GLOBAL FIBRE SUPPLY STUDY
WORKING PAPER SERIES

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by

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FOREWORD

In late 1995, the FAO Forestry Department initiated the Global Fibre Supply Study (GFSS) with an outlook to the year 2050. The study was recommended by the FAO Advisory Committee on Pulp and Paper (now the Advisory Committee on Paper and Wood Products). The general objective of the study is to contribute reliable data, information, forecasts and analysis of industrial fibre sources in order to promote sustainable forest management.

The GFSS will include a compilation of the latest available inventory data, including recovered and non-wood fibre, focusing primarily on the sources of industrial fibre as raw material for the sawmilling, wood-based panels, and pulp and paper industries. It will also include a projection and analysis of future developments in fibre supply, based on explicit consideration of the major factors affecting supply.

The GFSS is unique among FAO studies in that special emphasis is placed on collection and compilation of fibre volume inventory and growth data for the developing regions - Africa, Asia-Pacific, and Latin America and the Caribbean. The study complements other FAO work, such as the Asia-Pacific Forestry Sector Outlook Study and the upcoming Forest Resources Assessment 2000. FAO is also updating its statistics on forest plantations and developing a method for estimating fibre volumes from non-forest areas in the tropical regions. Available data from these studies will be included in the GFSS.

The major products of the GFSS will include:

- A database accessible on-line through the Internet providing estimates of commercial wood volumes from natural, semi-natural and plantation forests;
- An on-line interactive fibre-supply model incorporating key determinants of supply;
- A statistical and descriptive report on the data and three fibre-supply scenarios which are based on factors deemed to be the most critical;
- A working paper describing in detail the methods for data compilation, gap filling, data validation, forecasting and definitions, survey forms and country list;
- A series of additional working papers on sustainable forest management, improved forest productivity from industrial forest plantations, fibre-supply modelling, recovered and non-wood fibre, and other topics; and
- An issue of *Unasylva*, FAO's quarterly journal on forestry and the forest industry, dedicated to the theme of global fibre supply.

This paper, solicited by the GFSS and co-authored by Warren Mabee and Harshad Pande, shows the potential significance of recovered and non-wood fibre in the global fibre-supply picture. We sincerely hope that it contributes productively to the world-wide dialogue on sustainable forest management for fibre and other values.

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ACKNOWLEDGEMENTS

This series of working papers have seen the contribution of many silent partners. Our colleagues in the Forestry Department provided much needed advice on several issues. In addition, there have been many outside reviewers from different research institutions and technical cooperation agencies who have provided valuable information. We also want to thank our special assistant Ms Elisa Rubini who guided each report through the many technical hurdles in document preparation.

1. INTRODUCTION

The purpose of this working paper is to describe the assumptions, methods, model development and definitions used for the Global Fibre Supply Study (GFSS). It is intended to serve as a guide to the technical underpinnings of the study. It is probably most useful to analysts who wish to understand the details of our approach and it will also help in the further devleopment and management of the database and provide the essential details for improving the supply models.

The study output consists of two main components: the forest resource database and a fibre supply model used for examining alternative futures. The data and forecast model results along with analysis will be presented in an interim report, early 1998.

2. GENERAL BACKGROUND ON THE GFSS

In late 1995, the FAO Forestry Department initiated the (GFSS) with an outlook to 2010 and beyond. The forest industry community and the public raise the question: *Where is the raw material going to come from to cover our forest products needs?*

To address this question, the overall goal is "to contribute to the world-wide forest policy development through the provision of reliable data, information and analysis of industrial fibre sources". The aim is to assist in addressing concerns on the over-exploitation of natural forest resources and options for the development of new resources or for the use of currently under-utilised raw material. The intended audience for this information is broad and includes decision-makers in governments, financial institutions and industry and non-governmental organizations.

The study can act as the starting point of a process to sensitize policy-makers with respect to the critical policy issues which surround industrial raw material sources and sustainable uses and it will highlight the necessity to improve their data collection and analysis in this field. It will also feed into a larger regional and global outlook study process in the FAO Forestry Department.

The GFSS database establishment and modelling is being monitored by representatives from the forest products industry and a special Steering Committee is providing guidance on the scope of the project and feedback on the information generated.

The meaning of fibre is to be understood as fibrous wood and non-wood raw material for primary industries producing sawn timber, wood-based panels, and pulp and paper products. The majority of this fibre exists in standing form in forest undisturbed and disturbed by man and plantation forests. Other kinds of fibre are in the form of recovered paper, and non-wood fibres. The study concentrates on these current sources of industrial fibre as well as projection and analysis of future developments in fibre supply, based on a consideration of the major factors affecting them. These factors include:

Natural Forest	**Industrial Plantation Forest**
• sustainable forest management	• forest plantations development gains
• increase in protected area	• plantation afforestation rate
• deforestation	**covered and Non-wood fibre**
	• non-wood fibre usage and yield
	• recovered paper usage and yield

3. OBJECTIVES AND SCOPE

The specific objectives of this working paper are to present the:

- major assumptions made in database development and in supply modeling;
- study design and methods in terms of countries selected, general database description and fibre supply modeling strategy;
- details on the fibre supply models employed;
- database structure, fields and linkages; and
- definitions and survey forms used to collect data.

The analysts used Microsoft Access as the relational database management program and Visual Basic as the programming language for supply forecasting. (Another forecast model was developed in FORTRAN and it is described in more detail in the GFSS working paper No. 5.)

Due to limited resources, and in order to keep the project to a more managable size, it was decided that this project could not include at this time:

- fuelwood;
- trees outside of forests;
- non-industrial forest plantations;
- the geographic area of the Middle East;
- the geographic area of the republics of the former USSR;
- countries where industrial roundwood production is less than 100 000 m3, unless the information was easily avaialble.

In the future it will be necessary to collect the additional statistics or geographic regions mentioned in order to present a global picture of fibre supply for industrial and non-industrial uses.

4. ASSUMPTIONS

A project of this nature requires the analysts to make key assumptions in data collection, intrepretation, organization and manipulation. In addition, for any fibre supply modeling exercise it is necessary to make another set of assumptions in model construction and development in order to make the model reflect a possible future.

It is imperative that these assumptions be made transparent in order to gain any widespread acceptance of the information and the forecasts. This is the underlying purpose of this section.

4.1 BASE DATA

Most countries have incomplete data sets for natural and plantations forests. In order to fill in the essential information needed various assumptions were made in developing the base data. These are described below for the forest undisturbed and disturbed by man, the industrial plantation forest and the non-wood and recovered fibre.

4.1.1 Forest Undisturbed and Disturbed by Man

4.1.1.1 Area

Area estimates contain three major assumptpions.

a) The collection of total forest area statistics has a long history. It is now possible to calculate forest area with remote sensing information and it was assumed that this is the best possible estimate for many countries. The FAO Forest Resources Assessment 1990 is based on country reports that use mostly remote sensing data and therefore it forms an important part of the GFSS area assessment in developing countries.

b) It is also assumed that other wooded lands will not yield a significant amount of industrial roundwood. Thus it is excluded from the current GFSS assessment.

c) There are distinctly different points of view on the issue of area available for fibre supply and they are legitimate differences. While the precise boundary of the area available for wood supply cannot be defined, it is necessary for an industrial fibre outlook study to assess the area what is available under current market conditions, with current technology and infrastructure. Therefore assumptions were made using country experts and other data sources to deduct the forest area not available for wood supply. Forest area not available for wood supply was placed into the following classes and sub-classes:

   i) legally protected according to IUCN classes 1 and 2;
   ii) economically inaccessible;
      - physically inaccessible due to factors such as steepness of terrain (in the case of the USA this category was used to describe private forest with no harvesting, such as riparian areas);
      - far from industrial sites due to transportation distance or lack of infrastructure;
      - too low in commercial volume, degraded forest or some other legitimate reason specific to each country.

It is interesting to note that a similar evaluation procedure was taken in the 1980 Forest Resource Assessment where tropical forest which were not productive for physical reasons and the forest unproductive for legal reasons were identified.

4.1.1.2 Volume and Growth

Growing stock volume in m^3 per hectare is reported at the diameter class mentioned in the inventory reports. It is important to note that these statistics are not necessarily a reflection of the forest volume available for future wood supply.

Commercial species volumes are based on the tree species considered commercial under current market conditions for a particular country. The commercial or potentially commercial volume in the natural forest of tropical countries is normally far lower that the total growing stock. It is very important to pay special attention to the reported diameter class of the the growing stock. In many cases the statistics is not a reflection of the commerical growing stock available today for industrial uses but of all age classes of commercial species greater than 10 cm.

Forest undisturbed by man in the tropical forest areas will not, in general, have any net growth since mortality is an offsetting factor to any annual growth. This is not the case in the forest disturbed by man and estimates of increment by forest type are included. There is a paucity of good data in this area.

4.1.1.3 Removals

Harvesting intensity estimates for the tropics will change with the transition from forest undisturbed by man to forest disturbed by man forests under the current method of management in many forest management scenarios. Working paper #6, which is an annotated bibliography on this subject, strongly support this assumption.

Under sustainable forest management practices harvest intensity should remain fairly constant in a forest disturbed by man forest with each cutting cycle. The cutting cycles statistics attempt to reflect the common silvicultural and harvesting prescription used most commonly in a country.

4.1.2 Industrial Plantation

The plantation area includes all plantations whose objectives are industrial roundwood - that is sawlogs, veneer logs, pulpwood. They include areas of "non-forest" species, such as rubber and coconut and to a lesser extent, oil palm. Presently relatively few countries are using these species but more use is anticipated in the future. They exclude all plantation areas where it was possible to identify, or in some cases infer, that the objective was non-industrial - that is mainly fuelwood but also poles, tan-bark and areas managed exclusively for other non-timber products. If, however, an area is managed for a non-timber product such as naval stores e.g. some of the pines in Sri Lanka which are then available for timber then they are included in industrial roundwood.

The mean annual increment is an estimate by species and by country of the overbark increment in m3/ha/yr continued over the commercial rotation of the crop.

4.1.3 Recovered Fibres

The percent of wastepaper recovered is a fraction of total paper & paperboard production. For a few countries, particularly those with policitical turmoil, figures were either unreliable or unavailable. In such cases estimated values were used to fill data gaps. Working paper # 4 describes the background of wastepaper statistics in detail.

All available recovered fibre is provided by wastepaper recovery. While this is not always the case, as there are viable operations concerned with recovering solid timber and engineered wood products, the use of recovered fibre is still predominantly in the pulp and paper industry with the recovery and recycling of waste paper.

4.1.4 Non-wood Fibres

All non-wood fibre produced is used towards the production of pulp for paper. Non-wood fibre usage is significant in only a limited number of countries. In some cases estimates were made to fill data gaps and these are also described more fully in working paper #4.

4.2 FORECASTING

4.2.1 Forests Undisturbed and Disturbed by Man (Natural Forest)

4.2.1.1 Forest Area

Conversion forests: Conversion forests (i.e. forest area targeted for conversion to other land use) may or may not have a cutting cycle attached. In the instance that no cut cycle is assigned, the forests are assumed to be harvested over the 55 years that the model runs.

Adjusting the legally protected forest areas: Targets for legally protected forest area are expressed as a % of the current legally protected area (i.e. that exists in 1995). Therefore, the total legally protected area can be said to increase or decrease by the target percentage. The target date is fixed at 2010. It is also assumed that increases or decreases in the legally protected forest area will be applied evenly over forests both undisturbed and disturbed by man.

Transformation from undisturbed forest: All undisturbed forests are assumed to transform to disturbed forests after a single harvest. Transformed areas are assumed to still contribute to the overall productive capability of the disturbed forest although in many forest types the sustainable productivity will be at a lower.

Deforestation: The annual deforestation is applied to a percentage of the area available for wood supply. The original rate is provided by the *State of the World's Forests* (FAO, 1997). One year of deforestation reduces the overall area available for wood supply, which is reflected in the next year's calculation. Thus, the actual area being deforested and, as a result, the area available changes from year to year. The deforestation rate itself is applied evenly over every year of the cutting cycle. The deforestation rate is applied evenly over the entire undisturbed and disturbed forest area available for supply.

Adjusting the deforestation rate: Changes to the overall deforestation rate are expressed as a percentage of the current deforestation rate. Thus, the deforestation rate can be said to increase or decrease by the target percentage. This target percentage is applied as an even reduction or gain in the overall deforestation rate over each year of the cutting cycle. Changes in the deforestation rate are applied evenly to both the disturbed and undisturbed forest areas.

4.2.1.2 Forest Volume

Potential commercial growing stock. It is the portion of the actual growing stock that will be potentially utilized and includes all age class of potential commercial value.

Inventory diameter class. One of the most critical factors in compiling forest inventory data is establishing the diameter class of the inventory. Each country compiles data at different classes and the challenge is to find the forest volume at the 10 cm class. Crude conversions, described in Section xxxxx, have been used for reporting pursoses.

4.2.1.3 Forest Growth and Removals

Growth. It is assumed that the forest undisturbed by man has little or no growth in terms of a net increase in the potential commercial growing stock.

Removals. For the undisturbed forest the removals is assumed to be the forest volume spread out over the cutting cycle for a particular forest type. Removals should not exceed the net growth of forest once the forest is disturbed.

4.2.1.4 Yield Calculations

Sustainable supply. Countries might have to define a sustainable supply, especially given the recent pressure on timber producing countries to make quantitative commitment in terms of forest harvesting levels. Numerous international forest policy discussions being held by the International Tropical Timber Organization, the CSDs Intergovernmental Panel on Forest and several regional discussions on Criteria and Indicator will all require measurable indicators to be effective. A sustainable supply level is one such measure.

Sustainable supply as a concept has now been broadened from the traditional notion of sustained yield to include the concepts of biological diversity and ecosystem management (See working paper #3). This means broadening the analysis to include spatial as well as aspatial possibilities in forest yield regulation, and despite the increased complexity quantify the long term sustainable supply.

Yield regulation diameter class. Sustainable supply calculations requires the specification of the diameter class, Since different countries chose different diameter classes for yield regulation calculations it is important to compare the diameter classes used before comparing modelling results

Adjusting the cutting cycle: Increased reliance on practices regarded as contributing to forest sustainability are reflected in an increase in the cutting cycle term. Conversely, abandoning the principles of SFM are reflected by a decrease in the cutting cycle. Target changes in the cutting cycle are applied at the beginning of the cycle. Therefore, implementing a management plan which entails improved SFM would have an immediate effect upon the model.

4.2.2 Industrial Plantations

Afforestation rate: The afforestation rate is derived from various government sources and other published information assembled by the FAO Forest Plantation Officer. Where no information is available the estimates are made by plantation experts with knowledge of the region. It is assumed to be an annual planting rate. However, to offset the effects of replanting a currently existing plantation or changes in government initiatives, the afforestation rate is reduced by 7% annually and thus is brought to 0% by the year 2010.

Adjusting the afforestation rate: Changes to the afforestation rate are expressed as a percentage of the overall afforestation rate. Thus, the rate may increased or decreased by a target percentage. This rate only refers to additional area planted and not the replanting of the same area with each cutting cycle.

Industrial plantation area available for supply: The plantation area that is available for supply is variable. It is assumed that 20% (this will be reduced later to 5%) of a country's industrial plantation area is available in 1995. This percentage rises linearly until the year 2015, when it is assumed that 80% of a country's plantation area is available for supply. However where reliable information on the area currently available exists, it will be used in the simulations.

Development gains: There is provision in the model for gains from improved plantation development, such as better silvicultural practices or improved genetic stock. The development gains factor is expressed as a target percentage. Essentially it represents a percent increase in industrial plantation production capacity. The target percentage is evenly applied over 55 years until the year 2050. The default is set at 30% as a default but working paper #2 give a more detailed review of other percentages that could be used.

Actual increment: The industrial plantation increment values are commonly very high. The model reduces the increment value by 25% in order to take into account bark, age class distribution, inadequate management practises, environmental restrictions, losses incurred in harvesting and transport or possible over-estimations of plantation growth.

4.2.3 Recovered Fibres

Conversion of metric tons to cubic metres: The conversion factor to convert metric tons to cubic meters is assumed to be 2.5 m^3/MT. This factor is a estimate taken from an amalgamation of various sources.

Existing recovered paper usage rate of change: The rate of change in recovered fibre use as estimated by Mabee (1997) is applied on a linear basis over the 55 years of the model run. The existing rate of change is derived from historic wastepaper recovery statistics and paper and paperboard production figures, as published by the FAO (FAOStat 1997).

Maximum recovered paper: The wastepaper recovered will not exceed twice the 1995 level (i.e. if they recover 100 tons in 1995, nowhere in the forecast will they recover more than 200 tons).

Maximum recovered paper usage rate: The wastepaper recovered will not exceed 70% of the overall paper production, based on current trends of paper production. This prevents any unreasonable amounts of wastepaper recovery.

Adjusting the recovered fibre usage rate of change: The rate of change in wastepaper recovery can be adjusted by setting a target percentage and then adjusting the rate of change up or down by this percentage. The target date is 2010. This allows the pattern of wastepaper recovery usage to be adjusted over the course of the model run.

4.2.4 Non-wood Fibres

Conversion of metric tons to cubic metres: The conversion factor to convert metric tons to cubic meters is assumed to be 2.5 m^3/MT. This factor is a rough figure taken from an amalgamation of various figures compiled by different sources.

Existing non-wood fibre usage rate of change: The rate of change in non-wood fibre use is estimated by Pande (1997) and applied on a linear basis over the 55 years of the model run. The existing rate of change is derived from historic non-wood fibre usage statistics and pulp production figures as published by the FAO (FAOStat 1997).

Adjusting the non-wood fibre usage rate of change: This adjustment is made by establishing a target percentage (i.e. non-wood fibre use might increase or decrease by a percentage over the next 15 years) and then applying this change to the existing non-wood fibre usage rate of change. Thus, the pattern of non-wood fibre usage could change over the course of the model. The target date for this factor is 2010 (15 years into the model).

5. STUDY DESIGN

The initial task was to construct an appropriate database for data compilation and information management. Definitions have been developed, and the final input tables for data compilation are now complete. A team of experts worked on a country-by-country basis through the latest available forest inventory reports to extract the data necessary to complete the country profiles in terms of forest area, and volume, removals and growth, for the major industrial roundwood producers in Africa, Asia-Pacific, Latin America and the Caribbean. The remaining regions of the world were covered using other data sources and country experts.

In order to forecast to the year 2050, it is necessary to place the fibre supply projections into an appropriate context. Based on a thorough review of the issues addressed in previous supply studies, the major policy factors quantified are:

- Sustainable forest management;
- Deforestation;
- Protect areas;
- Afforestation through increased industrial plantations;
- Improved plantation forest productivity; and
- Recovered and non-wood fibre.

The implementation of the study is monitored by a Steering Committee, composed of FAO staff and experts from the forest industry sector, representing important producer and consumer companies.

5.1 SELECTION OF COUNTRIES

Table 0-1 lists, by region, the 108 countries that have been included in the GFSS database. This list will be expanded to include the minor countries, at least in terms of industrial roundwood production, for a comprehensive global overview.

Table 0-1: List of countries included in the GFSS

Africa (26)	North America (3)	Asia (22)	Europe (30)
Angola	Canada	Afghanistan	Albania
Botswana	Mexico	Bangladesh	Austria
Cameroon	Usa	Bhutan	Belgium-Luxembourg
Central African Republic		Brunei Darussalam	Belarus
Congo, Democratic Republic of	Central America (8)	Cambodia	Bulgaria
Congo, Republic of	Belize	China	Croatia
Côte d'Ivoire	Costa Rica	India	Czech Rep
Equatorial Guinea	Dominican Republic	Indonesia	Denmark
Gabon	El Salvador	Iran	Estonia
Ghana	Guatemala	Japan	Finland
Guinea	Honduras	Korea, Democratic People's Republic of	France
Guinea-Bissau	Nicaragua	Korea, Republic of	Germany
Kenya	Panama	Laos	Greece
Liberia		Malaysia	Hungary
Madagascar	South America (13)	Myanmar	Ireland
Malawi	Argentina	Nepal	Italy
Morocco	Bolivia	Pakistan	Latvia
Mozambique	Brazil	Philippines	Lithuania
Nigeria	Chile	Sri Lanka	Netherlands
Sierra Leone	Colombia	Thailand	Norway
Somalia	Ecuador	Turkey	Poland
South Africa	French Guiana	Viet Nam	Portugal
Tanzania	Guyana		Romania
Uganda	Paraguay	Oceania (5)	Slovakia
Zambia	Peru	Australia	Slovenia
Zimbabwe	Suriname	Fiji	Spain
	Uruguay	New Zealand	Sweden
	Venezuela	Papua New Guinea	Switzerland
		Solomon Islands	UK
			Yugoslavia
			Russia (1)
			Russian Federation

6. IDENTIFYING APPROPRIATE DEFINITIONS

In conducting a study of this nature it is critical to have a clear set of definitions from the outset. These definitions must have the following characteristics to be useful for both consistency for various statistical reports and for outlook work:

1. The terms must be flexible enough to utilize old data sets (e.g. FRA 1980).
2. The terms must be in general agreement with new terminology (e.g. FRA 2000).
3. The major terms must be able to accommodate the country level data collected.
4. The terms must be readily understandable to a wide audience of users.

The guiding principle for the development of the definitions is that the common FAO Forest Resources Assessment definitions be used where such exist. Any variance is indicated in the text. Where needed definitions that are not covered in the common FRA terminology, has been developed by the GFSS team of experts. Annex 1 contains a complete list of definitions used in the study.

7. DATA AND DATABASE

7.1 DATA REQUIREMENTS

The initial task was to construct an appropriate database for data compilation and information management. To conduct a forest fibre supply forecasts requires assessing the following basic elements: forest area, total and commercial volume of existing forest, removals , increment or additions to the forest. All elements are included and the database was constructed to describe them in some detail. The major issues to be considered are:

1. Breadth of inquiry - The emphasis is on the industrial fibre supply not the fuelwood supply which requires a separate methodology. Where possible, the local industrial supply uses were also considered.
2. Level of detail - In collecting data it is important to go to the level of detail where information is available and which country reviewers will readily understand. This allows for greater accuracy in data compilation and for a more successful review of the statistics.
3. All fibres - It is important that the database structure allow for the inclusion of non-wood and recovered fibre materials. These are seen as increasing in importance in the future.
4. Plantations - Industrial plantation forest will have an increasingly prominent role in future fibre supply. It is important to have the appropriate species groups, the other appropriate elements for fibre supply forecasting.
5. Global Forest Resources Assessment 2000 - One important requirement of the GFSS is to identify the area available for wood supply. This requires the netting down of forest area for such factors as protected area and economic accessibility in order to identify the area which may be used for industrial uses. Key elements for economic accessibility are constraints that are considered permanent (steepness, swamps) and the transport distance resp. the lack of infrastructure (remote location). Another important economic element is low commercial volume and forest degradation, which usually results in low volume. Other factors such as temporary logging bans were considered as economic constraints. Transport distance, the lack of infrastructure and low volume account for the lion’s share of the forest area reductions in the GFSS database.

6. Data gaps - For several countries there is simply no information on the amount of forest cover removed by forest harvesting or the growth of the forest. In order to present countries with complete estimates it was necessary to examine the volumes and growth in similar condition in adjacent countries. This is an essential step in the preparation of preliminary estimates of future fibre supply. These estimates can be improved once more dialogue with the countries or once new inventories and research results become available. Regional workshops are being held in Asia-

Pacific, Latin America and Africa in order to improve the data.

7. Pretesting - In order to decide on the final database structure for the data mentioned above, it was necessary to do a pretest of countries using a selected number of countries. The main objective was to examine countries along the spectrum from good inventory information to really poor or outdated inventory information in order to find the structure which would not eliminate key data from some countries but also not establish a completely unrealistic data expectation for countries with poor information.
8. Replication - The database is designed so that each data source is entered as a separate record. The final GFSS estimate is also a separate record. This allows any reviewer the option to retrace the step taken to develop our preliminary estimates by reviewing the complete dataset with the reference material. As much background information as possible is kept in annotation fields and in paper files. This approach also permits analysts to add new data entries and to make new assessments in the future.

7.1.1 Classification of Fibre Resources

Fibre is classified according to natural forest (forest undisturbed by man, forest disturbed by man), industrial plantations, recovered fibre and non-wood fibre (Figure 7-1). For forest undisturbed by man and plantations this classification scheme is in accordance with the FAO Global Forest Resources Assessment 2000 definitions, except for the economically inaccessible forest, which had to be defined more in detail for the purpose of the GFSS.

Forest volumes, growth and harvest potential are described in Figure 7-2.

Information on recovered fibre is not included in the FAO Forest Resources Assessment. Bamboo and palm formations are part of the forest undisturbed by man forest. They are thus covered by the FAO assessment as well as coconut plantations.

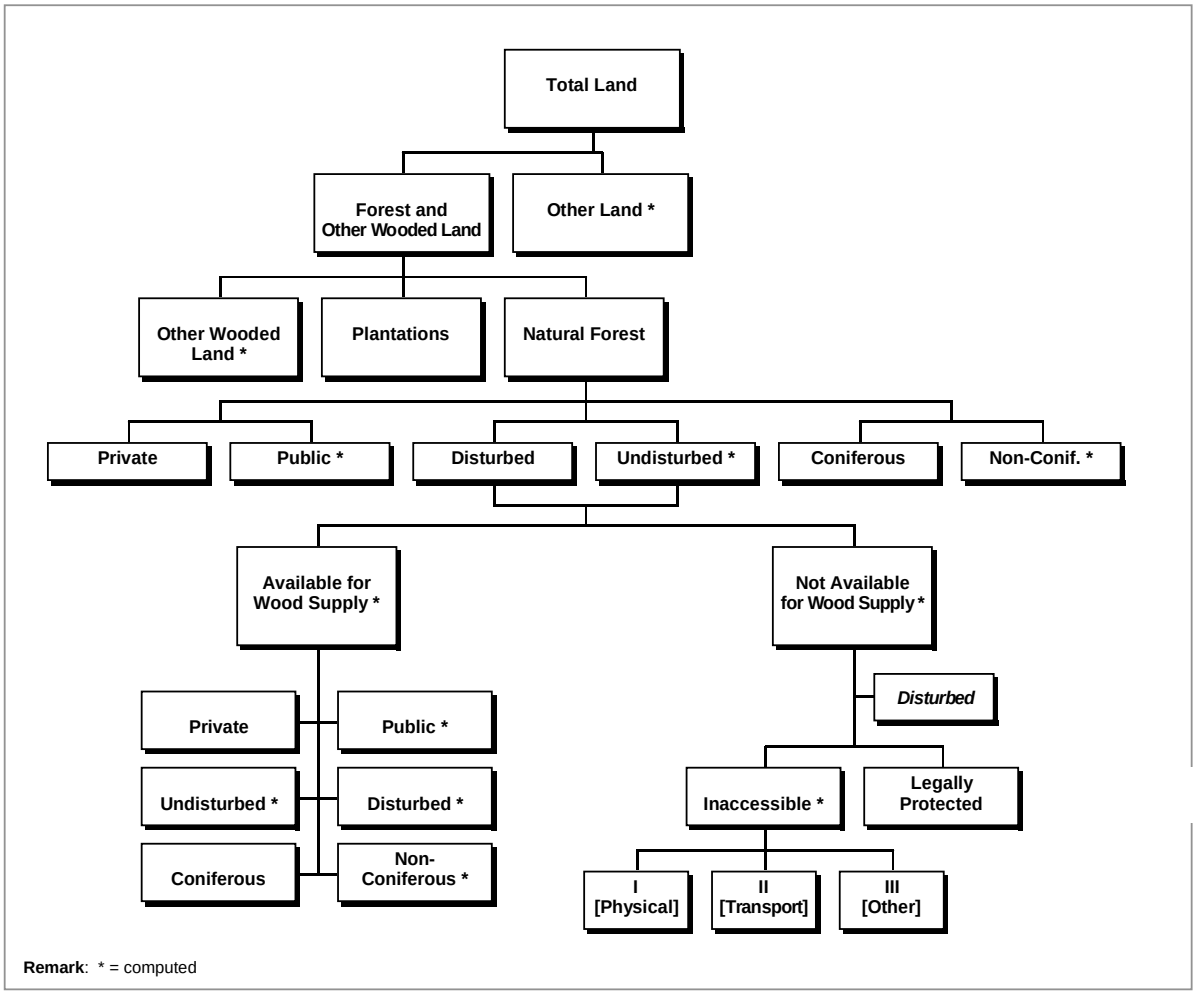


Figure 0-1: Land classification for the Global Fibre Supply Study

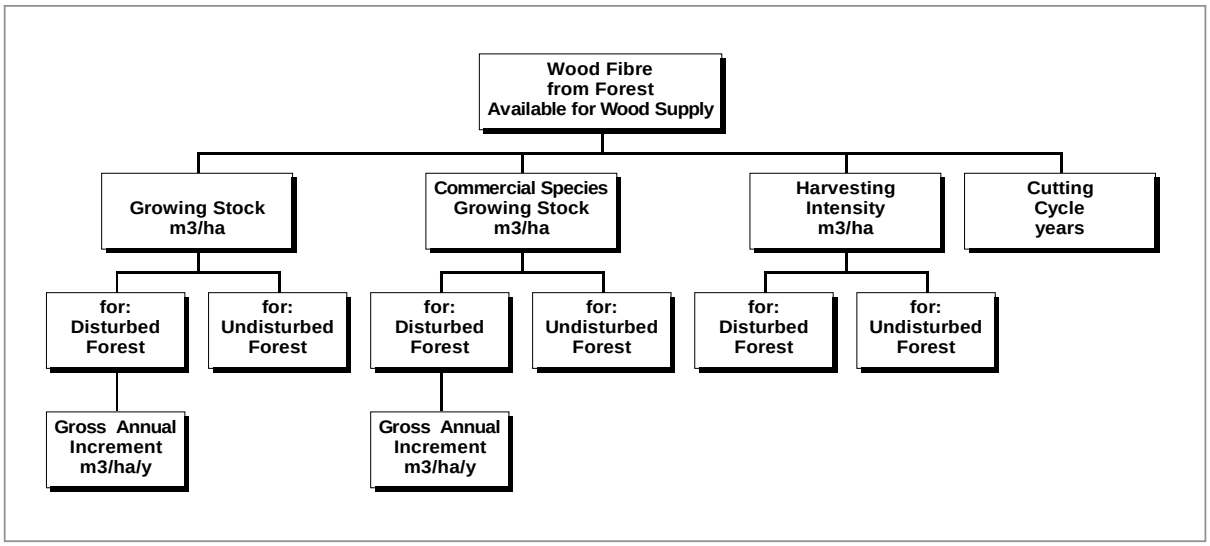


Figure 0-2: Classification of forest volume, growth and harvest potential

7.1.2 Data quality and resolution

Data quality is very mixed, inconsistent or missing altogether. For example in Indonesia there is forest inventory data of outstanding quality and very recent while in Cambodia poor inventory information is avaible and what exists is very old.

Data resolution means the spatial scale at which the forest inventory data was collected and the intensity of the survey conducted. It is difficult to aggregate data from the field level to the country level. Often forest inventory project are small scale with a much narrower purpose and it is difficult to take the information and apply it to the country level. For example, the field project may estimate that the average growth of the forest in a particular forest type is 1.8 m3 per year. Given that there is no other information on other forest types in the country, does it mean that it should not be applied to the country data?

7.1.3 Statistical inconsistencies

Many countries do not declare their statistical assumptions in defining their forest inventories. The critical factors include, definition of commercial species, volume expansion factors to standardize forest volumes, defining the accessible forest area, and increments in open and closed forest formations. It is also difficult to get a standard definition of land area, forest area, and protected areas.

In many cases there are different numbers for the same area or volume issue. Deciphering the best number required extensive effort by our country assessment team.

7.2 DATA SOURCES

In order to focus on areas where the data is the weakest, it was decided that the primary data collection exercise would concentrate on Latin America, Asia-Pacific, and Africa. For the CIS (Former USSR) region, the figures were obtained from a database created by IIASA. To cover the European and North American regions it was necessary to rely upon data collected by institutes, federal governments or other UN agencies.

7.2.1 Africa, Latin America, Asia-Pacific

The Tropical Forest Resources Assessment Project in 1980 was the first attempt to provide a comprehensive overview of the fibre resource information in these regions. It is a very important reference point for the Global Fibre Supply Study and it provides:

- a methodological approach that is still valid today for resources assessment type of work;
- statistics on the area that is physically available for wood supply and area not available for wood supply;
- statistics on the volume actually commercialized, that are now referred to as harvesting intensity;
- detailed estimates on industrial and non-industrial plantations;
- an analysis by country of the fibre supply situation using an extensive network of consultants.

In 1990 the emphasis of Forest Resource Assessment (FRA 1990) was changed. There was a focus on the use of new technology to improve the quality of data, specifically the improvement of statistics on forest area and on ecological typing of the forests. The focus was also on the deforestation occurring throughout the tropical world.

The FRA 1990 also presented a global overview of the forest area statistics. As a part of that Assessment, industrial forest plantation were also analyzed for each of the major countries in a separate report, Forestry Paper #128. This provided an important starting point in our plantation data.

The country inventories were the next major source of information. Using regional experts, the FAO library, in house expertise and contacts in the regions, the available inventory reports were reviewed. The strategy chosen was to present the information by the major forest grouping or types as prepared by the countries themselves. The benefits of this approach are at least two-fold. First, maintaining country standards gave a great deal of information which would be loss due to the shear difficulties in the conversion of data. Second, reporting the data on more than just a country average level would give country forest inventory experts better information for review.

Unfortunately many countries, if they do have inventories, do not have up-to-date inventories. On the other hand, it was decided that using a reference to a statistics that had no empirical backing also seemed the wrong approach. Therefore it was decided to screen various secondary and tertiary sources for reliable data. This included, forest sector master plans, consultant reports, respected journals and other government and industry reports.

Each piece of information was entered into the database and kept in separate records. After data screening and entry an initial GFSS estimate of the forest area, volume, growth and removals was developed.

7.2.2 Europe

For Europe it is necessary to take a different approach to data collection. After reviewing the data sources, a number of criteria were developed to assist in the data. The criteria used were:

- consistency of data (lack of contradiction from other sources);
- most updated statistics;
- best fit to the GFSS definitions;
- degree of difficulty to process data for GFSS;
- comprehensiveness of data coverage; and
- degree of standardization.

7.2.2.1 Major sources and application of criteria:

The major sources of the data included:

a) National sources '***The Forest Resources of the Temperate Zones***, 1990'.

It was published in a period when significant political changes took place in Europe. Therefore the data is of limited use since new country boundaries have been drawn and this will change the forest inventories.

b) In the beginning of October 1996 some freshly updated data of '***The Forest Resources of the Temperate Zone'*** were provided to the GFSS group by Alexander Korotkov at ECE/FAO in Geneva.

The data from the 1996 survey was gathered by sending out questionnaires to country correspondents in Europe, the states of former Soviet Union, Canada, USA, New Zealand, Australia, and Japan. The updated figures were based on the replies from country correspondents. The objective of this mission was to present an interim report before the next "real" update of "The Forest Resources of the Temperate Zones". The 1996 updated data material had therefore not been scrutinised to the same extent as "The Forest Resources of the Temperate Zones" from 1990. Furthermore, it was not as extensive in its coverage of forest data. A number of inconsistencies occurred when data in the updated data material were compared with corresponding figures in "The Forest Resources of the Temperate Zones 1990".

Examples:

i) When the 1990 figures for "Exploitable forest" in the October 1996 updated material and '***The Forest Resources of the Temperate Zones 1990'*** were compared, many figures did not correspond.

The same applied to all other data categories.

ii) In several cases it was not specified what forest category the figures in the October 1996 report referred to, e.g. if "Growing stock" in the updated material referred to "Forest and tree resource (living trees)", "Forest" (i.e. exploitable and unexploitable forest), or just "Exploitable forest".

c) The European Forestry Institute (EFI) material will not be available until later in 1997 and due to time and logistic limitations it is not be possible to make the definitions correspond to those created for the GFSS.

d) A 1995 update of the most important figures in the report mentioned in item #a. The result was the report ***'The Outlook for the European Forest Resources and Roundwood Supply, ECE/TIM/DP/4'***. which was published in conjunction with the European Timber Trends Study V project.

e) The 1997 State of the World's Forest Report contains updated estimates based on the report mentioned in item #4. This assessment also included the Central Asiatic republics of the former USSR.

7.2.2.2 Final selection

Since there was inconsistencies in the 1996 survey and the GFSS project's resources were limited, the GFSS group decided to use data from SOFO 1997 update of the ***'The Outlook for the European Forest Resources and Roundwood Supply 1995'*** to the extent it was possible. The data in this report had been analyzed from a consistency point of view.

Since the data was not standardized in the 1996 survey, it could only be used when no other data were available, even though the updated data material covered new countries. ***'The Forest Resources of the Temperate Zones'*** from 1990 was used in some cases because there were figures there that were not found in the other reports, e.g. mortality rates (forest undisturbed by man losses). The primary source of data is the updated SOFO 1997 estimates of the 1995 report.

A summary chart applying the criteria is a summary of our findings.

Source	Availability	Consistency	Updated	Best fit	Processing	Coverage	Standardized
1990 report	Y	Y	N	N	N	Y	Y
1996 survey	Y	N	Y	N	Y	N	N
1995 report	Y	Y	Y	N	Y	N	Y
EFI	N	Y	Y	?	?	?	Y
1997 SOFO	Y	Y	Y	N	Y	Y	Y

7.2.3 Former USSR

The data for the former USSR was obtained from the International Institute of Applied Systems Analysis, Forest Sector group Meetings were held in Vienna with the team of experts dealing with the Russian timber supply. The portion of the Institute's work deemed to be most relevant is located in the following databases:

- Forest inventory data at the forest enterprise level for Russia (2,500 enterprises);
- Industrial wood data at the forest enterprise level for Russia (2,500 enterprises);
- Forest industry data for Siberia (850 enterprises);
- Detailed cost and productivity data for the forest industry in Siberia (130 enterprises);
- Socio-economic data for Russia (65 administrative regions).

In addition to this information, various maps have been collected that will be used in a GIS-system developed around the database handling system. See Appendix 1 for more details on the Russian project.

7.2.4 North America

For North America the data was obtained from official government reports. Many industry analysts disagree with the official government statistics saying they are overly optimistic. However, it is beyond the scope of this working paper study to address the difficulties associated with this type of disagreement. It could be addressed at a later date.

In Canada, the Canadian Forestry Service provided invaluable assistance and use the Canadian Forest Inventory database to help fill in our data survey sheet. The greatest challenge is to make definitions match between different database and finding information which had not previously been collected. In the United States, the United States Forest Service assisted and many of the same data challenges emerged. Separate files on the Canadian and US data are available.

7.3 DATA COLLECTION AND ENTRY

Various experts were used to collect data for various regions of the world. They were chosen on the basis of their technical expertise in forestry, their language skills and availability to review the major wood producing countries

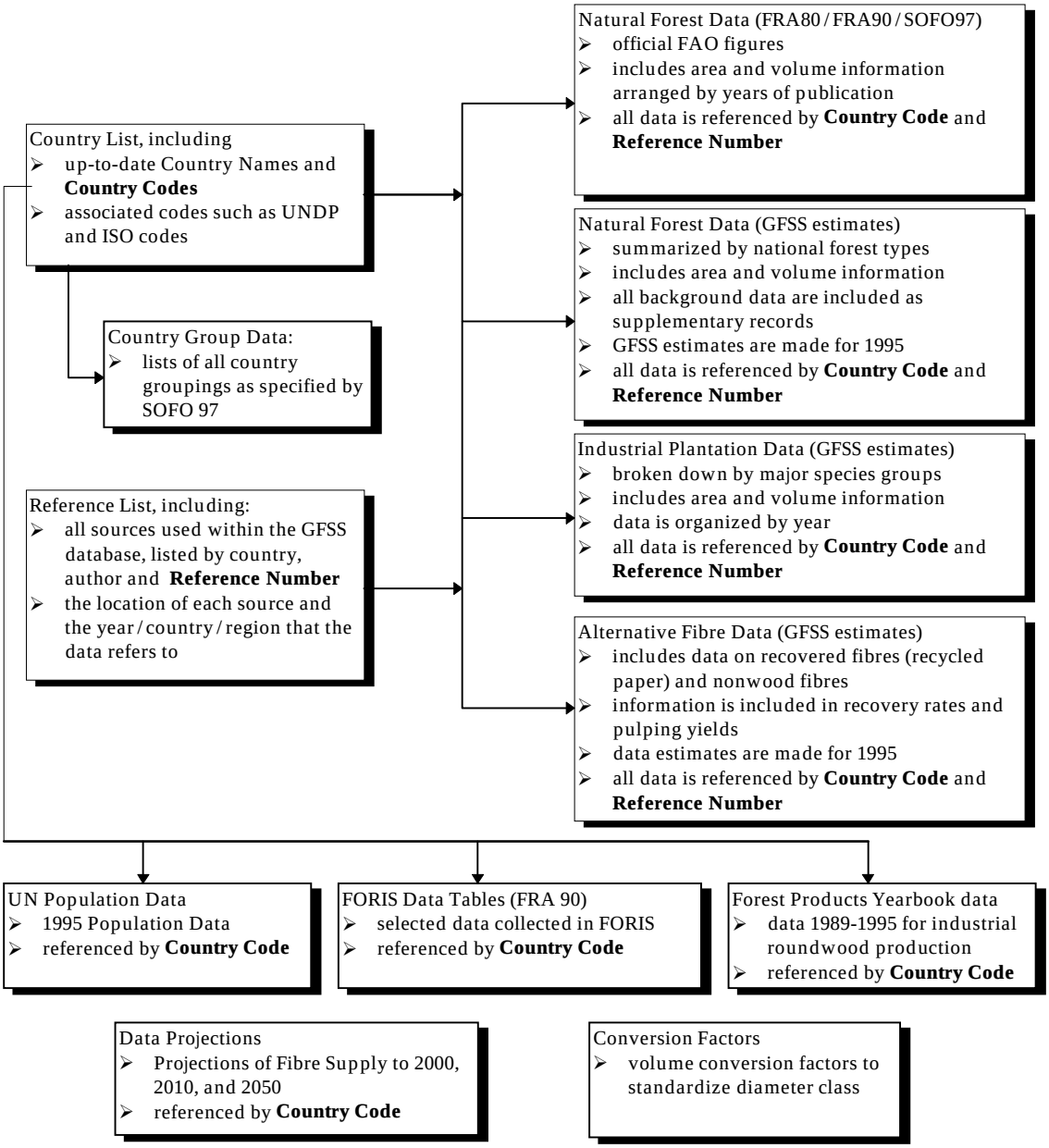
In order to ensure consistency in data entry one person was placed in charge of reviewing all data submitted by various consultants. This allowed for double checking of the numbers submitted by the consultants and it also ensured that with interpretation of statistics there was a much higher degree of consistency.

7.4 DATABASE STRUCTURE

Figure 7-3 is a summary of the GFSS database structure. The country list is provided by FAO's WAICENT statistical group. The natural forest data from the Forest Resource Assessment 1980, 1990 and the recent State of the World's Forest report is included as both an information source and as a basis for comparison. The second natural forest data table includes both the GFSS estimates and the non-FAO source data on the which the estimates were made. The industrial plantation data is now directly linked to the data produced in the FAO plantation fibre database. The alternative fibre tables contains both data and computed estimates on non-wood and recovered fibre.

The country list is also organized by the sub-regional and regional groupings. This provides the maximum flexibility in reporting. The list are connected to additional tables from either UN or other FAO sources on population, the Forest Resource Assessment 1990 (FORIS) data files and the Forest Products Yearbook industrial roundwood production. The data projection table is generated by a model built in the database and the conversion tables permit the reporting of standardized volumes.

The reference list is linked to all fibre supply sources so that database users can easily track the source for the supplied data.



(individual tables are indicated by boxes; lines denote links between each table)

Figure 0-3: Global Fibre Supply Study database structure

7.5 DATA GAP FILLING AND DATA VALIDATION

The implementation of the study is monitored by a Steering Committee, composed of FAO staff and experts from the forest industry sector, representing important producer and consumer companies. Where possible, contacts in the industry to assist in the improvement of data quality.

Internal data validation processes are underway with individual staff members who have an in-depth knowledge of a particular countries' forest resources. This allows for a first review of the data

A series of three regional workshops are being conducted for another review of the data with experts from industry, governments and NGOs. They will also allow us to gather missing information and have the supply, assumptions and projections reviewed by the countries.

The workshops are being held in Brazil with representatives from Latin America, in Malaysia with representatives from Asia-Pacific and in Ghana with representatives from West Africa.

8. SUPPLY MODELLING

8.1 INTRODUCTION

In order to develop futures for the GFSS two supply models were developed. The first model has a set of yield regulation formulae which forecast supply. Selected variables which have significant impacts on supply are quantified in order to find the estimate the effects of certain policy decisions.

The second model is more specific. It was developed to forecast the tropical sawlog and veneer log supply based on average current harvest levels and on harvest intensity in the forest disturbed and undisturbed by man. The long run sustainable fibre supply level is at least indicated by the harvest intensity once all forest available for wood supply are logged at least once. The second model has the additional benefit of exploring the impact of forest volumes of new harvesting techniques.

Each model serves as a checked on the output of the other. Since Model 1 is driven in the long run on estimates of forest increment and Model 2 is driven by the average harvest intensity they are different variables which serve as a cross-chech, one to the other. The primary objective is to improve the reliability of the estimate.

Following is a more detailed description of the supply models. Model 1 is described in detail using selected countries as case studies to illustrate an important issue. Model 2 is described very briefly for the sake of completeness. It is described more fully in working paper No. 5 in GFSS series.

8.2 METHOD 1 - INTERACTIVE GLOBAL WOOD SUPPLY MODEL

There are many different approaches to forecasting the future of fibre supply. Method 1 used as a starting point a calculated static supply line which can be based on one of several formula. This approach was chosen for the following reasons:

- It is common with many governments to start their discussion on sustainable fibre supply by using a yield regulation formula. This calculations allows for an initial quantitative line around which one begins the formulation of forest policy.
- In the future it could be necessary for countries to have a yield regulation calculation since it is a very important starting point for discussions of sustainable forest management at the country level.
- Many alternative models to fibre supply do not lend themselves to the easy manipulation of assumptions quantitatively.
- Ideally, it is most useful to generate futures for different countries with country specific assumptions. The model has been developed with the capacity to begin this type of analysis.

8.2.1 A Starting Point- Static Supply Levels

The model starts with a calculation which is a single line. This line is a starting point, a very rough indicator of where a supply level might be given current growing stock, forest increments, harvest intensity and forest losses. The line is developed for each major source of fibre: forest disturbed and undisturbed by man, industrial plantations, non-wood and recovered fibre. The line is referred to in this document as the *Static Supply Level*. The following sections describe how this line was developed.

8.2.2 Forest Disturbed and Undisturbed by Man

The individual forest undisturbed by man and forest disturbed by man can be calculated in at least four ways. A fifth equation allow for the calculation of the combined forest undisturbed by man & forest disturbed by man forest curve. There are more yield regulation formula of course and these should be examined at a later time for possible application at the global level. The formulae are as follows:

I: $$\frac{G_{ud}}{c} + (i \cdot A_d)$$

II: $$\frac{G_{ud}}{c} + (0.5 \cdot i \cdot A_d)$$ [1]

III: $$\frac{H_i \cdot A_{ud}}{c} + (i \cdot A_d)$$

IV: $$\frac{H_i \cdot A_{ud}}{c} + (0.5 \cdot i \cdot A_d)$$ [2]

V: $$2\frac{(Gud + Gd)}{r}$$ [3]

Symbol	Explanation
G_{ud}	Commercial Species Growing Stock- Forest undisturbed by man
G_d	Commercial Species Growing Stock- Forest disturbed by man
A_{ud}	Area available for wood supply- Forest undisturbed by man
A_d	Area available for wood supply- Forest disturbed by man
H_i	Harvest intensity
i	Iincrement
c	Cutting cycle
r	Rotation period

Using the sample data from the first four equations above, the following curves can be constructed.

(Note that the fifth equation is not used to construct individual Undisturbed and Disturbed Forest by Man Curves. This equation is used in the construction of ??? later in this section).

[1] These conversions first suggested by Vanniere, 1975.
[2] This equation approximates the Cotta Yield Determination. This is included in a draft of *A Handbook for the Management of Tropical Forests*, 1997.
[3] This equation approximates the Von Mantel Method which is included in a draft of *A Handbook for the Management of Tropical Forests, 1997.*

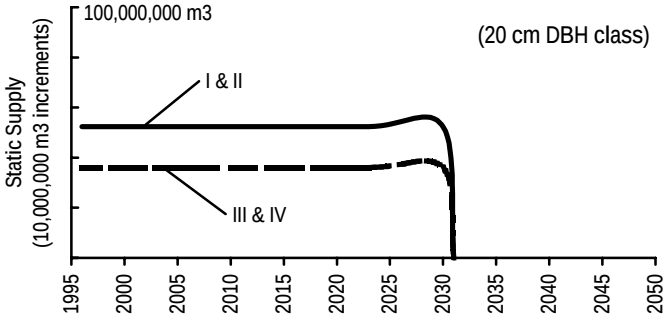


Figure 0-1: Undisturbed forest by man - Static supply levels

Figure 0-1 shows the type of curves that can be expected from the calculations above for the forest undisturbed by man. It can be seen that the fibre supply values in Equation I and II are much higher than those obtained using Equations III and IV. The lines represent the maximum annual supply of 20+ cm logs from the forest undisturbed by man forest, given a 35-year cutting cycle.

Note that no changes are made to the calculations with regards to harvest efficiency, sustainable forest management or deforestation rate. The only change is that land which is in forest undisturbed by man land, once harvested, becomes part of forest disturbed by man. Figure 0-2 for the forest disturbed by man present a different shaped supply curve.

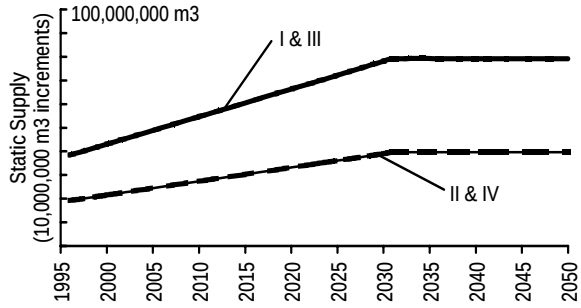


Figure 0-2: Forest disturbed by man - Static supply levels

The harvest levels for forest disturbed by man are calculated to be higher than those obtained for the forest undisturbed by man. Since the forest harvest levels are based on growth increment and forest disturbed by man forest area (which increases over time).

Having constructed the curves for the forest undisturbed by man and forest disturbed by man, they can be combined, to produce a single static supply level. Figure 0-3 below illustrates how this combination looks. Note that the data produced with Equation V (the Von Mantel Method) is included here for comparison purposes.

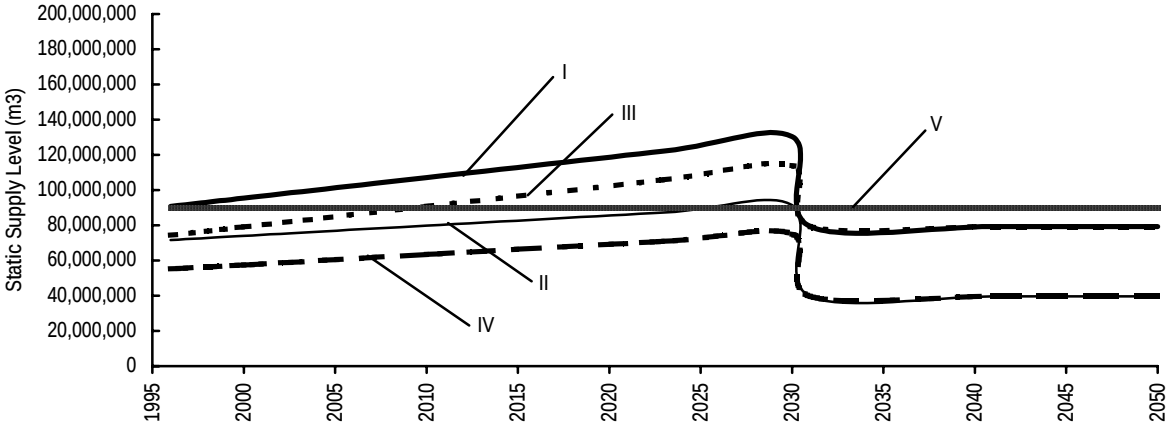


Figure 0-3: Combined forest undisturbed by man and forest disturbed by man - Static supply level curves

It is clearly depicted in Figure 0-3 that a range of figures for the Static Supply Level of Forest undisturbed by man and Forest disturbed by man can be calculated. Equations I-IV are more dynamic, however, Equation V provides cumulative values that are very similar to Equations I and II. Equation V may be very useful when unsure of the increment values, as it provides a fairly close estimate of Equations I and III.

It is important to stress that this static supply line is not a singleline forecast of the future. In the futures, which are described later, there is included, for example, the current FRA90 deforestation rate. The impact of a .96% deforestation rate in Indonesia could bring the long run static supply line down from around 75 000 000m3 to 35 000 000m3 if you use equation IV. The other supply factors which are being adjusted for describing different futures will be described in Section 0.

8.2.2.1 Addressing the Reference Diameter Class

As mentioned in previous sections, a major challenge with combining our data for forest undisturbed by man and forest disturbed by man forests is that there is not a standard ***reference diameter class*** used by each country. In order to present a comparable total and commercial species growing stock volume and to calculate biomass, conversion factors were used to bring all forest inventories to a 10cm diameter class. Brown's equation (developed for Forest Resource Assessment 1990) is used to standardise forest undisturbed and disturbed by man forest data to the 10 cm diameter class. The equation is:

Brown's Equation[4]:

$$e^{\{1.300-0.209\cdot\ln(VOB_{30})\}}$$

VOB_{30} = *Inventoried volume from 20-30 cm*

This solution, however, does not resolve the entire issue. Timber supply inventories for the forest undisturbed by man forest in tropical countries often refers to wood that is 50 cm in diameter or greater. At the present time, no formula exists to transform volumes from the 20 to 50 cm class. However, work has been done on this problem, in a report produced jointly by the Government of Indonesia and the FAO[5]. It was found that approximately **63%** of the wood reported to diameter class 20 cm could be considered wood in the 50 cm diameter class. The actual conversion factors varied between forest types are shown in Annex 1. They were developed for the Forest Resource Assessment 1990.

For equations I, II and V, the diameter class used can dramatically influence the static supply level that calculated. Figure 0-4, graphically illustrates this impact. Using Yield Equation I, the static supply level has been calculated for the combined forest undisturbed by man and forest disturbed by man for Indonesia. The white bars illustrate the production level one can expect when the forest undisturbed by man forest is adjusted to the 50+ cm diameter class, while the grey bars show the production values as standardised to the 10+ cm diameter class. The dotted line indicates the level of the unaltered, original data, taken directly from Figure 0-3.

[4] Formula from Brown, 1997, *Estimating biomass & biojmass change of tropical forests.* Forestry Paper #134, p. 9

[5] Conversion factors from *Final forest resources statistics report* pp. 32-33.

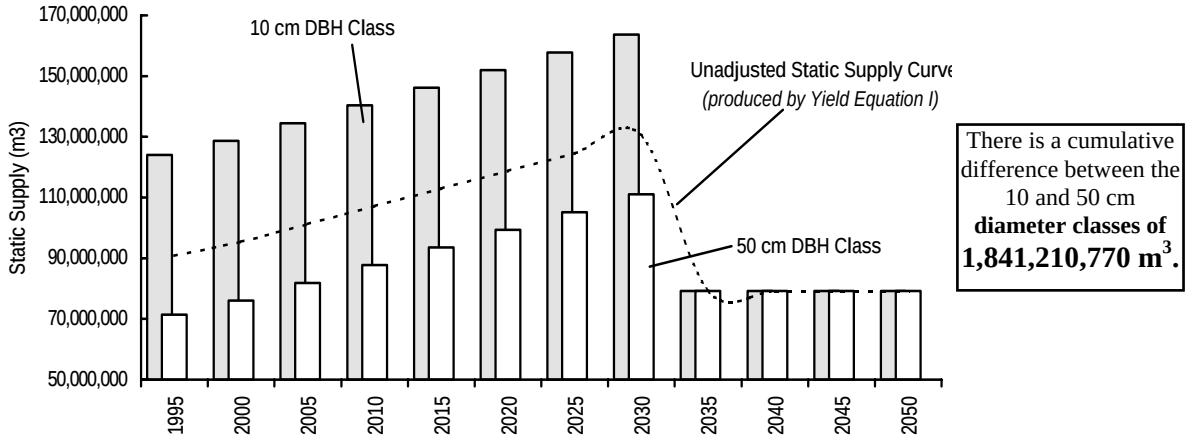


Figure 0-4: Combined forest undisturbed by man and forest disturbed by man - Static supply levels

Until more resources are allocated to deal with the diameter class issue, it is necessary to use equations III and IV for producing potential static supply lines.

8.2.3 Industrial Plantations, Non-wood Fibres and Recovered Fibres

In determining the static supply levels for industrial plantations, non-wood fibres, and recovered fibres, the array of options are narrower than with forest undisturbed by man and forest disturbed by man forests. A single calculation for each component are as follows:

Industrial Plantations: $i \cdot A_p$

Non-wood Fibres: $\%_{NPC} \cdot T_{pc}$

Recovered Fibres: $\%_{WPR} \cdot T_{pac}$

Symbol	Explanation
i	mean annual increment
A_p	net reported area of plantation
%NPC	percent non-wood pulping capacity
%WPR	percentage waste paper recovery
T_{pc}	total pulp production
T_{pac}	total paper production

In calculating the static supply level, each of these factors would be held constant. This is why the fibre supply values specified for non-wood and recovered fibres are set to the 1994 level - currently the latest year of data published by the FAO in the Forest Products yearbook at the time of writing. The wastepaper recovery rate, the non-wood pulping capacity, and the net industrial plantation area will also be set constant at the latest available figure. No changes in land use, paper consumption, or pulping capacity is incorporated when creating this line.

Using the data from Annex 3 and the three equations listed above, it is possible to produce the three lines represents the static supply level for the component indicated.

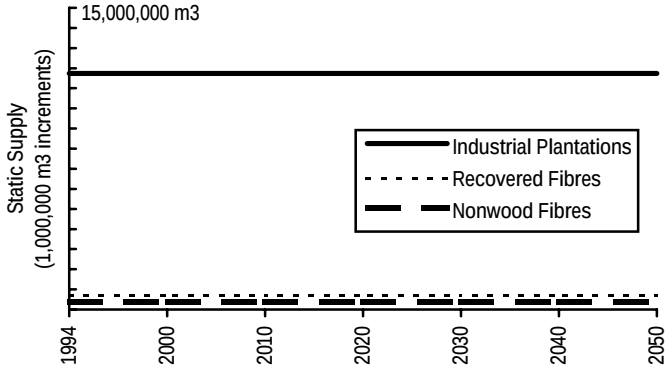


Figure 0-5: Static supply levels for industrial plantations - Non-wood fibres - Recovered fibres

Note that the levels indicated here are not cumulative. Each represents the exact static supply level that one can expect, given the current conditions and no changes to any of the factors involved. The current expected levels of recovered fibres is very low. This is due to the low levels of paper consumption in Indonesia and the lack of wastepaper available. At the current time, wastepaper is imported from the United States and Europe to achieve recycling quotas.

The levels of non-wood fibres are also very low. Indonesia relies for the most part on forest undisturbed by man and forest disturbed by man, with industrial plantations expected to become much more important in the future.

8.2.4 Verifying forecast range

Up to this point, the focus has been on calculating the static supply level. To this end, five equations have been described for calculating this value for forest undisturbed by man and forest disturbed by man, as well as defining single calculations for the industrial plantation, non-wood fibre, and recovered fibre components. All these calculations provide five levels of static supply. How can this data be related to what it is already known?

Table 0-1: Industrial roundwood production vs. static supply levels (m^3)

Equation #	Natural forest	Industrial plantations	Total static supply level	Industrial roundwood production (7-year average)	Reported annual allowable cut for natural forest
			m^3		
I & III	32,995,996	11,740,000	44,735,996		
II & IV	22,627,167	11,740,000	34,367,167		
				38,286 143	
					31,000,000

There are two publish values useful for comparision. The published industrial roundwood production for Indonesia is 38,286,143 m^3/year (taken as the 7-year average Industrial Roundwood Production). In addition, the Annual Allowable Cut for Indonesia has been given as 31,000,000 m^3/year. These values are compared in with those below. *(Note that data from Equation V is not compatible with this analysis).*

In Table 9-2 reference is only to wood taken from the forest undisturbed by man forest that is greater than 50 cm, as well as that from industrial plantations. The assumption could be made that forest

disturbed by man is made up of less valuable and second-growth wood, is not usually logged while forest undisturbed by man forest land is available, at least for sawlog and veneer log production. The volume which currently comes from non-wood and recovered fibre is currently neglibile as indicated in Figure ???-5.

The AAC for tropical countries is often calculated for the volume over 50 cm, and this fact can be confirmed in the case of Indonesia[6]. The figure represents the cut levels set for forest undisturbed by man harvest alone. Therefore the published figure of 31,000,000 m3 can be compared with the range of static supply levels that have been calculated for the forest undisturbed by man forest. The values range from 22.6 to 33 million cubic metres, which means that the GFSS calculation is reasonably aligned with the government's published figure.

The historic average industrial roundwood production figure of 38,286,143 m3/year likely includes wood from the forest undisturbed by man forest that is over 50 cm in diameter, as well other timber taken from industrial plantations. The data in Table 9-2 ranges from 35 to 44 million cubic metres.

What does this example demonstrate? The range of values calculated correlate both to other FAO figures and to national assessments. The selection of an appropriate yield regulation formula is critical to determining the Static Supply Level. Also each of our five static supply level equations for the forest undisturbed by man/forest disturbed by man forest has merit.

8.2.5 Totalling Static Supply Levels from Fibre Sources

Section 0, summarizes several methods to calculate static supply levels for forest undisturbed by man and forest disturbed by man, as well as a single calculation each for the industrial plantation, non-wood fibre, and recovered fibre components of the fibre supply. Combining these values, means it is possible to produce five different **total** static supply levels. Of these values, that produced by Equation I is the highest, while Equation IV returns the lowest overall static supply. These two equations are used in the creation of Figure 0-6.

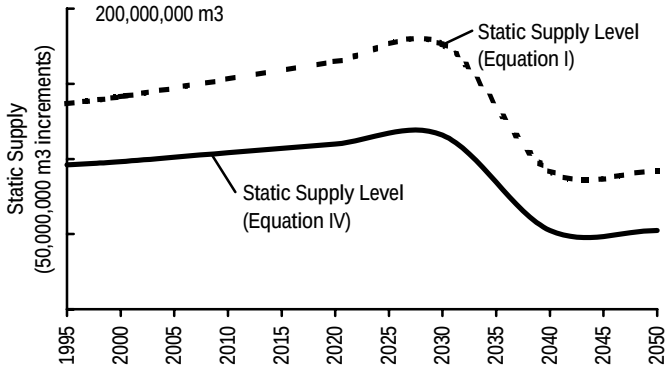


Figure 0-6: Combined static supply levels

After extensive consultations, Equation III is chosen for the moment to create the static supply level for the forest undisturbed and disturbed by man. Once the overall, combined static supply level has been created, it is possible to construct possible futures.

[6] Confirmed in *Situation and Outlook of the Forestry Sector in Indonesia, Volume 2 (forest resource base).* pp. 106-107.

8.2.6 Model Display

Table 0-5 summarizes some of the current trends for Indonesia. These statistics are critical to the calculating of forecasting trends as see in Figure 0-7.

Table 0-2: Area and volume statistics for Indonesia

Source of Fibre	Area Available for Supply	Harvesting Intensity	Cutting Cycle	Deforestation Rate[7]
Forest undisturbed by	38,187,000 ha	33 m^3/ha	35 years	1%
	Area Available for Supply	Mean Annual Increment		Deforestation Rate*
Forest disturbed by man	35,979,000 ha	1.4 m^3/ha/year		1%
	Reported Area	Survival Rate	Mean Annual Increment	Afforestation Rate*
Industrial plantations	8,317,000 ha	61%	8 m^3/ha/year	250 000ha/yr to 2010
	Pulp for Paper Production	Historical Pulp for Paper Production Rate of Change[8]	Non-wood Fibre Usage Rate	Historical Non-wood Fibre Rate of Change[9]
Non-wood Fibres	1,971,021 m^3	23%	20%	(2%)
	Paper+Paperboard Consumption	Historical Paper+Paperboard Consumption Rate of Change†	Wastepaper Recovery Rate	Historical Wastepaper Recovery Rate of Change‡
Recovered Fibres	2,583,067 m^3	7%	26%	0.4%

Using this data and the total static supply levels (shown in Figure 0-6), a cumulative fibre supply graph can be drawn, as shown in Figure 0-7 below.

[7] Figures provided by Abu-Hassan, p. 22

[8] Rate of change for paper consumption and pulp production calculated using FAO Forest Products Yearbook Figures, 1988-1994

[9] Rate of change for wastepaper recovery and non-wood fibre use provided by Mabee & Pande.

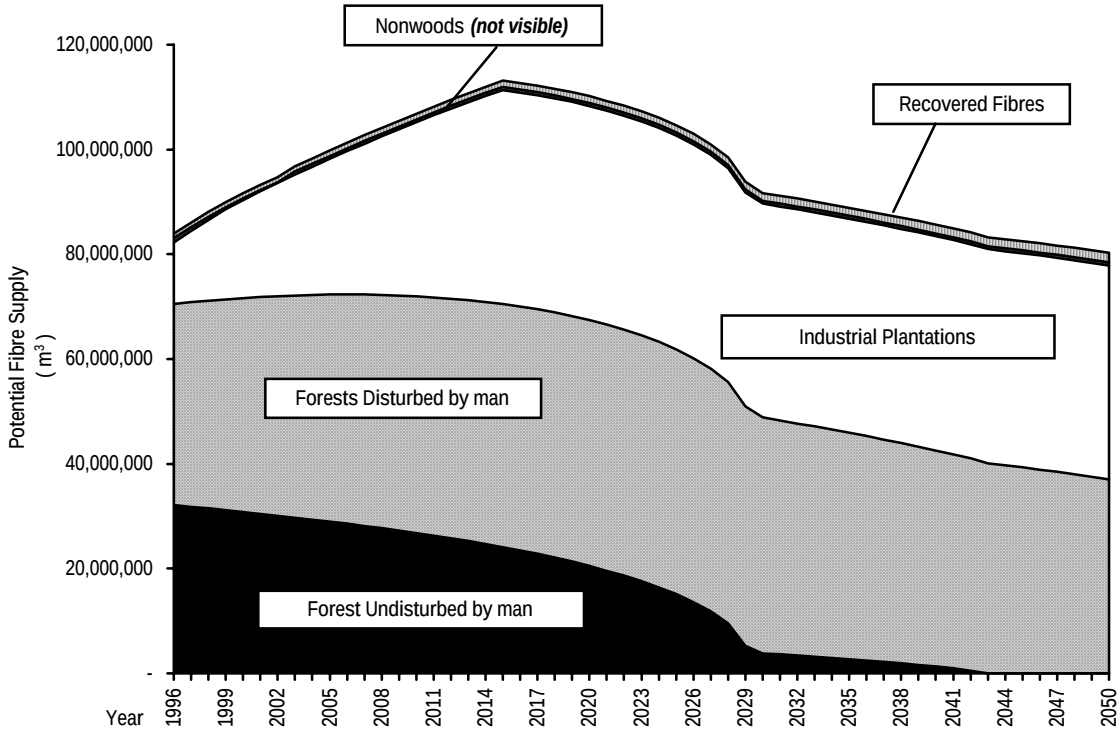


Figure 0-7: Potential future fibre supply under current trends in area available for wood supply

Figure 0-7 represents one of the possible "futures" for Indonesia. It included the current trends in land use (deforestation), industrial plantation establishment (afforestation), paper consumption and pulp production, non-wood fibre use, and wastepaper recovery.

In the forest undisturbed by man where the change is largely defined by the harvesting intensity and cutting cycle, the harvesting intensity number reflect the volume of wood removed at the forest site. In many situations the volume of wood delivered to the mill for production is at least 30% less because of waste in the form of logging residue.

The next section explains the other prevailing factors developed to simulate other possible futures for a country.

8.2.7 Factors Influencing Supply

8.2.7.1 Introduction

Table 0-3 summarized the major factors reviewed for the global fibre supply study. They include the deforestation, sustainable management, change in legally protected areas, afforestation, plantation development gains, changes in non-wood pulping capacity and increase in wastepaper recovery rate. These factors were identified by reviewing fibre supply studies carried out in recent decades and as presented in

Table 0-3.

Table 0-3: Selected major factors to influence fibre supply

	Future 1	Future 2	Future 3
Forests disturbed/undisturbed by man:			
Land Use (Deforestation):			
Sustainable Management(as expressed by cutting cycle):			
Legally Protected Area change:			
Industrial Plantations:			
Land Use (Afforestation):			
Development Gains:			
Non-wood Fibres:			
Non-wood Fibre Pulping Capacity:			
Recovered Fibres:			
Wastepaper Recovery Rate:			

Table 0-4: Timber supply issues identified in the last decade

Theme #	Major Industrial Roundwood Supply Issues	# of Cita-tions	GFSS Scenario	Link to Formula AAC=Growing Stock/Rotation Age + Increment	Range of Change in Supply	#1-Boulter and Darr 1996	#2-Margules Groome and Poyry 1996	#3 Waggener and Lane 1996	#4 Reid Collins 1995	#5 Apsey and Reed 1995	#6-Reed 1995	#7-Nilsson 1995	#8-Wall 1995	#9-Nilsson 1996	#10-McNutt 1996	#11-Sedjo and Lyons 1990	#12-Sedjo and Lyons 1995	#13-Arnold 1993	#14- Zhang and Buongiorno
1	Level of investment in basic and intensive silviculture (tree improvement, fertilization, biotechnology) and developing (emerging) countries investment stimulation policies and other assistance programs for land and mills	10	Investment in Silviculture	Increment/ Rotation	+.5%/a	US	AFR & Asia & GLO		GLO	GLO		RUS	EUR		GLO	GLO	GLO	TEM & BOR & TRO	
2	Ecosystem management eg. Riparian Areas = Environmentalist Pressures, Wood Certification, Biodiversity	8	SFM	Rotation	-60%	US & CAN	GLO	GLO		GLO			EUR	GLO	GLO			GLO	
3	Material efficiency and technology change (including logging and wood residues)	8	Material & Technology	Growing Stock	.5%/a	US	GLO	GLO	GLO			RUS			GLO	GLO	GLO		
4	Higher timber prices expanding supply	7	Economic Supply	Growing Stock	.2% to 1.2%/a	US	GLO		GLO	GLO	GLO				GLO	GLO			
5	Reduction of the land base for other interests	7	Area Change	Growing Stock		CAN	GLO	GLO		GLO				GLO	GLO			TEM & BOR	
6	Land ownership- the non-industrial landowner, fragmented ownership, privatization trends.	5	Resource Ownership	-		US	GLO						EUR		GLO			GLO	
7	Higher management and harvesting costs	5	Economic Supply	Growing Stock	100%		GLO				GLO		EUR		GLO			GLO	
8	Poor wood quality included in the inventory or poor forest condition	4	Economic Supply	Growing Stock		CAN		GLO			GLO		EUR						
9	Poor industrial and institutional infrastructure	4	Economic Supply	Growing Stock		CAN	RUS					RUS			GLO				
10	Original forest depleted	4	SFM	Growing Stock			SE ASIA								GLO		GLO	TEM & BOR	
11	Emergence of recovered and non-wood fibres	4	New Fibre	Growing Stock			GLO						EUR	GLO	GLO				
12	Plantations	3	Investment in Silviculture	Growing Stock/ Increment/ Rotation	200 000ha/a 600 000 ha/a									GLO		GLO	GLO		
13	Re-classification of the growing stock or the emergence of non-traditional supply areas	2	Area Change	Growing Stock		US	GLO												
14	Sustainable forestry which includes more social and economic objectives	2	SFM	Increment		CAN		GLO											
15	Financial abilities/flexibility of the wood products industries - Industrial restructuring	2	Resource Ownership	-			GLO								GLO				
16	Product substitution	2	Material and Technology	Growing Stock					GLO	GLO				GLO					
17	Air pollution and Global Warming	2	Investment in	Increment/Rotation								RUS						GLO	

Theme #	Major Industrial Roundwood Supply Issues	# of Cita-tions	GFSS Scenario	Link to Formula AAC=Growing Stock/Rotation Age + Increment	Range of Change in Supply	#1-Boulter and Darr 1996	#2-Margules Groome and Poyry 1996	#3 Waggener and Lane 1996	#4 Reid Collins 1995	#5 Apsey and Reed 1995	#6-Reed 1995	#7-Nilsson 1995	#8-Wall 1995	#9-Nilsson 1996	#10-McNutt 1996	#11-Sedjo and Lyons 1990	#12-Sedjo and Lyons 1995	#13-Arnold 1993	#14- Zhang and Buongiorno
			Silviculture																
18	Difficult operating terrain	1	Economic Supply	Growing Stock		CAN													
19	Competition for roundwood supply -Wood Energy and Non-wood forest products	1	New Fibre	Growing Stock				GLO						GLO					
20	Age class imbalances and lower yields on subsequent rotations	1	Investment in Silviculture	Increment/Rotation				GLO										GLO	
21	Data Uncertainty and Error	1	SFM	Increment	-20%							RUS							
22	Afforestation	1	Area Change	Growing Stock														TEM & BOR	
23	Deforestation/Conversion	1	Area Change	Growing Stock														TRO	
24	No data regarding forest area, stock and growth, therefore use production data p97																		Bingo

8.2.7.2 Forest Disturbed and Undisturbed by Man

8.2.7.2.1 Land use Change (Deforestation)

Deforestation rates used for the GFSS assessment were taken directly from the Forest Resource Assessment 1990 (Forestry Paper #112:11) using the deforestation model developed for the project. The method of calculation is now be replaced with a new model- the area production model - and it is possible to integrate this model in the near future to improve the GFSS assessment or land use change.

8.2.7.2.2 Sustainable Forest Management

In order to better understand the fibre supply impacts of the following emerging factors: sustainable forest management, wood product certification, ecosystem management, and management for biodiversity a special study was commissioned (See GFSS Working Paper #3). The study was asked to:

- Identify and quantitatively estimate the impacts of ecosystem management practises and the implementation of the accompanying silvicultural systems on projected harvest volume (both per hectare and for the overall regional supply) and timber production costs by region or country;
- Review and discuss recent developments in wood certification and assess the implications for forest management, using scenarios, where appropriate, to illustrate key points related to changes in the fibre supply;
- Discuss and assess the implications of biodiversity guidelines on future forest harvesting in terms of industrial roundwood volumes and wood quality; and,
- Provide a linkage between ecosystem management, wood certification and biodiversity guidelines and analyze their joint impact on fibre supply in the various regions, using examples, where appropriate, to illustrate key points.

The impacts vary from site to site, country to country, region to region. In order to best quantify these impacts, a cutting cycle variable was used to explore the impacts of sustainable forest management. In general, more consideration to SFM requires long-cutting cycles or in the case of clear-cut harvesting systems it requires the longer forest rotations. Therefore, a cutting cylce variable was included.

8.2.7.2.3 Land use change (Protected area)

The area of protected forest is still in a stage of significant flux and in order to explore the implications of forest policies a separate variable can be modified for each country to explore the implications.

8.2.7.2.4 Material Efficiency

There has been significant improvements in the use of wood fibre in the production of wood products in the recent decades. The GFSS team attempted to with statistics the degree of this improvement, that is the change in the amount of industrial roundwood required to produce the same amount of a particular wood product. However the results at this point have not seemed reasonable at this point to have an indication of a reasonable range of improvement.

In order to collect better baseline and projected fibre data a scientist with expertise in material efficiency and technological change is required to the following major products groups (sawnwood, pulp and woodbased panels) and, where possible, by major world regions and/or production technology. This information could then be used to broaden the analysis of the GFSS supply model.

8.2.7.3 Industrial Plantations

Development improvements

Since the growing of plantation forest is frequently cited as a solution to meet future needs for wood fibre, and it is the area where tree improvement, and is most widely applied, it is important to have a variable which reflects the variability in this improvement.

These improvement can take one of two forms: genetic gains or silvicultural improvements. The initial assumption is that development gains will lead to a 30% gain in the performance of industrial plantations. The GFSS Working Paper #2 provides a detailed assessment of field trials by some major plantations species.

8.2.7.4 Recovered and non-wood fibre

The study aims at establishing and analysing baseline data and preparing outlook scenarios for supply and utilization of recovered wood and virgin/recovered non-wood fibre. Recycling of paper will have very significant impacts in countries with strong recovered fibre programmes.

Similarly, non-wood fibre are major sources of supply in other countries.

8.2.8 Quantifying the Futures

Having established the static supply levels for the country at hand, and having utilised current trends to provide us with one possible outlook of future fibre supply, the next challenge is to find a reasonable way to utilize various factors to establish other 'future' potential fibre supply.

? In Figure 5-1, we presented one possible future based on current trends. If this was to be considered one of our futures for the actual model, we have adjusted factors as shown in Table 0-5 below. The other two futures have been left blank. It is our hope that we will be able to fill them during our discussion.

Table 0-5: Factors and scenarios for GFSS

	% Annual Change			
Factor:	Static Supply Level	$Future_1$	$Future_2$	$Future_3$
Forest undisturbed/disturbed by man:				
Land use (Deforestation):	0%	25%	-25	
Sustainable management:	0%	-10%	10	
Legally protected area change:	0%	50%	10	
Industrial plantations:				
Land use (Afforestation):	0%	50%	-20	
Development gain:	0%	100%	30	
Non-wood fibres:				
Non-wood fibre usage rate of change:	0%	10	-10	
Recovered fibres:				
Wastepaper recovery rate of change:	0%	50	10	

8.2.9 Summary

This discussion paper has described much of the background work that we have done in creating *Static Supply Levels*. It also attempts to illustrate the manner in which we will use these static supply levels to create possible *Futures*, through the manipulation of various *Factors*.

Four key points should be considered.

- There are using four techniques to calculate our *Static Supply Level* for forest undisturbed by man and forest disturbed by man forests. For GFSS model the equations selected under for now are equations #3 and #4.
- The issue of diameter class is rapidly becoming extremely problematic. If future fibre supply based is projected based on the 10 cm diameter class with the first three equations, but the primary industries in that country are lumber-based rather than fibre based, then our projections will have little relevance. It is also imperative that more research be done on the translation of wood volumes from one diameter class to another
- The question of data validation is another pressing concern. Currently, our techniques for checking data involve using other FAO figures, or in rare cases an independent fibre supply report produced to the national level. Working group meetings in three regions also improved our estimates. Broader commentary from representatives in government and industry will iporve the data even more.
- Assumptions must be reviewed and eventually transformed into quantitative variables in order to create more realistic futures.

8.3 METHOD 2 - HARVESTING INTENSITY BASED FOR TROPICAL FOREST ONLY

The benefits of this alternative modelling exercise are three-fold:

1. It serves as a basis of comparison with the GFSS model output. More specifically, it is possible to compare the sustainable yield outcomes based on harvesting intensity with yield futures based on increment (growth) of the forest.

2. It helps to divide future timber supply between high quality (sawlog/veneer log) and low quality (pulp) in term of supply. This could greatly enhance the policy discussion..

3. It allows sustainable forest management to be expressed in practical terms - average logging intensity. This expression is also useful to describe the long-term benefits of applying sustainable forest management in terms of sustainable harvest volumes.

In order to have a basis for comparing the results of the GFSS supply model, an alternative approach was taken using the harvesting intensity statistics collected from a literature review (see working paper #6). In order to model fibre supply in the tropical forest, this model presents alternative futures for the sawlogs and veneer logs component of the tropical forest and establishes two possible futures. The scope of the analysis is important to keep in mind. It is designed only for the tropical closed broadleaved forest which is now part of the forest disturbed and undisturbed by man.

9. CONCLUSIONS

This working paper presents the essential building blocks for the GFSS database and modelling efforts. It was written in an attempt to make the methodology transparent and to invite commentary and criticism from analysts in the forestry sector. It is hoped that the effort will lead to a continual effort to improve the quality of data by convincing governments and industry on the usefulness of good forest inventory data. This in turn will make the selection of 'good'policy choices in forestry more achievable.

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11. ANNEX 1: DEFINITIONS AND CONVERSION FACTORS

MAJOR DEFINITIONS USED IN THE GLOBAL FIBRE SUPPLY STUDY (GFSS)

Table of Contents

Special notes: The markings in the left hand margin indicate the definitions which are extracted directly from Global Forest Resouce Assessment 2000 definitions.

Also note that the back pages are organizational charts explaining how land is organized for GFSS report.

1. LAND CLASSIFICATION

1.1. TOTAL AREA

Total area of country, including area of inland water bodies.

Excludes: offshore territorial waters

1.1.1. Inland water

Area occupied by major rivers, lakes and reservoirs.

1.1.2. Land area

Total area, excluding inland water.

1.2. OTHER LAND

Land not classified as forest or other wooded land as they are defined in this study.

1.3. FOREST AND OTHER WOODED LAND

1.3.1. Forest

1.3.1.1. Natural forest (does not exist in the GFRA)

Land with tree crown cover (or equivalent stocking level) of more than 10 percent and area of more than 0.5 hectare. The trees should be able to reach a minimum height of 5 m at maturity *in situ*.

May consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground; or of open forest formations with a continuous vegetation cover in which tree crown cover exceeds 10 percent. Young natural stands and all plantations established for forestry purposes which have yet to reach a crown density of 10 percent or tree height of 5 m are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention or natural causes but which are expected to revert to forest.

Includes: forest nurseries and seed orchards that constitute an integral part of the forest; forest roads, cleared tracts, firebreaks and other small open areas within the forest; forest in national parks, nature reserves and other protected areas such as those of special environmental, scientific, historical, cultural or spiritual interest; windbreaks and shelterbelts of trees with an area of more than 0.5 hectare and width of more than 20 m. Rubberwood plantations and cork oak stands are included.

Excludes: land predominantly used for agricultural practices.

It is worthwhile pointing out that the definition of forest used in the present study has a minimum vegetation cover requirement and is quite different from a legal definition of forest (i.e. an area proclaimed to be forest under a Forest Act or Ordinance).

Natural forest can be:

1.3.1.1.1. Forest undisturbed by man

Forest which shows natural forest dynamics, such as natural tree composition, occurrence of dead wood, natural age structure and natural regeneration processes, the area of which is large enough to maintain its natural characteristics and where there has been no known significant human intervention or where the last significant human intervention was long enough ago to have allowed the natural species composition and processes to have become re-established.

1.3.1.1.2. Forest disturbed by man (GFRA: semi-natural forest)

Forest which is neither "forest undisturbed by man" nor "plantation" as defined separately.

1.3.1.2. Plantation(s)

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 plantation, even age class, regular spacing.

Excludes: Stands which were established as plantations but which have been without intensive management for a significant period of time. These should be considered semi-natural.

1.3.2. Other wooded land

Land either with a tree crown cover (or equivalent stocking level) of 5-10 percent of trees able to reach a height of at least 5 m at maturity *in situ*; or crown cover (or equivalent stocking level) of more than 10 percent of trees not able to reach a height of 5 m at maturity *in situ* (e.g. dwarf or stunted trees) and shrub or bush cover.

Excludes: areas having the tree, shrub or bush cover specified above but of less than 0.5 ha and width of 20 m, which are classed under “other land”; land predominantly used for agricultural practices.

1.3.2.1. Other wooded land undisturbed by man

Other wooded land which shows natural forest dynamics, such as natural tree composition, occurrence of dead wood, natural age structure and natural regeneration processes, the area of which is large enough to maintain its natural characteristics and where there has been no known significant human intervention or where the last significant human intervention was long enough ago to have allowed the natural species composition and processes to have become re-established.

1.3.2.2. Other wooded land disturbed by man (GFRA: semi-natural)

Other wooded land which is neither "other wooded land undisturbed by man" nor "plantation" as defined separately.

2. FOREST CLASSIFICATION SYSTEM

For the purpose of the present study it has been decided to use the country’s own forest classes as much as possible. The advantage of this approach is that country experts can readily understand our data description and can readily evaluate our estimates. We also anticipate that many countries will continue to maintain their forest inventories using these classes, or at the very least some link to these classes**.**

Countries can classify forests by geographic location, by forest type, or some combinations of these elements. However, where no such classes were available, closed and open forest definitions as developed for the 1980 FAO Tropical Forest Resources Assessment were used. Examples of the classification systems used by the countries and in the GFSS are presented in 0, 2.1. Country classes. Each forest class can also be further subdivided in species groups. The definitions of these groups are presented in 0, 2.2. Species Groups.

2.1. COUNTRY CLASSES

2.1.1. Geographical location

Geographical systems usually refer to the location or the altitude where the forests occur (montane forest, lowland etc.). An example for a geographical classification is Colombia. Publications that report forestry related data on a national level usually refer to *Pacifico*, *Andina*, *Caribe*, *Orinoquia* and *Amazonia*. Another example is the Republic of Congo, where data is reported according to the major geographical regions: *North*, *Chaillu*, *Kouilou-Mayombe*.

2.1.2. Forest type

Forest type classification systems used by countries usually refer to the forest formation (high forest, shrubs), to the climatic or edaphic conditions under which the forest is growing, to the species composition, to the quality of the timber and to many other factors (harvesting status etc.).

Examples for such types are: deciduous thornbush, Evergreen bushland and thicket, rainforest, swamp forest, etc. Frequently other factors such as the logging status or the timber density and quality become used in the classes. A typical example for such a system is Malaysia, which uses, for example, mixed dipterocarp forest superior, good, medium, poor, and commercial forest superior, good, poor etc. Frequently forest types are combined with geographical classes.

2.1.3. Closed/open

2.1.3.1. Closed Forest

Closed forests are vegetation formations where trees occur in single or multiple stories with crowns interlocking, which, in conjunction with the undergrowth, cover a high proportion of the ground and consequently do not have a continuous dense grass layer at the ground level. They are either managed or unmanaged forests, primary or in advanced state of succession and may have been logged-over one or more times, having kept their characteristics of forest stands, possibly with modified structure and composition.

2.1.3.2. Open Forest

Open forests are vegetation formations where trees occur with discontinuous, non-interlocking crowns, but with a crown coverage of at least 10 percent. Generally there is a continuous grass layer allowing grazing and spreading of fires. Examples are various form of “cerrado” and “chaco” in Latin America, tree and wooded savannas, and wooded lands in Africa, dry dipterocarps forests and “forêts claires” in Asia.

The division between closed and open forests is more of ecological than of physiognomic nature, not characterized only by a crown cover percentage. A dense forest after logging may look as open forest from crown cover point of view alone; however, it cannot be classified as open forest unless there are some permanent changes in flora, fauna and soil condition due to repeated fire, grazing, etc. which keep the forest in a sub-climax stage.

2.2. SPECIES GROUPS

2.2.1. Predominantly coniferous forest/other wooded land

Forest land on which more than 75 percent of the tree crown cover consists of species classified botanically as *Gymnospermae*. They are sometimes referred to as “softwoods”.

2.2.2. Predominantly broadleaved forest/other wooded land

Forest land on which more than 75 percent of the tree crown cover consists of trees classified botanically as *Angiospermae*. They are sometimes referred to as “non-coniferous” or “hardwoods”..

2.2.3. Predominantly bamboos, palms, etc.

Forest/other wooded land on which more than 75 percent of the crown cover consists of tree species other than coniferous or broadleaved species (e.g. tree-form members of the bamboo, palm, fern families).

2.2.4. Mixed forest/other wooded land

Forest/other wooded land on which neither coniferous, nor broadleaved, nor palms, bamboos, etc. account for more than 75 percent of the tree crown area.

3. FOREST FUNCTION

Forest function is defined with reference to the forest land capability to support land uses like nature conservation, soil and water protection, wood production, etc. For the present study two main classes are defined:

3.1. FOREST AVAILABLE FOR WOOD SUPPLY

Forest where any legal, economic, or specific environmental restrictions (see 0) do not have a significant impact on the supply of wood

Includes: areas where, although there are no such restrictions, harvesting is not taking place, for example areas included in long-term utilization plans or intentions.

3.2. FOREST NOT AVAILABLE FOR WOOD SUPPLY

Forest where legal or economic restrictions prevent any significant supply of wood.

Includes:

3.2.1. Legal restrictions

Forest with legal restrictions or restrictions resulting from other political decisions, which totally exclude or severely limit wood supply, *inter alia* for reasons of environmental or biodiversity conservation, e.g. protection forest, national parks, nature reserves and other protected areas, such as those of special environmental, scientific, historical, cultural or spiritual interest.

Area under IUCN management categories I or II is considered as protected from wood harvesting (for IUCN management categories see 0.

3.2.2. Economic restrictions

Forest with economic restrictions due to environmental, physical or wood quality factors, e.g. environmental regulation on harvesting systems, steep terrain; terrain dominated by swamps and/or rocks interspersed with some commercial trees; deformed growth of individual trees; and fire, insect and/or disease damaged forests. All restrictions other than legal restrictions can be summarized as economic restrictions. For the purpose of the GFSS, they are subdivided in three classes:

3.2.2.1. Physical reasons (I)

Harvesting is economically unfeasible at the current wood price level because the terrain conditions require extraordinary equipment or time.

3.2.2.2. Transport distance/lack of infrastructure (II)

Remote forests where transport distance for logs or products is too high or where access is currently not provided. The situation can change if for instance the government or the industry invests in infrastructure.

3.2.2.3. Other (III)

E.g. low growing stock volume, wood quality too low, no commercial species.

4. OWNERSHIP

Three classes of ownership are distinguished:

4.1. PUBLIC

Forest/other wooded land belonging to the state or other public bodies.

4.1.1. State

Forest/other wooded land owned by national, state and regional governments, or by government-owned corporations; crown forest and other wooded land.

4.1.2. Other public

Forest/other wooded land belonging cities, municipalities, villages and communes.

Includes: any publicly owned forest and other wooded land not classified as being “in state ownership”.

4.2. INDIGENOUS AND TRIBAL PEOPLES

Indigenous and tribal peoples in independent countries are defined as those who:

(1) are regarded as indigenous on account of their descent from the populations which inhabited the country, or a geographical region to which the country belongs, at a time of conquest or colonization or the establishment of present state boundaries and who, irrespective of their legal status, retain some or all of their own social, economic, cultural and political institutions;

(2) are tribal peoples whose social, cultural and economic conditions distinguish them from other sections of the national community, and whose status is regulated wholly or partly by their own customs or traditions or by special laws and regulations.

For both categories (1) and (2) self-identification as indigenous or tribal shall be regarded as the fundamental criterion for determining the groups. (Source: ILO Convention No. 169 on "indigenous and tribal peoples").

For the purpose of the Global Fibre Supply Study this data is collected under “private ownership”.

4.3. PRIVATE

Forest/other wooded land owned by individuals, families, co-operatives and corporations which may be engaged in agriculture or other occupations as well as forestry; private forest enterprises and industries; private corporations and other institutions (religious and educational institutions, pension and investment funds, nature conservation societies, etc.).

4.3.1. Individuals

Forest and other wooded land owned by individuals or families, including those who have formed themselves into companies.

Includes: individuals and families who combine forestry with agriculture (farm forests), those who live in or near their forest holdings, and those who live elsewhere (absentee owners).

4.3.2. Other private institutions

Forest/other wooded land owned by private corporations, co-operatives or institutions (religious, educational, pension or investment funds, nature conservation societies, etc.).

5. DEFORESTATION AND DEGRADATION

5.1. DEFORESTATION

Deforestation refers to change of land use with depletion of tree crown cover to less than 10 percent. Changes within the forest class (e.g. from closed to open forest) which negatively affect the stand or site and, in particular, lower the production capacity are termed forest degradation.

5.2. DEGRADATION

Forest degradation takes different forms, particularly in open formations, deriving mainly from human activities such as over grazing, over exploitation (for firewood in particular), repeated fires, or due to attacks by insects, diseases, plant parasites or other natural sources such as cyclones. In most cases degradation does not show up so much as a decrease in the area of woody vegetation but rather as a gradual reduction of biomass, changes in species composition and soil degradation. The logging of forests for sawlogs and veneer logs without a proper management plan can contribute to degradation if the extraction of mature trees is not accompanied with their regeneration or if the use of heavy machinery causes soil compaction or loss of productive forest area.

6. PLANTATION

6.1. FOREST PLANTATIONS

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 plantation, even age class, regular spacing.

6.1.1. Industrial forest plantations

Forest plantations grown mainly for the production of industrial roundwood (sawtimber, veneer, pulp, reconstituted wood). Note that industrial roundwood may also come from non-forest plantations and trees grown outside the forest.

6.1.2. Non-industrial plantation

Planted trees established mainly for domestic use or for use in non-forest industries, including fuelwood and poles, non-wood forest products and for service functions such as protection. Non-industrial tree plantations are assumed not to make a significant contribution to industrial roundwood supplies and thus data referring to these plantations (where they can be identified) are not used as inputs to the GFSS.

6.1.3. Indigenous tree species

Tree species which have evolved in the same area, region or biotope where the forest stand is growing and are adapted to the specific ecological conditions predominant at the time of the establishment of the stand. May also be termed native species or autochthonous species.

6.1.4. Introduced tree species

Tree species occurring outside their natural vegetation zone, area or region. May also be termed non-indigenous species.

Includes: Hybrids

6.2. TREES OUTSIDE THE FOREST

Trees on land other than forest or other wooded land.

Includes: Trees on land that meets the definitions of forest and of other wooded land except that the area is less than 0.5 ha and the width is less than 20 m; scattered trees in permanent meadows and pastures; permanent tree crops such as fruit tree orchards and coconut palm plantations; trees in parks and gardens, around buildings, in hedgerows and in lines along streets, roads, railways, rivers, streams and canals; trees in shelterbelts and windbreaks of less than 20 m in width and 0.5 ha in area.

6.3. PLANTATION AREA

6.3.1. Reported area

The plantation area reported to be present, either by government, industry, or some outside source. Normally this refers to the area planted or planned, but does not take into account the area actually stocked.

6.3.2. Net area

The reported area reduced by a factor to allow for plantation area losses due to failed plantation areas, fire etc. In the absence of any specific information or opinion a default value of 0.7 reduction has been used (taken from FAO Forestry Paper #128).

7. FOREST VOLUME AND GROWTH

7.1. BIOMASS

7.1.1. Tree

A woody perennial with a single main stem or, in the case of coppice, with several stems, having a more or less definite crown.

Includes: bamboos, palms and other woody plants meeting the above criterion.

7.1.2. Shrubs and bushes

Woody perennial plants, generally of more than 0.5 m and less than 5 m height, and often without a definite stem and crown.

7.1.3. Woody biomass

The mass of the woody parts (wood, bark, branches, twigs, stumps and roots) of trees, alive and dead, shrubs and bushes, measured to a minimum diameter of 0 mm (d.b.h.).

Includes: Above-stump woody biomass, and stumps and roots.

Excludes: Foliage.

7.1.4. Above-stump woody biomass [tons/ha]

The mass of the woody part (stem, bark, branches, twigs) of trees, alive or dead, shrubs and bushes, excluding stumps and roots

7.1.5. Stumps and roots

Parts of the whole tree volume, which exclude the volume of the above-stump woody biomass. The height of the stump is taken to be that at which the tree would be cut under normal felling practices in that country or region.

Excludes: Small roots.

7.2. VOLUMES

7.2.1. Growing stock [m^3 /ha]

Living volume of standing trees, above-stump measured overbark to top. Includes all trees with diameter over a reported reference diameter (diameter at breast height, d.b.h.).

Excludes: branches.

7.2.2. Commercial growing stock [m^3/ha]

Part of the growing stock, that consists of species considered as actually or potentially commercial under current (1995) market conditions, at the reported reference diameter (d.b.h.). Can be identical to the growing stock, but can also be much smaller if only very few species are merchantable or greater if the forest available for supply consists of high volume stands only.

Includes: species which are currently not exported, but potentially commercial having appropriate technological properties; species provided to the local market are included.

7.2.3. Reference diameter [cm]

Inventory diameter at breast height used for determining the growing stock and commercial growing stock. Volumes can be converted to different reference diameters, using conversion factors as presented in 0.

7.3. GROWTH

7.3.1. Gross annual increment (mean annual increment) [m^3/ha]

Average annual volume of increment over the reference period of all trees, measured to a minimum diameter breast height (d.b.h.) of 0 centimetres (cm).

7.3.2. Natural losses [m^3/ha]

Average annual losses to the growing stock during the given reference period, measured to a minimum diameter of 0 cm (d.b.h.), due to mortality from causes other than cutting by man, e.g. natural mortality, diseases, insect attacks, fire, windthrow or other physical damage.

7.3.3. Net annual increment [m^3/ha]

Average annual volume over the given reference period of gross increment less that of natural losses on all trees to a minimum diameter of 0 cm (d.b.h.).

7.4. AGE

7.4.1. Cutting cycle [years]

The silvicultural/harvesting cycle chosen for the sustainable harvest of timber. It is dependent on management objectives for the forest.

7.4.2. Rotation age [years]

The planned number of years between the establishment or regeneration of a tree crop or stand and its final cutting at a specified stage of maturity.

8. VOLUME AND BIOMASS CONVERSION

8.1. GROWING STOCK CONVERSION

Where nationwide, or local growing stock volumes are not available from the inventory data base, or if volume data are reported only for a fraction of species (usually commercial species) special measures will be necessary to obtain standard cubic meter volume estimates.

To obtain growing stock volumes for all dbh classes down to 10 cm d.b.h., use should be made of appropriate conversion tables. Volume conversion factors, dependent on given minimum limits can be found in the table, which was prepared from data given in the following sources:

> Brown, Sandra (1990): Volume expansion factors for tropical forests. Paper prepared for the FAO Tropical Forest Resources Assessment 1990 Project. University of Illinois, Department of Forestry, 9pp.
>
> Brown, Sandra (1997): Estimating biomass and biomass change of tropical forests: A Primer. FAO Forestry Paper 134, Rome.

The equation used to convert total growing stock (m^3/ha) from the reference diameter to the adjusted diameter of 10 cm was as follows:

$$\text{Total Growing Stock (Adjusted)} = \text{Total Growing Stock} \cdot \text{Volume Expansion Factor}$$

where the volume expansion factor was dependent upon forest type and diameter class, as indicated below.

Undisturbed (Closed) Forest	Disturbed (Closed) Forest	Diameter Range
1	1	If 10<d<20
1.2	2.1	If 25<d<30
1.5	2.5	If 35<d<40
2.2	4.1	If 45<d<50

8.2. BIOMASS CONVERSION

To convert growing stock (m^3/ha) to total forest biomass, the appropriate conversion factor is found using the equation postulated by Brown (1990). This equation is as follows.

$$\textbf{Total Forest Biomass} = \textbf{Growing Stock } (\mathbf{m^3 / ha}) \cdot \textbf{Wood Density } (\mathbf{t / m^3}) \cdot \textbf{Biomass Expansion Factor}$$

where wood density is dependent on the region, as shown below:

(Africa):	0.58 t/m^3
(Latin America):	0.60 t/m^3
(Asia):	0.57 t/m^3

and b**iomass expansion factor** is:

$e^{\left\{3.213-0.506\cdot\ln(GrowingStock(m^3/ha)\cdot WoodDensity(t/m^3)\right\}}$ where {growing stock*wood density} < 190 t/ha

or

1.74 where {growing stock*wood density} = 190 t/ha

This equation provides the total forest biomass, a number which indicates the entire volume of leaf, branch, and stem of all trees and shrubs within the forest ecosystem.

9. FOREST UTILIZATION

9.1. ANNUAL FELLINGS [1,000 M^3]

Average annual standing volume of all trees, living or dead, measured overbark to a minimum diameter of 0 cm (d.b.h.), that are felled during the given reference period, including the volume of trees or parts of trees that are not removed from the forest, other wooded land or other felling site. Includes: silvicultural and pre-commercial thinnings and cleanings left in the forests; and natural losses that are recovered (harvested)

9.2. UNRECOVERED FELLINGS (HARVESTING RESIDUES) [1,000 M^3]

Felling residuals, which are left in the forest after felling and not salvaged.

Excludes: parts of the tree left *in situ* after felling, e.g. stumps and roots, and parts of the felled tree not recorded in the volume of fellings (see above). Normally the volume over bark.

9.3. ANNUAL REMOVALS [1,000 M^3]

Average annual of those fellings that are removed from the forest, other wooded land or other felling site during the given reference period.

Includes: removals during the given reference period of trees felled during an earlier period and removal of trees killed or damaged by natural causes (natural losses), e.g. fire, windblow, insects and diseases.

9.4. HARVESTING INTENSITY [M^3/HA]

Volume actually removed from the forest within one cutting cycle. This volume may include wood for industrial purposes (e.g. sawlogs, veneer logs, etc.) and for local domestic use (e.g. rural uses for construction). Use of wood for fuelwood will not be included in this category. May show a significant difference for natural and semi-natural forest.

9.5. ROUNDWOOD (CONIFEROUS, NON-CONIFEROUS) [1,000 M^3]

Wood in the rough. Wood in its natural state as felled or otherwise harvested, with or without bark, round, split, roughly squared or in other form. It may also be impregnated or roughly shaped or pointed. It comprises all wood obtained from removals, i.e. the quantities removed from forests and from trees outside the forest, including wood recovered from natural, felling and logging losses during the period, calendar year or forest year. Commodities included are sawlogs and veneer logs, pulpwood, other industrial roundwood (including pitprops) and fuelwood. The FAO statistics include recorded volumes, as well as estimated unrecorded volumes.

9.5.1. Industrial roundwood [1,000 m^3]

The commodities included are:

- Sawlogs and veneer logs
- Pulpwood
- Other industrial roundwood (includes roundwood used for tanning, distillation, match blocks, gazogenes, poles, piling, posts, pitprops, etc.).

9.5.2. Fuelwood and charcoal

Wood in the rough (from trunks and branches of trees) to be used as fuel for purposes such as cooking, heating or power production. Wood for charcoal, pit kilns and portable ovens is included.

10. ALTERNATIVE FIBRES

Any fibre source that does not come directly from a tree. These fibre sources include:

10.1. NONWOOD FIBRES

Fibres that come from a nonwood species of plant. Nonwoods include Abaca (Manila Hemp), Bagasse, Bamboo, Corn stalk and Sorghum, Cotton fibre and stalks, Crotalaria (Sun Hemp), Esparto, Flax straw, Hemp, Jute, Kenaf core & bast, Rags, Reeds, Rice straw, Sisal and Wheat straw.

Nonwoods are scientifically defined as non-woody cellulosic plant materials from which papermaking fibres can be extracted. Most nonwoods are annual plants that develop full fibre potential in one growing season or less. Historically, paper was made almost exclusively from nonwoods. Today, most nonwoods are used in other industries, such as textiles. Other related terms are:

10.1.1. Nonwood Fibre Usage Rate

The percentage of pulp for paper production that consists of nonwood fibres.

10.1.2. Historical Nonwood Fibre Usage Rate of Change

The annual percent change in the nonwood fibre usage rate. This is calculated by using the past five years worth of data on nonwood fibre usage and pulp for paper production. Not to be confused with the *Nonwood Fibre Usage Rate of Change* factor (see Section 0below).

10.1.3. Pulp for Paper Production

The total production of pulp that is intended for paper or paperboard products.

10.2. RECOVERED FIBRES

Recovered fibre refers to any fibre that is recycled, or used ore than once in the manufacture of paper or board products. A recovered fibre may be wood or nonwood in origin. It may be recovered more than once, although the accepted upper limit for recycling is about 5 times. A recovered fibre is not as strong as a virgin fibre, often possesses less flexibility, and are likely to split along the vertical axis. Most recovered fibre comes from recycled paper sources. Other related terms are:

10.2.1. Wastepaper Recovery Rate

The percent of overall paper and paperboard consumption that is recovered for recycling. This figure is not always related to the consumption of recycled products.

10.2.2. Historical Wastepaper Recovery Rate of Change

The annual percent change in the wastepaper recovery rate. This is calculated by using the past seven years worth of data on wastepaper recovery and paper and paperboard consumption. Not to be confused with the *Wastepaper Recovery Rate of Change* factor (see section 12 below).

11. GFSS FUTURE PROJECTION TERMS

Quite a number of terms are used in constructing GFSS future potential supply curves. These include:

11.1. FUTURES

This term replaces other misleading or confusing terms such as *scenario* or *outlook*. In the context of the GFSS, futures refers to the different potential supply curves that we can construct by adjusting factors and projecting the results over the next half century. The GFSS will produce three such futures, labeled $Future_1$, $Future_2$, and $Future_3$.

11.2. FACTORS

The variables that are included in the construction of future projections for each component. These variables are listed by component below.

11.2.1. Factors affecting natural forests

11.2.1.1. Land use (Deforestation)

The factor which controls the rate of deforestation caused by thinning or conversion of forests to a deforested state, i.e. a permanent crown cover of less than 10%.

11.2.1.2. Land use (Conservation)

The factor which controls the amount of forested land with legal restrictions which totally exclude or severely limit wood production, *inter alia* for reasons of environmental and biodiversity conservation, e.g. national parks, nature reserves and other protected areas such as those of special environmental, scientific, historical, cultural or spiritual interest.

11.2.1.3. Harvest efficiency

The factor which controls the efficiency with which timber is removed from the landscape and subsequently utilized. This affects both the amount of unrecovered fellings that one can expect in harvesting, and the yield that individual trees can provide due to better or worse harvesting techniques.

11.2.1.4. Sustainable forest management

The factor which controls the impact of sustainable forest management programs. The impacts of such programs affect total fibre yield to change the harvest scheduling in the area available for wood supply. To express sustainable forest management in quantitative terms means changing the silvicultural/harvesting system which in turn means changing the cutting cycle or increasing the rotation age used for forest utilization. Using this approach gives the forest manager a greater ability to address forest management issues such as riparian zone management, wildlife corridors management, appropriate regeneration programs, biodiversity and appropriate technology for tree harvesting.

11.2.2. Factors affecting industrial plantations

11.2.2.1. Land use (afforestation)

The factor controlling the rate at which new plantation area is added to the overall reported area.

11.2.2.2. Success rate

The factor which controls the plantation success rate, allowing for improvements in plantation establishment and management to be included in the model.

11.2.2.3. Research and Development gains

R&D gains, includes improvement in the establishment success rate (i.e. fewer gaps to reduce yields), as well as increases in growth and yield arising from research (especially tree improvement but also establishment techniques, site amelioration etc), improved management, and from greater experience of staff and labour.

11.2.3. Factors affecting alternative fibres

11.2.3.1. Nonwood fibre usage rate of change

The factor which controls the change in percent nonwood fibres used in the manufacture of pulp for paper. This allows for eventual increases or decreases in the percent used.

11.2.3.2. Nonwood fibre yield

The factor which controls the yield of nonwood fibres from a hectare of land. Adjusting this factor allows us to model improvements in agricultural and harvesting practices.

11.2.3.3. Wastepaper recovery rate of change

The factor which controls the change in percent recovery of wastepaper.

11.2.3.4. Wastepaper recovery fibre yield

The factor which controls the amount of fibres that one can receive from a metric ton of wastepaper.

11.3. BASE REFERENCE POINT

The calculated, agreed-upon 1995 figure in the GFSS database that is used as a starting point for all future calculations. Each component of a projected line is somehow constructed from the base reference point.

11.4. STATIC SUPPLY LEVEL

A “flat” projection of fibre supply that is extended into the future. The difference between this and the possible futures is that no factor is adjusted and no trends are included. All the future models are built off of this line. All of the factors listed above are held static at the 1995 level for the construction of the static supply level.

12. IUCN MANAGEMENT CATEGORIES

[I] Strict Nature Reserve / Wilderness Area: protected area managed mainly for science or wilderness protection

These areas possess some outstanding ecosystems, features and/or species of flora and fauna of national scientific importance, or they are representative of particular natural areas. They often contain fragile ecosystems or life forms, areas of important biological or geological diversity, or areas of particular importance to the conservation of genetic resources. Public access is generally not permitted. Natural processes are allowed to take place in the absence of any direct human interference, tourism and recreation. Ecological processes may include natural acts that alter the ecological system or physiographic features, such as naturally occurring fires, natural succession, insect or disease outbreaks, storms, earthquakes and the like, but necessarily excluding man-induced disturbances.

[II] National Park: protected area managed mainly for ecosystem protection and recreation

National parks are relatively large areas, which contain representative samples of major natural regions, features or scenery, where plant and animal species, geomorphological sites, and habitats are of special scientific, educational and recreational interest. The area is managed and developed so as to sustain recreation and educational activities on a controlled basis. The area and visitors' use are managed at a level which maintains the area in a natural or semi-natural state.

[III] Natural Monument: protected area managed mainly for conservation of specific natural features

This category normally contains one or more natural features of outstanding national interest being protected because of their uniqueness or rarity. Size is not of great importance. The areas should be managed to remain relatively free of human disturbance, although they may have recreational and touristic value.

[IV] Habitat/Species Management Area: protected area managed mainly for conservation through management intervention

The areas covered may consist of nesting areas of colonial bird species, marshes or lakes, estuaries, forest or grassland habitats, or fish spawning or seagrass feeding beds for marine animals. The production of harvestable renewable resources may play a secondary role in the management of the area. The area may require habitat manipulation (mowing, sheep or cattle grazing, etc.).

[V] Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation and recreation

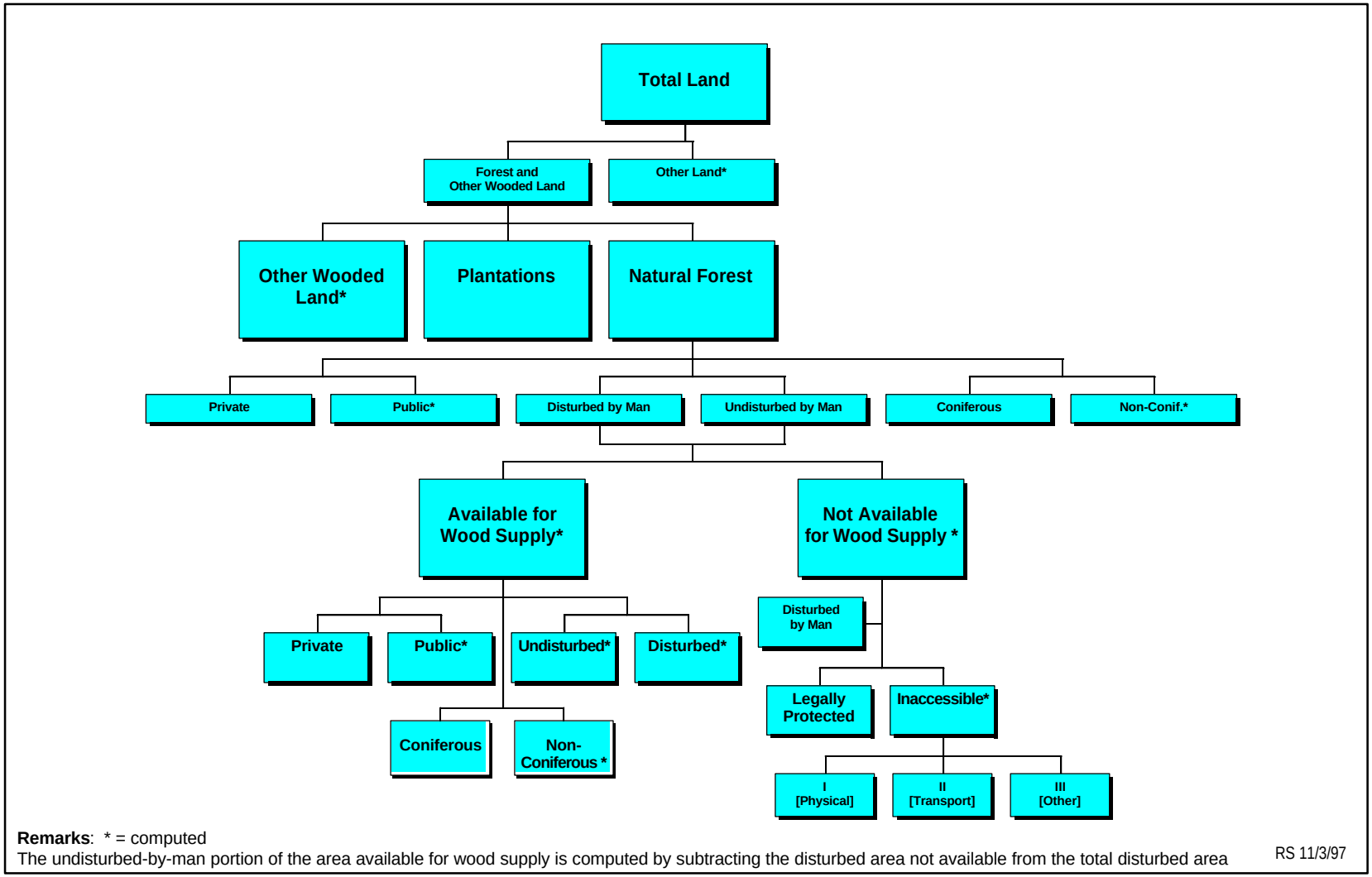
The diversity of areas falling into this category is very large. They include those whose landscapes possess special aesthetic qualities which are a result of the interaction of man and land or water, traditional practices associated with agriculture, grazing and fishing being dominant; and those that are primarily natural areas, such as coastline, lake or river shores, hilly or mountainous terrains, managed intensively by man for recreation and tourism.

[VI] Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural ecosystems.

Normally covers extensive and relatively isolated and uninhabited areas having difficult access, or regions that are relatively sparsely populated but are under considerable pressure for colonization or greater utilization.

Global Fibre Supply Study

Forest Area Classification



Remarks: * = computed
The undisturbed-by-man portion of the area available for wood supply is computed by subtracting the disturbed area not available from the total disturbed area

RS 11/3/97

Figure 1: Forest area classification

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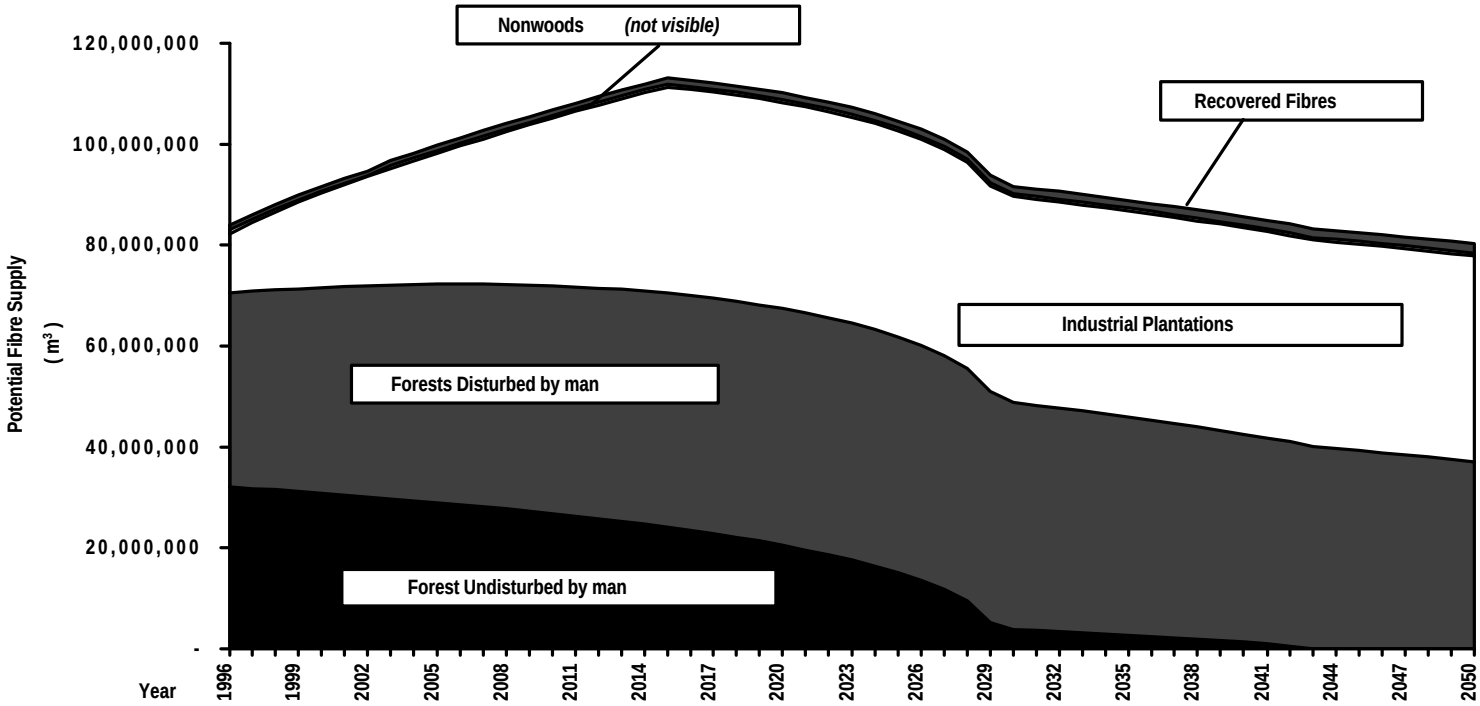

Figure 2: Forest volume and growth classification

12. ANNEX 2: DATA SURVEY SHEETS

Country		Source		Reference Year	

	Forest type	Forest undisturbed by man Forest Area (excl. plantations)						Forest undisturbed by man Forest Not Available for Supply								
		Total Forest undisturbed by man Forest	of 2: private	of 2: undisturbed by man	of 2: disturbed by man	of 2: coniferous	Total	Legally Protected	Economically Inaccessible					of 7: disturbed	of 7: private	of 7: coniferous
	Comment:	excluding Plantations	individuals, industry, cooperatives, indigenous and tribal people	unlogged (so-called primary or virgin forest) [4 + 5 = 2]	Total area disturbed by man (logged-over at least once) [4 + 5 = 2]			=8+9+10+11	IUCN class I & II	I physical reasons (steepness, water etc)	II transport/ Infrastructure	III low volume, no commercial species, other reason		**not** available for wood supply, but already logged-over at least once	private forest **not** available for wood supply	coniferous forest **not** available for wood supply
	See definitions chapter:	1.3.1.1	4.3	1.3.1.1	1.3.1.1	2.2.1	3.2	3.2.1	3.2.2		3.2.2	3.2.2	1.3.1.1	4.3	2.2.1	
	1	2	3	4	5	6	7	8	9		10	11	12	13	14	
		000 ha	000 ha	000 ha	000 ha	000 ha	000 ha	000 ha	000 ha		000 ha	000 ha	000 ha	000 ha	000 ha	
	TOTAL															
1																
2																
3																
5																
6																

GFSS Area Survey

Country	Source	Reference Year

	Forest type	Natural Forest Area (excl. plantations)						
		Total Natural Forest	**of 2: undisturbed by man**	**of 2: disturbed by man**	**of 2: private**	**of 2: predominantly coniferous**	**of 2: predominantly bamboos, palms, etc.**	**of 2: mixed forest**
	Comment:	excluding Plantations	unlogged (so-called primary or virgin forest) [3 + 4 = 2]	Total area disturbed by man (logged-over at least once) [3 + 4 = 2]	individuals, industry, cooperatives, indigenous and tribal people	more than 75% of the tree crown cover consists of species classified as Gymnospermae	more than 75% of the tree crown cover consists of tree species other than coniferous or broadleaved species	neither coniferous, nor broadleaved, nor bamboo, palms etc. account for more than 75% of the tree crown cover
	See definitions chapter:	**1.3.1.1**	**1.3.1.1**	**1.3.1.1**	**4.3**	**2.2.1**	**2.2.3**	**2..2.4**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
		000 ha	**000 ha**	**000 ha**	**000 ha**	**000 ha**	**000 ha**	**000 ha**
	TOTAL							
1								
2								
3								
4								
5								
6								

GFSS Area Survey

Country									
	Forest type	**Natural Forest Not Available for Supply**							
		Total	**Legally Protected**	**Economically Inaccessible**			**of 9: disturbed**	**of 9: private**	**of 9: predominantly coniferous**
	Comment:	=10+11+12+13	IUCN class I & II	**I** physical reasons (steepness, water etc)	**II** transport/ Infrastructure	**III** low volume, no commercial species, other reason	**not** available for wood supply, but already logged-over at least once	private forest **not** available for wood supply	coniferous forest **not** available for wood supply
	See definitions chapter:	**3.2**	**3.2.1**	**3.2.2**	**3.2.2**	**3.2.2**	**1.3.1.1**	**4.3**	**2.2.1**
	1	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
		000 ha	**000 ha**	**000 ha**	**000 ha**	**000 ha**	**000 ha**	**000 ha**	**000 ha**
	TOTAL								
1									
2									
3									
4									
5									
6									

GFSS Volume Survey

Country											
	Forest type		**Volume**				**HI**	**Growth**		**Rotation**	
			Growing Stock	**Com-mercial GS**	**Reference Diameter**	**Remarks**	**Harvest Intensity**	**GAI**	**Natural Losses**	**Cutting Cycle**	**Rotation Age**
	Comments:		all species	commercial species growing stock	inventory diameter			gross or mean annual increment	average annual losses to the growing stock		
	See definitions chapter:		**7.2.1**	**7.2.2**	**7.2.3**		**9.4**	**7.3.1**	**7.3.2**	**7.4.1**	**7.4.2**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
			m3/ha	**m3/ha**	**cm**		**m3/ha**	**m3/ha/y**	**m3/ha/y**	**years**	**years**
	TOTAL										
1		**Undisturbed**									
		Disturbed									
2		**Undisturbed**									
		Disturbed									
3		**Undisturbed**									
		Disturbed									

Country											
	Forest type		**Growing Stock**				**HI**	**Growth**		**Rotation**	
			Total	**Com-mercial**	**Referenc e Diameter**	**Remarks**	**Harvest Intensity**	**GAI**	**Forest undisturb ed by man Losses**	**Cutting Cycle**	**Rotation Age**
	Comments:		all species	commercial species	inventory diameter			gross or mean annual increment	average annual losses to the growing stock		
	See definitions chapter:		**7.2.1**	**7.2.2**	**7.2.3**		**9.4**	**7.3.1**	**7.3.2**	**7.4.1**	**7.4.2**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
			m3/ha	**m3/ha**	**cm**		**m3/ha**	**m3/ha/y**	**m3/ha/y**	**years**	**years**
	TOTAL										
1		**Undisturbed**									
		Disturbed									
2		**Undisturbed**									
		Disturbed									
3		**Undisturbed**									
		Disturbed									

13. ANNEX 3: SOURCE DATA FOR FIGURES, SECTIONS IN INDONESIA

Equation	Diameter Class	Fibre Source	**Static Supply Level** 1995	2000	2010	2020	2030	2040	2050
I	20	Forest undisturbed by man Forests	52,400,000	52,400,000	52,400,000	52,400,000	52,400,000	-	-
	10	Forest undisturbed by man Forests	85,602,018	85,602,018	85,602,018	85,602,018	85,602,018	-	-
	50	Forest undisturbed by man Forests	32,995,996	32,995,996	32,995,996	32,995,996	32,995,996	-	-
	~	Forest disturbed by man Forests	38,414,778	43,074,465	54,723,682	66,372,899	78,022,116	79,187,038	79,187,038
II	20	Forest undisturbed by man Forests	52,400,000	52,400,000	52,400,000	52,400,000	52,400,000	-	-
	10	Forest undisturbed by man Forests	85,602,018	85,602,018	85,602,018	85,602,018	85,602,018	-	-
	50	Forest undisturbed by man Forests	32,995,996	32,995,996	32,995,996	32,995,996	32,995,996	-	-
	~	Forest disturbed by man Forests	19,207,389	21,537,233	27,361,841	33,186,450	39,011,058	39,593,519	39,593,519
III	20	Forest undisturbed by man Forests	36,004,886	36,004,886	36,004,886	36,004,886	36,004,886	-	-
	10	Forest undisturbed by man Forests	63,946,859	63,946,859	63,946,859	63,946,859	63,946,859	-	-
	50	Forest undisturbed by man Forests	22,627,167	22,627,167	22,627,167	22,627,167	22,627,167	-	-
	~	Forest disturbed by man Forests	38,414,778	43,074,465	54,723,682	66,372,899	78,022,116	79,187,038	79,187,038
IV	20	Forest undisturbed by man Forests	36,004,886	36,004,886	36,004,886	36,004,886	36,004,886	-	-
	10	Forest undisturbed by man Forests	63,946,859	63,946,859	63,946,859	63,946,859	63,946,859	-	-
	50	Forest undisturbed by man Forests	22,627,167	22,627,167	22,627,167	22,627,167	22,627,167	-	-
	~	Forest disturbed by man Forests	19,207,389	21,537,233	27,361,841	33,186,450	39,011,058	39,593,519	39,593,519

V	~	Combined Forest undisturbed by man & Forest disturbed by man Forests	89,971,429	89,971,429	89,971,429	89,971,429	89,971,429	89,971,429	89,971,429
	~	Industrial Plantations	11,740,000	11,740,000	11,740,000	11,740,000	11,740,000	11,740,000	11,740,000
	~	Non-wood Fibres	388,291	388,291	388,291	388,291	388,291	388,291	388,291
	~	Recovered Fibres	679,347	679,347	679,347	679,347	679,347	679,347	679,347
I	20	**Total**	**103,622,416**	**108,282,103**	**119,931,320**	**131,580,537**	**143,229,754**	**91,994,676**	**91,994,676**
	10	**Total**	**136,824,434**	**141,484,121**	**153,133,338**	**164,782,555**	**176,431,772**	**91,994,676**	**91,994,676**
	50	**Total**	**84,218,412**	**88,878,099**	**100,527,316**	**112,176,533**	**123,825,750**	**91,994,676**	**91,994,676**
II	20	**Total**	**84,415,027**	**86,744,871**	**92,569,479**	**98,394,088**	**104,218,696**	**52,401,157**	**52,401,157**
	10	**Total**	**117,617,045**	**119,946,888**	**125,771,497**	**131,596,105**	**137,420,714**	**52,401,157**	**52,401,157**
	50	**Total**	**65,011,023**	**67,340,867**	**73,165,475**	**78,990,084**	**84,814,692**	**52,401,157**	**52,401,157**
III	20	**Total**	**87,227,302**	**91,886,989**	**103,536,206**	**115,185,423**	**126,834,640**	**91,994,676**	**91,994,676**
	10	**Total**	**115,169,275**	**119,828,962**	**131,478,179**	**143,127,397**	**154,776,614**	**91,994,676**	**91,994,676**
	50	**Total**	**73,849,583**	**78,509,270**	**90,158,487**	**101,807,704**	**113,456,921**	**91,994,676**	**91,994,676**
IV	20	**Total**	**68,019,913**	**70,349,756**	**76,174,365**	**81,998,973**	**87,823,582**	**52,401,157**	**52,401,157**
	10	**Total**	**95,961,886**	**98,291,730**	**104,116,338**	**109,940,947**	**115,765,555**	**52,401,157**	**52,401,157**
	50	**Total**	**54,642,194**	**56,972,038**	**62,796,646**	**68,621,255**	**74,445,863**	**52,401,157**	**52,401,157**
V	~	**Total**	**102,779,094**	**102,779,094**	**102,779,094**	**102,779,094**	**102,779,094**	**102,779,094**	**102,779,094**

14. ANNEX 4: FORECASTING SUPPLY FOR BRAZIL

In each of the six previous sections, we have used the example of Indonesia to illustrate how the GFSS constructs a *static supply line*, and how we can build on this line to create possible 'futures'. In Figure 5-1, we presented one possible future potential supply curve for Indonesia, based on an analysis of current trends. In this section, we will apply the exact same procedure to create a future potential supply curve based on current trends for **Brazil**. This curve is presented in Figure 7-1 below.

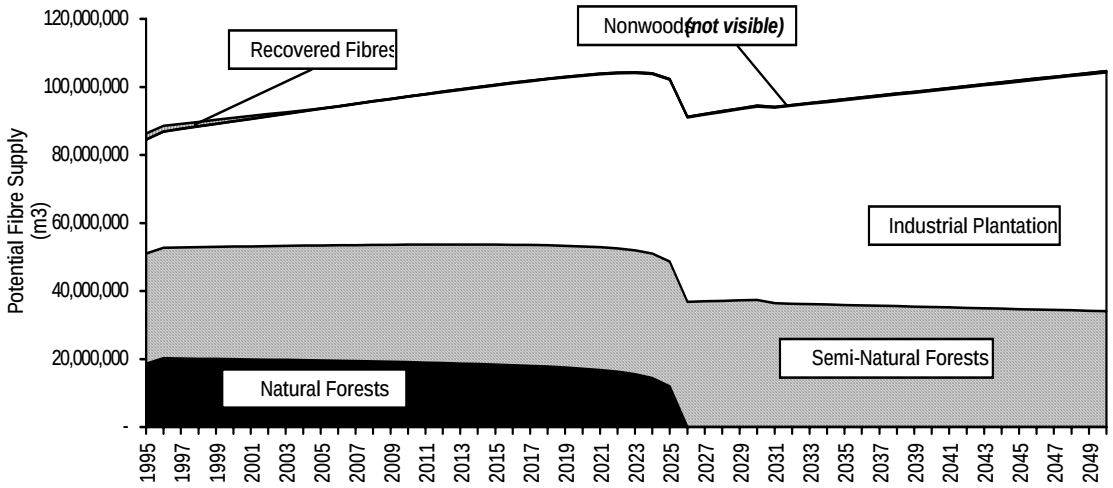

Figure 0-1: Current trends potential fibre supply, Brazil

Note that the composition of Brazil's fibre supply is much different than that of Indonesia. The forest undisturbed by man forest component is much less important than the plantations component here, while recovered and non-wood fibres barely register as a component of the overall fibre supply.

Note that, because certain factors are not included in the current trends model, the future supply curve for plantations is essentially a straight line. For instance, there is no attempt here to introduce fibre reductions based on sustainable forest management factors, fibre increases based on harvest or material efficiency improvements, or increased plantation harvests based on improved survival rates. However, as our model becomes more intricate and more factors are included, the overall curve will reflect these changes.

15. ANNEX 5: FORECASTING SUPPLY FOR GHANA

As we did in Section 7, we can apply our methodology to create a future potential fibre supply curve based on current trends for Ghana. This graph is interesting because the forest undisturbed by man forest component is completely absent when dealing with Ghana's future fibre supply. In combination with the fact that no factors for sustainable forest management and material efficiency are included, this means that the future potential fibre supply is essentially a straight line. However, the scale here is less than 1/100th of the scale in Figure 7-1.

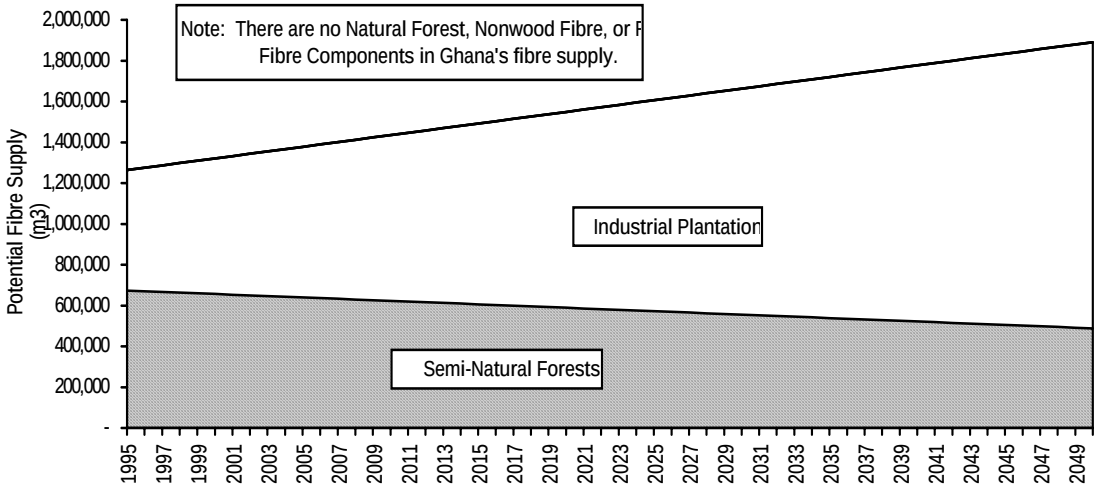

Figure 0-1: Future potential fibre supply under current trends, Ghana

It should be stressed here that this is one possible future based on current trends alone. No attempt has been made to introduce factors to account for sustainable forest management, increased harvesting or material efficiency, or improved plantation success. As these factors are included, the model becomes more and more intricate, allowing the potential future fibre supply to reflect a more realistic future.

16. ANNEX 6: DESCRIPTION OF SIBERIAN FORESTRY PROJECT

Essentially the. IIASA has been engaged in work related to forests for many years, and during the 1980s the Institute conducted a major global forest sector study. In 1992, the Forest Resources Project developed a four-year plan to study the Forest Resources, Environment and Socioeconomic Development of Siberia. In a major collaborative effort with Russian institutions, concrete research began in mid-1993. The overall objectives of the study are: (1) to identify possible future sustainable development options for the Siberian forest sector, and (2) to identify policies for these different options to be implemented by Russian and international agencies.

The resources of the Siberian forests (collectively West Siberia, East Siberia and the Far East) have lately been brought to the world's attention. Siberia has about 20 per cent of the world's forested area and some 40 per cent of the growing stock of the world's coniferous forests. The industrial wood supply conditions are changing. Due to environmental restrictions, the wood supply from the west coast of the USA, Canada and the regions of tropical forests will decline. There are not any big wood baskets, except Siberia, left to fill the gap of supply on the world market. Today, only about 30 per cent of the potential wood supply is utilized in Siberia. However, in order to meet the international market requirements, the whole forest sector of Siberia needs to undergo fundamental changes from structural, organizational, managerial and technological points of view.

On the other hand, the Siberian forest resources are also a precious ecological asset, which has attracted the attention of the international environmental community. There are studies indicating that the Siberian forests are nearly as important as the Amazon basin from a greenhouse gas balance point of view. An international debate is taking place concerning the role of the temperate and boreal forests in the global greenhouse gas balance. Without more reliable analyses on the role of the Siberian forests, this debate can never be settled. Landscapes and biodiversity are other topics on the international environmental agenda. Due to the fact that there are huge undisturbed areas in Siberia, there are great possibilities to analyze different landscape and biodiversity concepts for the boreal forests.

IIASA and Russia initiated the Forest Resources, Environment and Socioeconomic Development of Siberia Study several years ago, but concrete research only began in mid-1993, with the establishment of the Russian component. This component consists of more than 20 scientific institutions with nearly 100 collaborators involved in the research, including regional forest institutions from Kamtchatka, Far East, East Siberia, West Siberia and the European North.

Objectives

The overall objectives of the Study are: (1) to identify possible future sustainable development options for the Siberian forest sector (assess the biospheric role of Siberian forests, identify suitable strategies for sustainable development of forest resources, the industry, the infrastructure and the society); and (2) to identify policies for the different options to be implemented by Russian and international agencies. The options identified and policies required should balance the future socioeconomic, non-wood aspects, global change and sustainability requirements in Siberia and globally.

Overall Objectives of the Siberian Forest Study

To identify possible future sustainable development options for the Siberian forest sector, and
To identify policies for the different options to be implemented by Russian and international agencies. The options identified and policies required should balance the future socio-economic, non-wood, global change and sustainability requirement in Siberia and globally. In order to achieve these objectives the Study is dealing with the following major components: forestry, ecology and global change, industry and infrastructure, markets and socio-economics. Negotiations with Russian (then

USSR) authorities first began in 1990 with an official agreement between IIASA and Russian authorities being signed in 1992. However, it was mid-1993 before the research work could really begin. The work will be carried out in blocks or phases. Phase I, which lasts until late Summer of 1994, consists of establishing a collaborative network, data collection and generation of databases. We are also now planning Phase II, which will focus on the assessment analysis. The third phase of the Study will be to perform the integrated assessments and the final phase to formulate policy options.

The following databases have already been or will be generated by mid-1994:

- Ecoregion database for Siberia (65 eco-regions and about 2,000 parameters for each region);
- Forest inventory data at the forest enterprise level for Russia (2,500 enterprises);
- Industrial wood data at the forest enterprise level for Russia (2,500 enterprises);
- Forest industry data for Siberia (850 enterprises);
- Detailed cost and productivity data for the forest industry in Siberia (130 enterprises);
- Environmental status data in Siberia (for administrative regions), and
- Socio-economic data for Russia (65 administrative regions).

In addition to this information, various maps have been collected that will be used in a GIS-system developed around the database handling system.

The Study so far has thus been able to generate uniquely consistent databases on the Siberian and Russian forest sector which will be used in the upcoming analyses. So far, the collaborating network in Russia consists of 20 different research organizations with about 100 Russian scientists involved in the work. The present core-team at IIASA consists of ten people, although this is expected to grow in Phase II of the Study. An international network of scientific organizations and international organizations (such as the World Bank) are cooperating with the Study.

As illustrated earlier, the efforts to date have concentrated on establishing the collaborating network, and data collection and appraisal. We have not yet therefore generated many results. However, a lengthy working paper on Siberian forestr based on official data is now available. A larger article will also appear in AMBIO entitled, What do we know about the Siberian Forests? Later in the year we expect to produce two books. The first by Dr. Charles A. Backman of the core-team at IIASA deals with the Russian forest industry and the future supply of forest products. The driving force behind the second book is Professor Anatoly Shvidenko, also at IIASA. The book deals with the development of ecoregions in Russia. During 1994 we also hope to prepare some additional publications based on contracted work in Russia and North America.

GLOBAL FIBRE SUPPLY STUDY
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The Global Fibre Supply Study (GFSS) of the FAO Forestry Department operates under the guidance of an Advisory Committee on Paper and Wood Products. The GFSS has produced a number of publications. To obtain a list, or to order a single copy of this publication free of charge, please contact:

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