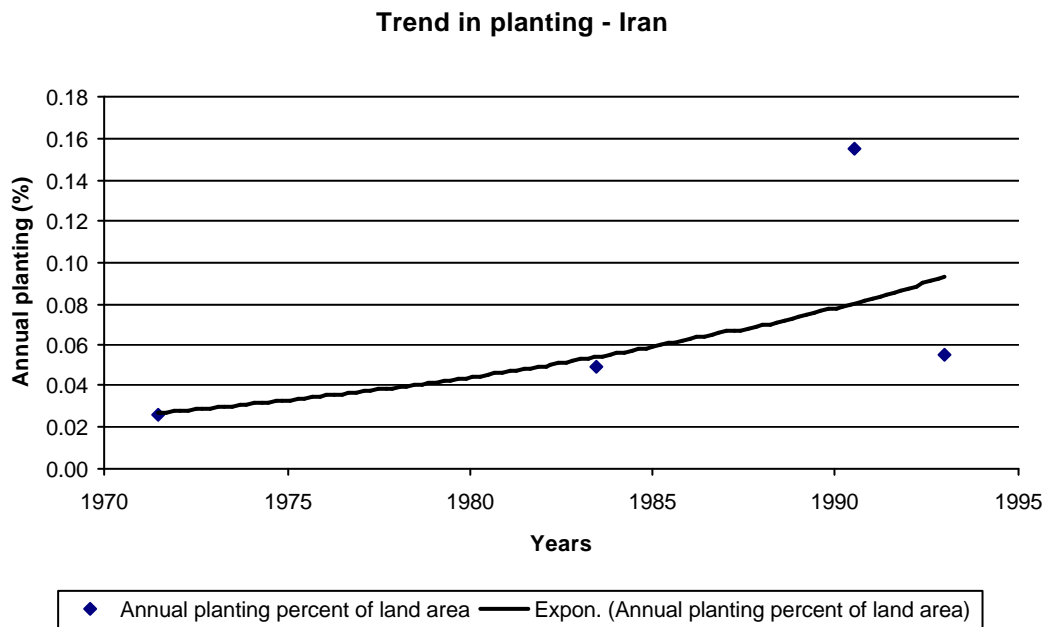


Figure 11

Thailand (Figure 11) and Iran (Figure 12) show also positive trends but relatively lower compared with the other countries, corresponding to 82,000 and 147,000 thousands ha/year respectively. Iran has only 4 observations and its trend can not be considered too reliable.

Figure 12

Malaysia (Figure 13), Viet Nam (Figure 14), Myanmar (Figure 15) and Philippines (Figure 16) have positive trends but are generally based on too few and scattered observations to derive very reliable trends. The resulting trends are not very representative of their dynamics on planting. Also, Viet Nam reports a very high peak on planting showing 1.8 millions ha planted during period 1989 – 1996 (Lung, N.N. 1996).

Figure 13

Annual planting - Malaysia

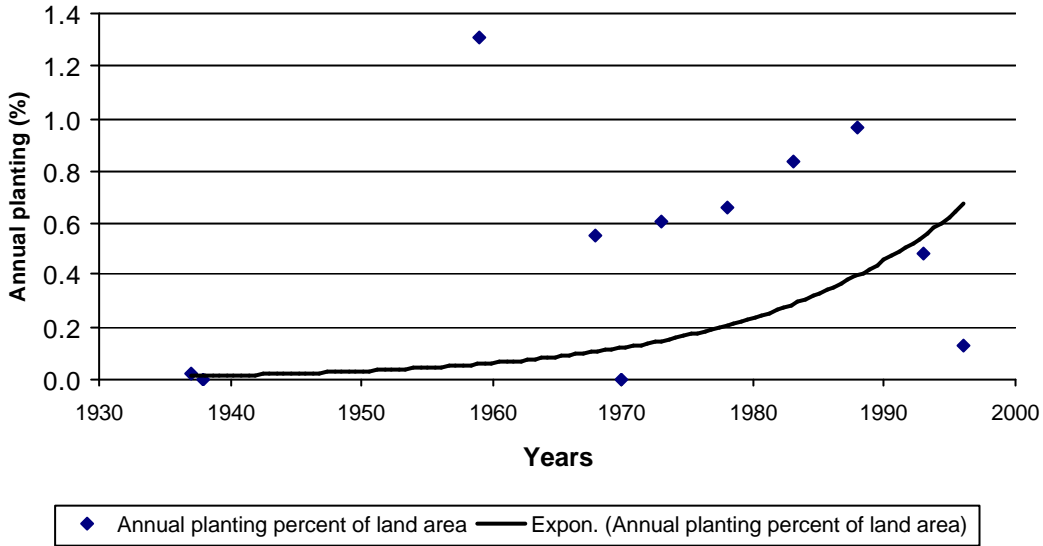


Figure 14

Trend in planting - Viet Nam

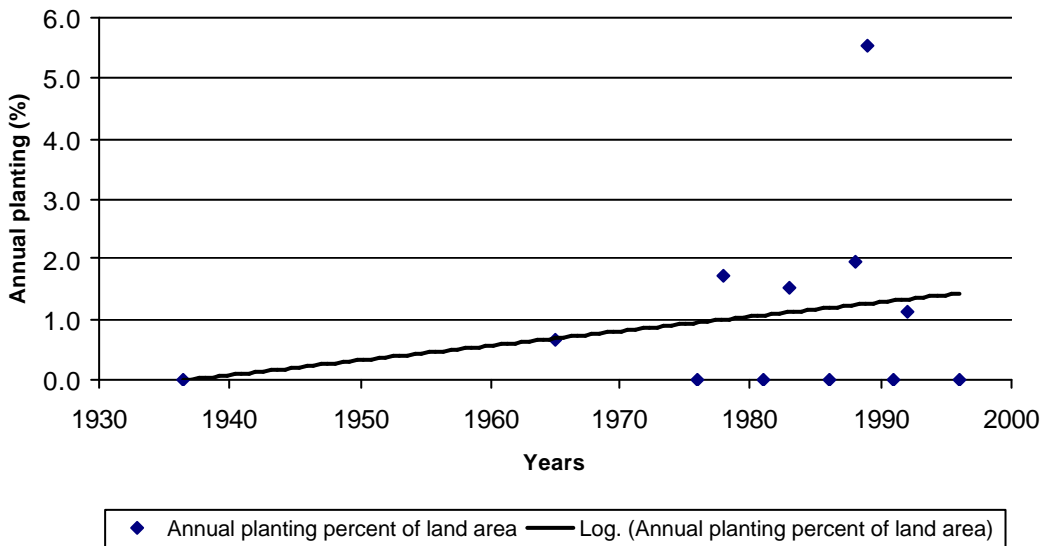


Figure 15

Trend in planting - Myanmar

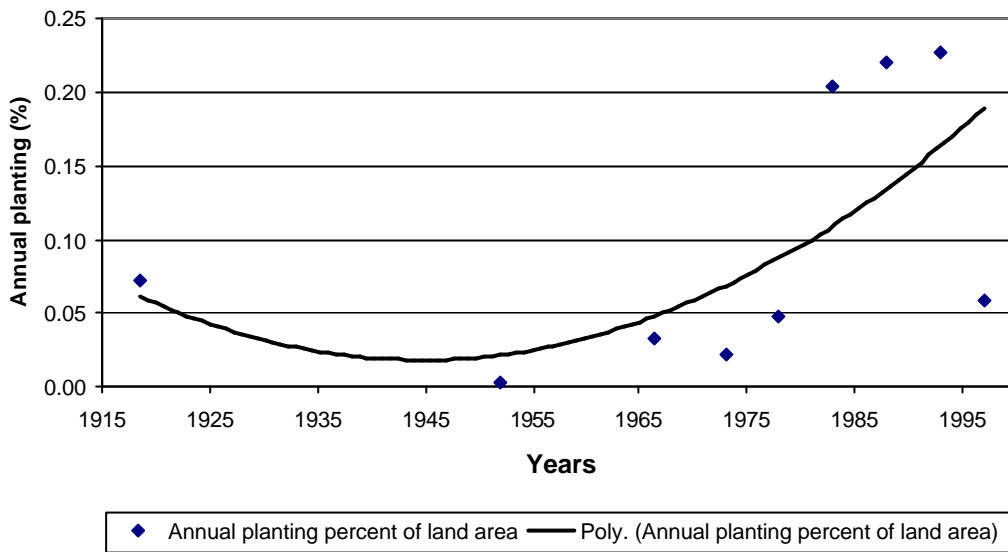
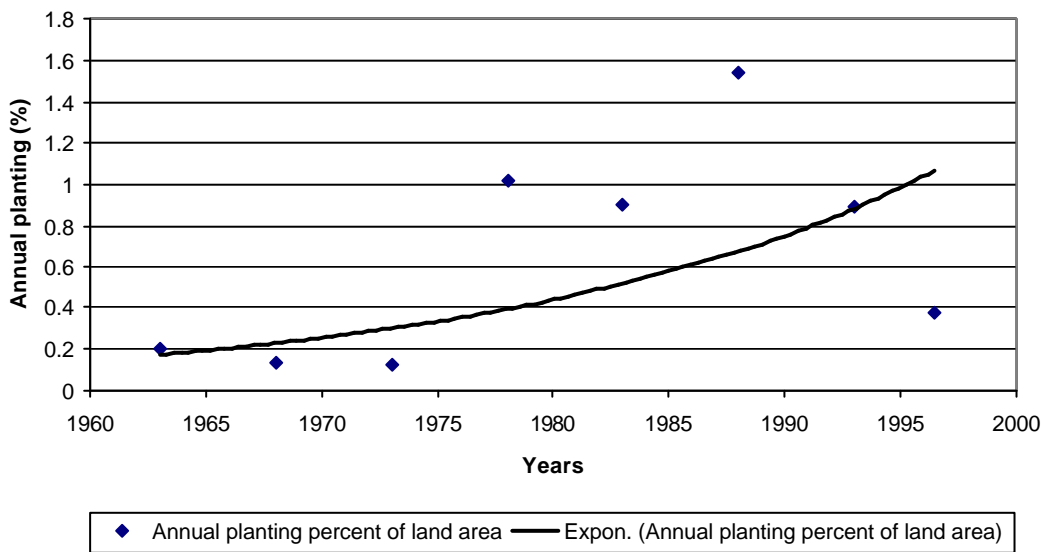


Figure 16

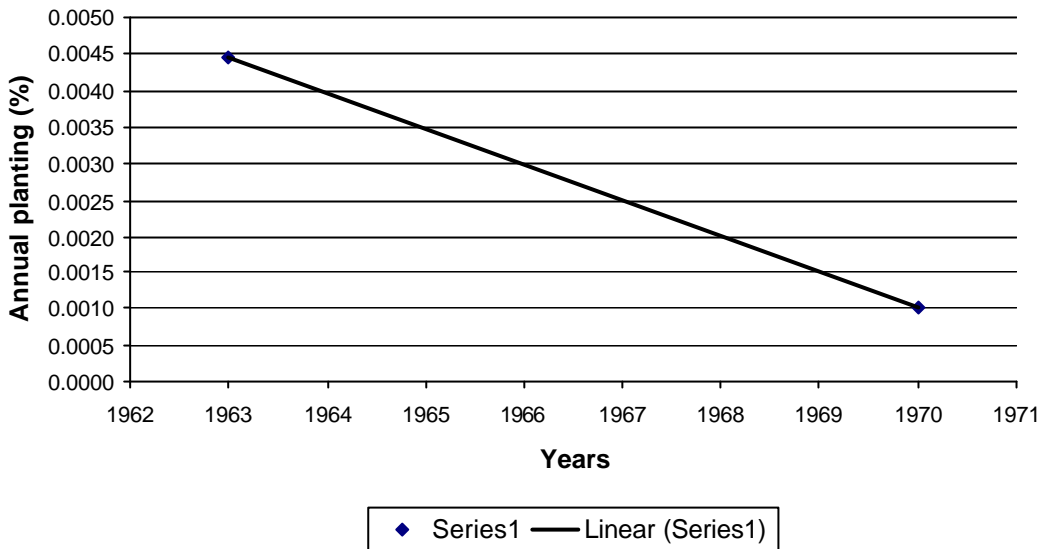
Trend in planting - Philippines



America

Figure 17

Trend in planting - Brazil

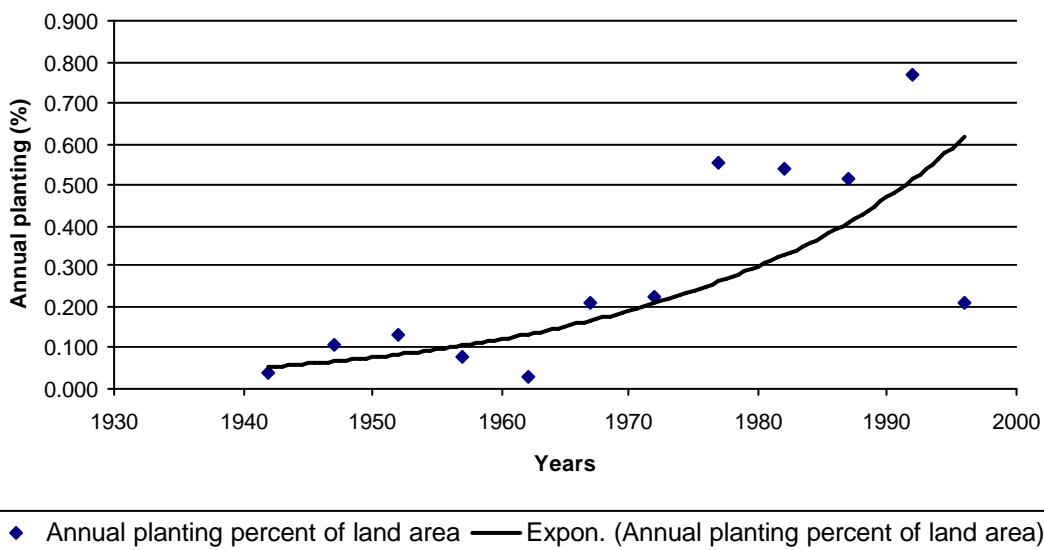


The PFDB contains two relatively low reliability observations for Brazil (Figure 17) which show a strong decrease from 60's to 70's. No more updated data for Brazil was available after the 70's.

Chile (Figure 18) and Argentina (Figure 19) show very positive trends that are still increasing and corresponding respectively to 464,000 and 112,000 ha per year respectively. Venezuela (Figure 20) shows only two observations, not very reliable indicating a very positive trend.

Figure 18

Trend in planting - Chile



◆ Annual planting percent of land area — Expon. (Annual planting percent of land area)

Figure 19

Trend in planting - Argentina

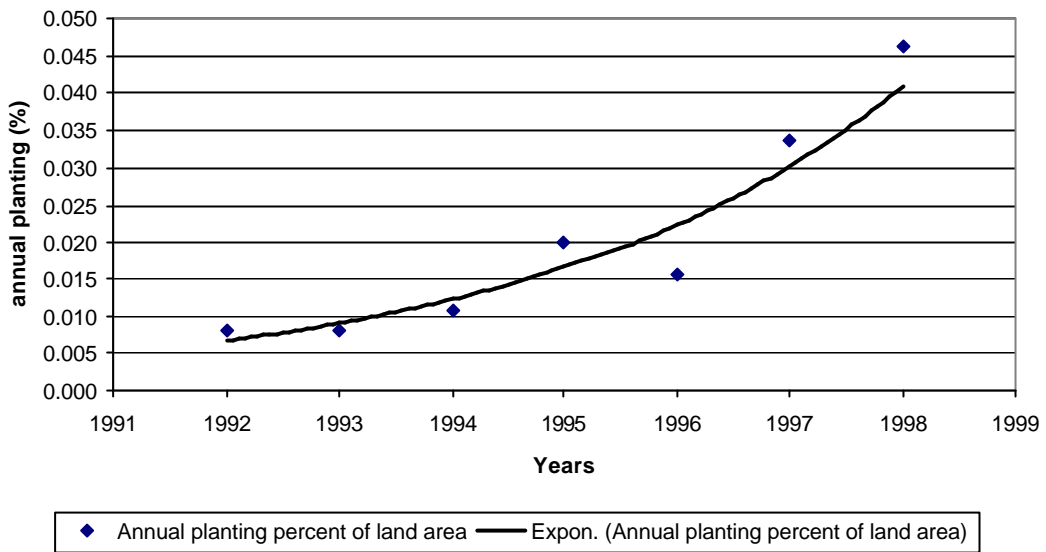
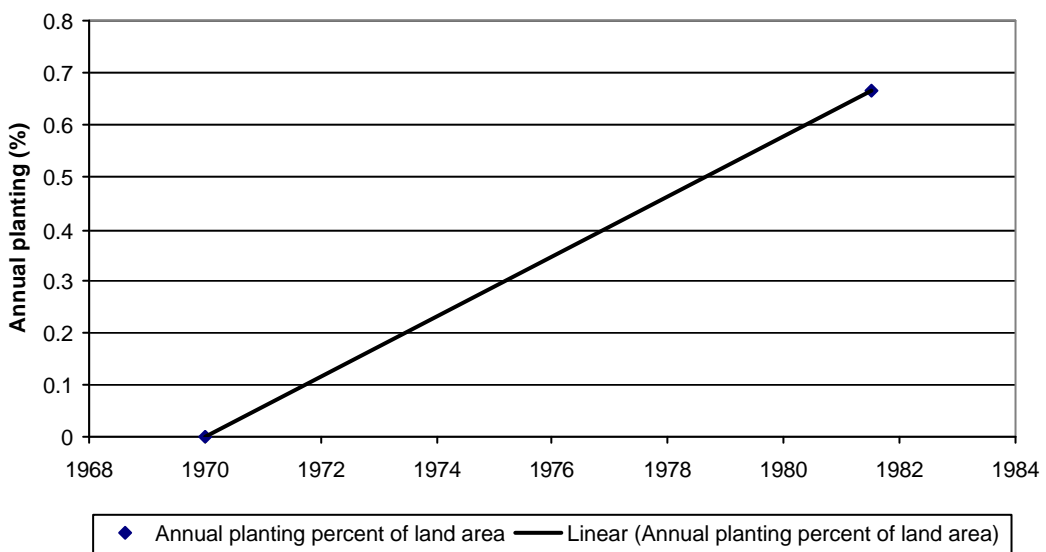


Figure 20

Trend in planting - Venezuela



Oceania

The two countries representing Oceania, New Zealand (Figure 21) and Australia (Figure 22), account for almost all new planted forest are for the region and the quality of data compiled in the PFDB are very reliable so that their trends could be suitable to extrapolate information beyond the year 2000. Both countries have reliable, current and very positive trends corresponding to 430,000 and 461,000 ha/year respectively.

Figure 21

Trend in planting - New Zealand

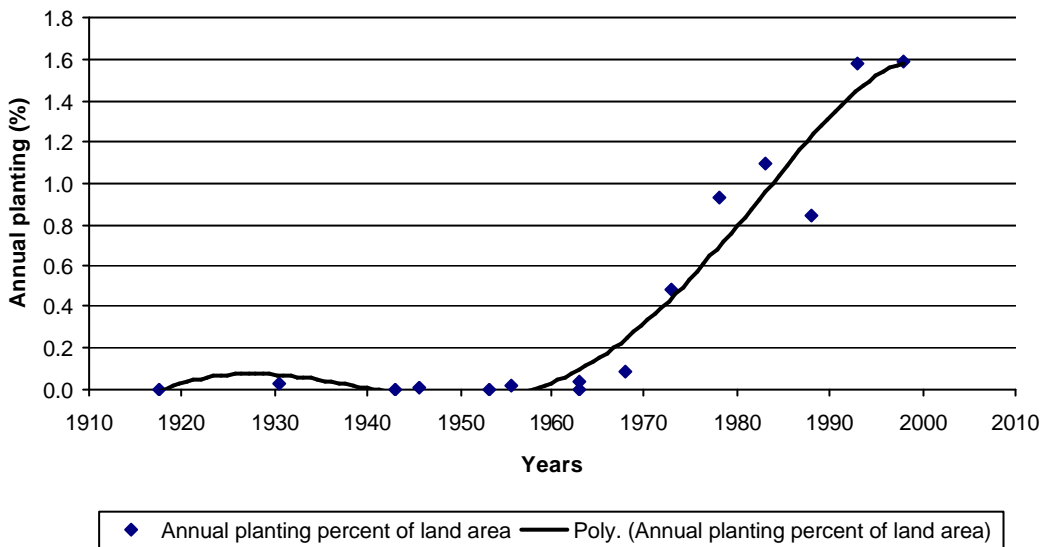
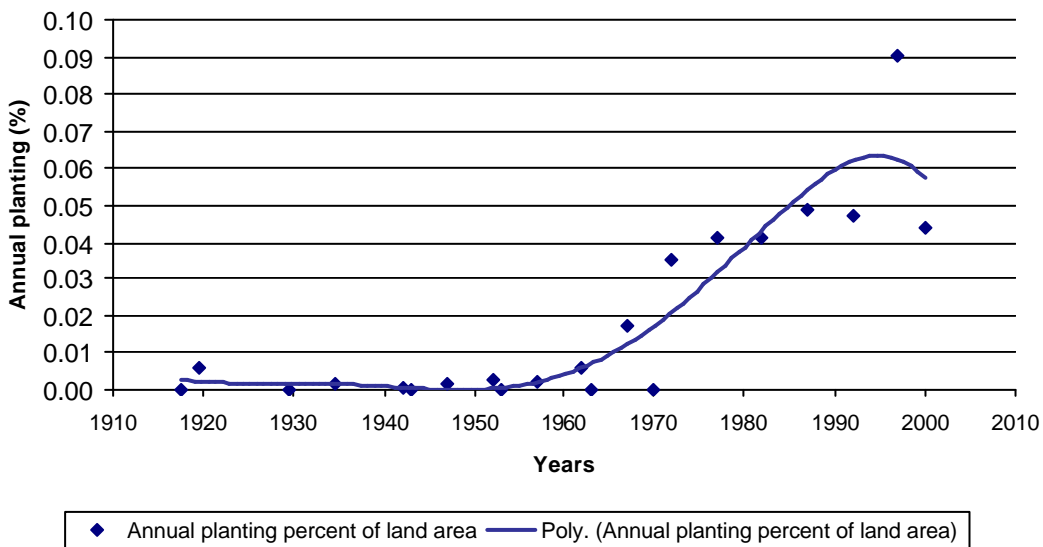


Figure 22

Trend in planting - Australia



Europe

Although represented by 6 countries in the T30C list the PFDB accessed data that was incomplete and unreliable for Europe (Figures 23 and 24). The main reason is due to definitions adopted by FAO for non industrialized countries and by ECE, responsible for collecting data for industrialized countries. The collaborative work undertaken between FAO, IPCC, IUFRO, CIFOR, UNEP and other experts in harmonization of forestry related definitions serves as an excellent avenue for harmonization of plantation definitions and will provide more useful information in the next FRA 2005 and beyond.

Figure 23

Trend in planting - Spain

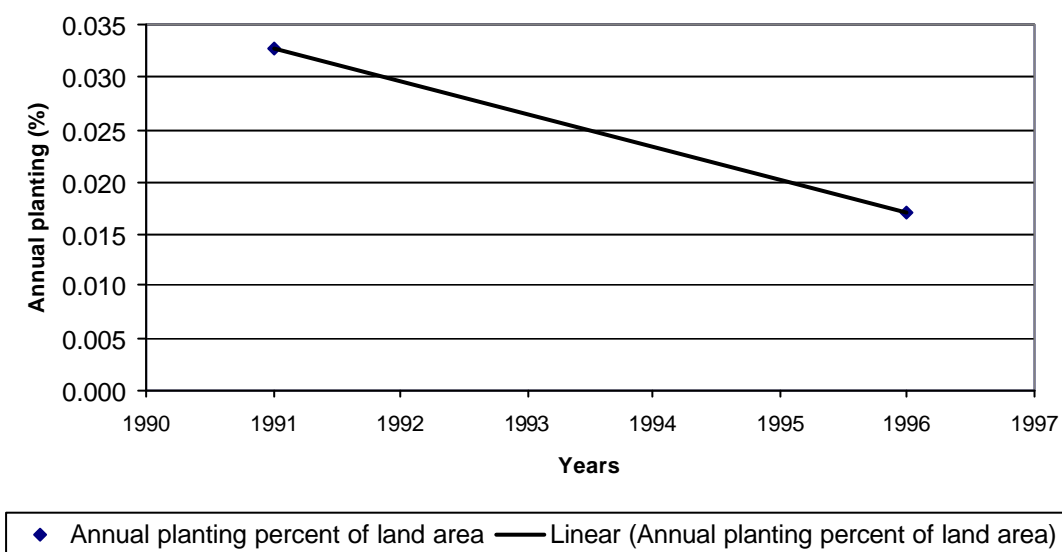
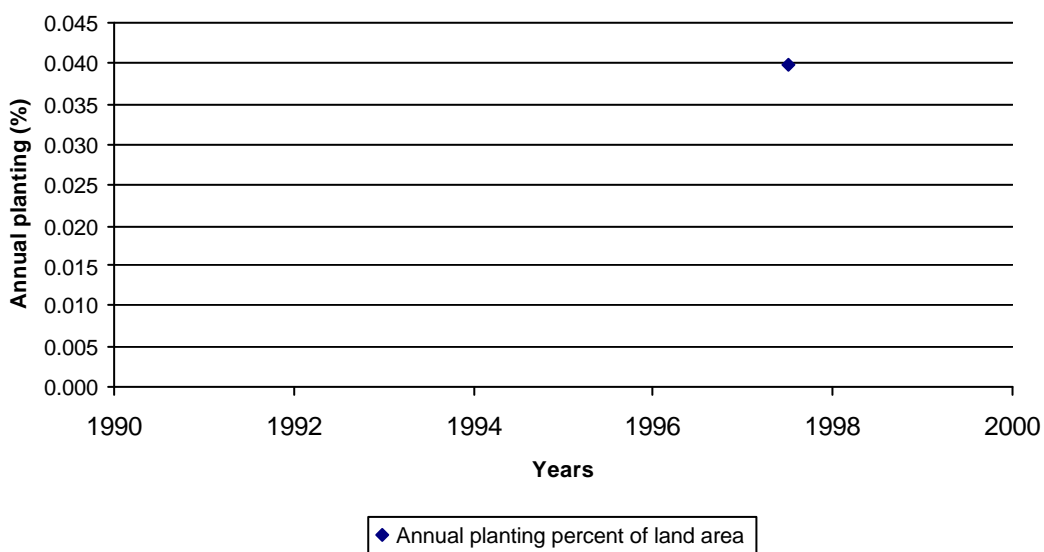


Figure 24

Trend in planting - Bulgaria



2.2 *Trends and dynamics in the sub-regions*

The following exercise is an attempt to provide trends from different sub-regions. Ideally it would have been more interesting to have trends for all the countries but the data contained in the PFDB are still too weak to produce reliable trends at country level.

Each region has been divided into sub-regions according the latest endorsed classification adopted by FAO in the State of World's Forest 1997 (SOFO97) (Table 3, Chapter 2, pag. 61). Country data on annual planting has been grouped by sub-regions and plotted in graphs. Data of each graph has been interpolated with regression a line that shows the trend on annual planting. A final graph for each region compiles all the regional trends and helps to understand how annual plantings vary.

Every regional trend line is associated with a bar chart that shows the proportion of FRA2000 plantation area between countries that do contribute to the annual planting figures and the other remaining countries. This very simple method has been used to asses the reliability of trends for all the sub-regions and therefore the regions.

The next paragraphs contain the description of sub-regional trends in the different regions and the bar graphs are given for every sub-region together with their sub-regional trends.

2.2.1 *Africa*

According to SOFO 97 and FRA 2000, the 56 countries of Africa have been grouped into 8 sub-regions: North Africa, East Sahelian Africa, West Sahelian Africa, Central Africa, West Moist Africa, Insular East Africa, Southern Africa Tropical and South Africa Non Tropical.

In the list of the Top 30 countries Africa is only represented by four of them: South Africa, Algeria, Nigeria and Sudan and, already explained, database reports on annual planting figures only for South Africa and Algeria.

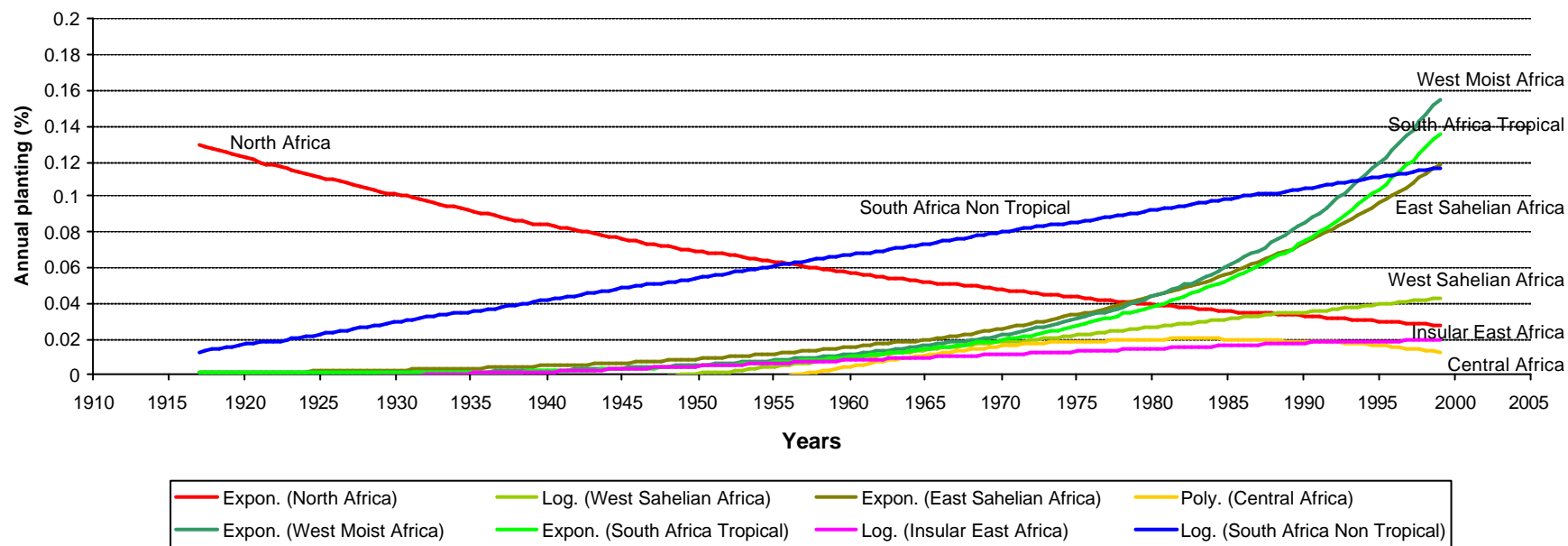
Trends in annual planting have been provided in the graph below and could be grouped in

- 'very positive trends' for South Africa Non Tropical, East Sahelian Africa, West Moist Africa and South Africa Tropical, with the trend line on annual planting ranging at the end of 90s at around 0.1%, or more, of the total land area;
- 'positive trends' in West Sahelian Africa, Insular East Africa and Central Africa where trend in annual planting varies between 0.02 and 0.04 % of the total land area;
- 'negative trends': North Africa.

As overall the African sub-regions show very low increasing in annual planting (Figure 25) and very few and poor data in terms of reliability. This is also confirmed by the square R provided for all the regressions that partially help to understand the trends (Table 2).

Figure 25

Trends in annual planting - AFRICA



The following paragraphs refer to the descriptions of all the regions.

Table 2: Annual planting trends in Africa: interpolation lines and related R^2

Sub-region	interpolation line	R^2
North Africa	Exponential	0.05
West Sahelian Africa	Logarithmic	0.02
East Sahelian Africa	Exponential	0.28
Central Africa	Polynomial	0.23
West Moist Africa	Exponential	0.45
South Africa Tropical	Exponential	0.35
Insular East Africa	Logarithmic	0.27
South Africa Non Tropical	Logarithmic	0.06

1. Sub-regions with very positive trends

South Africa Non tropical. Countries: South Africa, Swaziland, Lesotho.

Trend (Figure 27 b) can be considered reliable since it is based on two countries out of three and is representing 99% of the total planted area (Figure 27 a). Also, the linear trend has been calculated over 26 observations covering a period of almost 60 years.

Figure 27 a: Forest Plantation area (FRA 2000 source)

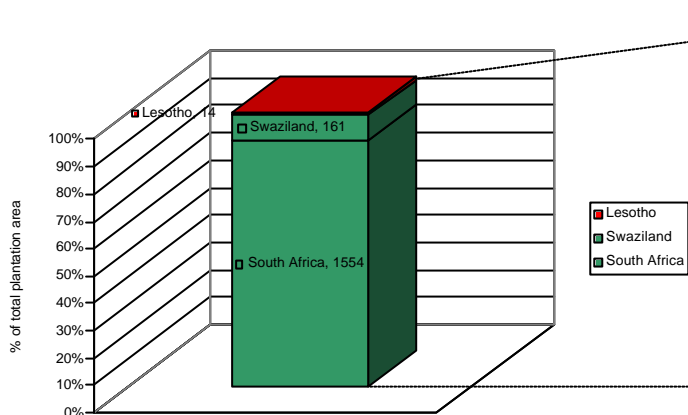
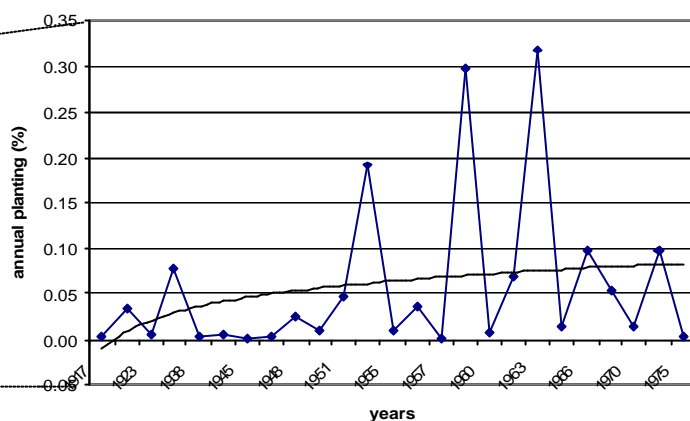


Figure 27 b: Annual planting (PFDB source)



East Sahelian Africa. Countries: Kenya, Eritrea, Somalia, Sudan, Ethiopia, Djibouti.

Trend (Figure 28 b) is not reliable since it reflects only Kenya and Somalia. The two countries account for 23% of the total regional plantation area (Figure 28 a).

In this region Sudan, the largest country of Africa, is also the last country of the T30C but unfortunately does not have data on annual planting. Although the trend has been assessed over a period of more than 60 years it is based upon nine observations mainly representing Kenya

Figure 28 a: Forest Plantation area (FRA 2000 source)

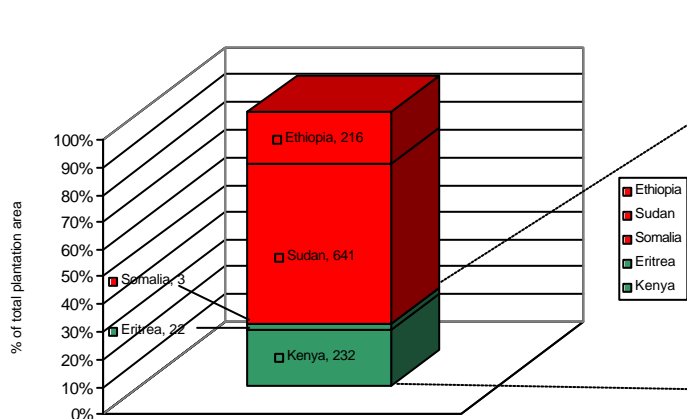
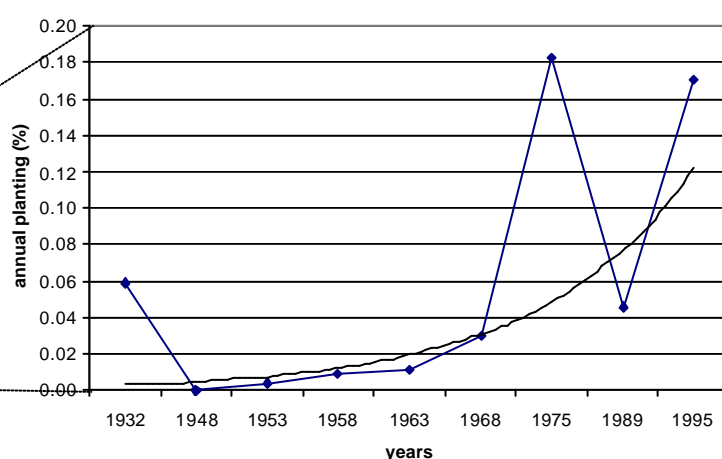


Figure 28 b: Annual planting (PFDB source)



West Moist Africa. Countries: Côte d'Ivoire, Benin, Togo, Sierra Leone, Nigeria, Liberia, Ghana, Guinea. The very positive trend (Figure 29 b) for this sub-region is not reliable since it represents only 27% of the total planted forests (Figure 29 a). Unfortunately Nigeria, that is

also part of the T30C, does not have figures on annual planting. The trend has been calculated over 26 observations and covers a period of more than 70 years.

Figure 29 a: Forest Plantation area (FRA 2000 source)

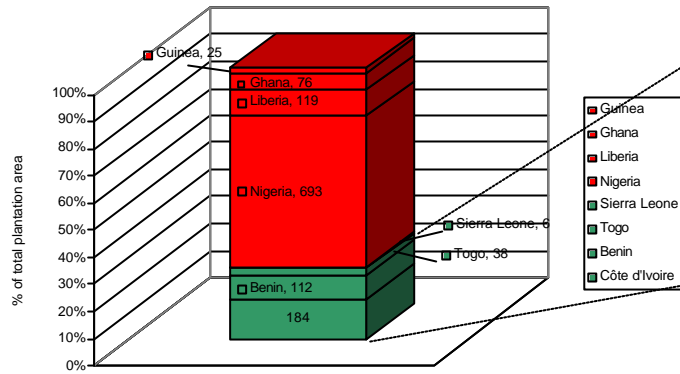
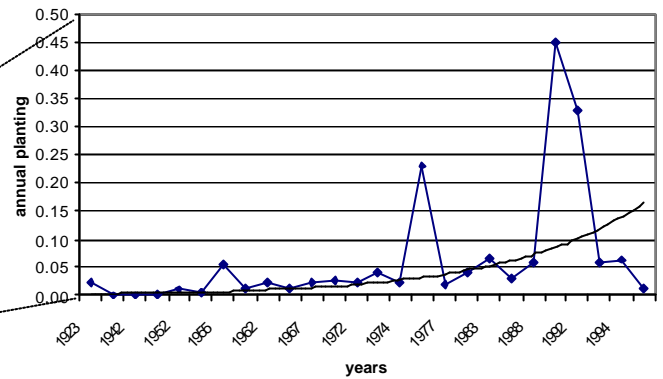


Figure 29 b: Annual planting (PFDB source)



South Africa Tropical. Countries: Angola, Zimbabwe, Tanzania, Malawi, Zambia, Mozambique, Saint Helena, Botswana, Namibia. Although only four of the nine countries report on annual planting, their area of planted forests accounts for 80% of the total (Figure 30 a) therefore the regional trend (Figure 30 b) can be considered reliable. Trends have been calculated over 24 observations and covers a period of more than 50 years.

Figure 30 a: Forest Plantation area (FRA 2000 source)

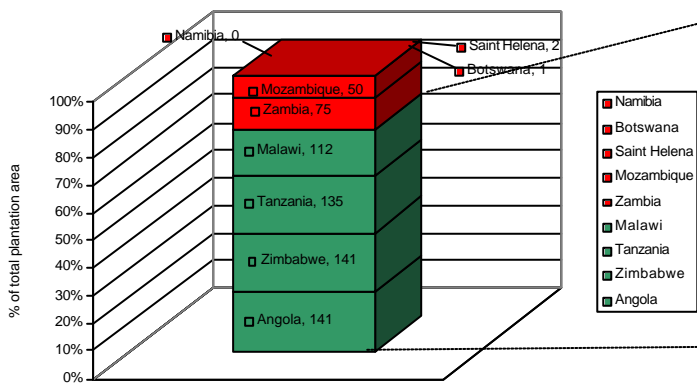
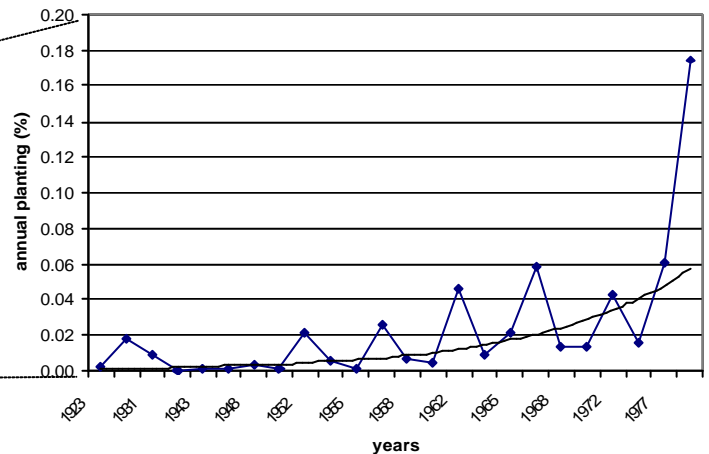


Figure 30 b: Annual planting (PFDB source)



2. Sub-regions with positive trends

West Sahelian Africa. Countries: Senegal, Niger, Burkina Faso, Mauritania, Mali, Chad, Gambia, Guinea-Bissau, Cape Verde.

The trend (Figure 31 a) represents six countries out of the total nine. These countries have a total area of planted forests that accounts for 84% of the total area in the sub-region (Figure 31 b) and the trend has been calculated over 28 observations that range from 1945 to 1999, over a period of more than 50 years, therefore it can be considered quite reliable and representative of the region.

Figure 31 a: Forest Plantation area (FRA 2000 source)

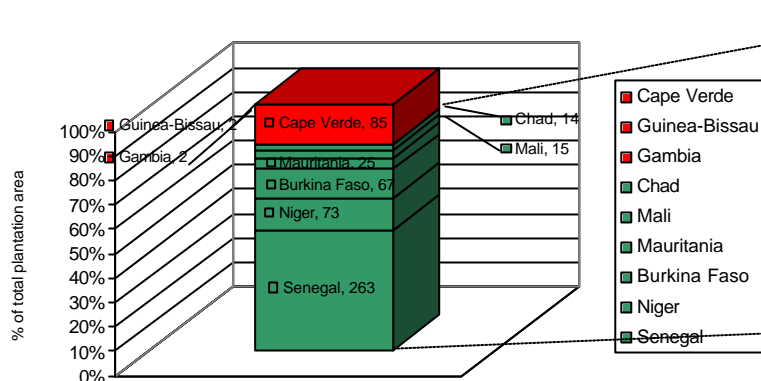
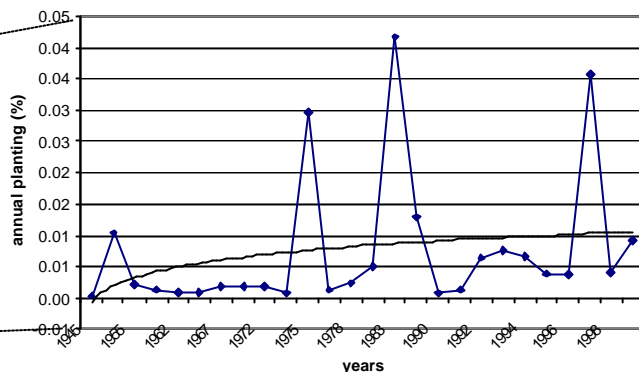


Figure 31 b: Annual planting (PFDB source)



Insular East Africa. Countries: Madagascar, Mauritius, Seychelles, Réunion, Comoros.

Only Madagascar reports on annual planting but the total planted forests area for this country accounts for 94% of the total regional area (Figure 32 a). The trend (Figure 32 b) might represent the sub-region even based on outdated figures which range from 1938 to 1970 and are based upon only 7 observations. Also, the trend line, even if fitting the data well is not considered the most representative since the last observation shows a strong decreasing in planting and there are no data available to assess the trend in the last 30 years.

Figure 32 a: Forest Plantation area (FRA 2000 source)

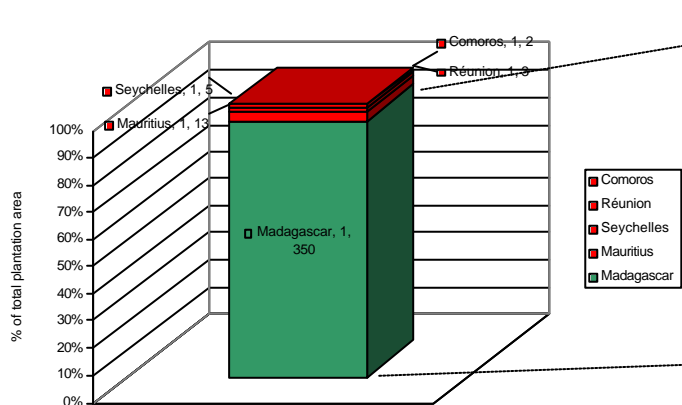
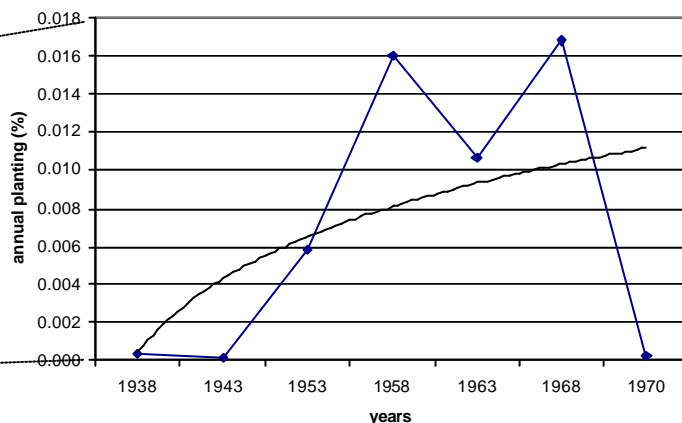


Figure 32 b: Annual planting (PFDB source)



Central Africa. Countries: Democratic Republic of Congo, Congo, Uganda, Gabon, Central Africa Republic, Rwanda, Cameroon, Burundi, Equatorial Guinea, Sao Tome and Principe.

Only three countries out of the total eight report on annual planting and their area of planted forests is 33% of the total area for Central Africa (Figure 33 a). Although the trend has been assessed over 13 observations (Figure 33 b) that cover a period of more than 40 years, from '50s up to end of '90s, it can not be considered representative of the entire sub-region.

Figure 33 a: Forest Plantation area (FRA 2000 source)

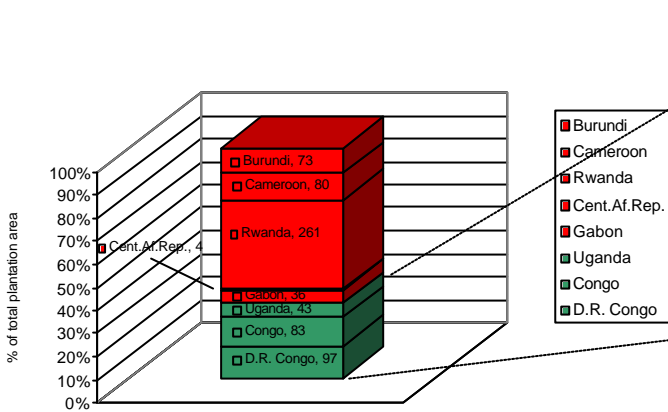
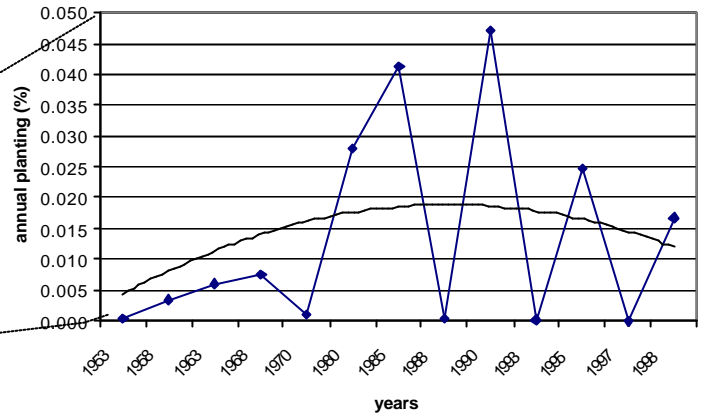


Figure 33 b: Annual planting (PFDB source)



3. Sub-regions with negative trends

North Africa. Countries: Algeria, Libya, Morocco, Tunisia, Western Sahara, Egypt.

Two of the three big countries of North Africa reports on annual planting and their area of planted forests accounts for 84% of the total regional area (Figure 34 a). The trend has been assessed over 15 observations that range from 1930 to 1999, over 70 years; therefore the trend can be considered reliable (Figure 34 b) and representative.

Figure 34 a: Forest Plantation area (FRA 2000 source)

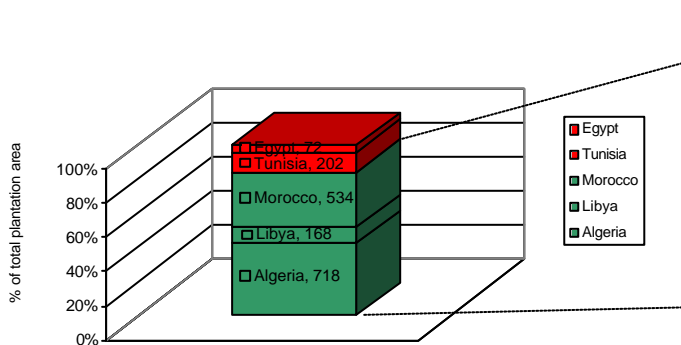
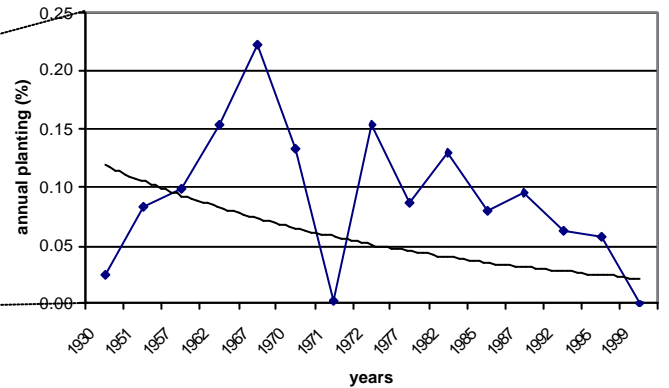


Figure 34 b: Annual planting (PFDB source)

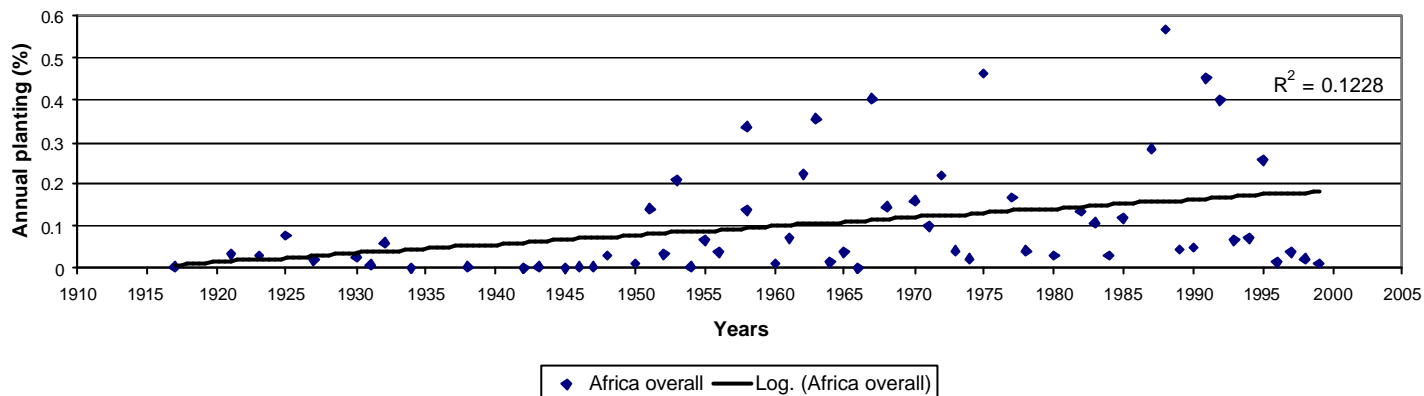


Remarks

The overall trend for Africa is slowly increasing (Figure 35). All the regions of Africa, except one, show positive, but small, trends on annual planting. However not all of them are based on reliable information.

Figure 35

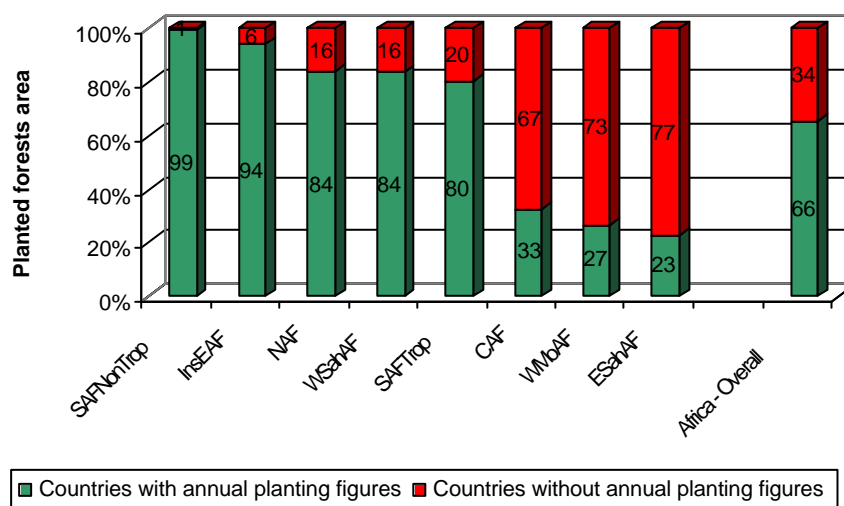
Annual planting: Africa



There are still regions like Central Africa, West Moist Africa and East Sahelian Africa where more reporting based upon inventory needs to be carried out and, among these regions, there are crucial countries for plantations including Sudan, Nigeria and Zambia.

Figure 36

Proportion of planted forests areas among countries providing annual planting figures and countries without figures - AFRICA



As overall, Africa has information on annual planting by countries with a total area on planted forests of 66% of the entire region (see above) so it is not possible to make any extrapolation of reliable trends in 34% of the region.

An in depth study for the Sudan, Nigeria and Zambia would be already sufficient to improve the quality of data for this region.

2.2.2 Asia

The 49 countries reported for Asia by FRA 2000 have been grouped in 5 sub-regions: South Asia, East Asia, Continental South East Asia, Insular South East Asia Middle East and Former USSR. This region only reflects a group of countries that, according SOFO97, were classified as belonging to the geographical area of Former USSR.

Asia is the most relevant region for forest plantations. In the T30C list 12 countries are Asians and data is available for almost all except Turkey and Pakistan.

Also, the scale of planting for this region is very large compared to other regions like Africa. Although trends (Figure 37) have been grouped in categories of ‘very positive’ and ‘positive’, there are no negative trends and the size of the planting ranges from 0.1, almost the maximum for Africa to 1.5 % of the total land area.

Trends for Asia have been grouped in:

- ‘very positive trends’ for South Asia with the trend line on annual planting ranging at the end of 90s between 0.6 and 1.5 % of the total land area;
- ‘positive trends’ in Insular East Asia, East Asia, Continental South East Asia and Middle East where the trend in annual planting varies between 0.1 and 0.4 % of the total land area;
- The only sub-region that does not have PFDB data on trends are the Asian countries of “Former USSR” but their total area on planted forests is relatively unimportant compared to the rest of the region.

Squared R coefficients in Asia are relatively higher than in Africa with the exception of East Asia (Table 3).

Figure 37

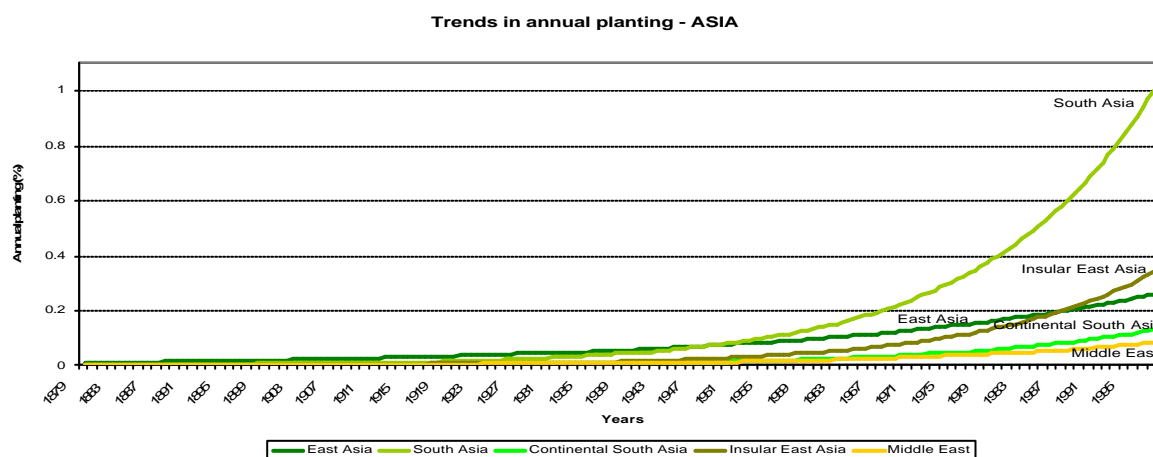


Table 3: Annual planting trends in Asia: interpolation lines and related R^2

Sub-region	interpolation line	R^2
South Asia	Exponential	0.58
Insular East Asia	Exponential	0.55
East Asia	Exponential	0.09
Continental South Asia	Exponential	0.17
Middle East	Exponential	0.39

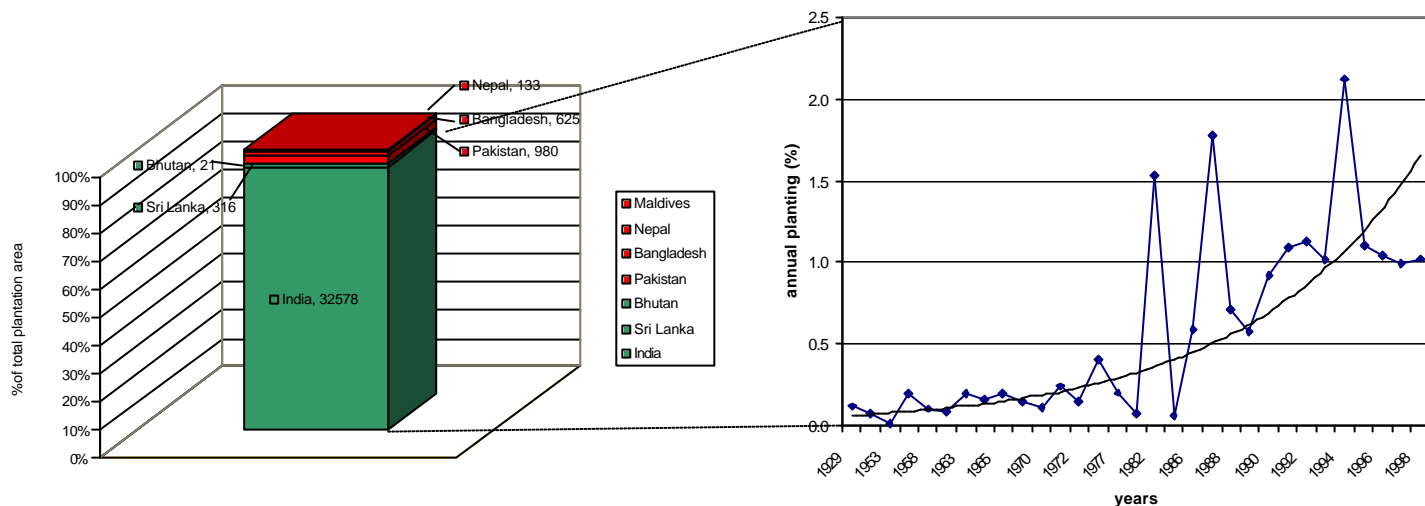
The paragraphs below refer to the descriptions of all the regions.

1. Sub-regions with very positive trends

South Asia. Countries: India, Sri Lanka, Bhutan, Pakistan, Bangladesh, Nepal, Maldives
 Although based upon three only countries, trend (Figure 38 b) is considered reliable because the FRA 2000 reported that planted forests area accounted for 95% of the total regional area (Figure 38 a). The exponential trend has been assessed over 31 observations that range over a period of almost 70 years.

Figure 38 a: Forest Plantation area (FRA 2000 source)

Figure 38 b: Annual planting (PFDB source)



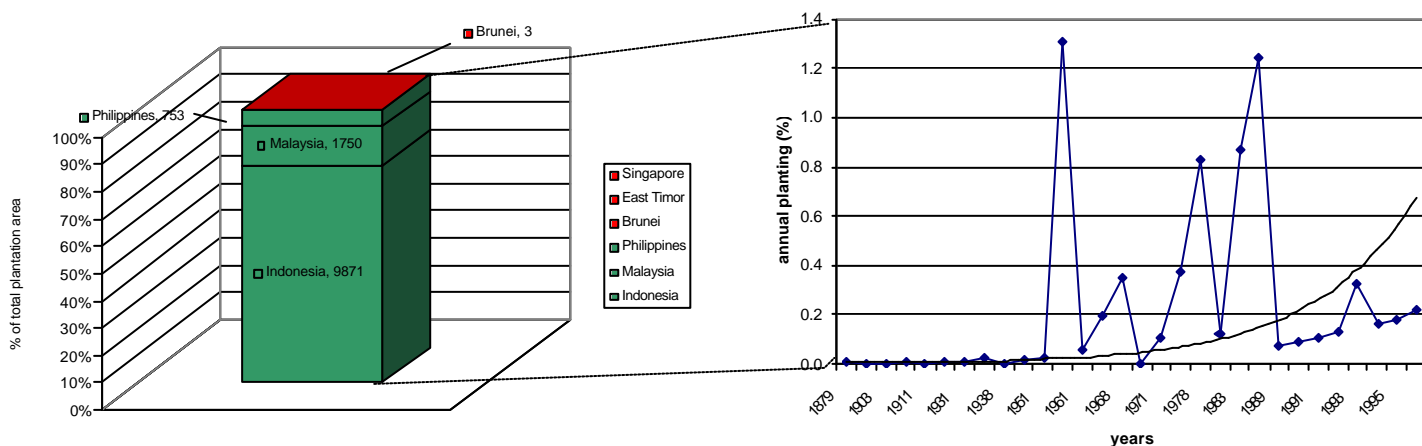
2. Sub-regions with positive trends

Insular East Asia. Countries: Indonesia, Malaysia, Philippines, Brunei, East Timor, Singapore.

Although reporting for three countries the trend (Figure 39 b) is very reliable since the planted forests area for these three countries accounts for 99.97 % of the total regional plantation area (Figure 39 a). The trend is based over 31 observations that range from 1879 to 1996.

Figure 39 a: Forest Plantation area (FRA 2000 source)

Figure 39 b: Annual planting (PFDB source)



East Asia. Countries: China, Japan, Mongolia, Republic of Korea, Democratic People's Republic of Korea.

The trend (figure 40 b) is reliable since it is based on four countries out of five. Here the bar chart is not so meaningful (Figure 40 a) because FRA 2000 reported forest plantations only for China and Japan and no area for Mongolia and Republic of Korea while the PFDB reports annual planting figures for all four countries. The very high peak shows that Republic of Korea planted more than 1.6 millions ha during the period from 1976 to 1985, average 1981 (Park, K.-S. 1996).

The trend has been calculated over 38 observations covering a period of almost 90 years.

Figure 40 a: Forest Plantation area (FRA 2000 source)

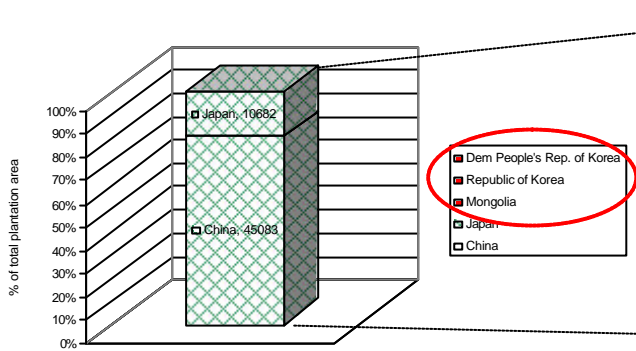
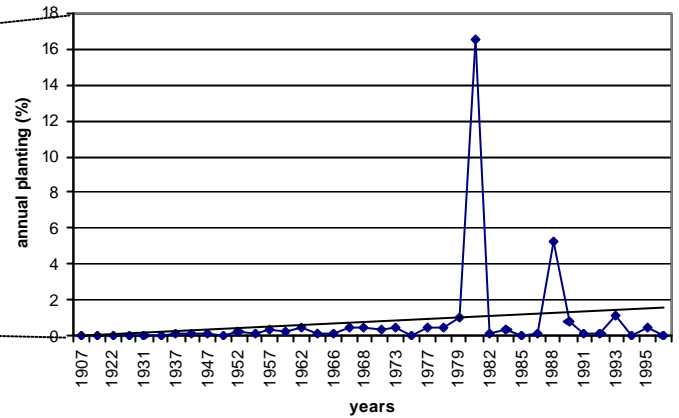


Figure 40 b: Annual planting (PFDB source)



Continental South East Asia. Countries: Thailand, Viet Nam, Myanmar, Laos, Cambodia

The trend (Figure 41 b) is very reliable since the countries reporting on annual planting have a total FRA 2000 forest plantation area accounting for 99% of the total regional area (figure 41 a) and the trend is based upon 26 observations covering a period of 80 years. The very high peak shows that Vietnam planted more than 1.8 millions ha during the period from 1986 to 1992, average 1989 (Lung, N.N. 1996).

Figure 41 a: Forest Plantation area (FRA 2000 source)

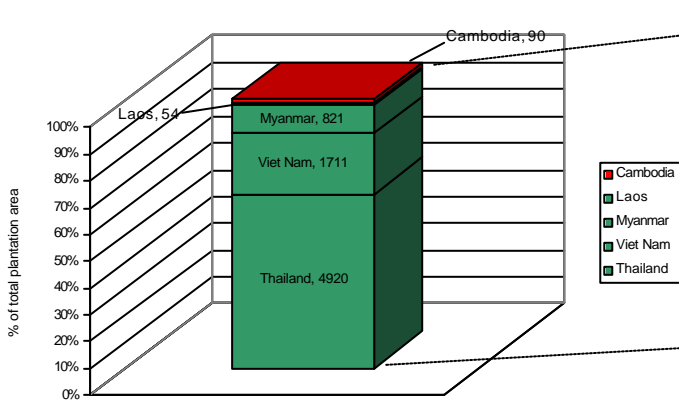
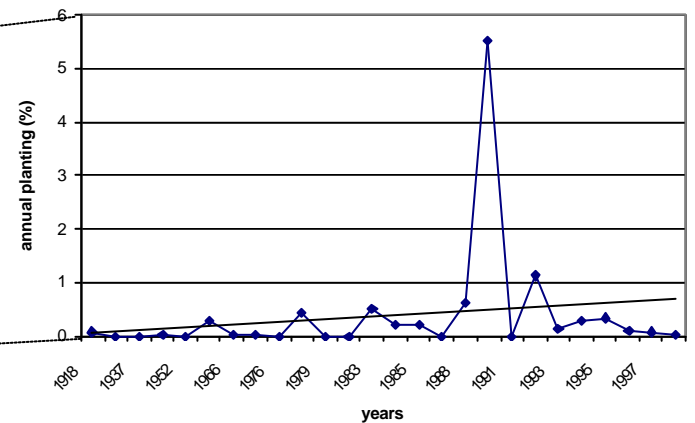


Figure 41 b: Annual planting (PFDB source)



Middle East. Countries: Iran, Syria, Turkey, UAE, Israel, Jordan, Iraq, Kuwait, Saudi Arabia, Lebanon, Oman, Qatar, Bahrain, Afghanistan, Cyprus, Gaza Strip, West Bank, Yemen.

The trend (Figure 42 b) is not very reliable because the planted forests area of the two countries with annual planting data accounted for 52% of the total sub-regional area (Figure 42 a). Turkey is part of this sub-region and is also included in the T30C list but unfortunately no data on annual planting was available.

The trend is based only on 8 observations that cover a relatively short period.

Figure 42 a: Forest Plantation area (FRA 2000 source)

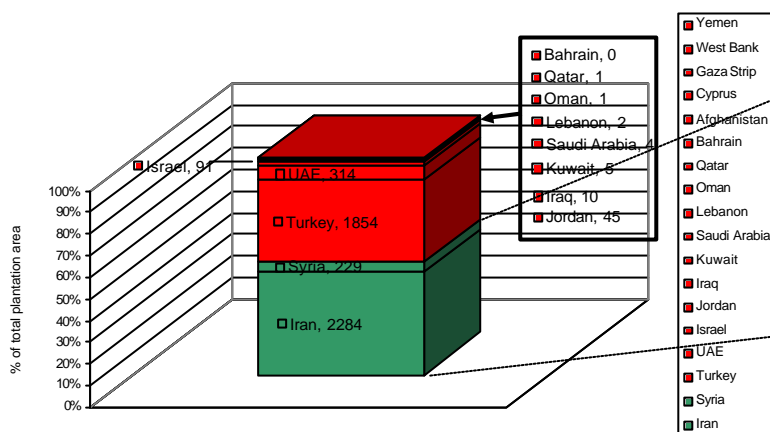
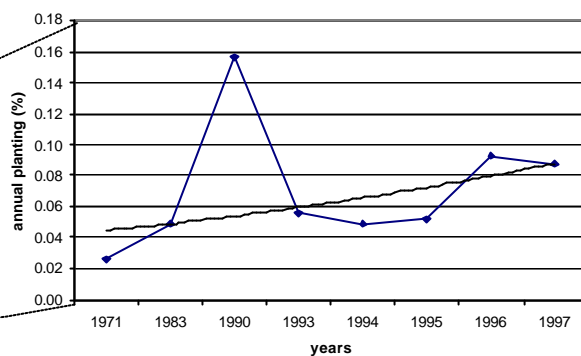


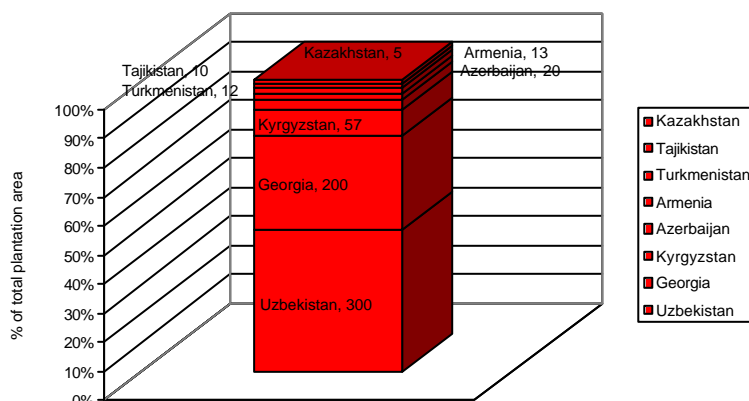
Figure 42 b: Annual planting (PFDB source)



Former USSR (Asian countries)

The PFDB does not provide data useful to build a trend on annual planting for any of the countries reported by FRA 2000 (Figure 43). This is mainly due to the new divisions in countries of the Former USSR, so limited data was available for USSR and not for the new countries.

Figure 43: Forest Plantation area (FRA 2000 source)



Annual planting (PFDB source)

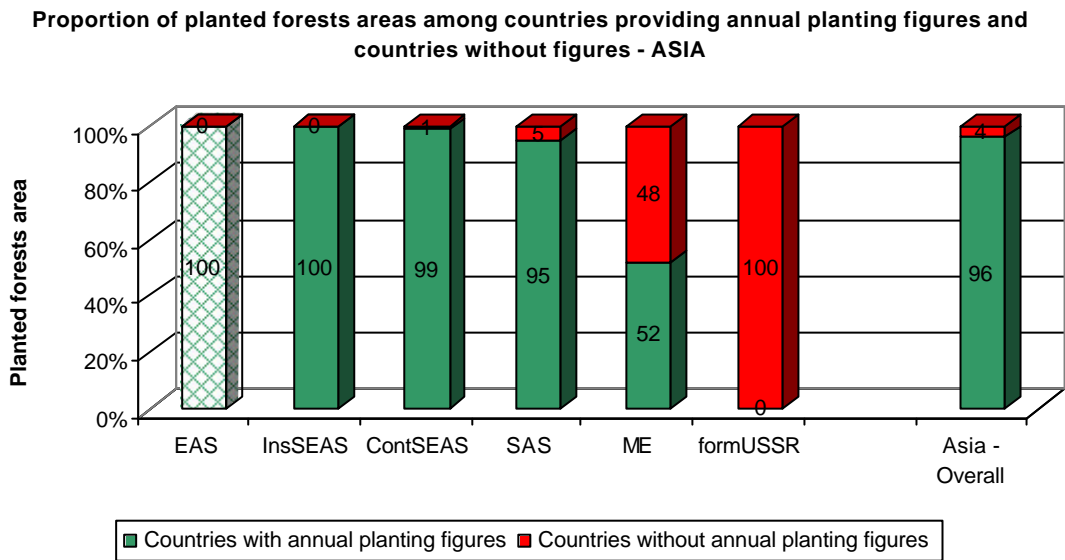
No trend available

Remarks

All Asia shows trends that range from high to very high except for the sub-region of the “former USSR countries” where no data on annual planting was available and compiled by the PFDB.

Almost all of the trends can be considered reliable because countries with reporting represent more than 96 % of the total country area (Figure 44) and the overall trend for Asia is very positive (Figure 45). The lighter colour of the bar related to East Asia (Figure 44) indicates that for some countries, reported by the PFDB (Mongolia and Republic of Korea), FRA 2000 could not provide forest plantations area. The Middle East has the lowest reliability trend mainly due to the gap of information on annual planting for Turkey.

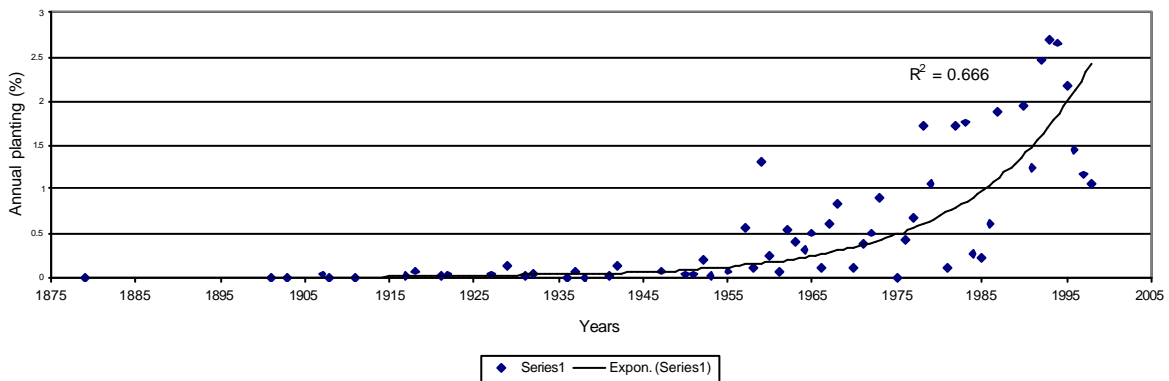
Figure 44



Although a large number of countries do not report on annual planting, their area is very low and accounts only for 4% of total Asia.

Figure 45

Annual planting: Asia



2.2.3 North and Central America

FRA 2000 reported 34 countries for North and Central America that according to SOFO97 have been grouped in three main sub-regions: Temperate North & Central America, Central America & Mexico and Caribbean. In terms of areas, the most important sub-region is Temperate North and Central America, since it is composed by two of the biggest countries in the world: United States and Canada. Central America and Mexico is composed of 8 relatively small countries and the Caribbean is comprised of 26 very small countries that do not account for large areas of planted forests. Even if not so important in terms of size, this third sub-region provides very reliable data according to figures compiled in the PFDB. In contrast Canada does not have forest plantations according to FRA 2000 definitions but the PFDB compiled data on annual planting for this country.

Although the scale of planting varies between 0.1 and 0.4% of total land area, only the United States of America rank in the Top 30 countries.

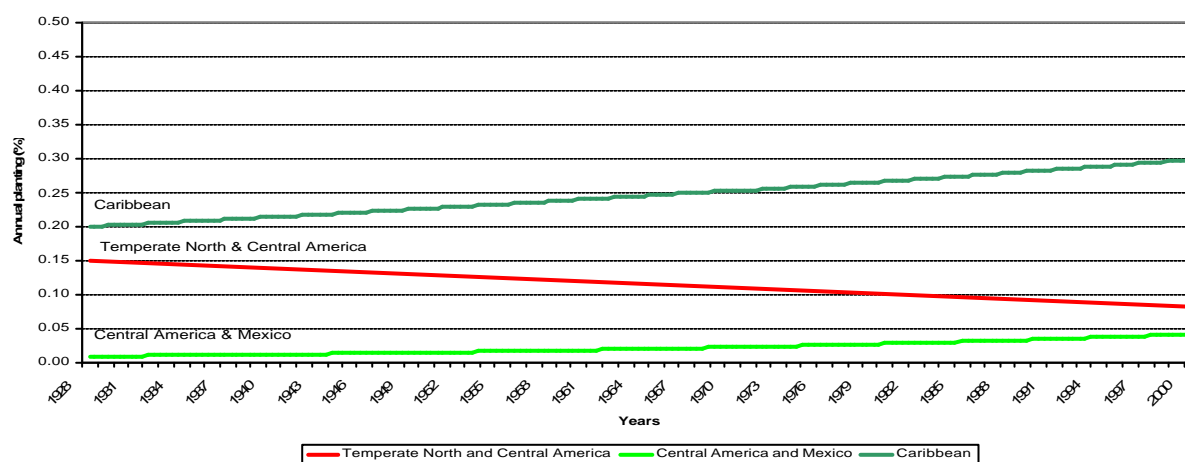
Trends (Figure 46) for North and Central America have been grouped in:

- “positive trends” for Caribbean and Central America and Mexico with the trend line on annual planting ranging at the year 2000 between 0.04 and 0.3 % of the total land area;
- “negative trends” for Temperate North and Central America.

The paragraphs below refer to the descriptions of all the regions.

Figure 46

Trends in annual planting - NORTH & CENTRAL AMERICA



The regression analysis for this region provided the lowest squared R coefficients (Table 4).

Table 4: Annual planting trends in North and Central America: interpolation lines and related R^2

Sub-region	interpolation line	R^2
Caribbean	Exponential	0.01
Central America & Mexico	Exponential	0.03
Temperate North & Central America	Linear	0.03

1. Sub-regions with positive trends

Caribbean. Countries: Cuba, Haiti Trinidad & Tobago, Jamaica, Guadeloupe, Grenada, Montserrat, Dominican R., Puerto Rico, Martinique, Saint Lucia, S. Vincent & Grenadine, Dominica, Barbados, Antigua and Barbuda, Bahamas, Bermuda, Br. Virgin Islands, Cayman Islands, Netherlands Antilles, Saint Kitts and Nevis, S Pierre & Miquelon, US Virgin Islands.

Although 8 countries do not have data (compiled and reported both in FRA 2000 and PFDB, see countries framed in the red square in the bar chart below), their area is so small that do not account very much in the overall statistics. The trend (Figure 47 b) can be considered reliable because represents 94% of the total planted area in the sub-region reported by FRA 2000 (Figure 47 a) and covers a period of 70 years in 27 observations.

Figure 47 a: Forest Plantation area (FRA 2000 source)

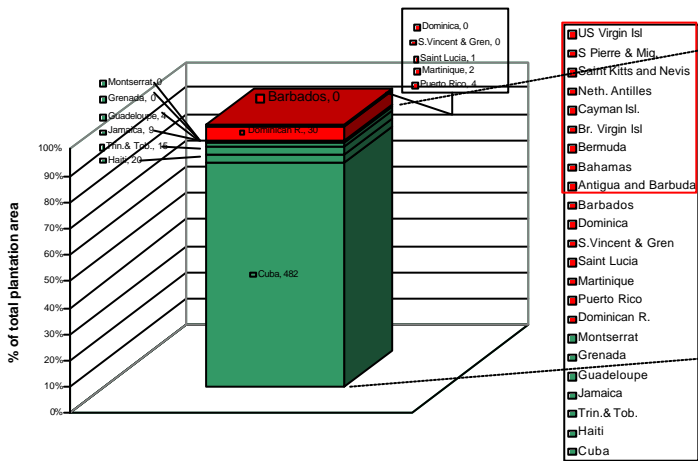
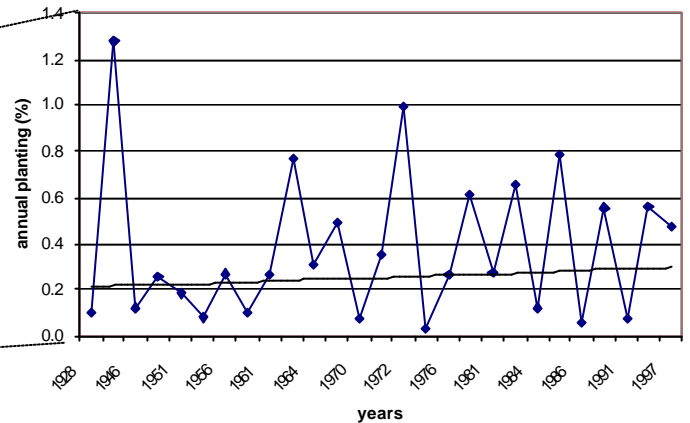


Figure 47 b: Annual planting (PFDB source)

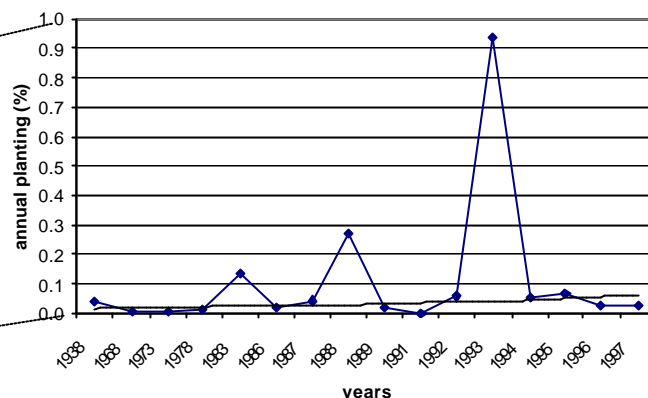
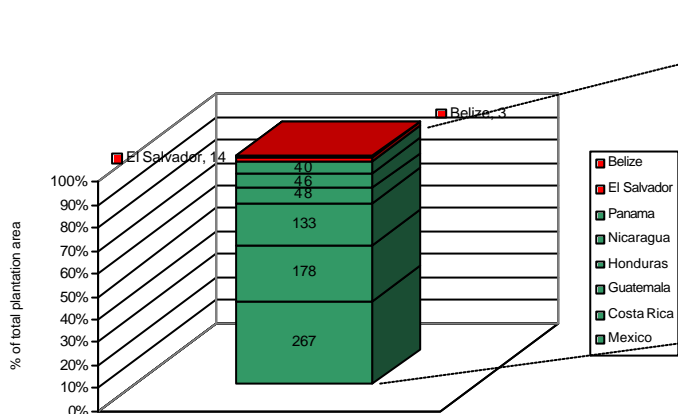


Central America and Mexico. Countries: Mexico, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, Belize.

The trend (Figure 48 b) is very reliable since it accounts for 98% of the total planted forests area in the sub-region (Figure 48 a) and refers to almost all countries except Belize and El Salvador that have very small forest plantation areas. It is based on 16 observations that cover a period of almost 60 years.

Figure 48 a: Forest Plantation area (FRA 2000 source)

Figure 48 b: Annual planting (PFDB source)



2. Sub-regions with negative trends

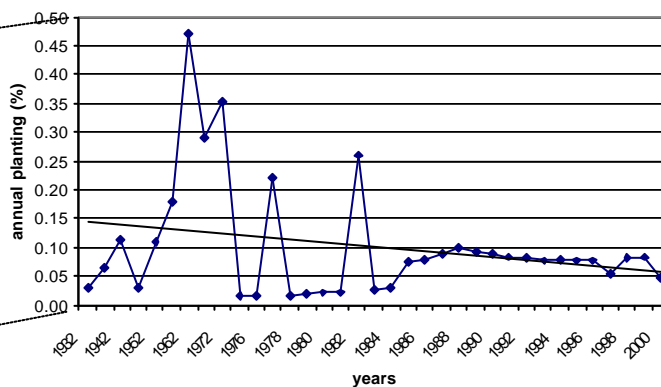
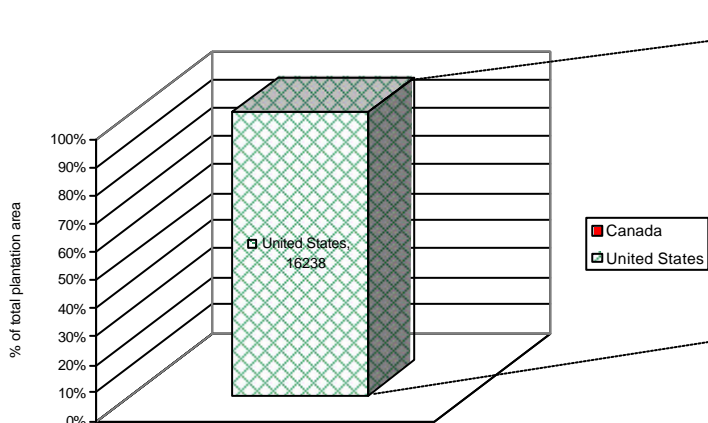
Temperate North and Central America. Countries: United States and Canada.

The trend is negative (Figure 49 b) and quite reliable because it is based on the PFDB data from Canada and USA, covering a period of 70 years.

Unfortunately it is difficult to assess how relevant these results are for Canada since their reporting to FRA 2000 did not include forest plantations.

Figure 49 a: Forest Plantation area (FRA 2000 source)

Figure 49 b: Annual planting (PFDB source)

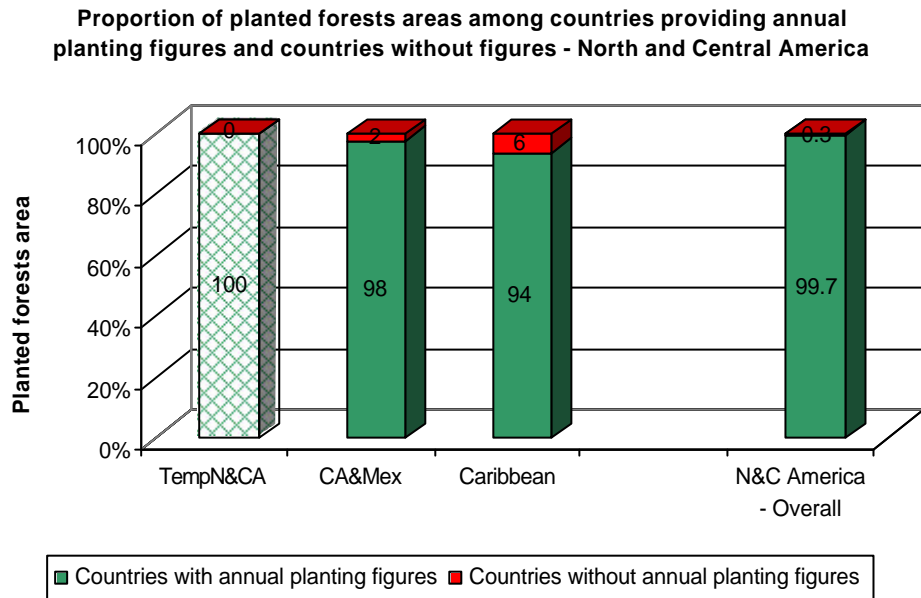


Remarks

Although the lack of forest plantation data for Canada, data represented 99.7% of the total planted forests area in the sub-regions (Figure 50). The southern regions show positive trends while the northern, but biggest, region show a negative trend reflected mainly by the United States of America.

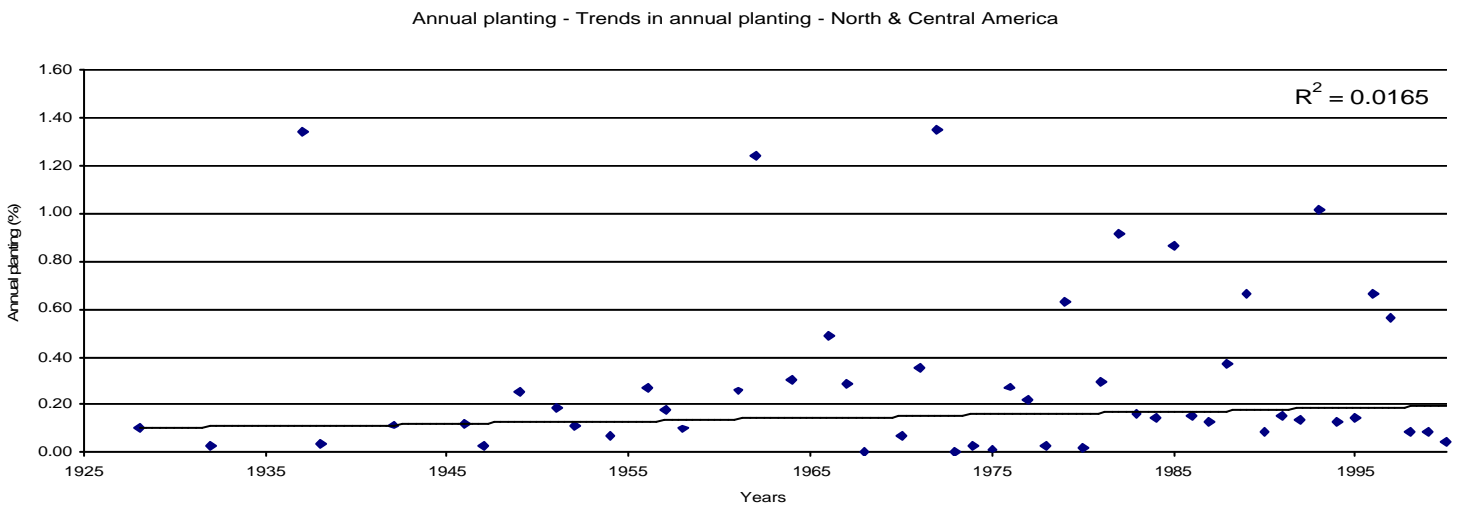
The lighter colour of the bar related to Temperate North and Central America (Figure 50) indicates that for Canada, reported by the PFDB, FRA 2000 could not provide forest plantations area.

Figure 50



The overall trend for North and Central America shows a minor increasing in planted forests area (Figure 51), as a balanced result of the negative trend of the northern regions with the positive trends of Caribbean.

Figure 51



2.2.4 South America

FRA 2000 reported 14 countries for South America that according to SOFO97 have been grouped in two main sub-regions: Tropical South America and Temperate South America. Brazil, one of the most important countries in terms of forests, is part of Tropical South America, ranks the 7th position in the “Top 30 countries” and, together with Chile, Argentina and Venezuela, that are also part of the Top 30 countries, account for almost 5% of the total plantation area.

The two regions show different trends (Figure 52):

- very positive trend of Temperate South America
- negative trend for Tropical South America

The scale of planting varies between 0.02 and 0.3% of total land area, relatively low if compared to other regions.

The regression analysis for this region provided very low squared R coefficients (Table 5) that give an idea of the relatively low quality of the data analysed or stable conditions in planting rates.

Figure 52

Trends in annual planting - SOUTH AMERICA

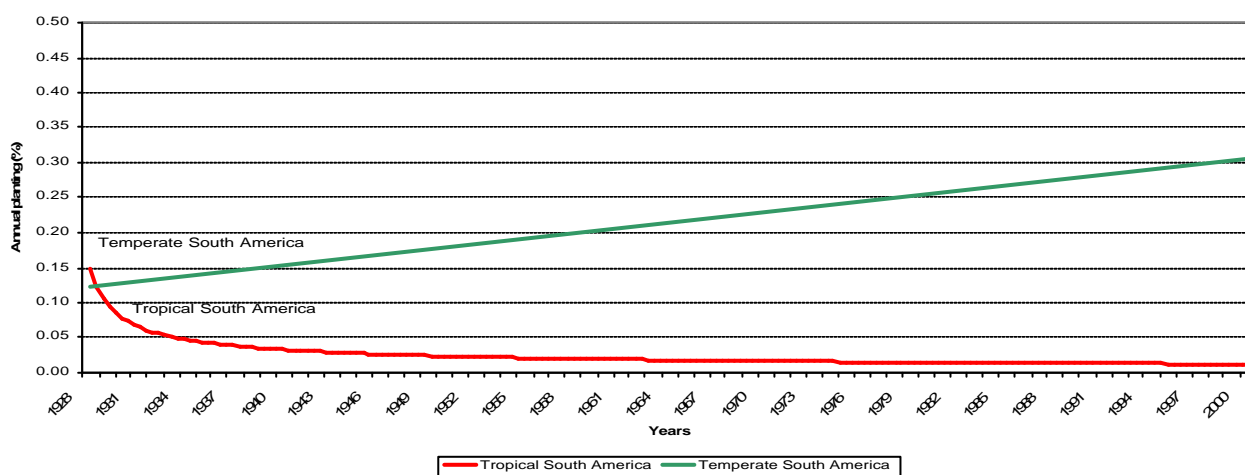


Table 5: Annual planting trends in South America: interpolation lines and related R^2

Sub-region	interpolation line	R^2
Temperate South America	Linear	0.01
Tropical South America	Power	0.02

The paragraphs below refer to the descriptions of the sub-regions.

1. Sub-regions with positive trends

Temperate South America. Countries: Chile, Argentina, Uruguay, Falkland Islands

Only the Falkland Islands are not part of the exercise but their area is so small that this does not affect the results for the sub-region. The trend (Figure 53 b) is positive and is important since Chile and Argentina are part of the Top 30 countries. Trend is very reliable because it represents 100% of the plantation area (figure 53 a) and is based over 20 observations covering almost 60 years.

Figure 53 a: Forest Plantation area (FRA 2000 source)

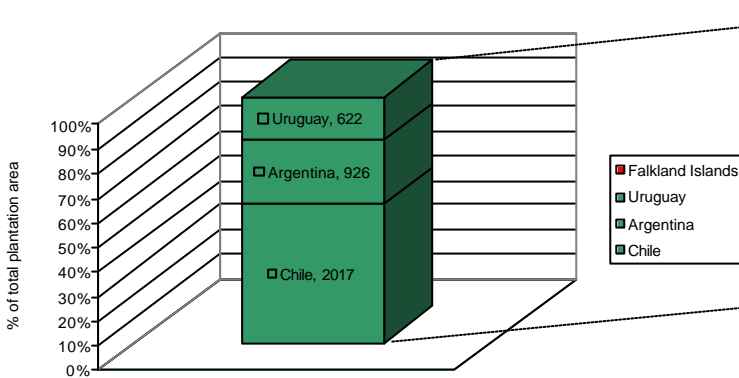
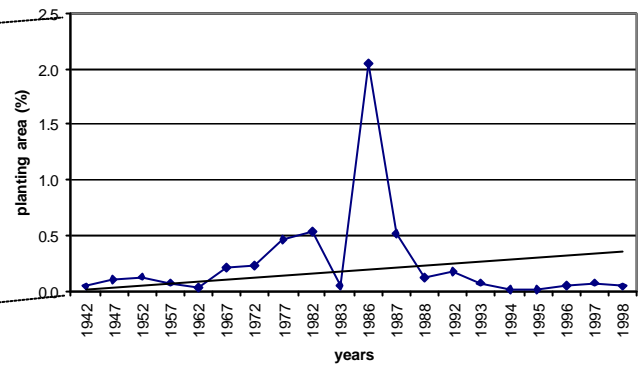


Figure 53 b: Annual planting (PFDB source)



2. Sub-regions with negative trends

Tropical South America. Countries: Brazil, Venezuela, Peru, Ecuador, Colombia, Paraguay, Suriname, Guyana, French Guiana, Bolivia

The trend (Figure 54 b) can be considered very reliable since it represents 99% of the total planted area in the region (Figure 54 a) and is based over 25 observations that cover a period of more than 60 years.

Figure 54 a: Forest Plantation area (FRA 2000 source)

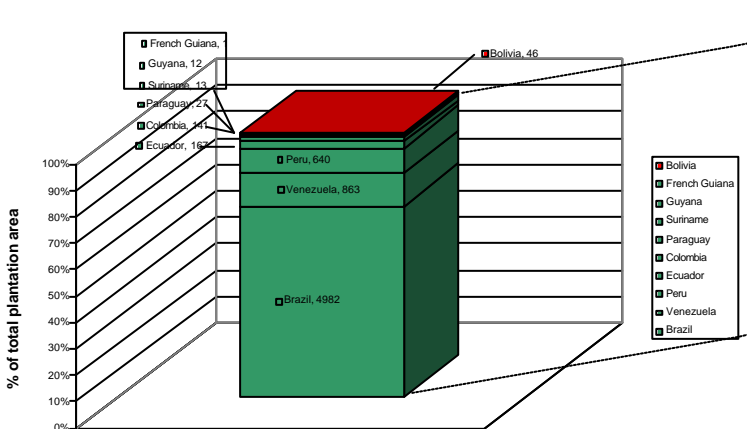
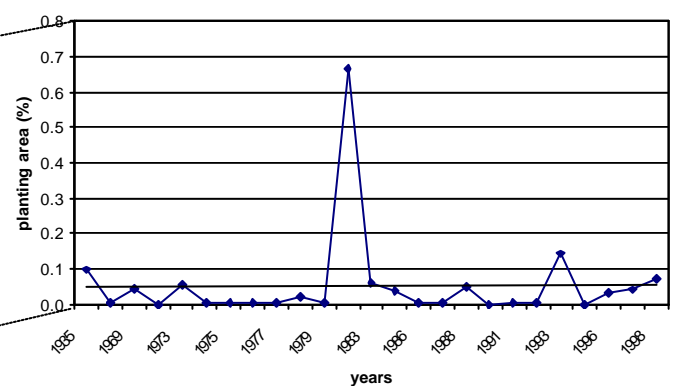


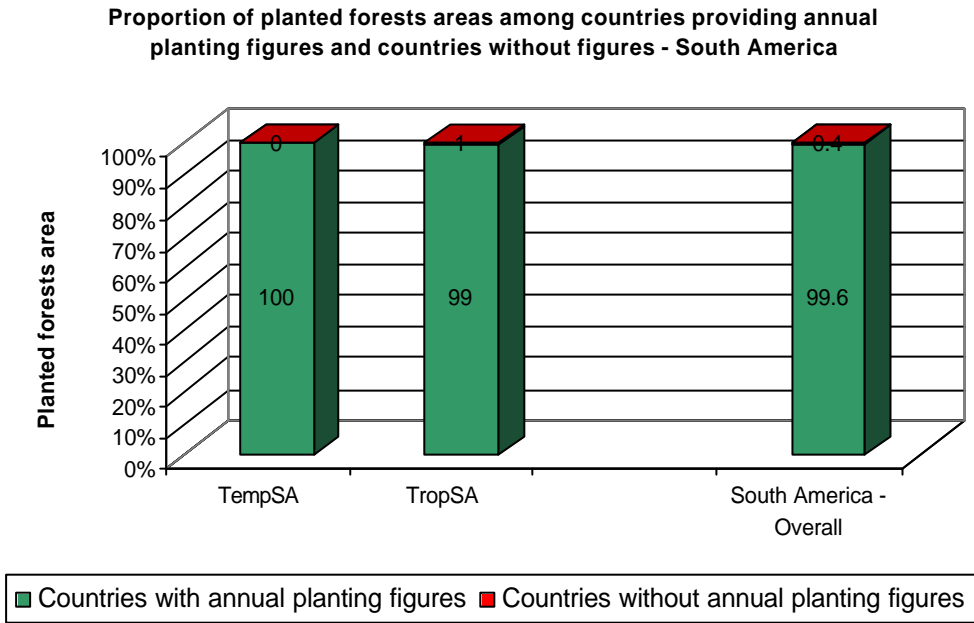
Figure 54 b: Annual planting (PFDB source)



Remarks

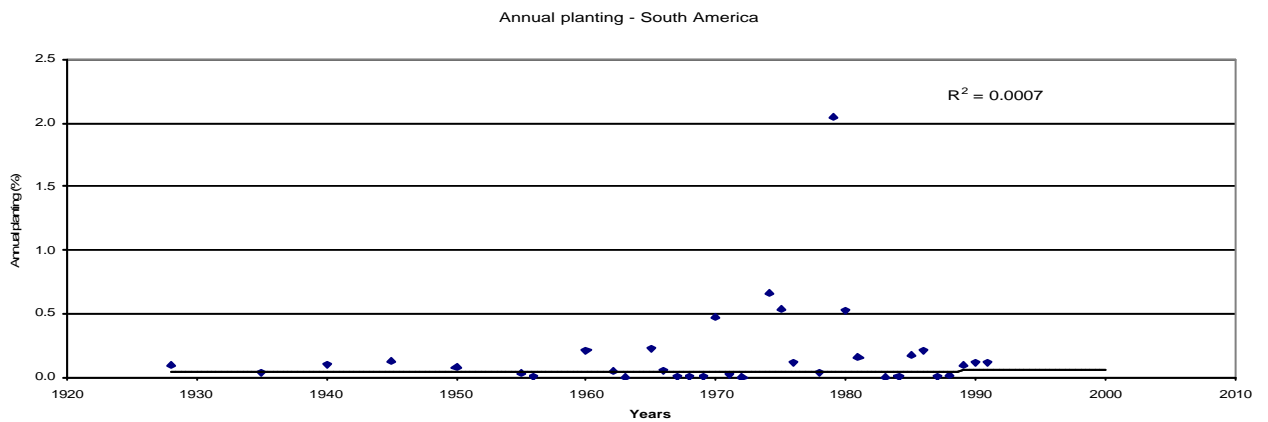
The South America region can be considered reliable in terms of information provided because the data represents almost the total of planted forests in the region (Figure 55). The trend in plantation for Tropical South America must be taken in consideration since it involves two important countries on planted forests with very weak data: Brazil and Venezuela.

Figure 55



The overall trend for South America is almost flat because it combines the positive trend of Temperate South America with the negative trend of Tropical South America.

Figure 56



2.2.5 Oceania

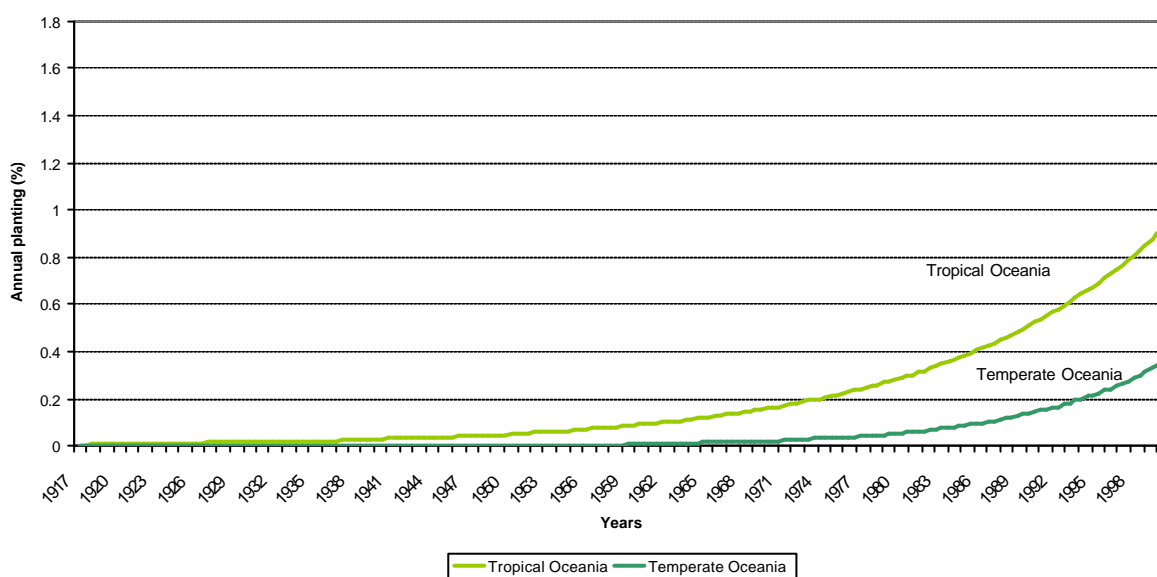
The 20 countries reported by FRA 2000 for this region has been grouped according to SOFO97 in two regions: Tropical Oceania and Temperate Oceania. Among the two sub-regions the most important for forest plantations is Temperate Oceania where both the two representative countries are listed in the T30C.

Both sub-regions show positive trends (Figure 57) with a scale of planting that varies between 0.4 and 0.9% of total land area at the end of years '90s

The paragraphs below refers to the descriptions of all the sub-regions.

Figure 57

Trends in annual planting - OCEANIA



The regression analysis for this region provided relatively high squared R coefficients (Table 6) that contribute proving the high quality of the data analysed.

Table 6: Annual planting trends in Oceania: interpolation lines and related R^2

Sub-region	interpolation line	R^2
Tropical Oceania	Exponential	0.62
Temperate Oceania	Exponential	0.50

Sub-regions with positive trends:

Tropical Oceania. Countries: Fiji, Solomon Islands, Samoa, Guam, Niue, Palau, Micronesia, American Samoa, Papua New Guinea, New Caledonia, French Polynesia, Vanuatu, Cook Islands, Tonga, Kiribati, Marshall Islands, Nauru, Northern Mariana Islands.

Although accounting for different countries, this sub-region is comprised of small groups of islands with small land areas. Tropical Oceania has a positive trend on annual planting (Figure 58 b) but can not be considered very reliable since it only reflects few countries that account for 58% of the regional area (Figure 58 a). One of the biggest countries for which the PFDB

does not have figures is Papua New Guinea whose area on planted forests accounts for 34% of the total area in the region. Also the number of observations is not very high, only 17, a bit low if compared with the number of countries.

Figure 58 a: Forest Plantation area (FRA 2000 source)

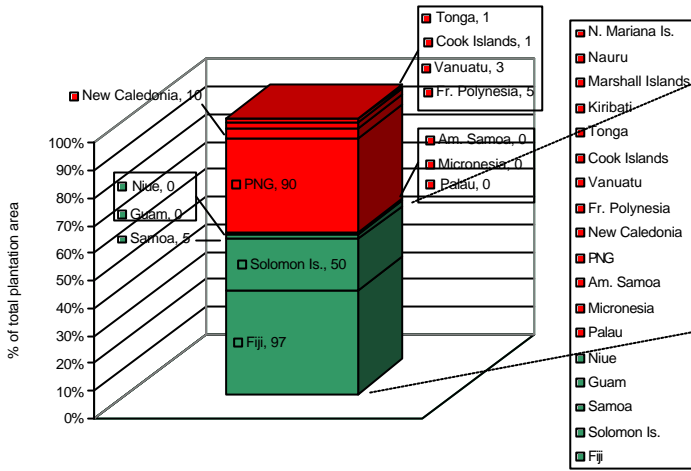
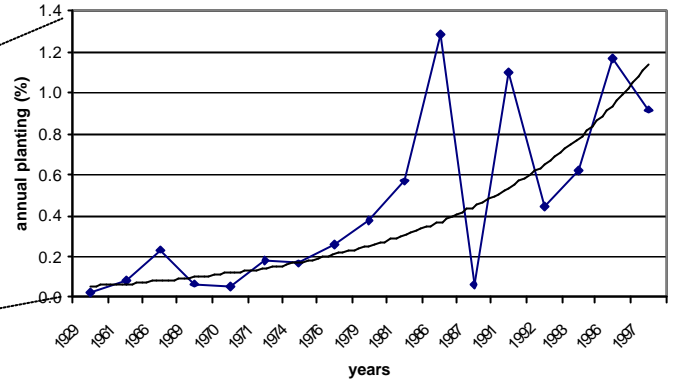


Figure 58 b: Annual planting (PFDB source)



Temperate Oceania. Countries: Australia, New Zealand

As already announced this region is very important both in terms of size and for planted forests. The trend is positive (Figure 59 b) and reliable since represents 100% of the region (Figure 59 a) and is based over 31 observations distributed in a period of more than 80 years.

Figure 59 a: Forest Plantation area (FRA 2000 source)

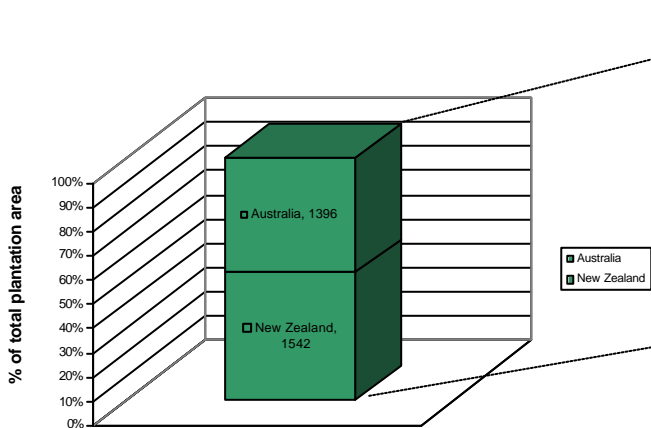
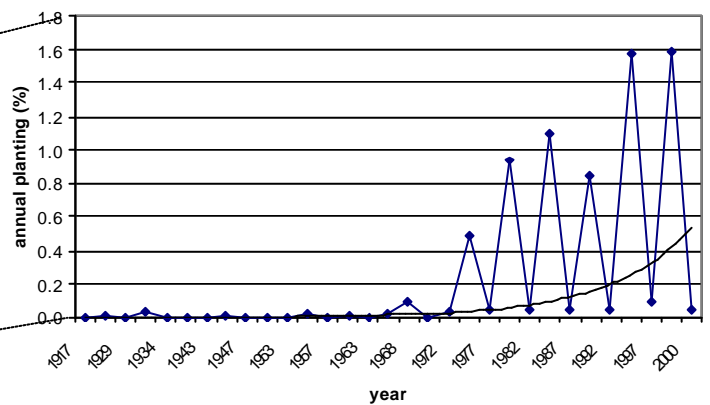


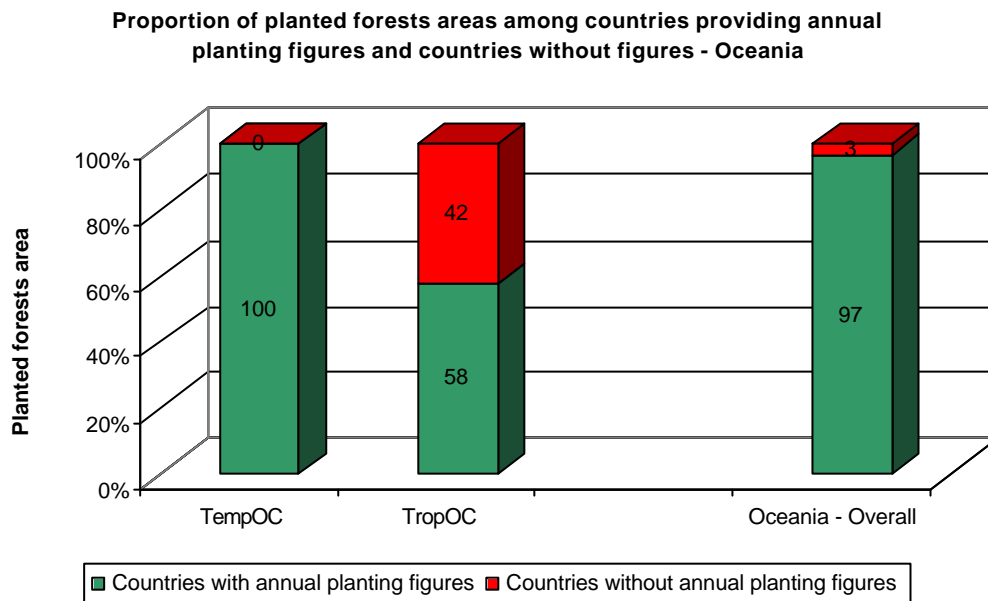
Figure 59 b: Annual planting (PFDB source)



Remarks

The positive trends found for Oceania can be considered quite representative of the region (Figure 60) although a lot of small countries of Tropical Oceania do not have annual planting data. Reliability of data could be increased a lot more by retrieving annual planting data for Papua New Guinea which has a significant forest plantation resource.

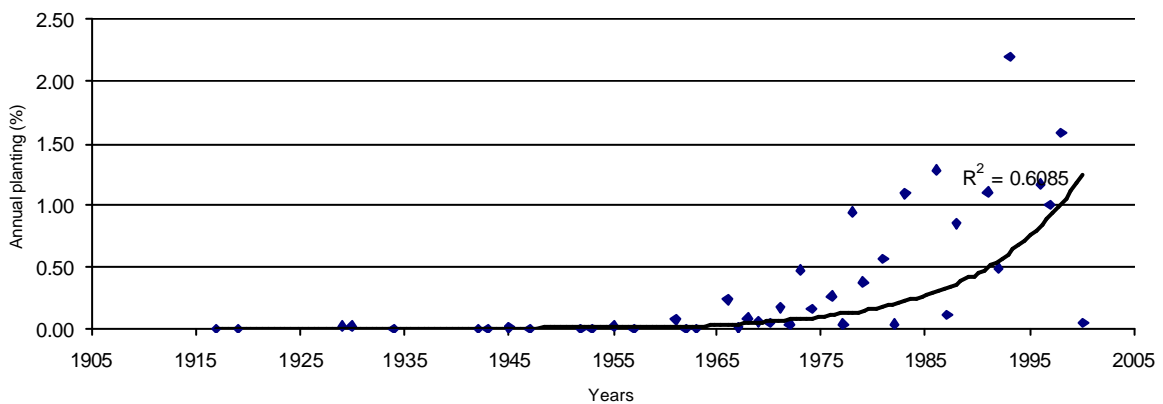
Figure 60



The overall trend for Oceania is very positive (Figure 61)

Figure 61

Annual planting - Oceania



2.2.6 Europe

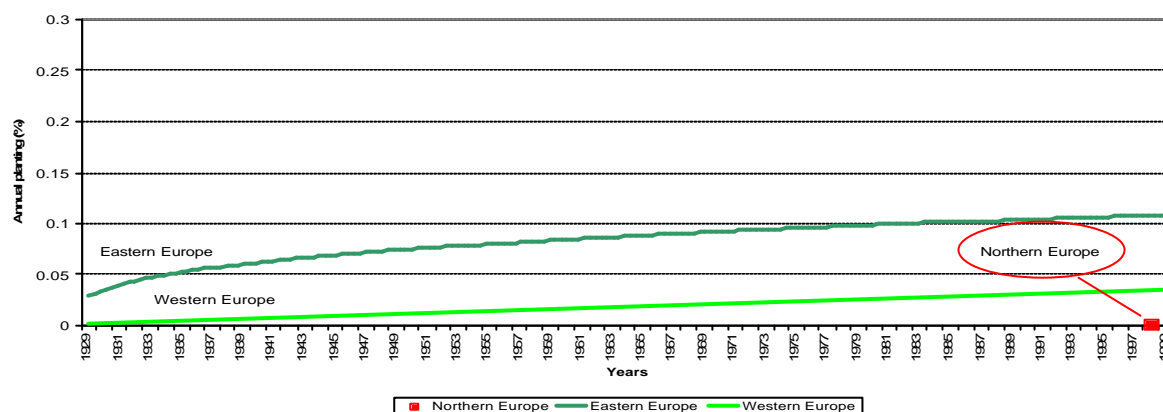
According to FRA 2000 and SOFO97, Europe is comprised of 40 countries divided in four sub-regions: Northern Europe, Eastern Europe, Western Europe and part of Former USSR. This region is very important for planted forests where 6 countries rank in the T30C. Unfortunately information found for European countries was very scarce and only for very few of them it was possible to compile annual planting data in the PFDB. The derived trends can not be considered very reliable or representative of their regions.

The exercise below show results only for two sub-regions: Eastern Europe and Western Europe while the PFDB had only one observation for Northern Europe, not enough to derive a trend.

Both the derived trends for Eastern and Western Europe (Figure 62) are positive but the area involved on planting is not high, ranging between 0.04 and 0.11 of the total land area at year 2000.

Figure 62

Trends in annual planting - EUROPE



The regression analysis for this region provided low squared R coefficients (Table 7) that give an idea of the relatively low quality of the data analysed.

Table 7: Annual planting trends in Europe: interpolation lines and related R^2

Sub-region	interpolation line	R^2
Eastern Europe	Exponential	0.30
Western Europe	Power	0.01
Northern Europe	-----	----

The paragraphs below refer to the descriptions of the two sub-regions.

1. Sub-regions with positive trends

Eastern Europe. Countries: Bulgaria, Hungary, Croatia, Yugoslavia, Albania, Romania, Bosnia Herzegovina, Poland, FYR Macedonia, Slovakia, Slovenia, Czech Republic.

Figure 63 a: Forest Plantation area (FRA 2000 source)

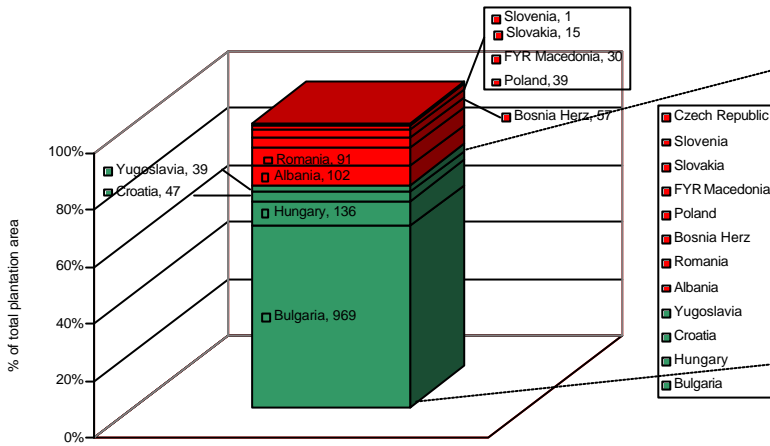
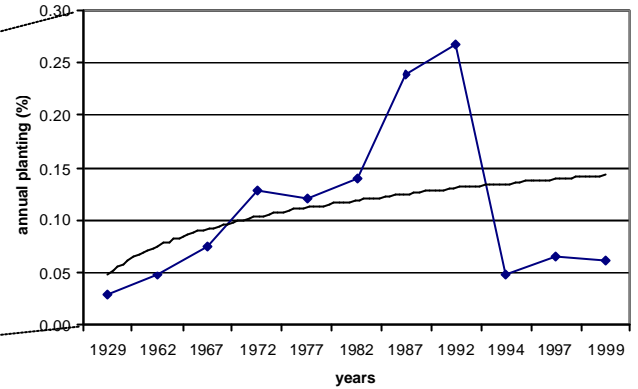


Figure 63 b: Annual planting (PFDB source)



Although the most reliable for the region, this trend too (Figure 63 b) is not so representative of the region since is based on 78% of the total plantation area (Figure 63 a) and only on four countries. Also the number of observations is relatively low: only 11.

Western Europe. Countries: Spain, Italy, United Kingdom, France, Portugal, Ireland, Denmark, Greece, Netherlands, Switzerland, Malta, Andorra, Austria, Belgium and Luxembourg, Germany, Liechtenstein, San Marino.

Figure 64 a: Forest Plantation area (FRA 2000 source)

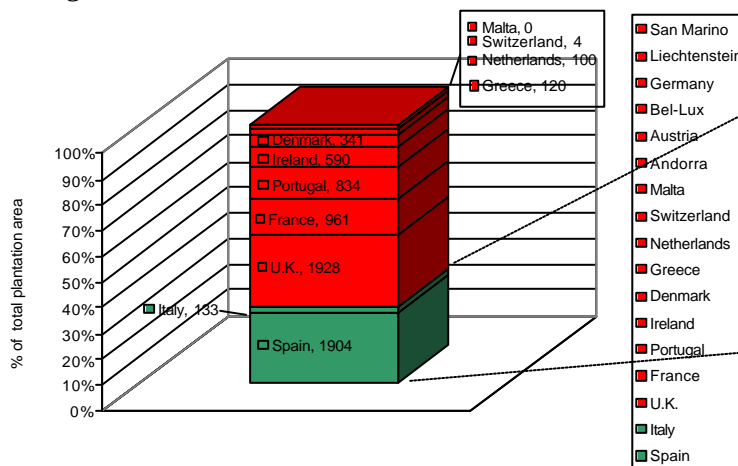
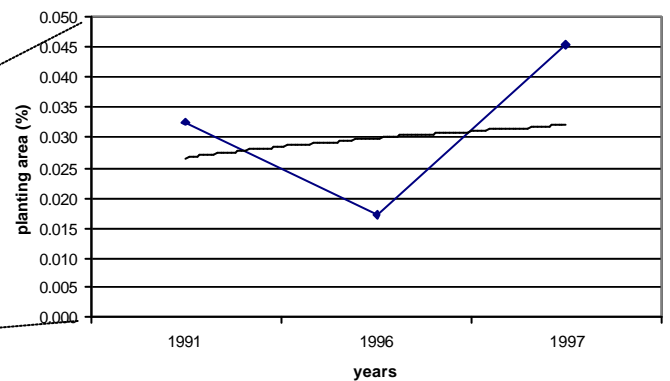


Figure 64 b: Annual planting (PFDB source)



The trend (Figure 64 b) can not be considered reliable: it is based on 3 observations only that cover a period of 6 years and is based only on two countries that represent 29% of the sub-regional area of planted forests (Figure 64 a).

Remarks

The positive trends found for Europe are not reliable and can not be considered representative of the region. Because of the differences in definitions adopted, there are still major relevant countries for which data was not available. More work needs to be carried especially for countries relevant on planted forests.

3 Overall remarks

The trends provided a simple means to extrapolate information on plantations for most of the T30C. The methodology applied was very simple, and although it masks gaps in information and needs refinements, interesting results were obtained.

In particular:

- Data provided is grouped for regions therefore it does not show the number of observations for every country.
- Trends can provide useful information to sub-regions but can be less reliable for specific countries.
- In order to compare large and small countries the annual new planting was converted to percentage of total land area.
- Graphs were derived from all information available in the PFDB by region, however, because of incomplete data, trends can mask gaps over time.
- The PFDB provided only 2 or 3 observations for Brazil, Spain, Venezuela and Europe that could only be interpolated by a linear function considered insufficient to represent a reliable trend.

There are still big gaps in information from all regions of the world that need to be filled. In particular the African region has major gaps in planted forest information. Annual planting data are lacking for Nigeria and Sudan, both belonging to the T30C.

There are also discrepancies due to the non harmonized data collected. Countries such as Canada, Mongolia, Republic of Korea and Democratic Peoples Republic of Korea do not report plantation areas on FRA 2000 although the PFDB has collected data on annual planting.

The concept and definitions of forest plantations and planted forests have varied markedly between different regions of the world. This has resulted in inconsistent interpretation and incomplete data recording in previous FRA exercises. There is a determination to resolve the difficulties in forest related definitions related to modified natural forests, semi- natural forests, planted forests and plantation forests that have hindered policy and decision- makers, planners and foresters for decades. The harmonization of forestry related definitions process coordinated by FAO in collaboration with the IPCC, CIFOR, IUFRO and UNEP have gathered strong endorsement from a wide stakeholder base of country experts, academics, scientists, intergovernmental and international non-governmental organizations (Carle and Holmgren, 2003).

New definitions will help to include data for planted forests (semi-natural) and forest plantations in countries that traditionally were not considered in previous FRA exercises.

Chapter 2 ⁽²⁾

VARIATION OF MAI AND ROTATION LENGTHS FOR THE MOST PLANTED SPECIES IN REGIONS AND SUB-REGIONS

1 Introduction

Mean Annual Increments (MAI) and Rotation Lengths are important parameters in silviculture and become more essential for decision makers when planning afforestation and wood fibre and biomass outlook studies. The following study, using the information contained in the PFDB, reports MAI and Rotation Lengths for the ‘top 14 most planted world’s trees’ found in the PFDB and the variations of MAI and Rotation Lengths in their different planting sub-regions.

⁽²⁾ Because of the large number of paragraphs, tables, graphs and pictures contained in the working paper, numbering in each Chapter begins from “1”.

2 the 'Top 14 Most Planted World's Trees'

Two silvicultural parameters, MAI and Rotation Lengths for 13 species and a 'genus' were extracted from the PFDB. The species considered referred as the 'Top 14 Most Planted World's Trees' (T14T) were the 10 most planted species in the world according to the ranking order found in the PFDB, 3 other relevant species and the genus *Populus* that includes a very significant group of trees in planted forests. *Populus* was included as 'genus' because of the lack of data available in the PFDB according to individual species.

Table 1 shows the T14T total planted area from the PFDB

Table 1

Genus and species	Total area planted in the world (ha)
<i>Pinus radiata</i>	3,796,176
<i>Tectona grandis</i>	2,913,086
<i>Acacia nilotica</i>	801,610
<i>Pinus merkusii</i>	901,910
<i>Pinus halepensis</i>	611,193
<i>Acacia auriculiformis</i>	564,854
<i>Eucalyptus grandis</i>	481,792
<i>Eucalyptus globulus</i>	390,470
<i>Pinus roxburghii</i>	319,874
<i>Dalbergia sissoo</i>	266,698
<i>Gmelina arborea</i>	209,448
<i>Swietenia macrophylla</i>	157,025
<i>Acacia mearnsii</i>	167,578
<i>Populus spp.</i>	182,727

The purpose of the following study was to use the PFDB data to describe how MAI and rotation length can vary for the same species in different planting regions to obtain more silvicultural information on the ecology of these species when planted both as native and exotic species.

2.1 MAI and Rotation Lengths by species

Pinus radiata, a tree originally from California is the most planted species reported by the PFDB in Oceania, South America and Africa.

Rotation lengths vary from 20 years in Africa and South America to 30 or 38 years for Oceania and Africa too. Average MAI are similar in the three regions with 20-22 m³/ha/year and have been reported to 30 m³/ha/year in East Sahelian Africa

Tectona grandis, a native to South Asia where is grown as both a natural and planted species, is also planted in other regions of Asia, in Africa and in Central and South America.

The PFDB data show that rotation lengths in Asia and Africa vary from 35 to 65 years with MAI from 4 to 12 m³/ha/year.

In Central and South America rotation lengths are shorter and vary from 24 to 35 years and MAI can reach 14 m³/ha/year in Tropical South America.

Acacia nilotica, originally from East Africa, has been planted in Africa and Asia. The PFDB data on rotation lengths are similar for the 2 regions with 21 years while MAI are greater in Africa than Asia, with 18 m³/ha/year in Africa and 10 m³/ha/year in Asia.

Pinus merkusii is native to Continental South East Asia where the species can be grown in natural or planted forests. It is also planted in Insular South East Asia with 27 years rotation length and MAI of 21 m³/ha/year.

Pinus halepensis, from the Mediterranean countries, is grown in natural and planted forests, is a very slow growing pine which lives in very dry and arid climates. The PFDB reports that this species is always planted in Mediterranean countries, with rotation lengths from 30 to 80 years and MAI that varies between 3 to 5 m³/ha/year. *P. halepensis* is also reported to be planted in Non Tropical Southern Africa with MAI reaching 12 m³/ha/year and 30 years rotation length.

Acacia auriculiformis, a native to Northern Australia, Papua New Guinea, and Eastern Indonesia is reported by the PFDB in Insular South East Asia and South Asia, according to short rotation of 10 years and MAI from 8 to 18 m³/ha/year.

Eucalyptus grandis is native to Australia but has been planted in most of the other world regions. The PFDB reports that *Eucalyptus grandis* is planted in Oceania, Asia, America and Africa in both long rotations (25 to 30 years) in Oceania and Non Tropical Southern Africa, and short rotations (6 to 14 years) in Africa, Asia and America. MAI is greater in Southern Africa and Asia and Tropical America where it can reach 30 to 35 m³/ha/year and are lower in Temperate Oceania and the rest of the world with 16 to 30 m³/ha/year.

Eucalyptus globulus a native to Oceania is planted extensively around the world and according to the PFDB is reported in Oceania, Africa, Asia, America and Europe, where it is planted in dry climates. Rotation lengths vary accordingly to the climate and are longer in dry climates and shorter in more humid and mild climates. They range from 10 to 30 years. Also MAI varies considerably from 10 m³/ha/year in North Africa to 35 m³/ha/year in Temperate Oceania

Pinus roxburghii, a native to South Asia has been reported by the PFDB to be planted only in Africa, not in Asia. There is a lack of data on MAI and rotation length for this species in Asia. In Africa *P. roxburghii* is grown in long rotations, 46 years, providing 9 m³/ha/year MAI.

Dalbergia sissoo a native to South Asia, has been reported by the PFDB in Asia and Africa with short rotations of 10 years, and 9-10 m³/ha/year MAI.

Gmelina arborea, a native to South Asia, has been reported by the PFDB in Africa, Asia and America with varying rotation lengths, from 9-10 years in America to 18-20 years in Africa and up to 60 years in Asia. The MAI also varies, from 10 to 15 m³/ha/year in Africa and Asia, but can also reach more than 30 m³/ha/year in Tropical South America.

Swietenia macrophylla, a native of South America, has been largely planted in America, Asia and Oceania. Rotation lengths vary from 20 years in America to 30 years in Oceania to 40-50 years in Asia. MAIs are more constant and vary from 7 to 10 m³/ha/year in Asia and Oceania with peaks of 15 m³/ha/year in America.

Acacia mearnsii, a native to Australia, is reported to be planted in Africa but not in Oceania most probably because of the lack of information still existing in the database. However the PFDB data shows that this species is grown with short rotations of 10-12 years and a productivity of 15 m³/ha/year

Populus spp., a widely planted genus in Africa, Asia, America and Europe with rotation lengths up to 25 years and MAIs that vary from 12 to 20 m³/ha/year.

2.2 MAI and Rotation Lengths by regions and sub-regions

2.2.1 Africa

The PFDB reports that the most planted species available in Africa are: *Eucalyptus grandis*, *Eucalyptus globulus*, *Tectona grandis*, *Pinus radiata*, *Pinus halepensis*, *Gmelina arborea*, *Acacia mearnsii*, *Acacia nilotica*, *Pinus roxburghii*, *Dalbergia sissoo*, and *Populus spp.* They are mostly reported in Southern Africa (Non Tropical and Tropical) but also in East Sahelian Africa and West Moist Africa. The PFDB reports only few data for North Africa and West Sahelian Africa while no information is reported for Central Africa and Insular East Africa.

Eucalyptus grandis is reported in East Sahelian Africa, Southern Africa, Tropical and Non Tropical, and in West Moist Africa. Data contained in PFDB show that *E. grandis* is grown in both short and long rotations according to its use. The shortest rotation length is reported for East Sahelian Africa with 6 years while the maximum rotation length was reported for Non Tropical Southern Africa with 25 years where it is used for industrial roundwood.

Also MAI vary according to the ecological conditions and the silvicultural treatments. The Maximum MAI reported is in Tropical South Africa with 30 m³/ha/year while the minimum is in West Moist Africa with 16 m³/ha/year.

Eucalyptus globulus is reported in East Sahelian Africa, North Africa and Southern Africa, Tropical and Non Tropical. Data reported that this species is grown in both short and long rotation lengths varying from 9 years in North Africa to 29 years in Non Tropical Southern Africa. MAI vary from 10 m³/ha/year for North Africa to 20 m³/ha/year for Non Tropical Southern Africa.

Tectona grandis is reported in East Sahelian Africa, Southern Africa Tropical, and in West Moist Africa and West Sahelian Africa. The species is grown in long rotation lengths typical of this species that vary from 45 to 60 years with relatively low MAI that do not exceed 12 m³/ha/year (maximum in West Moist Africa) and 4 m³/ha/year for East Sahelian Africa.

Pinus radiata is reported for East Sahelian Africa and Southern Africa, Tropical and Non Tropical. Although considered as a fast growing species *Pinus radiata* is also grown in Africa in relatively long rotations with minimum period of 20 years in Southern Africa Tropical and a maximum of 38 years in Southern Africa Non Tropical, probably due to the more dry climate. MAI is relatively high for the region and varies from 23 m³/ha/year in Non Tropical Southern Africa and 30 m³/ha/year in East Sahelian Africa.

Pinus halepensis is reported for North Africa and Southern Africa, Tropical and Non Tropical. Rotation lengths for this species are very long in Africa and vary from 30 years in Non Tropical Southern Africa to 80 years in North Africa where it is mainly used for sand dune fixation. MAI are very low with only 3 m³/ha/year in North Africa and not more than 12 m³/ha/year in Non Tropical Southern Africa.

Gmelina arborea is reported for South Africa Tropical, West Moist Africa and West Sahelian Africa. The only available data in PFDB for this species reports 18 years of rotation length in

West Moist Africa while MAI vary from 10 m³/ha/year for South Africa Tropical and West Sahelian Africa and 15 m³/ha/year for West Moist Africa.

Acacia mearnsii is reported in Southern Africa both Tropical and Non Tropical. Rotation lengths reported are vary from 10 to 12 years and MAI data are 14 m³/ha/year in Southern Africa Tropical and 15 m³/ha/year in Southern Africa Non Tropical.

Acacia nilotica is reported only in East Sahelian Africa with 21 years of rotation length and 18 m³/ha/year of MAI.

Pinus roxburghii is reported in Non Tropical Southern Africa and is grown in long rotation of 46 years and low MAI, 15 m³/ha/year.

Dalbergia sissoo is reported in West Moist Africa and grown in relatively short rotation of 10 years and MAI of 9 m³/ha/year.

Populus spp. are reported in Non Tropical Southern Africa, grown in 18 years rotation and MAI of 12 m³/ha/year.

2.2.2 Asia

The most planted species available in Asia are: *Tectona grandis*, *Populus spp.*, *Eucalyptus grandis*, *Gmelina arborea*, *Swietenia macrophylla*, *Acacia auriculiformis*, *Acacia nilotica*, *Pinus merkusii*, *Pinus halepensis*, *Eucalyptus globulus* and *Dalbergia sissoo*

The sub-regions where plantations are mostly reported are South Asia and Insular South Asia while Continental South East Asia, East Asia and Middle East show lower activities on planted forests.

Tectona grandis is reported in Continental South East Asia, East Asia, Insular South East Asia and South Asia and is grown in long rotations that vary from 35 to 65 years with relatively low MAI from 6 m³/ha/year in South Asia to 9 m³/ha/year in Continental South East Asia.

Populus spp. are reported for East Asia, Middle East and South Asia. Rotation lengths vary from 10 years in South Asia to 15 years in Middle East and MAI varies from 12 m³/ha/year in East Asia to 19 m³/ha/year in South Asia. The productivity of this genus seems to be bigger in South Asia where to longer rotation length is associated bigger production.

Eucalyptus grandis is reported for Continental South East Asia and South Asia. This species is grown in short rotation in both regions with 10 years for Continental South East Asia and 12 years for South Asia. MAI varies from 32 m³/ha/year in South Asia but do not exceed 18 m³/ha/year in Continental South East Asia.

Gmelina arborea is reported in Insular South East Asia and South Asia where it is grown in both short and long rotations that vary from 10 years and 34 m³/ha/year in South East Asia and 60 years and 13 m³/ha/year in South Asia. This species seems to be quite flexible and can be used with short rotation lengths and high productivity or longer rotation lengths with lower productivity of better wood quality.

Swietenia macrophylla is reported in Insular South East Asia and South Asia where it is grown in long rotations that vary from 39 years in Insular South East Asia to 50 years for South Asia. The productivity indicates also that *Swietenia macrophylla* is planted for production of wood quality since MAI vary from 7 m³/ha/year in South Asia, where rotation length is longer, and 10 m³/ha/year in Insular South East Asia.

Acacia auriculiformis is reported in Insular South East Asia and South Asia where it is grown in short rotation length of 10 years and MAI that varies from 8 m³/ha/year in South Asia to 18 m³/ha/year in Insular South East Asia.

Acacia nilotica is only reported in South Asia where it is grown in rotation length of 21 years and MAI of 10 m³/ha/year.

Pinus merkusii is reported in Insular South East Asia where it is grown in rotation length of 27 years and MAI of 21 m³/ha/year.

Pinus halepensis is reported in Middle East where it is grown in rotation length of 30 years and MAI of 3 m³/ha/year.

Eucalyptus globulus is reported in South Asia where it is grown in rotation length of 16 years and MAI of 20 m³/ha/year.

Dalbergia sissoo is reported in South Asia with MAI of 9 m³/ha/year.

2.2.3 America

The most planted species available in America are: *Tectona grandis*, *Swietenia macrophylla*, *Eucalyptus grandis*, *Eucalyptus globulus*, *Gmelina arborea*, *Pinus radiata* and *Populus spp.*

The sub-regions where plantations are mostly reported are Tropical South America, Central America and Mexico and Temperate South America. Caribbean and Temperate North and Central America report fewer species planted. This could be due to the characteristics of most of the species considered that are more typical of tropical countries but also because a great part of Temperate North and Central America is Canada and USA, which as industrialized countries, reported limited data in PFDB.

Tectona grandis is reported in the Caribbean, Central America and Mexico and Tropical South America where is grown in long rotation lengths (but shorter if compared with Asia and Africa) that vary from 24 to 35 years with relatively higher MAI that vary from 6 m³/ha/year in Caribbean to 14 m³/ha/year in Tropical South America.

Swietenia macrophylla is reported in Caribbean, Central America and Mexico and Tropical South America where is grown in long rotation lengths that vary from 20 years for Tropical South America and 36 years for Central America and Mexico. MAI also vary from 5 m³/ha/year for Central America and Mexico to 15 m³/ha/year for Tropical South America.

Eucalyptus grandis is reported in Central America and Mexico, Temperate South America and Tropical South America where is grown in short rotation lengths that vary from 7 years for Tropical South America and 14 years for Temperate South America. Productivity of this species in America is high and varies from 25 m³/ha/year in Central America and Mexico and 35 m³/ha/year in Tropical South America.

Eucalyptus globulus is reported in the same regions where also *E. grandis* is planted: Central America and Mexico, Temperate South America and Tropical South America. Silvicultural treatments are quite similar to those used for *E. grandis* and rotation lengths vary from 10 years in Temperate South America to 12 years in Tropical South America. Productivity is lower than *E. grandis* and varies from 16 m³/ha/year for tropical South America to 25 m³/ha/year for Central America and Mexico.

Gmelina arborea is reported in Central America and Mexico and Tropical South America where it is grown in short rotation lengths that vary from 9 years in Tropical South America and 13 years in Central America and Mexico. MAI varies from 20 m³/ha/year for Central America and Mexico to 33 m³/ha/year for Tropical South America.

Pinus radiata is reported in Tropical South America and Temperate South America where it is grown in short rotation length of 20 years and MAI of 20 m³/ha/year for both the regions.

Populus spp. are reported in Temperate North and Central America and Temperate South America where they are grown in rotation length of 12 years and MAI that vary from 12 m³/ha/year in Temperate South America to 16 m³/ha/year in Temperate North and Central America.

2.2.4 Oceania

The most planted species available in Oceania are: *Pinus radiata*, *Tectona grandis*, *Eucalyptus grandis*, *Eucalyptus globulus* and *Swietenia macrophylla*. Planted forests are more reported in Temperate Oceania than in Tropical Oceania.

Pinus radiata is reported in Temperate Oceania grown in rotation length of 31 years of and 22 m³/ha/year MAI.

Tectona grandis is reported in Temperate Oceania grown in rotation length of 33 years of and 8 m³/ha/year MAI.

Eucalyptus grandis is reported in Temperate Oceania grown in rotation length of 30 years of and 17 m³/ha/year MAI.

Eucalyptus globulus is reported in Temperate Oceania grown in rotation length of 17 years of and 35 m³/ha/year MAI.

Swietenia macrophylla is reported in Tropical Oceania grown in rotation length of 28 years of and 7 m³/ha/year MAI.

2.2.5 Europe

The PFDB could not report reliable data for this region mainly because of the different concepts and definitions on forest and criteria to collect data. However from the limited data available the most planted species reported were: *Populus spp.*, *Eucalyptus globulus* and *Pinus halepensis*. Planted forests are more reported in Western Europe than in the other regions. Only Western Europe reports the three species planted while the other two regions only report *Populus* as the species planted.

Populus spp. is reported in Northern, Eastern and Western Europe with rotation lengths that vary from 20 to 25 years and MAI from 12 m³/ha/year for Northern Europe to 19 m³/ha/year for Western Europe.

Eucalyptus globulus is reported for Western Europe with rotation length of 14 years and 18 m³/ha/year MAI.

Pinus halepensis is reported for Western Europe with 5 m³/ha/year MAI and no data available on rotation length.

3 Remarks

Although data contained in the PFDB remains incomplete, they provide very useful information on MAI and rotation lengths for the main species in planted forests.

The variations of MAI and rotation lengths in different regions and sub-regions are insufficient to describe the flexibility of the species according to different ecological zones (climatic and site conditions). Therefore more comprehensive information is needed to identify MAI and rotation lengths by ecological zones.

The results can only provide indications on variations of the two silvicultural parameters to identify the wider ecology of these species since parameters are only related to the data contained in the PFDB.

Conclusions

Although this study provided information on planting change by regions and sub-regions it has to be considered as an initial step to increase and strengthen the quality of information. Data remains too weak for most countries to be reliably used at the country level.

Among regions, Asia and Oceania have the most positive trends in planting. Asia hosts the countries with the largest areas planted, China and India. Oceania hosts Australia and New Zealand that have about 3 million ha of planted forests.

Africa shows a negative trend for the Northern sub-region and very slow positive trends in planting for the other sub-regions. There remain significant gaps in information that need to be filled for many countries.

The positive trends in planting for Europe are not reliable and can not be considered representative of the region. There remain major relevant countries for which data was not available. More work needs to be carried out for countries with indigenous, mixed species planted forests, often recorded as semi-natural forests.

The productivity of planted forests needs to be better documented. The silvicultural parameters such as mean annual increment (MAI) and rotation length data have been collected by different organizations, so continued examination of literature, connections to relevant institutes, and collection of new data will improve the quality of information.

More cooperation and feedback is needed to obtain a realistic picture of planted forest resources. FAO is providing technical support to National Forest Assessments and national forest inventories in developing countries. In this framework planted forest resource assessment should be one essential part of these assessments.

The lack of data is a serious constraint in policy and planning formulation, implementation, monitoring and reporting. Until the PFDB is improved, analysis on future scenarios may not provide a true assessment of forest plantation potential.

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See also: FRA Working Paper No.18