Gryphon Resources
Business Solutions

World Forestry Outlook to 2020

State of the World Forests and Future Demand for Forest Biotechnology Products and Services.

By

Alfonso Casasempere, Ph.D.

Gryphon Resources
http://www.gryphonresources.com

Richmond, British Columbia
Canada

November 6, 2000

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1. BACKGROUND

This report was undertaken for the purpose of providing a fresh independent perspective on the present and future state of World forestry to the **North American forest biotechnology industry**. A positive outlook for World forestry is important to the industry because it is a key driver of the demand for its products and services, and an important determinant of its projected financial health. All references to the clients who commissioned and sponsored the study are omitted to protect their privacy

The central issue at hand involved reviewing the limits of the widely held view that World forestry in general, and silviculture in particular, will remain strong in the foreseeable future, and at a level sufficient to configure good markets for genetically improved planting stock and biotechnology services.

The logical assumption underlying the above relationship is that, as the demand for wood and non-wood forest products and services increases, suppliers (industry and Government) rise to the challenge by:

(a) **Managing more intensively** the existing natural, semi-natural and man-made forests to increase growth and yield in the face of limitations imposed by the Sustainable Development Forest Management (SDFM) model.

(b) **Allocating more of the existing forests** to protected areas for conservation, wildlife and water management, parks, ecological reserves and ecotourism. This action naturally further aggravates the wood squeeze by reducing the commercial forests available for timber harvesting.

(c) **Creating new man-made (commercial) forests** to sustainably grow and harvest the increasing requirements of industrial timber, fuelwood, urban and agro forestry, renewable energy and the development of carbon sinks to help reduce global warming.

It follows, that as these three closely interrelated supply variables are acted upon, the derived demand for using more and better forest management inputs will also grow. While this effect will radiate to all inputs being used to establish, manage, protect and harvest forests, it will particularly impact on the requirement for having more and better seed and/or seedlings for fulfilling (a) and (c), and indirectly facilitating the delivery of (b). Should the outlook for world forestry remain strong, a growing production of forest products and services would greatly strengthen the derived demand for the forest biotechnology industry.

The present study is an attempt at reviewing some key features of the present and future state of World forestry for the purpose of examining the general validity of the above premises. It is not intended to be definitive but indicative in nature.

2. THE INDUSTRY

This study centres largely in the more mature companies found in the **forest biotechnology industry**, i.e. with over 10 - 15 years of advanced R&D. Furthermore, it focuses on the industry's main business which is the commercial development and production of genetically improved "seed", "artificial seed", "seedlings" and other propagules for reforestation, and related technology and services".

Companies as described above are generally well staffed and funded, with a dozen or two Ph.D. scientists engaged in production, process and product development, and related support activities. Their operations largely include state-of-the-art research laboratories and tissue culture production facilities. Some of these companies have established themselves as world leader in the rapidly growing marketplace for forest biotechnology and reforestation products and services. Throughout their operating history, their products and technologies have typically been evaluated, used and endorsed by several government agencies and the world's largest forestry companies operating in North America, Europe, Australasia and South America. The industry leaders have assembled **R&D, production and management teams**, widely considered to be among the most highly qualified and experienced in biotechnology in the world.

Furthermore, the industry generally maintains important **intellectual property rights** to a large number of important tissue culture and genetic transformation patents and technologies in key markets of the World. These rights represent a valuable and strategic intellectual capital for the industry to more fully benefit from growing market opportunities.

3. PRODUCTS & SERVICES

Typically, the industry's core business is to produce and commercialize patented and proprietary **clonal replication systems and related genetic engineering technologies**, which allow large volume production of commercial tree seeds and seedlings with selected superior traits, including:

➢ **Pest and disease resistance**	➢ **Increased wood fibre**
➢ **Faster growth**	➢ **Better quality wood**
➢ **Herbicide tolerance**	➢ **Frost and drought resistance**
➢ **Better pulping characteristics**	➢ **Improved seedling survival rate**

These technologies enable individual superior trees to be multiplied rapidly and efficiently to achieve levels of improvement exceeding "seed orchards" and "old vegetative reproduction programs", which can be both costly and time consuming.

Somatic embryogenesis (SE) and other clonal products are comparable to the results of selective breeding programs followed over many centuries in agriculture, but have the

advantage that the desired **genetic traits can be captured in a single generation**. This acceleration is critical in tree breeding where each life cycle spans many decades.

The industry's first genetically improved products have been derived from elite families and selected clones developed in a way which mimics the evolutionary process of genetic improvement through natural selection. In contrast to conventional propagation techniques involving seed orchard cuttings and selective tree breeding, advanced clonal replication provides a **low-cost production method** for the replication of selected natural embryos and shoots in large commercial volumes for reforestation. Some of these clonal products do not involve genetic engineering at the molecular level and therefore regulatory approvals are not required beyond normal forest practices guidelines.

The industry's clonal technologies also enable large volume delivery to markets of genetically improved products with specifically identified traits introduced to improve forest yields. These products known as **transgenic** are developed by introducing new or altered DNA. Using these proprietary transformation technologies, industry leaders can greatly improve forestry trees, including gymnosperm (conifers) and angiosperm (broadleaf) species. The industry has successfully developed transformation methodology and produced transformed lines from a variety of species, including Loblolly pine, Radiata pine, Douglas fir, Spruce, Slash pine, *Pinus elliottii x Pinus caribbaea* hybrids, Eucalypt, Poplar and many others. Work in progress includes the development of transformation methodology for several Poplar, Eucalyptus, Pine and other species. Both selected and transgenic ***clones*** are stored indefinitely in ***cryo-preservation banks*** where they remain fully viable until required for future "seed" production or additional genetic improvement work.

In their North American operations, the industry leaders typically produce the genetically improved propagules or seeds in-house and then deliver them to an existing network of in-house or commercial nurseries to grow the seedlings prior to distribution for reforestation. The industry's network of available nurseries includes some of the largest and most sophisticated tree nurseries in the world.

4. WORLD ECONOMIC OUTLOOK & FORESTRY DEMAND

While complex social and political factors can play a significant role in determining the demand for forest products, it is ultimately the changes in real economic growth and population that account for most of the impact. World **population** which stood at 5.7 billion in 1995, **is projected to rise to 7.5 billion** by 2020. Given this increase in population, it can be safely stated that within a specified range of supply cost, it will be the health of the World economy that will determine the future consumption of industrial forest products, i.e. posts and beams, lumber, panel board, and pulp and paper.

Global economic growth in 1999 reached 2.8%, up from 1.9% in 1998. The most salient positive developments of the World economy this last year were:

- A rapid change of technological innovation leading to a massive spread of the electronic age and vastly improved interconnectivity

- The outstanding performance of the North American economies, which posted a 4.1-4.2% increase in real **Gross Domestic Product (GDP)**.

- Strong signs that the Asian crisis is largely in the past, with China and Korea showing outstanding real GDP gains of 7.1% and 10.7% respectively.

- The comparatively substandard but improving performance of the Japanese economy that grew at a modest 0.3%, largely due to unsolved structural problems rooted in events going back as much as 10 - 15 years ago.

- Argentina shows a 3% GDP decline in 1999 due to a weakening currency and rising interest rates in the face of increased Government spending.

- Powered by large productivity improvements, low inflation and rising global trade, strong growth spreads to virtually all regions of the World.

This is indeed a positive picture that has resulted in a growing demand for most forest products. However, complicating matters was the inability of the forestry industry in general but of its largest group, pulp and paper, in particular, to generate satisfactory returns on capital. The complaints by investors about the lack of financial performance encouraged a process of:

- Increased industry consolidation regionally and globally with a focus on core activities and the desegregation of business units to foster transparency of financial return, discouraging vertical integration.

- Some difficulty in accessing fresh capital for plant expansions, especially in the US and Canada where the high tech investment frenzy has temporarily drained the pockets of Institutional, commercial and small investors.

- A silver lining in the form of a more stable outlook for supply/demand balances which will in turn produce a more stable price and profitability environment in the years to come. Having endured the strong cyclical nature of the industry for decades if not centuries, both industry and consumers alike have long cherished this lower volatility goal.

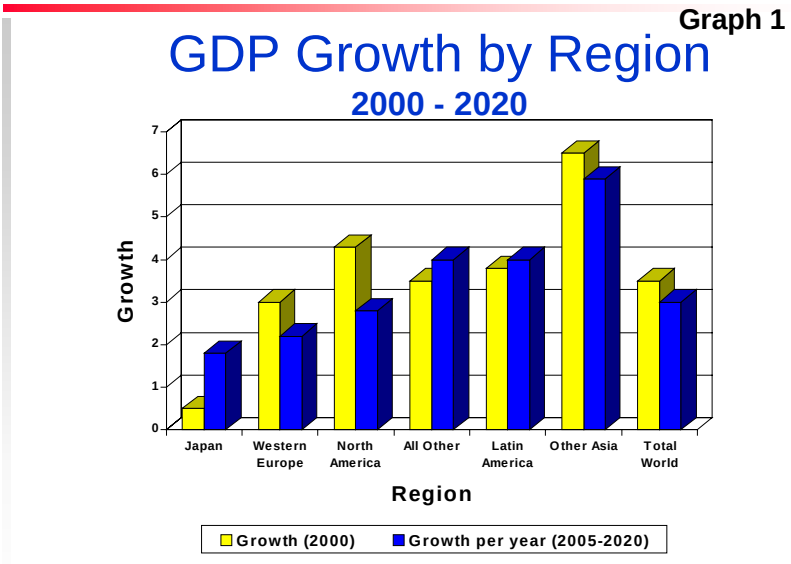
Table 1
World - Short, Medium and Long-term GDP Growth Projections by Region, 1999 - 2020
(% change per year)

Region	1999		Short Term 2000	Medium Term 1999-2004	Long Term 2005-2020	2020
	%	%	%	%	%	%
	Growth	Distribution	Growth	Average Growth/year	Average Growth/year	Distribution
Total World	**2.8**	**100**	**3.5**	**2.9**	**2.9-3.1**	**100**
North America	4.1	30	4.3	2.8	2.7-2.9	28
Western Europe	2.2	29	3	2.4	2.1-2.3	27
Japan	0.6	15	0.5	1.4	1.7-1.9	11
Other Asia	6.5	11	6.5	6.2	5.8-6.0	17
Latin America	0	6	3.8	4.1	3.8-4.1	7
All Other	2.7	9	3.5	3.8	3.6-4.1	10

Source: OECD, Bank of Canada and Gryphon

From **Table 1**, it is evident that a **rapid rate of economic growth** in the order of 2.9 - 3.1% is expected in the world for the period 2000 -2020. This is an unprecedented rate of growth that will be fuelled by additional increases in productivity brought about by an accelerating pace of technological innovation in electronics, communications, energy, and biotechnology. While the World as a whole will post good average growth, Latin America is projected to grow at a faster rate of 3.8 - 4.1% per year up to 2020. Still, other Asian economies (largely the ASEAN group and India) will grow at an even faster clip of 5.8 - 6% per annum.

Graph 1



Due to the increase in disposable income forecasted for most regions of the Globe (Africa could sadly be an exception here), economists agree that the growth in forest products demand will clearly outpace reductions associated with wood substitution and other negative externalities (excessive trade barriers, lack of foreign exchange, etc.). Should timber supply remain fairly price elastic (as has been in the past), the net result will be an **increase in consumption of 1.7% per year** up to 2020.

Faced with a growing market and significant reductions in the land base available for timber harvesting, the forest industry will turn to a two prong solution to alleviate the wood squeeze. It will:

(1) Increase the rate at which new areas are being forested (afforestation), and

(2) Improve the efficiency of timber growing, harvesting and processing. The latter will result from gains associated with the implementation of new technologies available for improved tree breeding, silviculture, forest management and wood transformation.

With more and better trees growing faster, potentially disease and frost free, in more accessible areas, supply will have the opportunity to catch up with demand ensuring a market equilibrium at a price increase of **3 -3.5%** per annum in real terms (a rate similar to the one experienced in the US South for most of the 1900's*).

5. STATE OF WORLD FORESTRY 1995 -2020

5.1. Present Framework

Forests are a unique and important natural resource providing essential ecological and recreational services, and raw material for basic construction, energy supply and industrial use. Fuelwood alone accounts for almost 52% of all wood use, an essential benefit to many in **Less Developed Countries (LDCs).** Logs, sawnwood (lumber) and panelboard are all key elements in construction and decoration, and pulp and paper are extensively used in printing, packaging and education. In all, forests and forestry provide a range of timber and non-timber products and services that number in the thousands.

In 1995, the world's forest, including natural forests and man-made forests were estimated at some 3.45 billion hectares (ha**)**, or 25% of the Earth's land area. About 55% of the world's forests are located in **LDCs** and 45% in **More Developed Countries (MDCs)**. The world's forests are almost equally divided between tropical/subtropical forests and temperate/boreal forests. Productive exploitable forests were estimated at 2.91 billion hectares (ha) in 1995. Industrial timber harvest was about 1.6 billion m^3 and total timber harvest close to 3.5 billion m^3 (45% industrial wood and 55% fuelwood).

About **3.4%** of the world's forests **are man-made forests**. The remaining 96.7% are natural or semi-natural forests. An increasing area of the semi-natural forests is being intensively managed similarly to man-made forests, whereby annual reforestation of cut-over areas is made with 100% nursery grown seedlings.

Forestry remains an integral component of the global economy. In recent decades, the multiple uses of forests has intensified and today, as the forest land base steadily shrinks (see Maps 1-5), there is an urgent concern for a more responsible use.

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* Binkley, C. S. and J. R. Vincent. 1988 Timber prices in the US South: past trends and outlook for the future. *S. J. Appl. For.* 12:15-18

"When properly managed, forests are inherently a renewable resource. Indeed, from an environmental standpoint, an attractive option is to rely more on wood products, through substitution for non-wood products in construction (replacing brick concrete and aluminium) or burning wood in place of fossil fuels to ***reduce anthropogenic emissions of carbon dioxide (CO_2)*** *that contribute to climate change.*

The non-commercial value of forests is also increasing as there is a rising demand for consumptive (hunting, fishing) and non-consumptive (wildlife viewing, hiking) uses associated with forests, and the public wishes to protect forests for their ecosystem functions (hydrologic balance, waste assimilation, biodiversity, etc)."

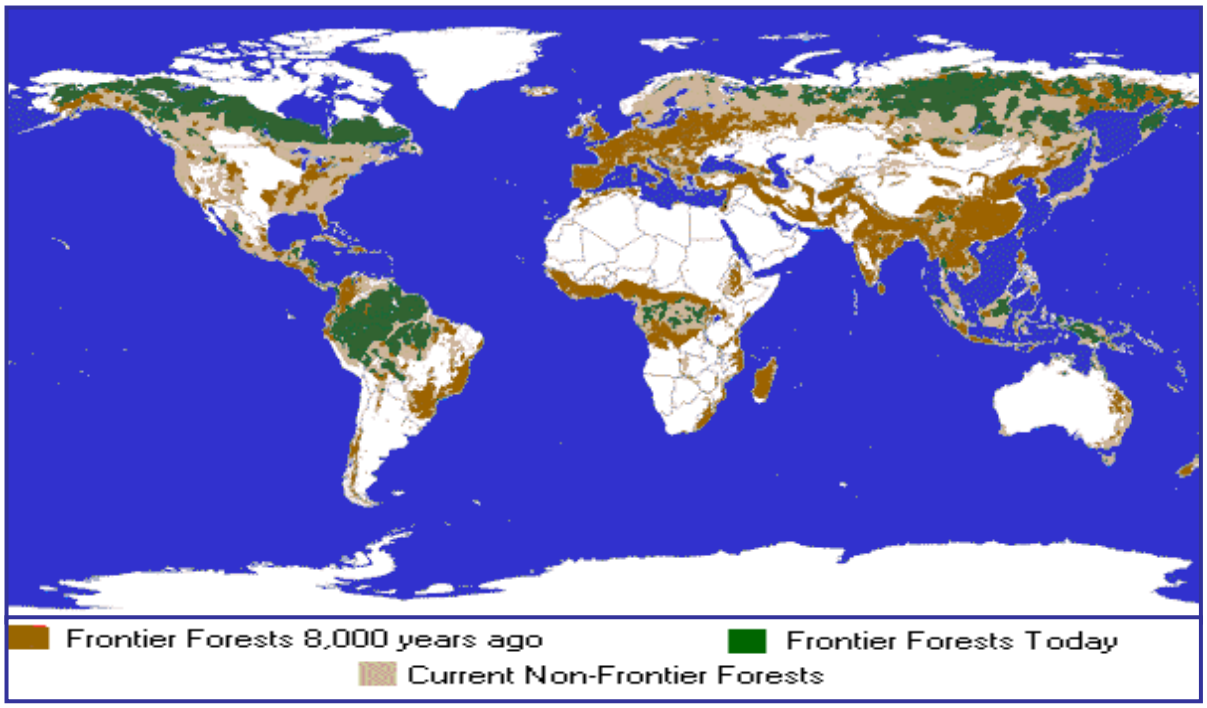
G. Cornelis van Kooten and Ilan Vertinsky, Chapter 1 in "Forest Policy - International Case Studies", CABI Publishing, 1999

The **sustained yield/multiple use objective**, although deep rooted within the forestry profession from a long-standing European tradition, was not always important in the public's mind. For centuries society ignored with reckless abandon the rate at which shifting cultivation and logging were consuming the resource. From1950 to 1970, the annual world harvest of industrial timber almost doubled to 1.3 billion m^3 . In the ensuing 20 years the pace of industrial harvesting expansion slowed somewhat but still an additional 300 million m^3 were added to the annual harvest that bloated to approximately 1.6 million m^3 by 1990.

After centuries of colossal losses due to **massive land use changes** (alienation for cattle grazing and agriculture), the extent of the world forests - net of any additions by planting, decreased a further 180 million ha between 1980 -1995. There was and increase of 29 million ha in MDC but a net loss of about 200 million ha in LDC. Between 1990 and 1995 there was an estimated net loss of a further 56.3 million ha brought about by an increase of 8.8 million ha of forests in MDCs and a decrease of 65.1 million ha in LDCs. Not a pretty picture. **Maps 1 - 5**, courtesy of the **Forest Stewardship Council (FSV)**, show the location and size of the world forests. They also illustrate the massive deforestation the Earth has undergone and the growing threat to its remaining forests.

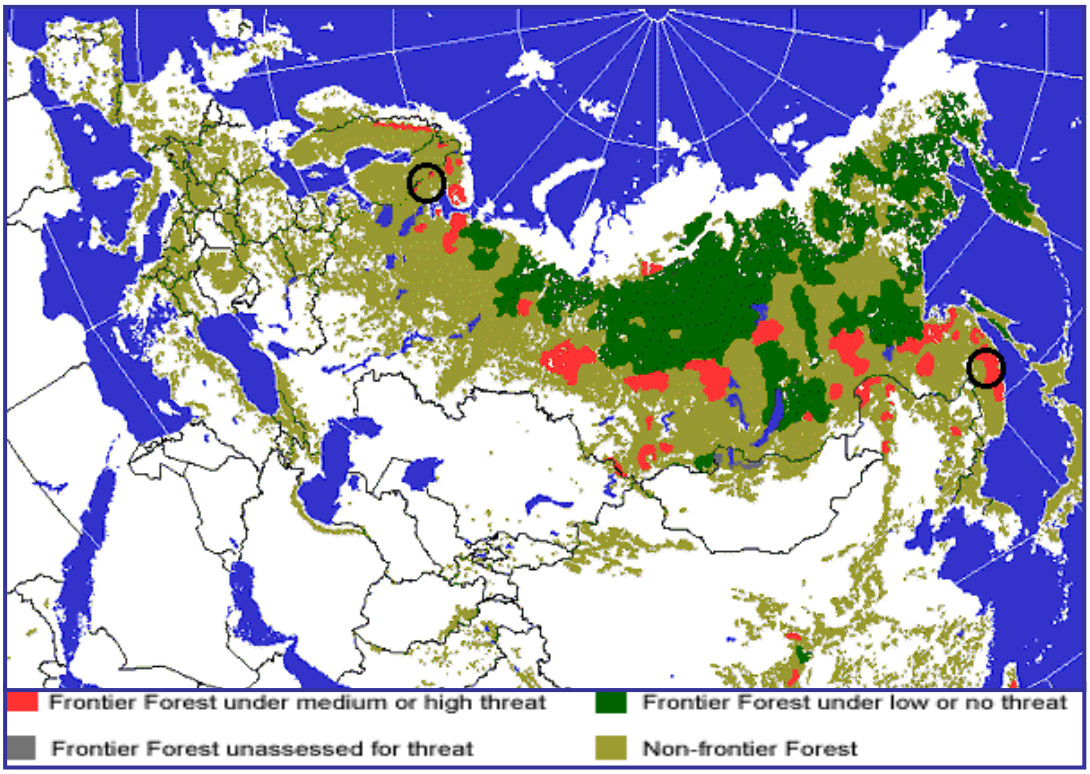
The excessive and wasteful use of forests soon became a Government issue and the lack of conservation became the focus of the environmental movement. The end result (which is still on-going) led inevitably to a major re-allocation of forest lands with a shift of large areas from commercial use to parks and other non-industrial use, and to mandatory restrictive regulation aimed at protecting the environment in the remaining commercial forests. The ensuing jump in timber costs forced industry and Government to become seriously interested for the first time in value added processing, and in more efficient silviculture and timber harvesting. We are now living this transformation process and will no doubt continue to bear the cost of past follies for some time to come. World society has come full circle and the reality check is gradually but forcefully causing all stakeholders to accept the inevitable - **world forests will have to be substantially rebuilt.**

Map 1
World - Frontier and Non-frontier Forests



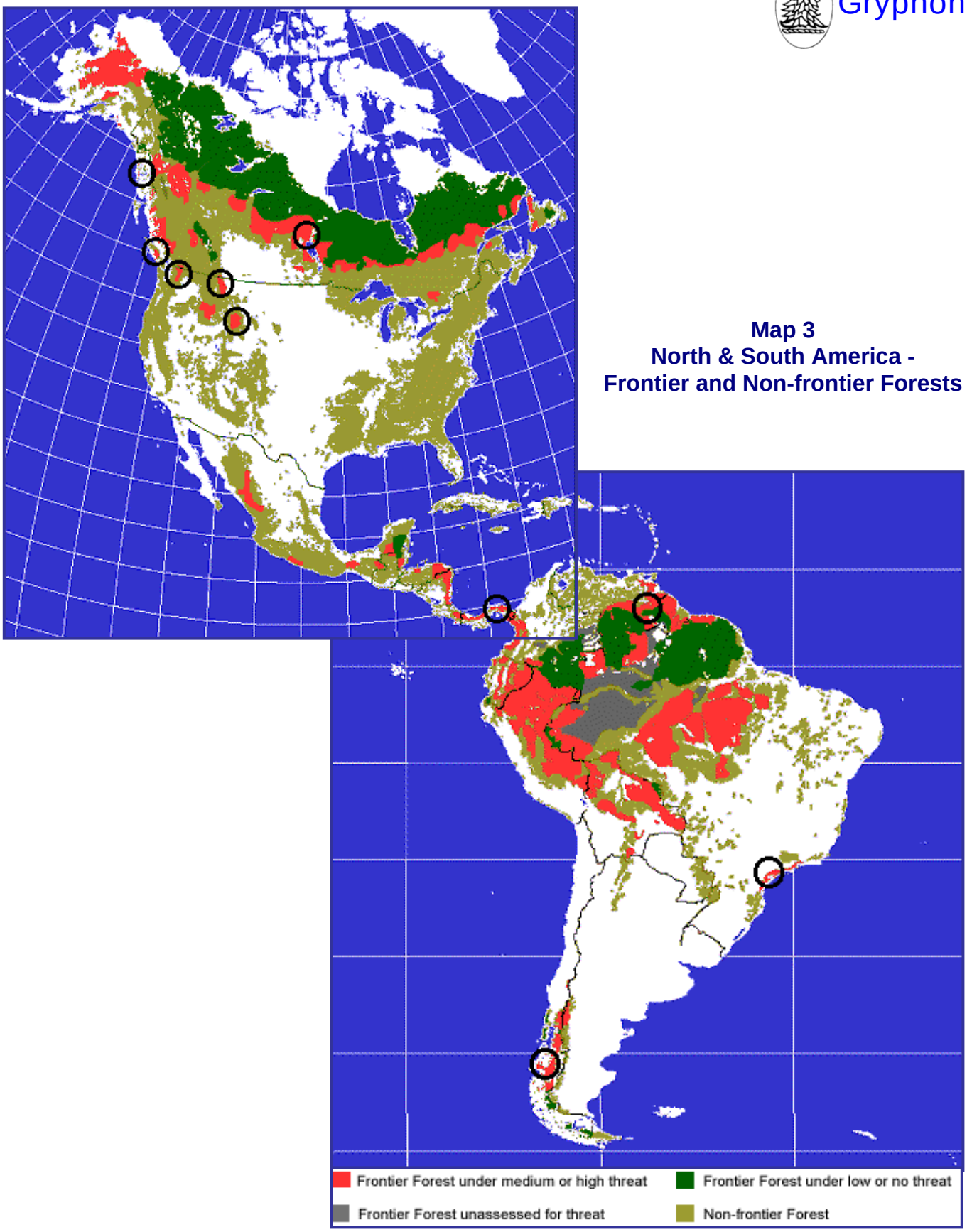
Source: FSC

Map 2
Europe & Russia - Frontier and Non-frontier Forests



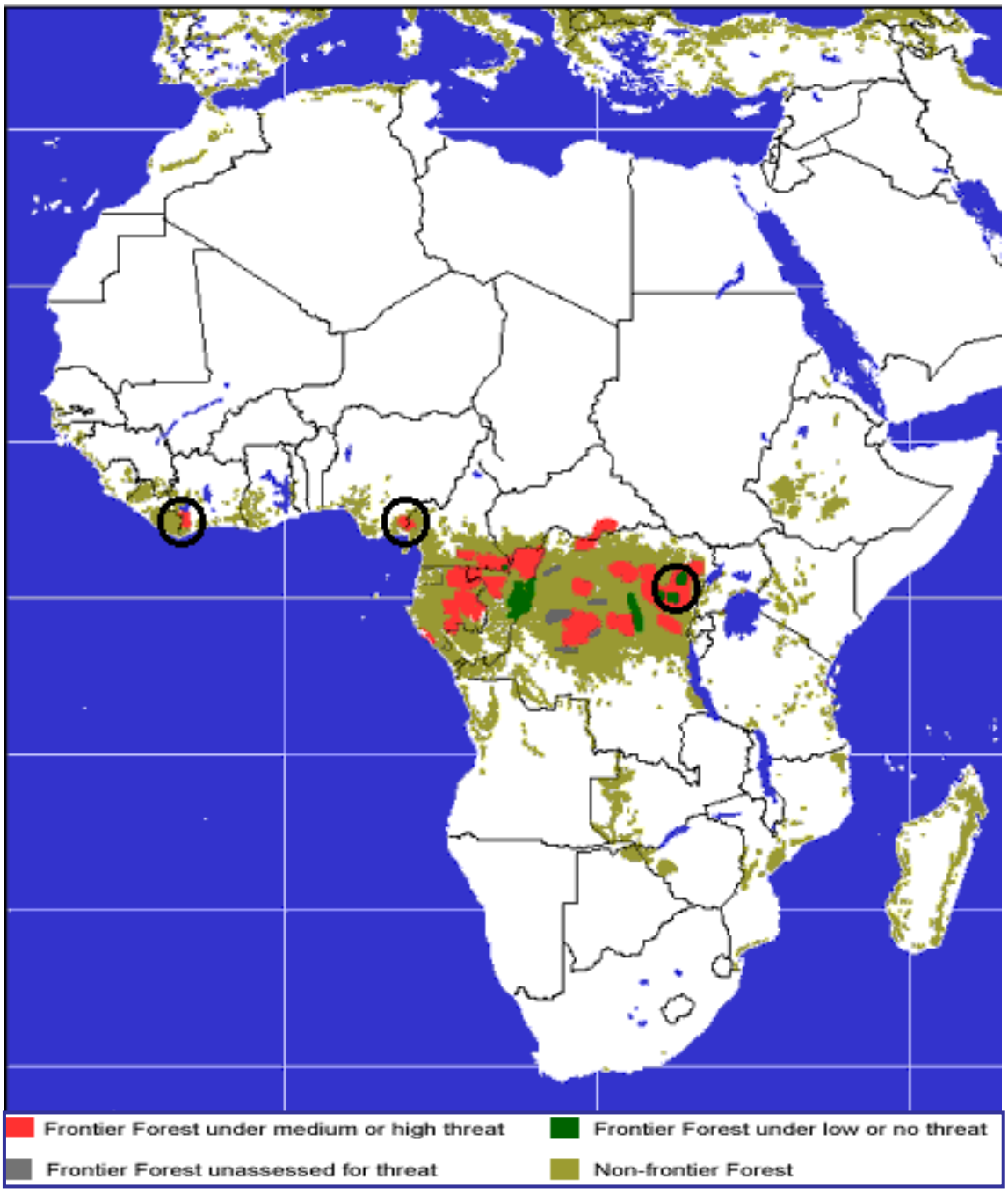
Source: FSC

Map 3
North & South America -
Frontier and Non-frontier Forests



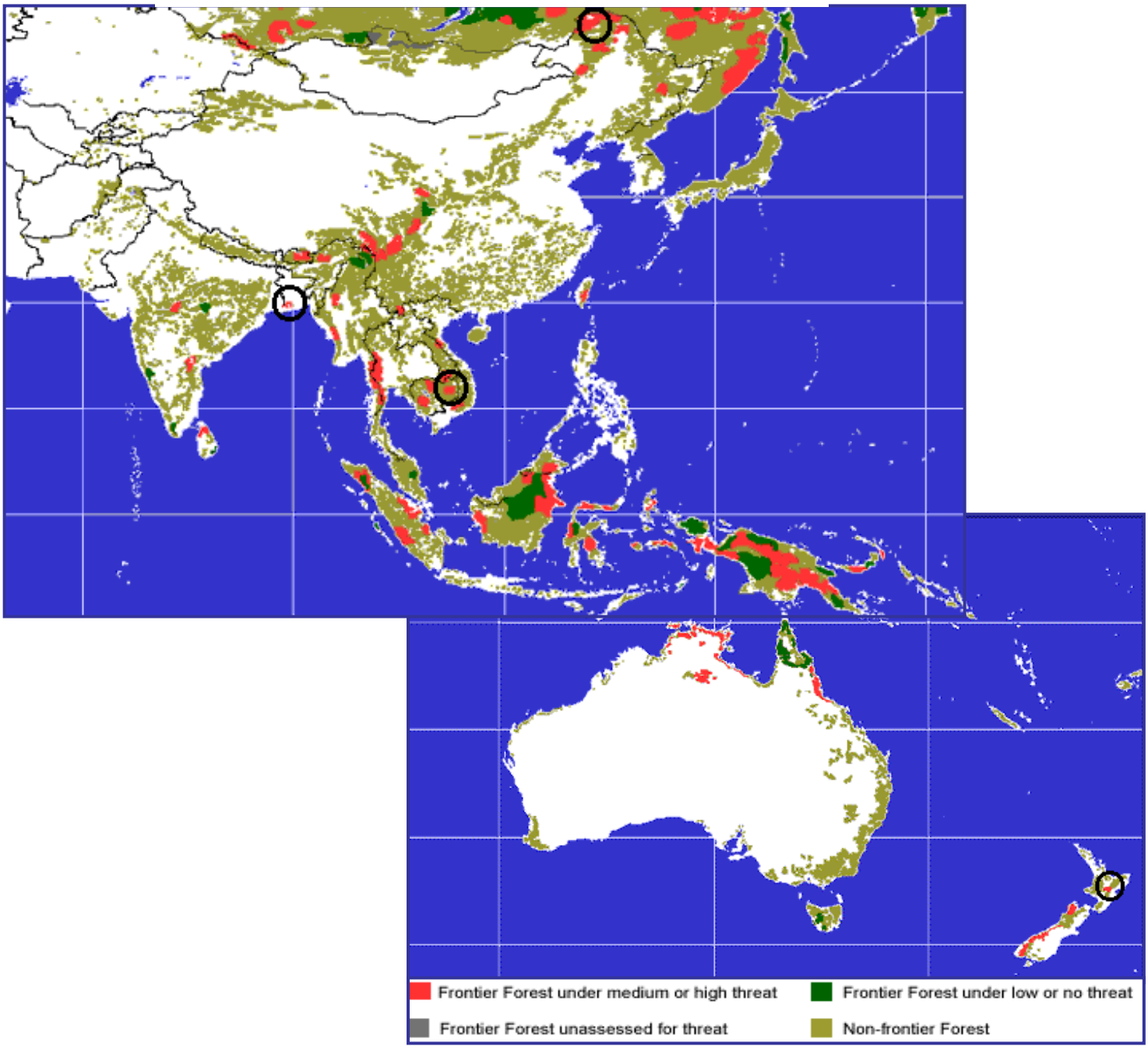
Source: FSC

Map 4
Africa - Frontier and Non-frontier Forests



Source: FSC

Map 5
Asia & Oceania - Frontier and Non-frontier Forests



Source: FSC

Data Base

At the time of writing this report, the most comprehensive and up-to-date forest resource and supply studies available are:

(a) **"1996 Global Timber Supply Outlook"** of **the European Forest Institute (EFI)** prepared for the International Panel on Forests (IPF) under the UN Commission for Sustainable Development (CSD)

(b) **"1995 Global Fibre Supply Model (GSFM)** of the Forestry Department, **Food and Agricultural Organization of the United Nations (FAO)**

(c) **"State of the World Forests 1999"** prepared by FAO

While the information from these three sources is detailed and comprehensive, all studies suffer from blanks in the data base due to the fact that the organizations responsible for updating them depend heavily on others for the periodic collection of the necessary figures. The reports received are not always accurate and field checks to corroborate them take time and are very costly. These blanks lead inevitably to inconsistencies between the studies which then need to be reconciled by additional future studies. As result, the difficult decision was made to select one study as the leader and use the others to supplement the former, rather than attempt a more flexible but unstructured case-by-case approach. The leading study chosen was the EFI "1996 Global Timber Outlook".

5.2. Forest Land, Commercial Plantations and Timber Supply 1995 - 2020

BASE SITUATION IN 1995

In its study, **"1996 Global Timber Supply Outlook"**, the EFI, commenced by grouping the world's forests into five management/ownership types. This classification was designed solely with the objective in mind of making practical sense of available resource and production information. The EFI began by creating three forestry types **(F1, F3 & F4)** from an analysis of the relatively comprehensive information available for the 16 temperate countries which account for 60% of the world's industrial timber production, i.e. Austria, Australia, Canada, Chile, Finland, France, Germany, Japan, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK and US. It then proceeded to create a fourth type **(F2)** to cover fast growing plantations in tropical and sub-tropical climates and a fifth type **(F5)** to group all remaining forests. **Table 2** describes these 5 forest types in detail.

The EFI's methodology consisted of estimating a base line scenario of productive forests, industrial harvest and a yield per ha called "production intensity" in 1995. Although not a measure of biological growth (or productivity) as is the mean annual increment per ha, "production (utilization) intensity" can be calculated by dividing the total timber harvest by the existing forest land base and then used as a benchmark for assessing future (potential) yields. **Table 2** below, was estimated by GRC from

the EFI table using complementary information from FAO and other in-house available information.

Table 2

World - Productive Exploitable Forests, Industrial Timber Harvest and Area Harvested in 1995

	FOREST MANAGEMENT TYPE	Exploitable Forest (million ha)	%	Industrial Timber Harvest (million m^3)	%	Apparent Utilization Intensity 1/ (m^3/ha/year)	Volume Extracted per Unit Area 2/ (m^3/ha)	Area Harvested 3/ (million ha)
F1	Temperate Industry Owned Forests	43	1.5	196	12.4	4.6	340	0.576
F2	Fast Growing Tropica/Sub-tropical Plantations	23	0.8	65	4.1	2.8	380	0.171
F3	Temperate Non-industry Privately Owned Forests	217	7.5	419	26.5	1.9	405	1.035
F4	Temperate Publicly Owned Non-reserved Forests	218	7.5	307	19.4	1.4	430	0.714
F5	Other Forests (Temp., Tropical and Sub-tropical)	2,407	82.8	592	37.5	0.3	102	5.804
Total World		**2,908**	**100.0**	**1,579**	**100.0**	**0.5**	**190**	**8.300**

Source: EFI, FAO and GRC

F1 **Intensively managed forests** (mostly semi-natural) **owned by industry** in the ***16 temperate countries*** that account for 69% of the world's industrial timber output and for which there is a relatively good data base available. Include Austria, Australia, Canada, Chile, Finland, France, Germany, Japan, New Zealand, Norway, Portugal,Spain,Sweden, UK and US. Includes all Southern US forests owned by industry.

F2 **Fast growing plantations** (man-made forests) held by **private and public owners** in the **tropics and sub-tropics** and managed for industrial timber production.

F3 **Intensively managed forests, owned by private, non-industrial owners** in the ***16 temperate countries*** , including fast growing plantations (e.g. Chile, New Zealand) and native forests (e.g. US and Canada).

F4 **Intensively managed forests** (non-reserved, i.e. open for timber harvesting) **publicly owned** in the ***16 temperate countries*** . Includes the Federal and State forests in the US and Crown lands in Canada.

F5 **All other forests of all types of ownership** but **mostly extensively managed (native) forests publicly owned** in **temperate climates** (e.g. Russia) and the **tropics** (e.g. Southeast Asia, Africa, South America)

1/ Average utilization of the existing resource, estimated by dividing the annual timber harvest by the existing area of forests. The EFI calls it "Production Intensity" in its report. Not to be confused with the mean annual increment (growth) of forests also expressed in m3/ha/year.

2/ Average volume extracted per unit area at time of harvest. Estimated by GRC.

3/ Estimated by dividing the industrial timber harvest by the volume extracted per unit area

Graph 2

World Forests & Timber Harvest - 1995

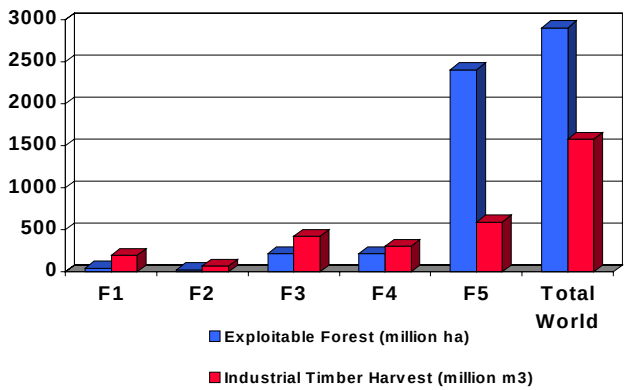
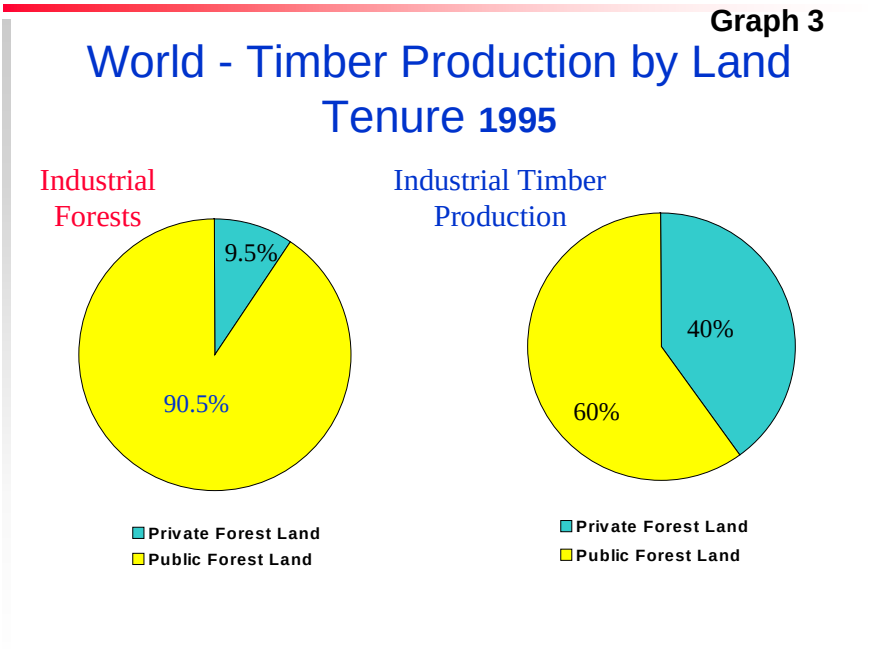


Table 2 and Graph 2 show that the total industrial timber output in 1995 was produced from harvesting approximately 8.3 million ha of productive forests. The total land base supporting this activity was 2,9 billion ha.

Graph 3 below, highlights the fact that private forests lands, which include most fast growing plantations, account for only 9.5% of

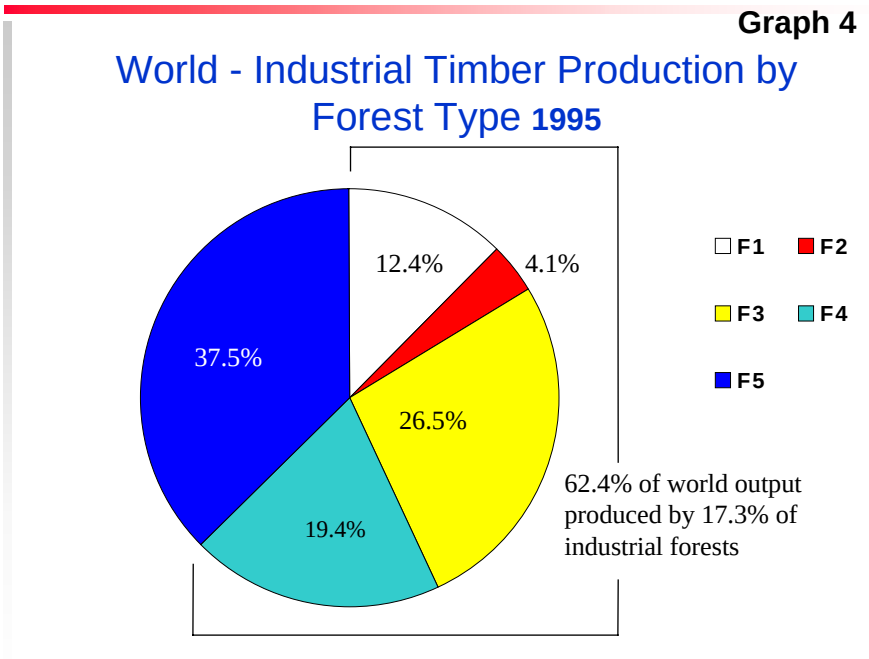
the productive (exploitable) forests of the world but provide, nonetheless, over 40% of the industrial timber harvested.

Graph 3



Graph 4 below, shows that less than 18% of the world's industrial forests **(those contained in F1, F2, F3 and F4)** produce over 62% of the world's industrial timber output.

Graph 4



Based on current biological productivity and even at the present low forest management intensity, if sufficient investment was made, the world's commercial non-reserved forests could support a greatly expanded annual harvest, possibly as much as 5 - 7 billion m^3 . This, however, is not likely to happen for several good reasons as follows:

- Total wood harvest including all uses (fuel wood and charcoal included) is actually over 3.5 billion m^3, about 50 - 70% of the potential.

- Lack of transportation infrastructure leading to economic inaccessibility in the largest forest reserve areas of the world, primarily **Russia** that contains over 20% of the Earth's timber reserves and the largest volume of presently underutilized softwoods.

- High present predominance of non-commercial species in the tropical forest reserves, i.e. South America and Africa.

- Over exploitation of the most accessible forests lands and on-going conversion of forests to subsistence agriculture by means of destructive slash-and-burn deforestation.

- Large future alienation of both tropical and temperate publicly-owned forests from the industrial reserve for other social uses, e.g. ecological reserves, water management, social amenity, creation of carbon sinks, etc.

Nevertheless, the supply of timber can be expected to increase in response to a rising demand. As mentioned earlier, future deficits of wood will result in higher real timber prices, which in turn will stimulate more intensive forest management in existing forests and the creation of new forests. These positive and negative factors are taken into account in the EFI's projections. Specifically:

- The area of man-made forests in temperate, sub-tropical and tropical countries, and the utilization (production) intensity in them will increase (F1, F2 and partly F3).

- The trend toward more land alienation from the commercial forests for a more non-consumptive use will lead to a reduction in the timber areas held by non-industrial private and public owners in temperate regions (F3 and F4). An equivalent situation will affect the remaining forests (F5).

While most of the EFI's assumptions are viewed as reasonable, it is the opinion of GRC that the world will experience a much greater decline in the publicly managed forests available for industrial timber harvesting than estimated by EFI. It is the consultant's opinion that recent developments in silviculture and forest biotechnology support a more optimistic view than EFI's for long term productivity increases in fast growing plantations.

FORESTRY OUTLOOK 1995 - 2020

Table 3 below, describes the outlook for industrial timber production and area harvested for the period 1995 - 2020.

Table 3
World - Industrial Timber Production and Forest Area Harvested
1995 -2020

Forecast Period	FOREST MANAGEMENT TYPE 1/ F1	F2	F3	F4	F5	Total (All Types)
Industrial (Exploitable) Forest (millions of ha)						
1995	43	23	217	218	2,407	2,908
2000	44	28	214	204	2,318	2,808
2010	46	39	207	177	2,205	2,674
2020	48	50	200	150	2,150	2,598
Average Utilization (Production) Intensity (m^3/ha/year)						
1995	4.56	2.83	1.93	1.41	0.25	0.54
2000	4.85	3.46	2.14	1.58	0.27	0.61
2010	5.42	4.73	2.57	1.91	0.31	0.74
2020	6.00	6.00	3.00	2.25	0.35	0.88
Timber (Harvest) Production (millions of m3)						
1995	196	65	419	307	592	1,579
2000	213	97	458	322	626	1,716
2010	249	184	532	338	684	1,987
2020	288	300	600	338	753	2,278
Volume Extracted per Unit Area (m3/ha						
1995	290	314	352	254	102	188
2000	306	343	388	265	110	189
2010	325	360	408	276	126	216
2020	346	387	437	291	143	242
Area Harvested (million ha)						
1995	0.576	0.171	1.132	0.714	5.804	8.397
2000	0.697	0.282	1.180	1.216	5.681	9.058
2010	0.767	0.512	1.304	1.225	5.404	9.213
2020	0.832	0.775	1.373	1.160	5.270	9.410

Source: EFI, FAO and GRC

1/ See Table 2 for definitions of the forest types

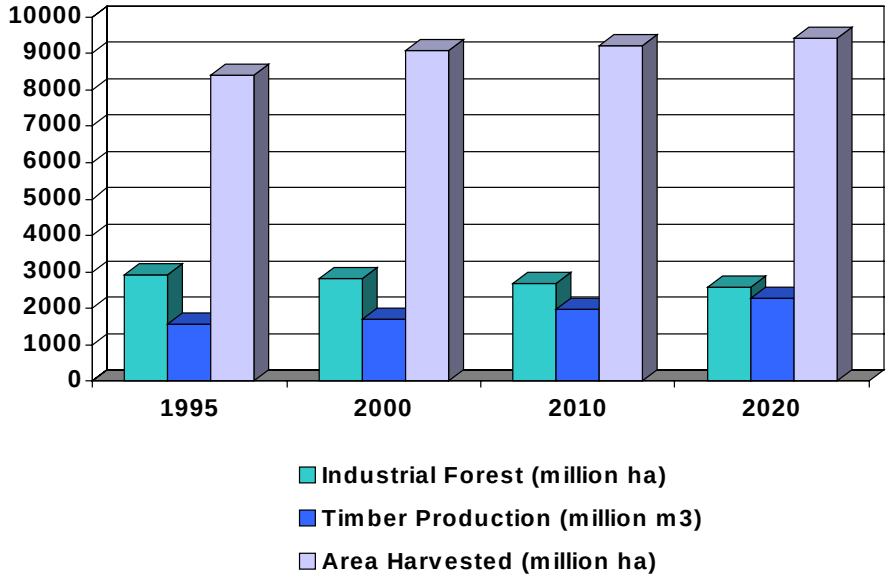
Table 3 and Graph 5 show that while the globe's industrial (exploitable) forests will decrease from 2.9 billion ha in 1995 to approximately 2.6 billion ha in 2020, the industrial timber harvest will grow from 1.6 billion m^3 per year to 2.3 billion m^3 during the same period. This represents a 43% increase in output during the 25 year forecast. The jump in productivity can be explained by the more intensive forest management that will be applied in industrial forests, producing 60% more timber

from 15% less land. Quite an extraordinary achievement by any measure, but well within the improved silviculture and harvesting practices currently in use and/or planned for the near future. With more of the existing forests being made accessible, and timber being increasingly grown and harvested in shorter cycles, the area of industrial forests harvested annually is estimated to increase from 8.4 million ha in 1995, to 9.4 million ha in 2020.

Graph 5

World - Industrial Timber Production

1995 - 2020



5.4. Derived Demand for Tree Seedlings 1995 -2020

1995-2020

Forecast Period	FOREST MANAGEMENT TYPE 1/ F1	F2	F3	F4	F5		Total (All Types)	
Reforestation								
Area Harvested - To be restocked by planting or natural regeneration (million ha)								
1995	0.576	0.171	1.132	0.714	5.804		8.397	
2000	0.697	0.282	1.180	1.216	5.681		9.058	
2010	0.767	0.512	1.304	1.225	5.404		9.213	
2020	0.832	0.775	1.373	1.160	5.270		9.410	
Planting Density - Number of Seedlings per ha								
1995	1,800	1,400	1,400	2,000	800			
2000	1,800	1,200	1,200	2,000	800			
2010	1,500	1,000	1,000	1,800	700			
2020	1,500	900	1,000	1,600	600			
						% Planted		
Derived Demand for Reforestation Seedlings (millions)						4/		
1995	1,037	239	1,585	1,428	836	18%	5,125	
2000	1,255	339	1,416	2,433	1,136	25%	6,579	
2010	1,151	512	1,304	2,205	1,702	45%	6,874	
2020	1,249	698	1,373	1,856	1,897	60%	7,072	
Afforestation - New Forests (including areas for non-consumptive use)								
								% Industrial
New Plantations Established (million ha)								Use 3/
1995 2/	1.253	1.654	0.465	0.910	2.310		6.592	87%
2000	0.950	1.254	0.386	1.000	2.660		6.250	85%
2010	1.038	1.700	0.497	1.180	2.850		7.265	79%
2020	1.400	1.850	0.613	1.360	3.043		8.266	62%
Planting Density - Number of Seedlings per ha								
1995	1,600	1,400	1,400	1,800	800			
2000	1,600	1,200	1,200	1,800	800			
2010	1,500	1,000	1,000	1,600	700			
2020	1,400	900	900	1,500	600			
Derived Demand forAfforestation Seedlings ('000)								
1995	2,005	2,316	651	1,638	1,848		8,457	
2000	1,520	1,505	463	1,800	2,128		7,416	
2010	1,557	1,700	497	1,888	1,995		7,637	
2020	1,960	1,665	552	2,040	1,826		8,043	
Total Derived Demand for Seedlings (millions)								
1995	3,042	2,555	2,236	3,066	2,684		13,582	
2000	2,775	1,844	1,880	4,233	3,264		13,995	
2010	2,708	2,212	1,801	4,093	3,697		14,511	
2020	3,209	2,363	1,925	3,896	3,723		15,114	

Source: Table 3, EFI, FAO & GRC

1/ See Table 2 for definitions of forest types

2/ Calculated from actual figures reported by D Pandey & J. Ball in "The Role of Industrial Plantations in Future Global fibre Supplies", in *Unasylva, 1998, Vol.49, No. 2 (Issue No. 193) Golbal Fibre Supply*

3/ Estimated by GRC and provided as an indicative trend only

4/ Proportion of the F5 forests regenerated by planting as compared to those left to naturally regenerate

Table 4 presents the derived demand for seedlings in **reforestation** (replanting of cut-over land) and **afforestation** (establishment of new forests) activities from 1995 - 2020.

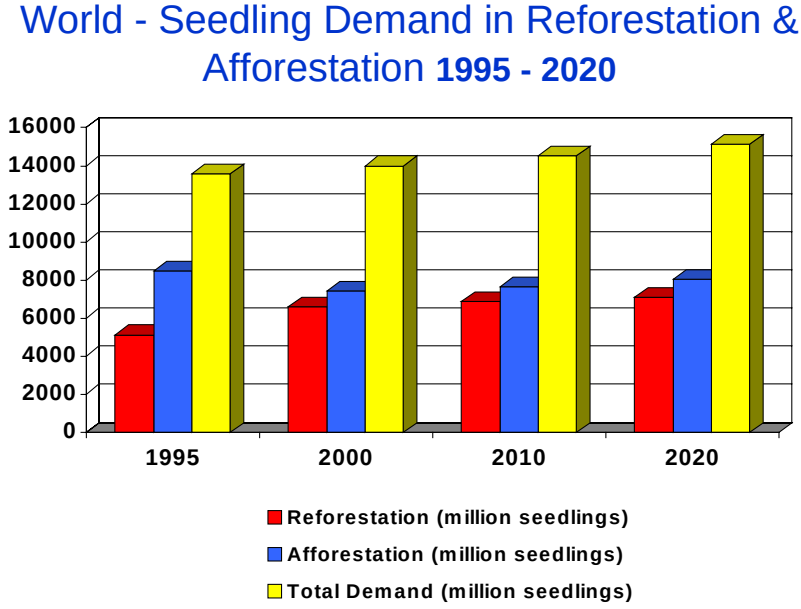
Graph 6 further illustrates **Table 4** which was derived from **Table 3** as follows:

(1) Based on the annual area harvested projected in **Table 3**, the number of plants required for reforestation was estimated by multiplying the average number of seedlings planted per ha by the area harvested.

(2) The number of plants required for afforestation was estimated using a similar method but applied over a **GRC forecast** of man-made forests created during the period.

(3) The two categories were added to provide an estimate of the total (all uses) annual demand for plants from 1995 - 2020.

Graph 6



The total demand for plants is estimated to grow from 13.6 billion plants in 1995 to approximately 15.1 billion in 2020. While only 37.7% of the plants produced were used in reforestation in 1995, the proportion will go up to 46.8% in 2020. Once again, this is a reflection of the increasing intensity with which natural and semi-natural forest are expected to be managed in the future, when natural regeneration of cut over lands will be increasingly discouraged and replaced by direct full or enrichment planting.

Table 5 shows estimates of the derived demand for tree seedlings by main specie in 1995 -2020. **Table 5** was calculated from **Table 4** using coefficients of species distribution derived from published and unpublished information, and the professional experience of the consultant.

Table 5

World - Derived Demand for Tree Seedlings by Species 1995-2020

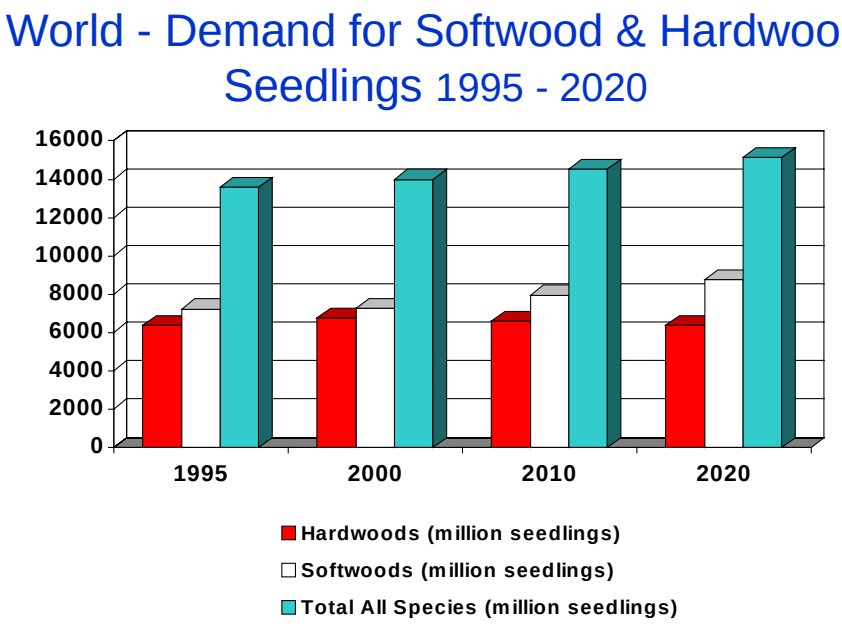
(millions of plants)

Species (All Regions & Uses)	YEAR							
	1995	Distrib.	2000	Distrib.	2010	Distrib.	2020	Distrib.
SOFTWOODS								
Southern Yellow Pine (Loblolly and Slash pine)	1,508	11.1%	1,581	11.3%	1,843	12.7%	2,056	13.6%
Radiata pine	190	1.4%	182	1.3%	218	1.5%	242	1.6%
Caribbean Pine + Hybrids	54	0.4%	42	0.3%	102	0.7%	212	1.4%
Pinus Patula	41	0.3%	28	0.2%	44	0.3%	60	0.4%
Other Pines	136	1.0%	112	0.8%	87	0.6%	91	0.6%
Douglas Fir	190	1.4%	210	1.5%	247	1.7%	257	1.7%
Spruce	1,711	12.6%	1,805	12.9%	1,988	13.7%	2,101	13.9%
Other Softwoods	3,396	25.0%	3,289	23.5%	3,410	23.5%	3,733	24.7%
Total Softwoods	**7,226**	**53.2%**	**7,250**	**51.8%**	**7,938**	**54.7%**	**8,751**	**57.9%**
HARWOODS								
Eucalyptus	1,005	7.4%	1,078	7.7%	1,524	10.5%	1,920	12.7%
Poplar	312	2.3%	364	2.6%	450	3.1%	574	3.8%
Acacia	1,535	11.3%	1,651	11.8%	1,872	12.9%	2,071	13.7%
Teak	190	1.4%	210	1.5%	290	2.0%	393	2.6%
Other Temperate & Tropical Species	3,314	24.4%	3,443	24.6%	2,438	16.8%	1,406	9.3%
Total Harwoods	**6,356**	**46.8%**	**6,746**	**48.2%**	**6,574**	**45.3%**	**6,363**	**42.1%**
TOTAL SEEDLINGS - ALL SPECIES	**13,582**	**100.0%**	**13,995**	**100.0%**	**14,511**	**100.0%**	**15,114**	**100.0%**

Source: Table 4, FAO, GRC & unpublished data

Table 5 and Graph 7 indicate that the proportion of softwood seedlings being used globally will decrease from around 53% in 1995 to 52% in 2000 but increase subsequently to about 55% in 2010 and 58% in 2020. This is no surprise given the generally higher value that industry has traditionally placed in growing softwood trees (with better and longer stem form) and less species diversity per unit area, than temperate and tropical hardwoods (with a more complex shape) and greater species diversity. Since not all the species found in a given hardwood stand are equally marketable, the extraction of lower volumes (the marketable ones) per unit area results in higher harvesting costs per m^3 than in a softwood forests. There is also the remarkable adaptation of exotic conifers (softwoods) to a variety of growing sites around the world, with superior growing capabilities, that make them a preferred species for establishing tree farms.

Graph 7

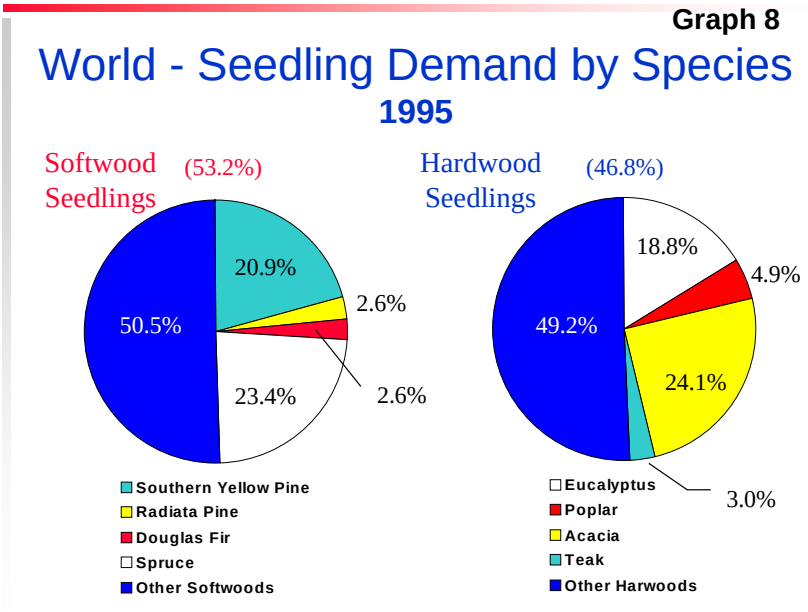


Graphs 8 and 9 show the comparative world seedling requirements by main species in 1995 and 2020, respectively.

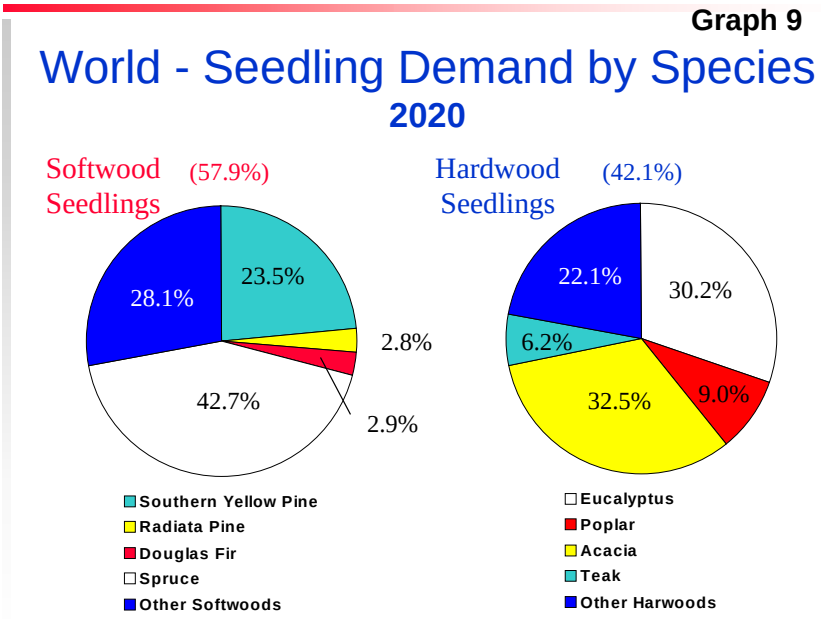
Total softwood requirements are estimated to grow from 7.2 billion seedlings in 1995 to some 8.7 billion in 2020. Should trends continue as in the last five years, the main species distribution will favour Spruce with 13.9% by 2020, followed closely by Southern Yellow pine (Loblolly and Slash pine) with 13.6%, Douglas fir 1.7%, Radiata pine 1.6% and Caribbean pines + Hybrids 1.4%.

Total hardwood requirements will comparatively be less at 6.4 billion plants in 1995 growing to 6.4 billion in 2020. The principal species used will be Eucalyptus with 12.7%, followed by Acacia with 13.7%, Poplar 3.8% and Teak 2.6%.

Graph 8



Graph 9



The rate of development, results attained (value added provided) and degree of acceptance of genetically improved seedlings will greatly shape the future demand by individual species used in plantings. With the ability to produce planting stock designed to meet the special needs of tree farmers, molecular biology and advanced tree breeding programs have the unique opportunity to responsibly help make the world greener while adding to forest resource productivity and their own welfare. In simple terms, they have the opportunity to help big and little foresters alike **"produce more with less"**. In a world soon to have 10 billion people this is indeed a privileged opportunity.

6. SUMMARY & CONCLUSIONS

The information analyzed in this report tends to strongly support the following findings and conclusions:

FINDINGS

Economic Growth & Forestry Demand

- Barring a major armed conflict, widespread famine or other catastrophe, world **population** which stood at 5.7 billion in 1995, **will rise to 7.5 billion** by 2020. The world's economy is also projected to grow rapidly, expanding at an average rate of 3% per year from 2000 - 2020.

- World demand for forest-based fibre (industrial timber, fuelwood, and other commercial consumptive uses such as hunting, fishing, etc.), and hence forests with a capability to deliver these goods, will continue to rise in line with growing world populations and economic growth. This will happen in spite of increasing wood substitution and other negative externalities surrounding the consumption of forest products.

- World demand for no-commercial forest goods and services (resource conservation, watershed & wildlife management, ecological reserves, creation of carbon sinks to ameliorate global warming, and other non-consumptive forest uses), and hence forests with a high capability to deliver these goods and services, will also continue to rise in line with growing world population and economic growth.

- The aggregate demand for all types of forest areas will snowball into increasing forest valuations (commercial & social) in both public and private land, leading to a more competitive (and aggressive) positioning of all stakeholders attempting to capture an increasing amount of the available forests for their personal enjoyment.

- Incremental demand for industrial timber will not be offset by the greater use of recycled fibre, forest industry residues, better utilization of species and increased efficiency in wood harvesting.

- Timber prices will grow at an average of 3.1 % per year in real terms from 2001 - 2010 and possibly at a somewhat faster rate of 3.5% from 2011 - 2020. This price increase will promote more intensive forest management (for higher growth and yield) in natural, semi-natural and man-made forests, stimulate manufacturing efficiency, and dampen excessive demand, all leading to an **increase in production/consumption** of 1.7% per year up to 2020.

Forest management and Creation of New Forests

- Forward looking entrepreneurs, government and Non Governmental Organizations (NGOs) will make efforts to solve the forest squeeze by

encouraging a more effective management of existing forests and the creation of new ones.

- **Investment into the establishment of** temperate, tropical and sub-tropical **man-made forests will increase** in line with the expectation of higher prices and returns to tree farm owners. Also, on-going reductions in the area of natural forests (in public lands) available for commercial harvesting will remain an of-setting influence on industrial timber and fuelwood supply, further increasing the need for managing the existing forests more intensively and creating new ones.

- The world's total industrial (exploitable) forests that stood at approximately 2.9 billion ha in 1995 will decrease to 2.6 billion ha by 2020. Driven by demand, **industrial roundwood production**, however, **will grow** from 1.6 billion m^3 in 1995 to 2.3 billion m^3 in 25 years, an increase of 43%.

- To produce the World's increasing timber output, the area of forests harvested annually will grow from 8.4 million in 1995 to 9.4 million ha in 2020. For the same reason, and to compensate for the increasing withdrawals of publicly-owned forests from the industrial reserve, the area of new forests established annually will grow from 6.6 million ha in 1995 to about 8.3 million ha in 2020.

- The world's total area in need of planting annually (in varying degrees), including reforestation and afforestation, will rise from around 15 million ha in 1995 to almost 17.7 million ha in 2020. The intensively managed forests (mostly semi-natural and man-made) will be entirely stocked with plants while the extensively managed (mostly natural) forests will be planted in a relatively lower but growing proportion (18% in 1995, increasing to 60% by 2020). The remaining area of natural forests will continue to be regenerated by natural means.

Demand for Tree Seedlings

- The need to fully stock or enrichment-plant annually a growing area of forests, will trigger a total derived **demand for tree seedlings** (all qualities and uses) that **will grow** from 13.6 billion plants in 1995, to 15.1 billion in 2020. The species distribution of the plant requirements in 2020 will tend to favour softwoods (58%) compared to hardwoods (42%).

- The most important species groupings planted by 2020 will be Spruce with 13.9%, followed by Southern Yellow pine with 13.6 %, Acacia 13.7%, Eucalyptus 12.7%, Poplar 3.8%, Radiata pine & Douglas fir 3.3%, and Teak 2.8%. These eight groupings will account for close to 64% of the world market for improved and unimproved seedlings. This species distribution, however, should be taken as indicative only given that the rate of development, results attained (value added provided) and degree of acceptance of genetically improved seedlings, will ultimately define the demand by species that will actually develop.

CONCLUSIONS

Based on the findings outlined above, it can be concluded that:

- The evidence **strongly supports** the premise outlined at the opening of the study. Namely, that for the next 20 years there will be **an increasing world demand** for forest products and services, and that industry and Governments will react by:

  (a) Managing more intensively the existing natural, semi-natural and man-made forests.

  (b) Allocating more of the existing forests to protected areas.

  (c) Creating new-man-made forests.

- In fulfilling (a), (b) and (c) above, and due to the close interrelation of resources, stakeholders will greatly increase the **demand for improved** forest management inputs in general, and **forestry seedlings** in particular.

- Finally, the findings give credence to the view that investment in world forestry in general and silviculture in particular, will remain sufficiently high in the medium and long-term to configure **strong market opportunities** for forest biotechnology products and services.