C I N T R A F O R

Working Paper 88

Assessing Implications of International Trade and Global Investments in Timberlands and Manufacturing with Respect to Southern Timber Supplies

John Perez-Garcia
Scott Marshall

April 2002

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This material is bassed on work supported by the USDA Forest Service under contract SRS 33- RJVA-99-673 and the USDA Cooperative State Research, Education and Extension Service. An opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the funding agency.

Technical Editors: Kendall Carson and Nicole Stevens

EXECUTIVE SUMMARY

The study examines where excess wood exists, how much can be imported to the US, and what opportunities exists for US investments overseas. The study begins with an examination of global demand. Data on global consumption of industrial roundwood reveals a structural break in consumption patterns during the early 1990's. Part of this break is the result of the collapse of the former Soviet Union. The shut down of not only its consumption but also its production sectors has had a visible impact on global consumption. Also efforts to produce timber in a sustainable fashion in tropical forests and environmental restrictions on softwood timber harvests significantly constrained timber supply in the 1990's, leading to reduced global consumption of forest products.

Two projections of future consumption are made. Using a growth rate of consumption observed prior to the 1990's results in projected consumption of nearly 3 billion cubic meters by 2050. Using a growth rate of consumption estimated during the 1990's results in a projection of 2 billion cubic meters by 2050. Near-term consumption is projected to increase from 300 million to 800 million cubic meters over the next 20 years.

The study also examines global timber supply projections using the ATLAS timber projection model, and their implication for excess supplies of wood fiber. Excess supplies are defined as the volume over rotation age assuming no growth in current demand. The model produces the biological potential for timber production for plantations established in New Zealand, Australia, Indonesia, Brazil, China, Argentina, Uruguay and Chile. The projections are based on specific assumptions about growth rates, rotation ages and areas planted in 1995. The projections indicate that in the short to medium term (from now to 20 years from now), there may be up to 400 million cubic meters (MMm3) of available wood in the Asian wood basket. These wood resources are close to China and represent 3.5 times the timber consumed in China in 1997. The Asian plantation wood is likely to compete with non-plantation wood particularly from Russia, and to some extent Scandinavia. Over the longer term, it is likely to compete with Chinese plantations as well.

Several countries in Latin America have the potential to develop inventories above rotation age totaling over 500 MMm3. Much of the additional short-term fiber from these plantations may fill European and North American markets, but are likely to come under competition from large non-plantation wood fiber sources in the northern hemisphere, such as Canada and Scandinavia, as well as the US fiber resource in the South.

The study also estimates economic supply for softwood logs using the CGTM. We develop cost curves by ranking the quantity of sawlog supply available at a given price. The cost curves assume no growth in demand over the projection period from 1993 to 2040. An additional 200 MMm3 of sawlogs would be produced with an increase of $188/mbf (2000US$ or $40/m3 in 1980US$). Finland produces the lowest cost sawlogs followed by New Zealand and then the US South. The three regions provide the bulk of the first 100 MMm3 of addition sawlogs. The interior region of western Canada, sourcing wood fiber from native forests, provides additional wood in the mid- to longer-term. Regions such as the US West provide little or no additional wood supply because they are meeting current demand.

Supplying the least cost manufacturing capacity is modeled in a similar fashion as supplying least cost sawlogs. The European region of Finland, Sweden and the western continental countries provide the majority of the lower cost manufacturing capacity.

The study concludes that while plantation wood may have a biological potential to produce nearly 1 billion cubic meters of wood fiber in the near-term term, there will be competition from wood fiber from non-plantation sources including Scandinavia, Canada and the US. The sourcing of non-plantation wood fibers from these regions appears to remain more competitive with plantation fiber according to simulations with the CGTM.

The 1 billion cubic meters of potential wood fiber is greater than the upper bound of 750 million cubic meters projected for the near-term demand for industrial roundwood. However, the projection of biological supply is sensitive to plantation growth rates and rotation ages used in the study. Timber inventory projections decline significantly with changes in these assumptions. Future work will require better information on area planted, their growth and management intensities defining rotation ages.

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1. INTRODUCTION AND JUSTIFICATION

Three key issues facing the southern forest sector are: Where is there excess wood now or in the future? What volume and or form of wood could come to North America and impact southern competitiveness? And what are the opportunities for forest sector investments outside of North America?

Structural changes in the global forest sector have led to intense scrutiny of international opportunities to expand timber production, invest in processing capacity or to source wood raw material or semi-processed products. Federal policy on public forests and new regulations on private timberland owners effectively have raised wood production costs in the West. Capacity expansion in the South has raised the demand for wood and increased the price of southern timber. The debate on Canadian lumber imports is likely to limit their participation in the US domestic market. These changes in the North American market have led to renewed interests to examine overseas opportunities to secure wood resources and gauge their potential impacts on southern timber resources.

These questions take on added importance since lower demand in the Asian economies have shifted trade flows to the US from emerging plantation areas of the southern hemisphere and Europe. The US market is now viewed as the global price-setting market for lumber. Costs of production in the US have risen to the point that any new increment of wood produced will likely be in response to higher product prices. Higher product prices are needed to squeeze new production out of US producers, but should also invite overseas producers to market their products in the US.

2. OBJECTIVE

The objective of the study is to provide answers to the following questions:

1. Where is there excess wood, now or in the future?

2. What volumes and or form of wood could come to North America and affect US competitiveness?

3. What are the opportunities for forest sector investments outside of North America?

By answering these questions the study provides useful information to understand the southern timber supply situation in the national and global forest products markets, the investment opportunities in the forest products sector and likely new sources of wood products in the future.

3. STUDY METHODS

The study provides measures of global demand, potential supply for selected regions and the relative cost of supplying additional increments of sawlogs and manufacturing capacity. Several models are used to project the share of production across the globe. Timber supply projections are based on survey results conducted by FAO on area plantings in countries across the globe and summarized in FAO (2000). Growth and yield estimates and average rotation age are used to develop an inventory profile with a distribution between softwood and hardwood components. The inventory profile, yield information and harvest projections are used to project future growth and inventory using ATLAS (Mills and Kincaid 1992). The information on growth developed by using ATLAS is incorporated into the CGTM's timber supply submodel (Cardellichio et al, 1988).

The CGTM (Cardellichio et al., 1989) is used to construct global supply curves for softwood sawlogs and softwood manufacturing capacity. The model interacts with ATLAS by providing a harvest projection to ATLAS and taking a growth projection from ATLAS to situated the sawlog supply curve for each year. Existing inventory and cost data for sawlogs define the initial position and subsequent movement of the timber supply curve in CGTM. With data on demand, manufacturing capacity and trade in sawlogs and lumber products, the CGTM is used to construct annual global supply curves, which are made up of each regions' contribution to supply ranked by cost.

The study begins with a look at global timber demand in section 4, and then shifts to an analysis of global supply of industrial wood fiber in section 5. Here, regional inventory distributions are presented and the section concludes with a discussion of the implications of plantation-sourced wood fiber. Section 6 describes how global supply curves for softwood sawlogs are developed using the CGTM. A portion of the section describes pulpwood projections used by the CGTM to construct supply for sawlogs, since wood fiber is allocated first to meet pulpwood demand, and then to meet the demand for lumber and plywood. The section presents the global softwood sawlog supply curves. Section 7 follows with a presentation of similar supply curves for manufacturing capacity. A discussion of the implications of plantation-based wood fiber, the results of global sawlogs supply and manufacturing supply curves is presented in section 8 followed by a section on conclusions drawn from the analysis.

4. GLOBAL DEMAND

Global supply must be balanced by global demand, and we use this condition to discuss the results of the study. Projections of demand are developed based on: 1) the outlook for GDP growth in various countries around the globe and 2) trend analysis of consumption of wood fiber and its relationship with economic growth. This relationship postulates that as global income increases so does the consumption of wood raw materials.

4.1. STRUCTURAL BREAK IN DEMAND FOR WOOD FIBER

Figure 4.1 charts the historical relationship using world gross domestic product (GDP), as the measure of global income converted to real US dollars using purchasing power parity, and consumption of industrial round wood in million cubic meters. The figure also includes two extensions of the historical growth rate based on two different sample periods. Industrial raw material is defined as timber that produces paper and paperboard products, solid wood products and other miscellaneous products, (i.e. no firewood). Data on GDP is taken from various World Bank and OECD publications. Industrial wood consumption data is taken from FAO.

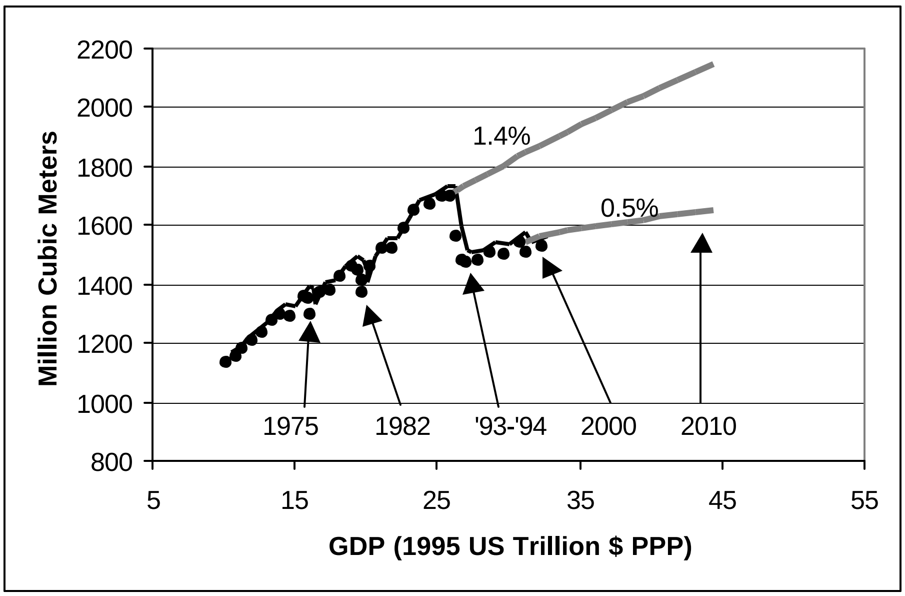


Figure 4.1. Consumption of Industrial Round Wood by Economic Activity from 1965 to 2000 and Projections (Grey Lines) to 2010.

The figure suggests that the global forest sector is below its historic consumption trend, and has been for a significant period of time. For example, prior to 1990, the forest products industry was increasing its use of wood by 1.4% annually with an average 3.5% rate of growth in the world economy. An extension of this utilization rate would have placed global consumption at around 2.1 billion cubic meters by the year 2010.

However, the last decade of the 20^{th} century produced significant changes in the global forest sector, which may prove to be permanent. Foremost, the demise of the Soviet Union had a large impact on global production and consumption of wood products. Also, efforts to produce timber in a sustainable fashion in tropical forests and environmental restrictions on timber harvests significantly constrained timber supply. These two changes are evident as the line representing the long-term relationship between consumption and income shifts downward in the early 1990's. The effects of the collapse of the Soviet Union and other factors resulted in a sharp decline in global consumption of industrial round wood.

Not evident in the chart is the fact that new sources of fiber were introduced to replace a part of the reduction in timber supplied from the Pacific Northwest, Russia and tropical regions. As these new sources of wood fiber were introduced to supply global demand, there have been adjustments in how the fiber is used. The shortage of wood produced by the collapse of the former Soviet Union and stricter regulations on harvesting wood resulted in higher prices and allowed wood-saving technologies to take hold. Data for the last decade on wood consumption and GDP suggest that, on average, the forest products industry worldwide was increasing its use of wood as a raw material at an annual rate of 0.5%, a sharp decrease compared to its consumption rate observed during the previous three decades. A projection of industrial use suggests global consumption of around 1.6 billion cubic meters by 2010, a level observed in the mid 1980s. The 0.5% growth assumption, also based on a global average 3.5% GDP growth rate, assumes that the structural changes associated with wood supply and wood use are permanent.

In addition to the structural change, there are cyclical movements of consumption associated with the global business cycle. There have been several dips in consumption as evident in Figure 4.1. The first two dips are a response from wood using industries to higher energy costs, which led to worldwide recessions in 1975 and 1982. A global slowdown in 1991 is also a factor in the decline in consumption, yet these cyclical events tend to average out over time. With recent data on GDP for 2001, it is likely that consumption is below the 0.5% trend line.

4.2. LONG-TERM PROJECTIONS

Projections over the longer term made by extending the global average for economic growth over the next several decades and using the historical trends in consumption place wood demand below those that would have resulted using pre-1990 data. By 2050 the range of consumption produced by our assumption of either a 0.5% or 1.4% rate of increase is from 2.0 billion cubic meters and 2.8 billion cubic meters, with a global economy of nearly five times the size in 2000. The bottom end of the range indicates an increase of 500 MMm3 over the fifty-year period. The top end of the range suggests an additional 1.3 billion cubic meters to meet demand. Mid-term, we are suggesting a 300 to 800 MMm3 increase in wood fiber consumption.

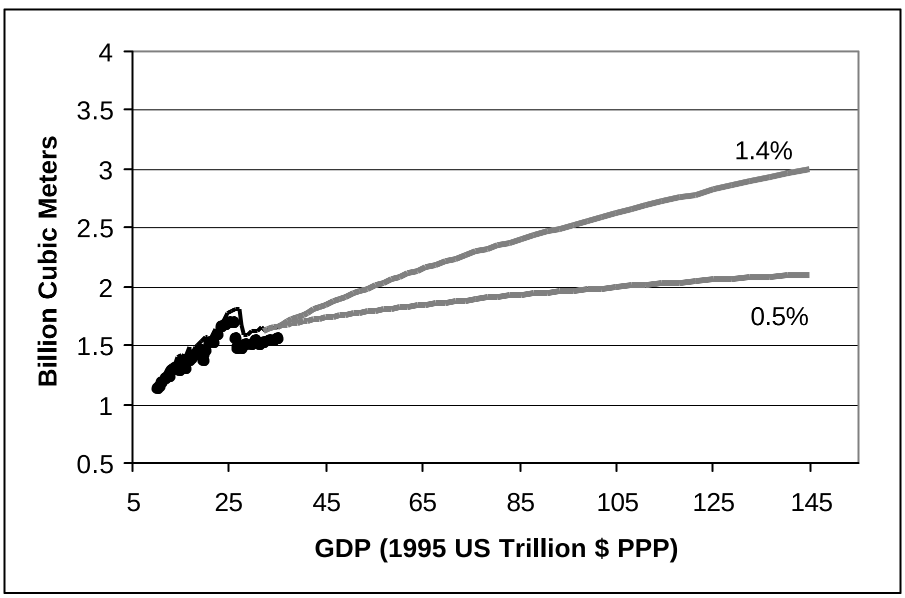


Figure 4.2. Consumption of Industrial Round Wood by Economic Activity from 1965 with Projections to 2050. Based on an Average GDP Growth Of 3.5.

5. GLOBAL TIMBER SUPPLY

The global demand projections include both hardwood and softwood fibers used in industrial applications. Under these projections, anywhere from 300 to 800 MMm3 of new wood fiber consumption will be required over the medium term. Since plantation wood may be the source of this new fiber, we examine it more closely in this section.

The section presents potential supply data for selected countries to illustrate the possible role new areas of wood fiber production may have in meeting growing demand for wood fiber. These countries include Chile, Uruguay, Brazil, Argentina, New Zealand, Australia, Indonesia and China. These countries were identified as potential areas where plantation establishment could lead to excess supply of wood fiber and impact the North American fiber supply. In addition, there may be interest to invest in these countries should the financial aspects of wood fiber production prove to be attractive.

For each of these regions we provide industrial wood plantation area statistics, species distribution, their likely utilization and potential yield expectations, and establishment trends (areas planted, age class). The data for this analysis is taken from FAO (2000). In several instances we utilize a range of values illustrating the degree of uncertainty in the data and their projections. The following presentations describe the inventory distribution for each region. More detail information on each region is provided in Appendix 1.

5.1. NEW ZEALAND

New Zealand has about 1.5 million hectares of plantations established by 1995. The main species in New Zealand is *Pinus radiata* representing 91%.

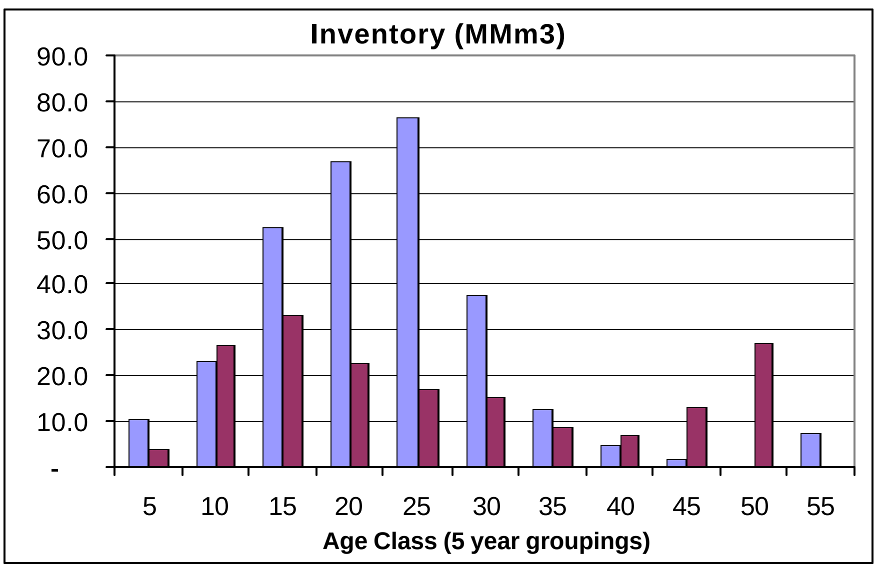


Figure 5.1. New Zealand 1995 Projected Inventory Distribution.

New Zealand has a relatively balanced age-class distribution, with a predominance of areas under 35 years old. Figure 5.1 presents the inventory distribution by age-classes using an average MAI of 18 m3/ha/yr and an average rotation age of 25 years. Two estimates of plantings are used to determine the inventory distribution for 1995. The higher estimates for mid-aged groups are from FAO (2000). The lower estimates are based on plantings distribution arrived from New Zealand statistics (Neumann and Perley 1992). Short-term volume available for harvests, defined as the volume above rotation age, is estimated at about 88 to 140 MMm3. Industrial roundwood production was estimated at 16.4 MMm3 in 1997 of which 20% was pulpwood (FAO 1999).

5.2. AUSTRALIA

Australia has about 1 million hectares of plantations according to the FAO study (2000). The main species is *Pinus radiata*, accounting for 62%. Figure 5.2 presents the inventory distribution by age-classes using an average MAI of 18 m3/ha/yr and an average rotation age of 25 years. The inventory has a relatively balanced age-class distribution, with a predominance of areas under 35 years old. No second estimate of area is available for Australia, hence only the FAO estimate is presented in Figure 5.2. Short-term volume that is available for harvest is about 140 MMm3. Industrial roundwood production was estimated at 20.2 MMm3 in 1997 of which 47% was pulpwood (FAO 1999).

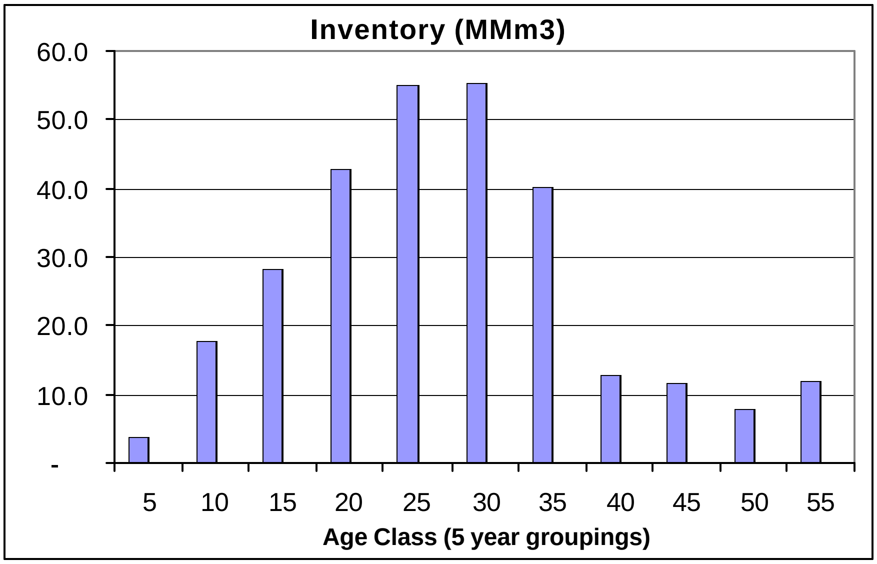


Figure 5.2. Australia1995 Projected Inventory Distribution.

5.3. INDONESIA

There are about 3 million hectares of forest plantations in Indonesia with a great variety of species planted. Figure 5.3 represents the inventory distribution based on an average growth rate of 12 m3/ha/yr and a 25 year rotation age. The chart indicates a relatively balanced inventory, expanding in the mid age classes, with volumes in older age classes as well. Industrial roundwood production was estimated at 47.3 MMm3 in 1997 of which 24% was pulpwood (FAO 1999).

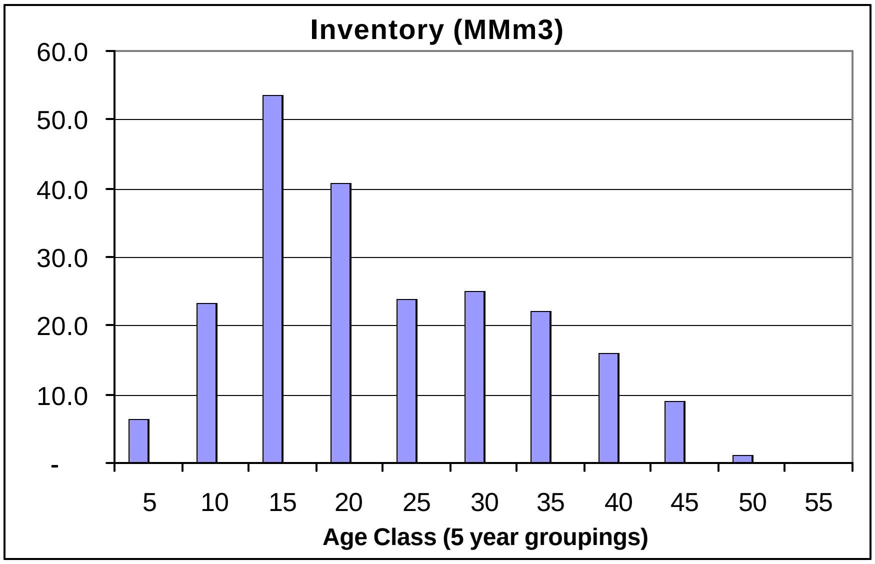


Figure 5.3. Indonesia 1995 Projected Inventory Distribution.

5.4. BRAZIL

Brazil has about 4.2 million hectares of plantations. The main species is *Eucalyptus sp*, which accounts for 65%. Assuming an 18 m3 per hectare per year growth rate, the inventory distribution indicates a relatively balanced age-class, with a large percentage of its volume above the 15-year age class: about 405 MMm3 of wood fiber. Industrial roundwood production was estimated at 84.7 MMm3 in 1997 of which 36% was pulpwood (FAO 1999).

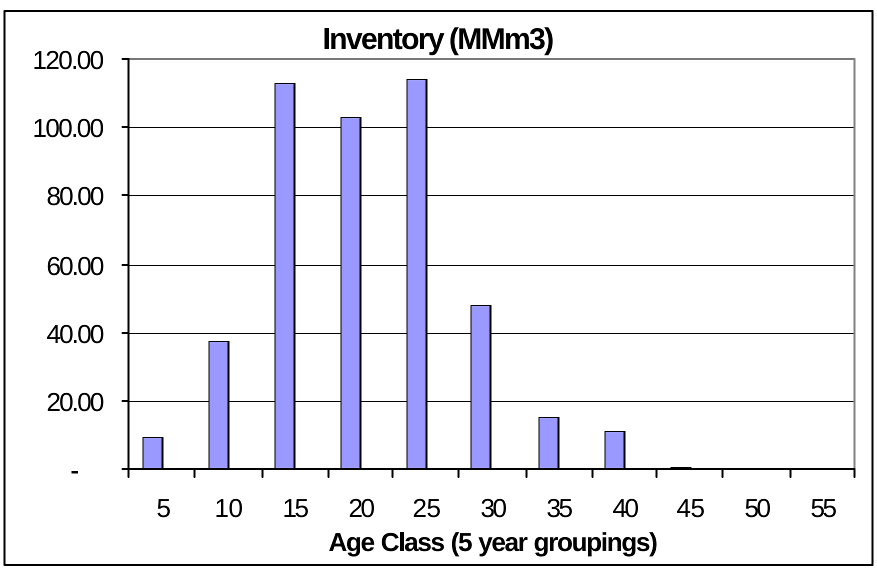


Figure 5.4. Brazil 1995 Projected Inventory Distribution.

5.5. CHINA

China has recently embarked on a plantation program that has resulted in a young plantation resource according to the FAO (2000) statistics. Over the past 15 year, China has planted over 17.5 million hectares. Reports on the success of these plantings have suggested limited success in early years and below average growth rates. We assume two growth rates and rotation ages to illustrate the potential range of their inventory distribution. Assuming a growth rate of about 1 m3 per hectare per year and a rotation age of 55 results in the inventory distribution illustrated in Figure 5.5, smaller bars. Assuming a higher growth rate of 10 m3 per hectare per year and a shorter rotation age significantly expands the resource base in China, as is illustrated in Figure 5.5 with the higher bars. Additional information is required to determine the average growth rate needed to more accurately project wood fiber production from plantations, since under these two plausible assumptions the plantation inventory resource in China ranges from 75 MMm3 to over 400 MMm3. Under both of these scenarios, however, the age of the resource limits its short-term availability. Industrial roundwood production was estimated at 108.7 MMm3 in 1997 of which 7% was pulpwood (FAO 1999).

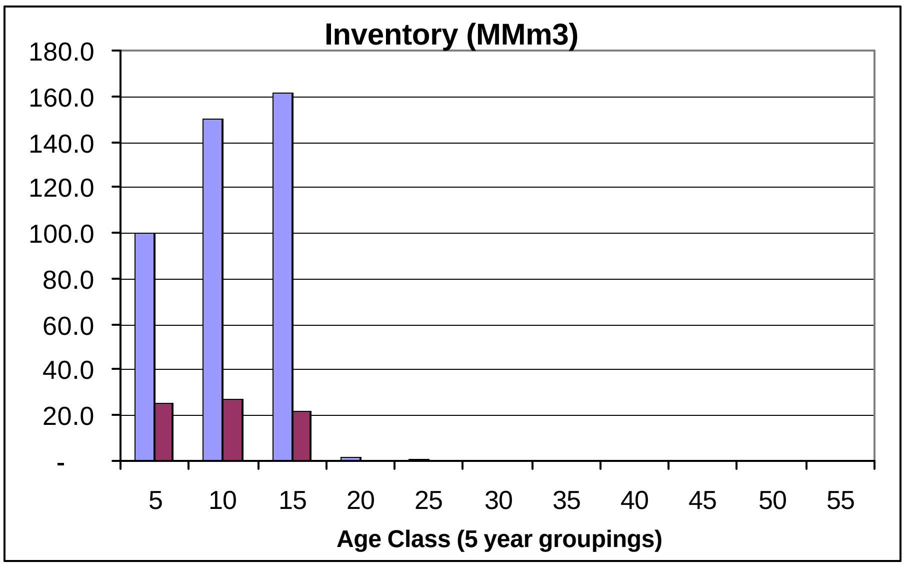


Figure 5.5. China 1995 Projected Inventory Distribution.

5.6. ARGENTINA

Argentina has planted nearly 700,000 hectares in softwood and hardwood species. Assuming a growth rate of 18 m3 per hectare per year, the inventory distribution indicates a growing base with short-term fiber available. About 90 MMm3 of wood fiber is 30 years and older. Industrial roundwood production was estimated at 7.7 MMm3 in 1997 of which 48% was pulpwood (FAO 1999).

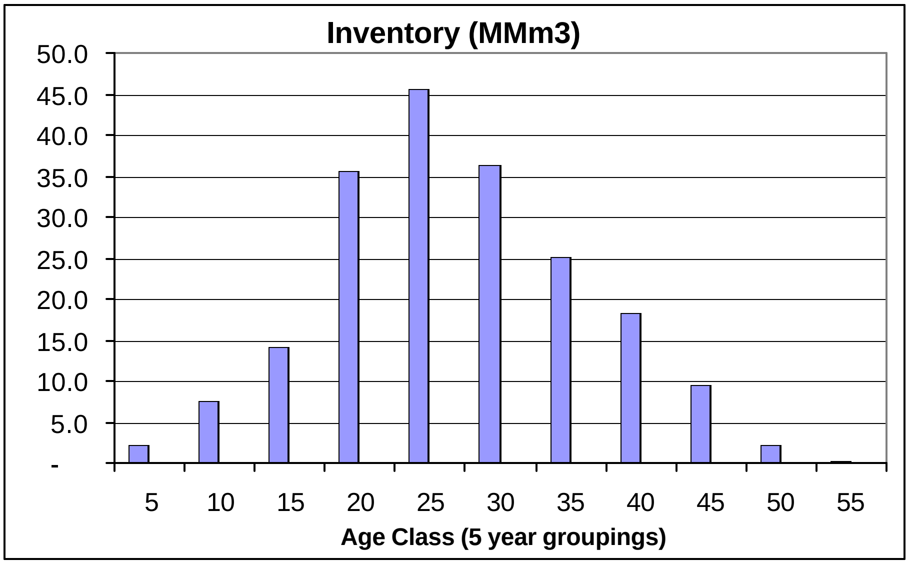


Figure 5.6. Argentina 1995 Projected Inventory Distribution.

5.7. URUGUAY

Uruguay has recently increased industrial plantings jumping from less than 2 thousand hectares in the late 80's to over 10,000 hectares per year in the early 90's. Over 80 percent of the species planted in *Eucalyptus*. Figure 5.7 indicates the recently planted volumes as well as large volumes in age classes above 20 years. Industrial roundwood production was estimated at 1.0 MMm3 in 1997 of which 21% was pulpwood (FAO 1999).

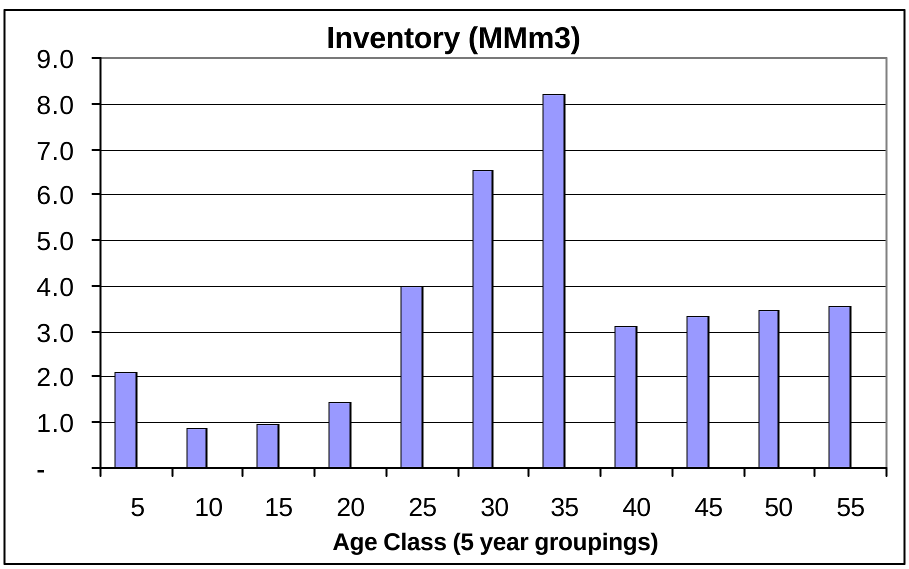


Figure 5.7. Uruguay 1995 Projected Inventory Distribution.

5.8. CHILE

Chile has about 1.7 million hectares of plantations. The main species is *Pinus sp.*, which represents 78%. The inventory estimated for 1995 has a relatively balanced age-class distribution, with a predominance of areas under 35 years old. A second estimate of the inventory distribution is included in Figure 5.8 and shows similar results, with the exception that the FAO estimates are indicating a large volume in older age classes. Short-term harvest potential amounts to146 MMm3. Industrial roundwood production was estimated at 19.8 MMm3 in 1997 of which 36% was pulpwood (FAO 1999).

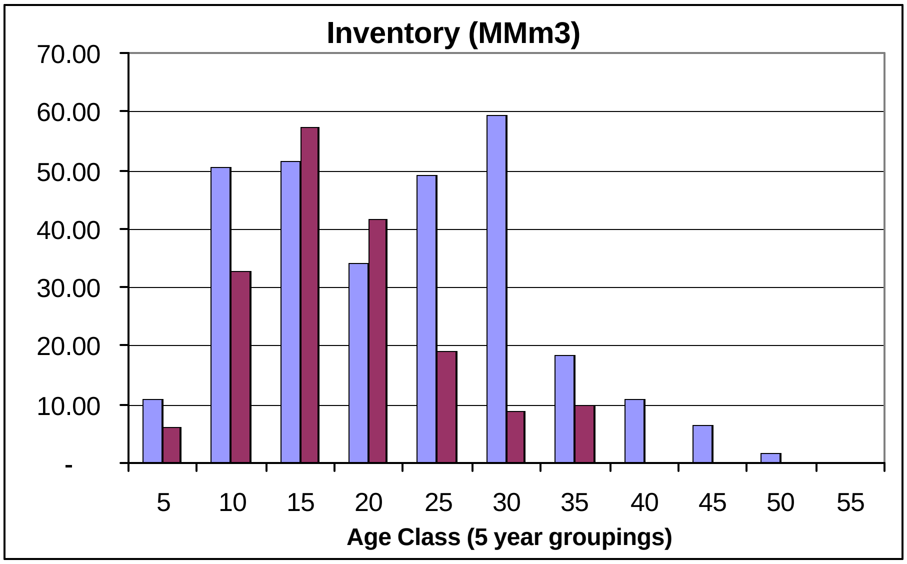


Figure 5.8. Chile 1995 Projected Inventory Distribution.

5.9. DISCUSSION OF PLANTATION PROJECTIONS

The short- to medium- term (from now to 20 years from now) available wood from the countries indicated above suggests that in the Asian wood basket, plantations in Indonesia, Australia, and New Zealand have over 400 MMm3 of harvestable based on the estimates of harvestable ages of +25 years and growth rates of 18 m3 per hectare per year (Table 5.1). These wood resources are close to China and represent 3.5 times the 113 MMm3 of wood fiber consumed by China in 1997. The projected demand for wood in China, combined with limited current short- to medium-term inventory, make these sources low cost options for China. The plantation wood is likely to compete with non-plantation wood, particularly from Russia, and to some extent Scandinavia, in the Chinese market. And, over the longer term, this plantation wood will also need to compete with Chinese plantations as they come on line.

Table 5.1. Total Volume in Age Classes Greater than Rotation Age.

Country	Rotation Age	Volume MMm3
China	35- 50	0
Indonesia	25	98
Australia	25	195
New Zealand	25	140
Argentina	25	137
Brazil	25	190
Uruguay	25	32
Chile	25	146
Total	25	938

In the American (North, Central and South) market, there is approximately 500 MMm3 from Argentina, Brazil, Uruguay and Chile (Table 5.1). Market demand for these fibers is not certain. Much of the additional short-term fiber from these plantations may fill European and North America markets, but again come under competition from large non-plantation wood fiber sources in the northern hemisphere, such as Canada and Scandinavia, as well as the US fiber resource in the South.

The amount of wood that can potentially be harvested in these plantation are likely to be sufficient to meet the growing demand for wood globally. The demand projections introduced earlier ranged from 300 to 800 MMm3 over the medium term, which is below the estimates provided above of potential supply from plantations.

6. LEAST COST SAWLOG PRODUCTION

The potential production from plantations is a biological potential rather than an economic one. In this section, the study applies economic costs to the biological potential so that those with a lower cost of supply can be identified. By doing so, we can disaggregate the potential production by costs into specific regions and describe the potential redistribution of wood fiber across markets implied by an increase in plantation roundwood. In addition, we include non-plantation wood fiber from regions that have historical supplied wood products. We do so within the economic modeling framework of the CINTRAFOR Global Trade Model (CGTM).

Cost data is fairly uncertain for many regions and are affected by many variables, such as existing infrastructure, availability of forestry professionals, transportation and cost of capital. As in the case with the growth estimates, which produced the inventory distributions above, we examine various alternative cost estimates to explore the potential economic harvests that may be obtained. Average costs figures are used, which may not reflect the true marginal nature of production decisions. However, they allow us to approximate the potential for these plantations to gain market share in the global market in an economic rather than biological sense.

6.1. CONSTRUCTION OF GLOBAL SUPPLY CURVES FOR SOFTWOOD SAWLOGS

We use the CGTM to construct global supply curves. Prior to our use of CGTM, we utilize the ATLAS model to project the timber inventories using the information in Section 5 on the age-class distribution. The interaction between ATLAS and the CGTM results in a harvest profile that is based on economic needs for each region and the projection of inventory growth, influenced by harvests and existing inventory levels. In order for ATLAS to project the timber inventory into the future, it uses the five-year harvest totals projected by the trade model. The resulting global supply curves consist of each region's additional contribution to supply based on log costs.

In constructing the global supply curves, we assume that global demand around the world remains constant at the 2000 level. This assumption allows only price-induced changes in demand to occur and is useful to discuss where low cost fiber exists irrespective of our view of regional demand differentials.

Prior to constructing the global supply curves for coniferous sawlogs, we present model assumptions on pulpwood demand. The economic model takes pulpwood demand as a given, and their projections are developed as indicated in the next section. It is important to understand the pulpwood demand since pulpwood comprises nearly 27% of the total industrial wood consumption. Following this section, we develop the cost curves for the world for softwood sawtimber.

6.2. ASSUMPTIONS ON PULPWOOD DEMAND

Pulp production and projections are used to derive pulpwood demand. Demand for pulpwood is met initially, followed by the demand for solid wood fiber. Projections for pulp production are determined using GDP and regional production shares, then distributing the shares among suppliers of pulpwood. The first step is to determine the change in the growth rate of real GDP per capita in percent terms by regions. Table 6.1 presents estimates of GDP per capita for a five-year period.

Table 6.1. Per Capita Projections of Change in GDP.

YEAR	USA	CAN	CAM	SAM	JPN	ASIA	EUW	OCN	AFRICA
90-94	1.90	1.50	0.40	0.40	1.90	2.00	0.80	2.00	0.80
95-99	2.55	2.15	1.20	1.20	-0.60	3.10	1.60	2.10	1.60
00-09	3.20	2.80	1.00	1.00	-3.10	2.00	1.50	1.90	1.00
10-19	4.70	2.40	1.00	1.00	-9.50	1.00	1.50	1.80	1.00
20-29	-0.10	-3.30	1.00	1.00	-13.20	1.00	1.50	1.50	1.00
30-39	0.00	-4.00	1.00	1.00	-15.00	1.00	1.50	1.50	1.00

Income group to estimate regional consumption of paper and paperboard products per capita uses real GDP with measures of income elasticity. The measures of income elasticity are taken from Perez-Garcia () and are reproduced below.

Table 6.2. Income Elasticity Estimates by Income Groups.

Income group	News	P & W	Other	Average	Higher	Lower
$0-$1999	0.406	0.470	0.538	0.471	0.538	0.406
$2000-$3999	0.880	1.666	1.460	1.335	1.666	0.880
$4000-$9000	0.588	1.268	0.916	0.924	1.268	0.588
$9000+	0.393	0.628	0.530	0.517	0.628	0.393

Table 6.3. Growth Rate of Paper and Paperboard Consumption.

YEAR	USA	CAN	CAM	SAM	JPN	ASIA	EUW	EUE	OCN	USSR	AFRICA
90-94	0.982	0.776	0.188	0.188	0.982	0.942	1.214	1.200	1.034	4.620	0.739
95-99	1.318	1.112	0.565	0.565	-0.310	1.460	2.427	1.200	1.086	4.600	1.478
00-09	1.654	1.448	0.471	0.471	-1.603	0.942	2.276	1.200	0.982	4.600	0.924
10-19	2.430	1.241	0.471	0.471	-4.912	0.471	2.276	1.200	0.931	4.600	0.924
20-29	-0.052	-1.706	0.471	0.471	-6.824	0.471	2.276	1.200	0.776	4.600	0.924
30-39	0.000	-2.068	0.471	0.471	-7.755	0.471	2.276	1.200	0.776	4.600	0.924

Note: The growth rates of EUE and USSR were determined exogenously.

The use of elasticity estimates and GDP growth rates produces estimates for the growth in paper and paperboard consumption broken down by region and time period.

Anchoring these growth rates to historical consumption numbers (production minus exports plus imports) produces annual estimates of paper and paperboard consumption. Summing the regional projections provides an annual estimate of world paper and paperboard consumption. Using the 1993 estimate for pulpwood used to meet world production and consumption numbers (0.7859 of wood pulp produced to meet 1 unit of paper and paperboard) produces the world wood pulp requirements.

World production of wood pulp is disaggregated by region based on wood pulp capacity data. Regional wood pulp capacity data is used to produce projections for pulp production by region. The pulp production demands are met by pulpwood harvested from forests and residuals supplied by sawnwood and plywood mills. Appendix 2 provides the pulp projections used in the present analysis.

6.3. SAWTIMBER SUPPLY ACROSS THE GLOBE

Having determined a projection of pulp consumption and regional production for the globe, we are now in a position to examine the global supply curves for sawtimber. We use the softwood sawlog sector as a starting point in our analysis. The supply curves are constructed by adding the next lowest cost increment of wood supply. The increment of wood is in 0.1 million cubic meters (about 20 mmbf). The region from which this increment in wood takes place is recorded. Also the value for each 0.1 MMm3 of logs is recorded and summed for the region. The regions are then ranked according to the total value of their wood supply. The result is a supply curve for the globe and cost ranking of region.

6.4. RESULTS FOR SAWLOG COST CURVE

Figure 6.1 represents the supply curves for 1993, 2010 and 2040. An additional 200 MMm3 of sawlogs would be produced with an increase of $40 (1980US$) /m3 ($188 /mbf 2000US$). The 2010 and 2040 curves are lower than the 1993 curve, due in part to the addition of plantation wood fiber, which lowers wood fiber prices, since these curves are constructed under a constant global demand scenario.

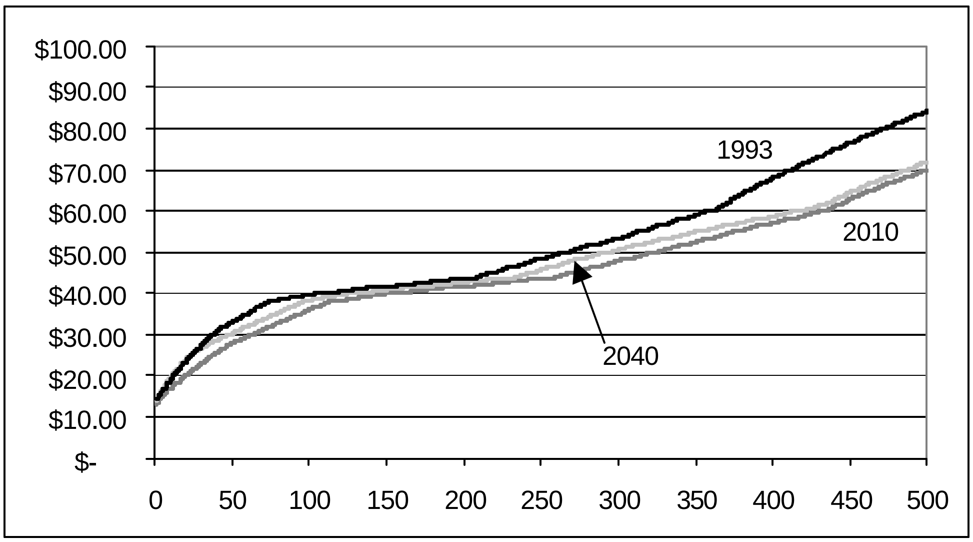


Figure 6.1. Global Supply Curve for 1993, 2010 and 2040 for Softwood Sawlogs (MMm3).

The regional break down for sawlog supply is listed in Table 6.4 and Figure 6.2. Each row identifies which region contributes to the 50 million cubic meter increment and by how much. For example in 1993 Finland (39.8), US North (2.1), Sweden (2.9) and the US South (4.2) supplied the first 50 MMm3 of wood fiber. The next increment of 50 MMm3 is recorded in the next row and indicates that, in addition to the previous suppliers, eastern and interior Canada and the US western regions also supply a portion of the wood fiber. Interior Canada increases the share of the 50 MMm3, as does the US South, while Finland reduces its share of the 50 MMm3 supplied. Interpretation of other numbers in the table follows the same process.

Table 6.4. Regional Distribution of Softwood Saw Logs by Incremental Volume (in million cubic meters). (For 1 MMm3 there are 0.424 billion bd. ft.).

Additional Volume	Finland	New Zealand	US North	Sweden	US South	West Europe	Eastern Canada	Interior Canada	US West
1993									
0-50	39.8	0	2.1	2.9	4.2	0	0	0	0
51-100	15.7	0	1	2.1	11.1	0	2.8	16.4	0.9
101-150	5.1	0.3	0.3	0.7	3.4	0	5.7	33.8	0.7
151-200	4.2	0.5	0.3	0.4	2.6	0	4.9	36	1.1
2010									
0-50	31.1	13.9	1.1	1.8	1.1	0	0	0	0
51-100	19.4	9.3	1.4	3.2	15.7	1	0	0	0
101-150	9.2	4.3	0.6	1.3	6.7	2.9	5	20	0
151-200	4.9	2.3	0.3	0.7	3.3	1.5	5.3	31.7	0
2040									
0-50	27	1.1	0	5.9	7.4	7.7	0	0	0
51-100	15.1	5.4	0.7	3.4	15.9	8.3	0	1.2	0
101-150	4.5	1.6	0.3	0.9	4.3	2.2	4.4	31.8	0
151-200	3.5	1.2	0.2	0.6	3.2	1.7	5.2	34.4	0

The table suggests several points. One is that Finland has the low cost sawlogs globally. This result is interesting in view of the plantation statistics provided earlier. Second, New Zealand follows Finland in the 2010 projections, then the US South. The three regions provide the bulk of the first 100 million cubic meters of additional sawlogs (20 billion board feet). Third, Interior Canada, sourcing wood fiber from native forests, takes on added importance to provide additional wood later in the projection period. Regions such as the US West provide little or no additional wood because their available wood supply is meeting current demand. Data presented in Table 6.4 is represented in bar charts in Figure 6.2.

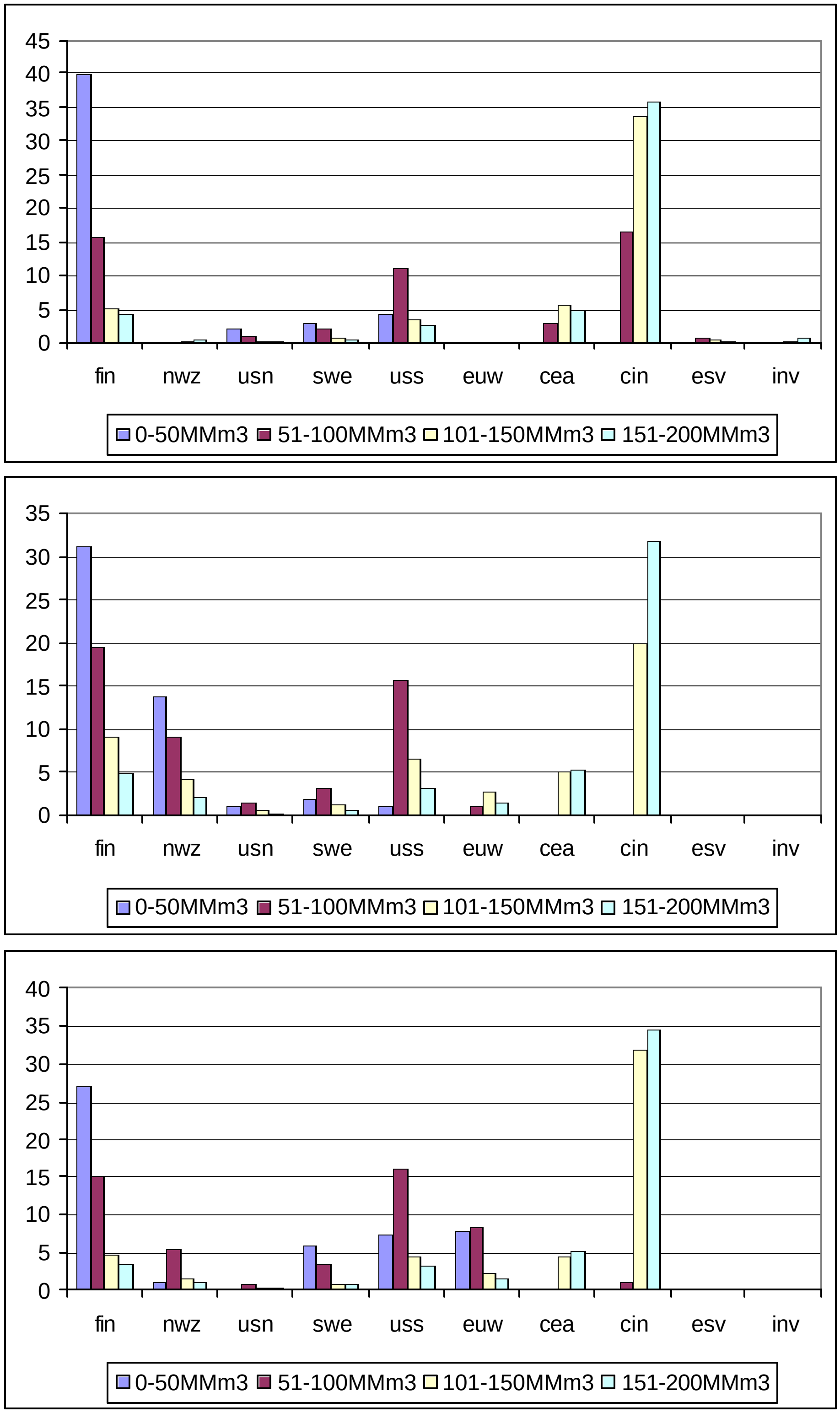


Figure 6.2. Regional Distribution of Softwood Sawlogs by Incremental Volume (1993 Upper Panel; 2010 Middle Panel; 2040 Lower Panel).

7. LEAST COST CURVES FOR SOFTWOOD LUMBER MANUFACTURING.

Supplying the least cost manufacturing capacity is modeled in a similar fashion as supplying least cost sawlogs. We have constrained the expansion of manufacturing capacity, along with demand to analyze the global cost curve for lumber manufacturing. Two curves are illustrated in Figure 7.1. Given the constrained nature of the business as usual, there is not much difference between the nature of the supply curves in 1993 and 2040.

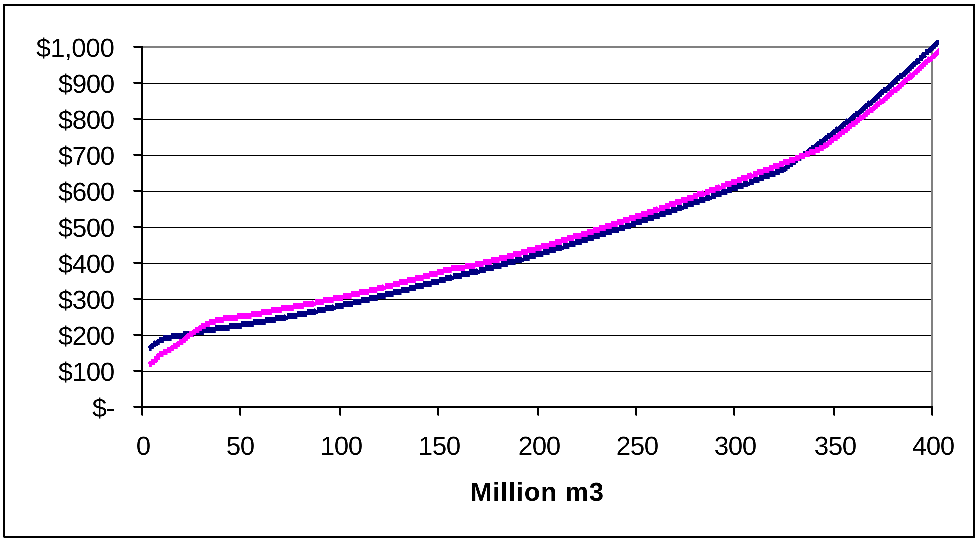
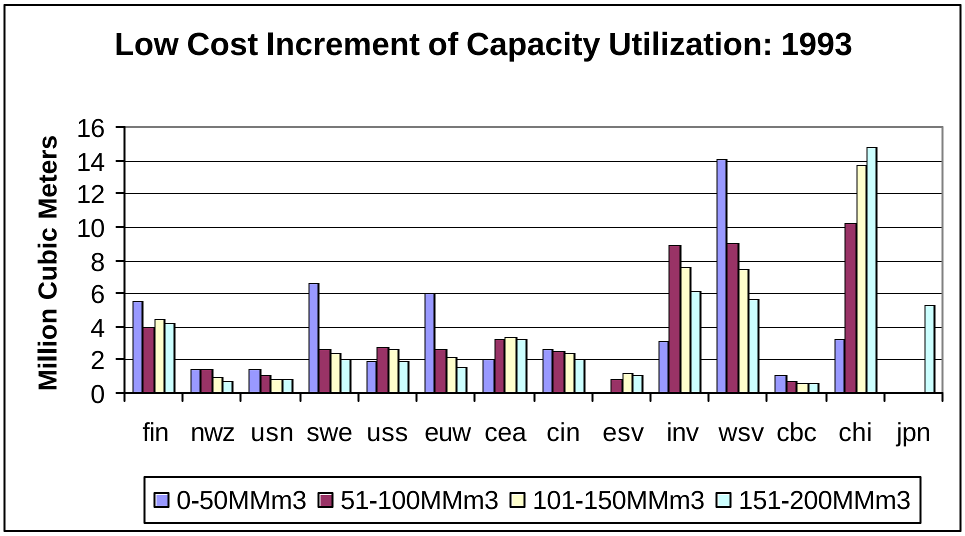


Figure 7.1. Global Cost Curve for Lumber Manufacturing 1993 and 2010.

Figure 7.2 illustrates the position of the countries in the capacity supply curves given above. While the cost structure of the curves does not change significantly between 1993 and 2040, their makeup does. For instance, the incremental cost of producing lumber changes is very similar, as illustrate in Figure 7.1 above. By 2040, however, the European regions of Finland, Sweden and Europe's western region, provide the majority of the lower cost manufacturing capacity. The results reinforce the gains to manufacturers of low cost sawlogs overtime as we hold capacity expansion and demand constant.



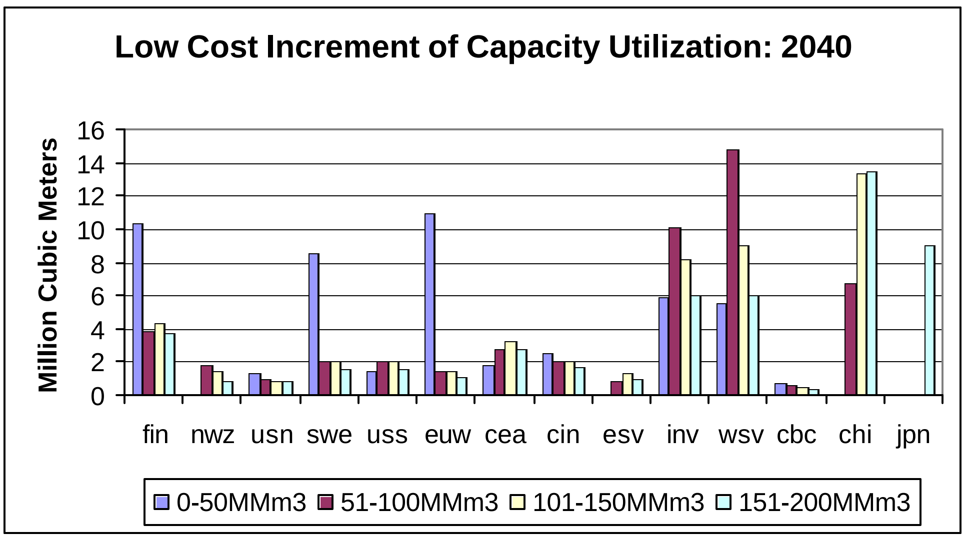


Figure 7.2. Regional Distribution of Softwood Limber by Incremental Volume (1993: Upper Panel; 2040: Lower Panel).

8. STUDY DISCUSSION

Global timber supply projections, like those produced by FAO (2000, Table 14, pg 101), suggest a potentially rapid increase in the biological production of plantation industrial round wood. By 2050, plantation round wood can produce up to 64% of projected global consumption (FAO 2000). Global consumption, under this scenario is expected to reach 2.34 billion cubic meters in 2050 from 1.5 billion in 1995. While the global consumption estimate agrees with the mid-point value produced in Figure 2.2, the estimated proportion of plantation wood consumed is different under the present study. Under the FAO estimate, a higher growth rate assumption for the consumption of industrial round wood lowers the percentage of plantation round wood contribution, suggesting that plantation-sourced industrial round wood would first be used to satisfy global consumption needs (FAO 2000 Table 14. pg 101).

While plantation wood has a biological potential to produce nearly 1 billion cubic meters of wood fiber in the short term, it will compete with wood fiber from non-plantation sources. These non-plantation sources include Scandinavia, Canada and the US. Half of the plantation wood fiber analyzed in this study is located in South America, while the other half is located the Pacific Rim region of Australia, New Zealand and Indonesia. Much of this latter wood fiber may fill in an expected demand by China and expected increase in South East Asia, until the Chinese plantations take hold in a couple of decades. Much of the South American wood fiber is likely to compete in US and European markets, as well as meeting rising demands in South America.

Non-plantation wood fiber appears to remain competitive with plantation fiber. Eliminating any demand growth differentials around the globe suggests that Finland is a competitive source of wood fiber. New Zealand's plantation resource is a second source of low cost wood. Once demand growth differentials across regions are incorporated into the discussion, the competitiveness of these regions would change depending on where demand growth will occur. Growth in Asian demand for wood fiber benefits plantation fiber, placing them nearer to the consumption regions that non-plantation sources, with the exception of Russian timber. Little demand growth in Europe would maintain lower wood fiber prices and sustains processing capacity competitive for non-plantation sources. In the US, little demand growth leaves the US West with a balance between capacity and wood fiber supply. Other regions in the US appear to have tighter processing capacity, which we indicate as areas where new investments may take place.

Outside of North America, the investment areas may include regions such as New Zealand, where inventory distribution and wood fiber availability, in combination with limited capacity indicates a potential for capacity expansion. Chile on the other hand possesses existing capacity that, with no demand growth, maintains wood costs low and existing capacity competitive.

9. CONCLUSION AND RECOMMENDATIONS FOR FURTHER WORK

Excess wood now and in the future is distributed between native forests of the northern hemisphere and new plantation areas of southern hemisphere and temperate regions. The marketability of this wood depends on many factors, including where demand growth is likely to occur, transportation costs and to some degree species utilization. Under homogenous demand across the globe, Scandinavian wood fiber is lower cost than plantation wood fiber from New Zealand, for example. Excess supplies in the South are also low cost over interior Canada. From this representation, we conclude that Scandinavian wood fiber is likely to be the most competitive with southern timber and can be viewed as an important marginal supplier to US markets. They are followed by New Zealand plantation fiber, which over the longer term drops out. Other plantation regions produce little excess volume that are important to US markets. An important factor to consider is the expected demand for wood fiber from China over the near term. Strong Chinese demand will draw New Zealand fiber away from US markets, and potential Scandinavian fiber as well.

The above conclusions are developed with simple inventory models of newly planted forests in emerging regions and an economic model of trade in forest products. There is much variation in the inventory profiles and potential harvests coming from these regions. This source of uncertainty comes from inadequate data on yields and forest plantation area. Also, species distribution and rotation ages affect growth and potential harvests into the future. The simplistic assumptions used to produce expected inventory in the future require further analysis and their impact on world wood fiber flows recorded.

10. REFERENCES

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Appendices

APPENDIX 1. REGIONAL ESTIMATES OF PLANTATION AREA, YIELD AND INVENTORY

This appendix presents projections of inventory by age class based on growth rate estimates, rotation age and area in forest plantations. The projections are made using a spreadsheet that allows alternative values of growth rates and rotation ages to be used to estimate the inventory distribution across age classes.

Column 1 describes the age class category.

Column 2 calculates the volume in each age class category. It is the growth rate (column 6) times the number of years in the age class.

Column 3 calculates the cumulative volume by adding the volume in column 2 with the cumulative volume from the previous age class and is graphed as yield curve in the figure below.

Column 4 establishes the target volume at rotation age. The target volume is the growth rate (MAI) times the rotation age. The target volume is used to adjust the growth rates in such a way as to reach the target volume by the rotation age.

Column 5 reports cumulative volumes used in ATLAS under an alternative yield and area distribution.

Column 6 is the growth rate used to calculate the volume in column 2. It is the volume growth per year. The growth rate is adjusted so as to reach the target volume by rotation age.

Column 7 saves the previous growth rate to compare with changes in the new growth rate of column 6.

Column 8 is an alternative estimate of area distribution by age class.

Column 9 is the FAO Industry estimate of area distribution.

Column 10 is the inventory distribution calculated as the area (column 9) by times the volume (column 2) divided by 1 million.

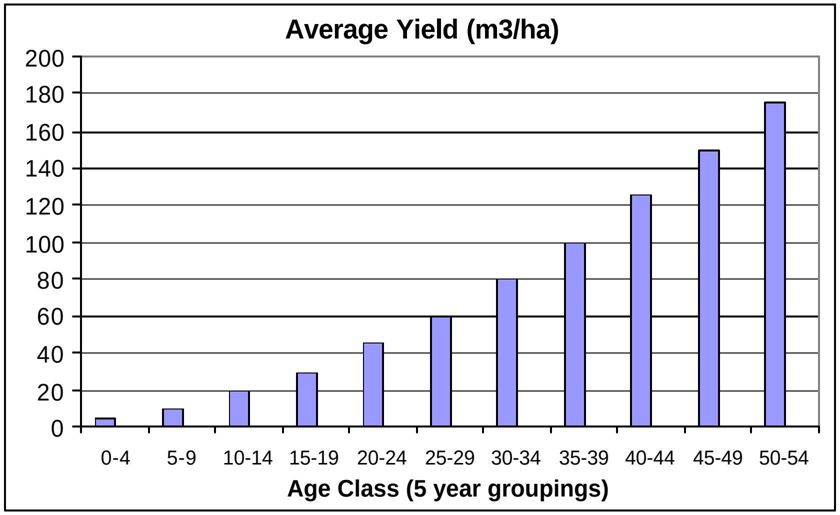
Column 11 is the inventory distribution calculated using the area in column 9 rather than column 9.

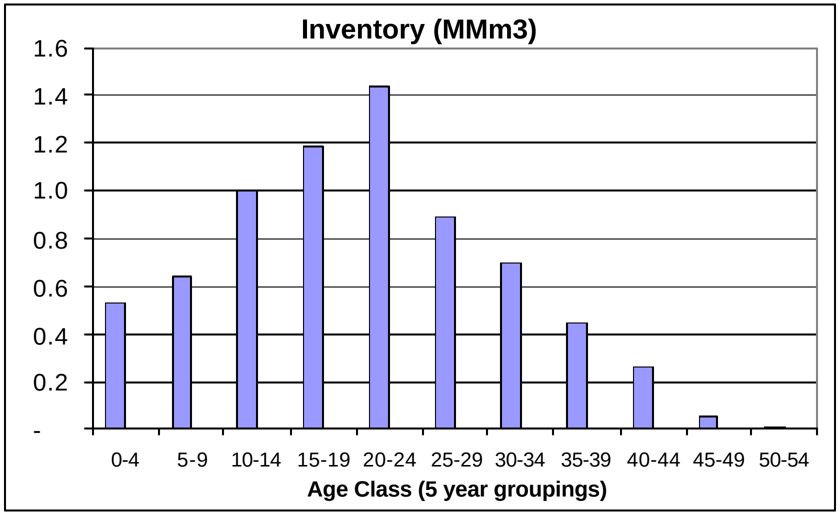
Columns 10 and 11 are graphed in the figures below each corresponding table.

Note: The column headings on the following pages are numbered according to the above explanations.

A1. **Argentina Industry**

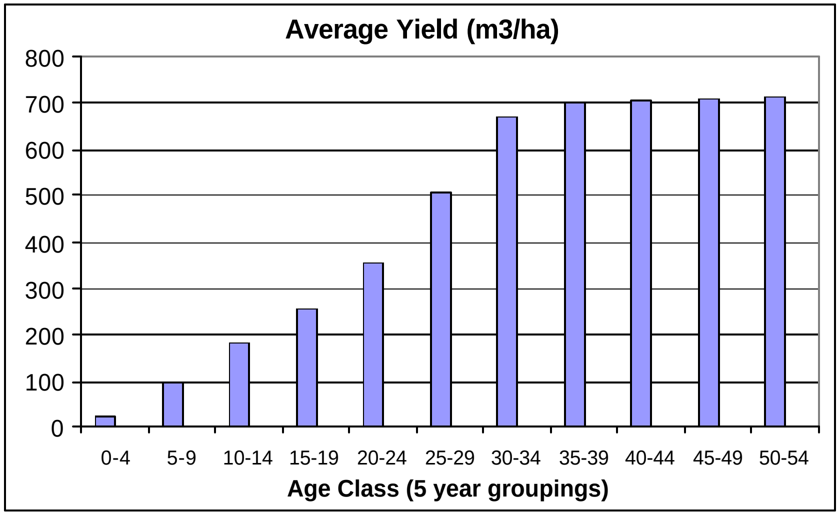
(1) Age Class	(2) Volume	(3) Cum Volume 1	(4) Target	(5) Cum Volume 2	(6) Growth Rate	(7) Previously Used Rate	(8) Hectares	(9) Hectares	(10) Lt. Grey	(11) Dk. Grey
0-4	5	5			1	4		105,235	0.5	
5-9	5	10			1	8		127,974	0.6	
10-14	10	20			2	16		100,590	1.0	
15-19	10	30			2	32		118,937	1.2	
20-24	15	45	50		3	35		95,957	1.4	
25-29	15	60			3	28		59,116	0.9	
30-34	20	80			4	22		34,699	0.7	
35-39	20	100			4	20		22,276	0.4	
40-44	25	125			5	0		10,281	0.3	
45-49	25	150			5	0		2,249	0.1	
50-54	25	175			5	0		171	0.0	

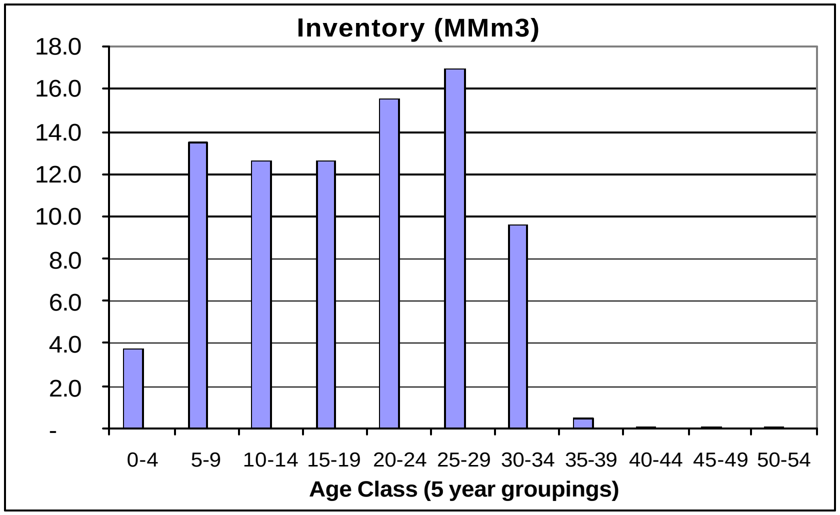




A2. **Australia Industry**

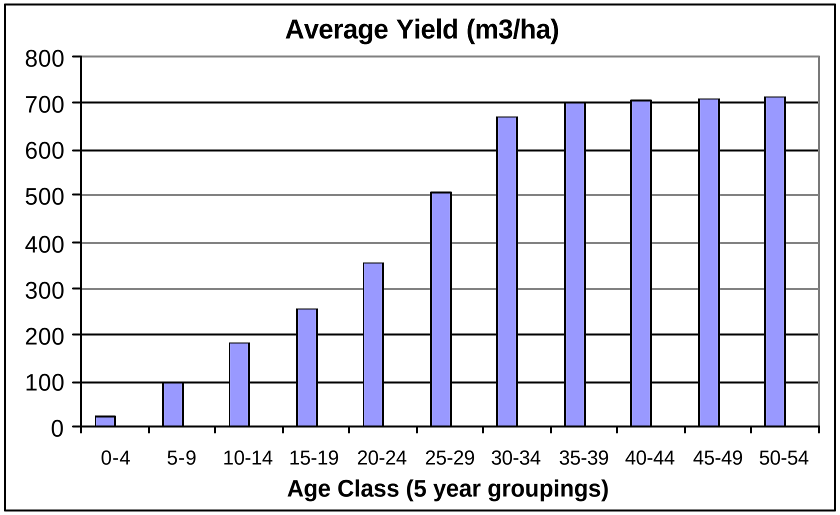
(1) Age Class	(2) Volume	(3) Cum Volume 1	(4) Target	(5) Cum Volume 2	(6) Growth Rate	(7) Previously Used Rate	(8) Hectares	(9) Hectares	(10) Lt. Grey	(11) Dk. Grey
0-4	25	25			5	4		151,335	3.8	
5-9	75	100			15	8		179,044	13.4	
10-14	80	180			16	16		157,388	12.6	
15-19	75	255			15	32		168,346	12.6	
20-24	100	355	450		20	35		155,191	15.5	
25-29	155	510			31	28		108,748	16.9	
30-34	160	670			32	22		59,810	9.6	
35-39	30	700			6	20		18,489	0.6	
40-44	5	705			1	0		16,323	0.1	
45-49	5	710			1	0		11,018	0.1	
50-54	5	715			1	0		16,872	0.1	

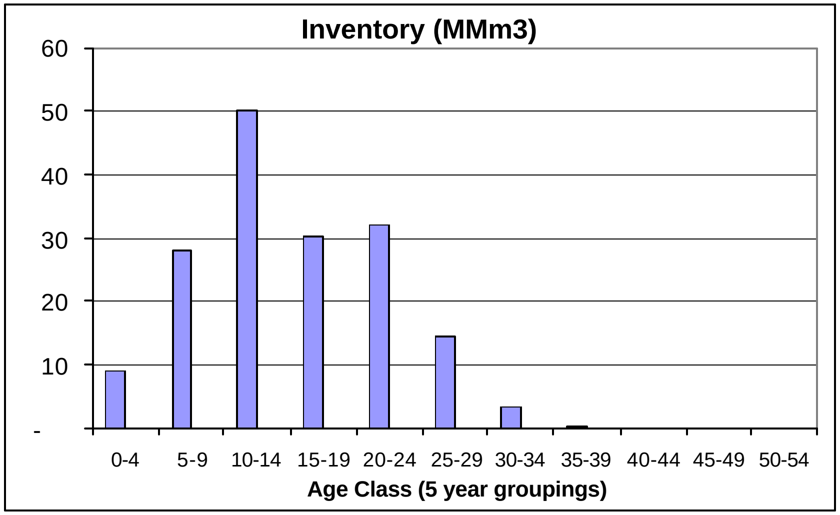




A3. Brazil Industry

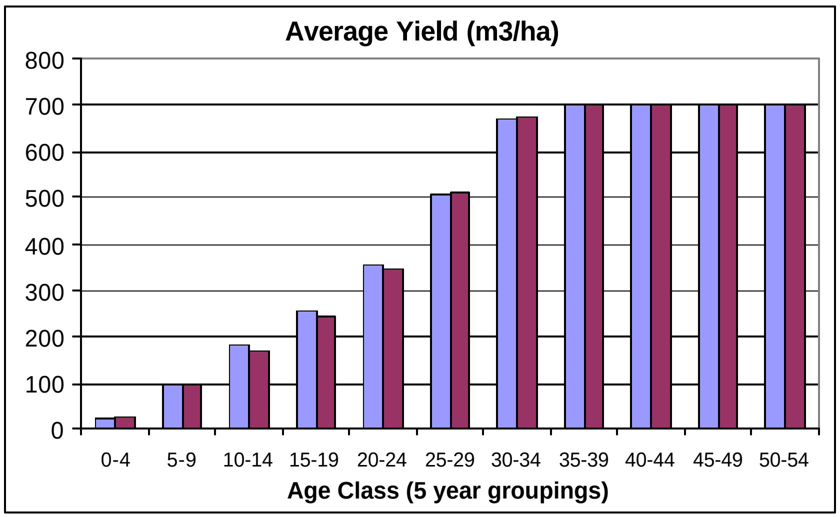
(1) Age Class	(2) Volume	(3) Cum Volume 1	(4) Target	(5) Cum Volume 2	(6) Growth Rate	(7) Previously Used Rate	(8) Hectares	(9) Hectares	(10) Lt. Grey	(11) Dk. Grey
0-4	25	25			5	4		372,301	9	
5-9	75	100			15	8		374,470	28	
10-14	80	180			16	16		628,383	50	
15-19	75	255			15	32		403,900	30	
20-24	100	355	450		20	35		320,986	32	
25-29	155	510			31	28		94,192	15	
30-34	160	670			32	22		22,338	4	
35-39	30	700			6	20		16,133	0	
40-44	5	705			1	0		1,055	0	
45-49	5	710			1	0		396	0	
50-54	5	715			1	0		124	0	

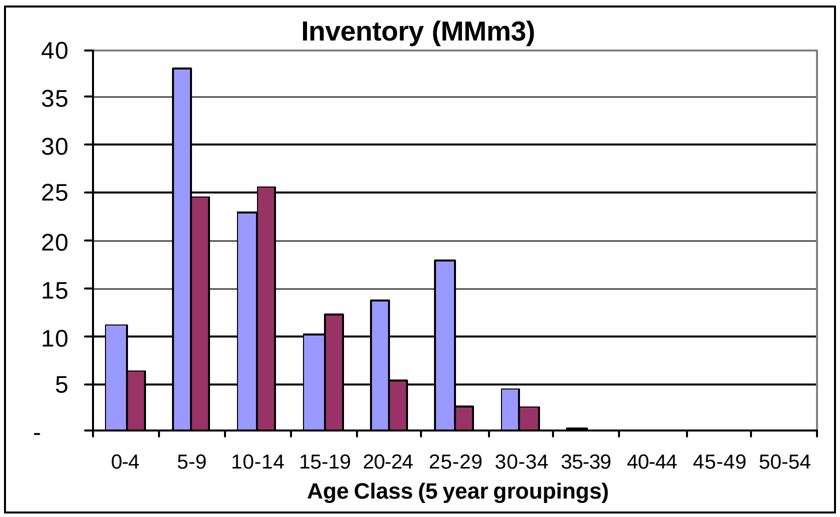




A4. Chile Industry

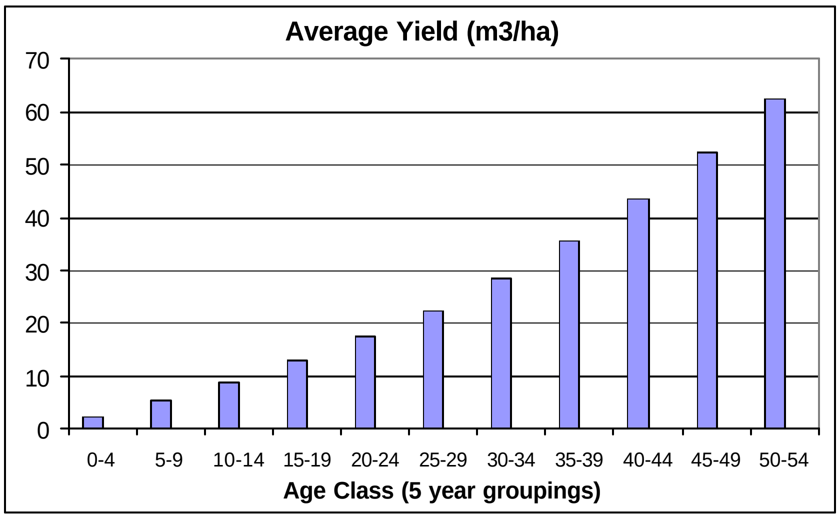
(1) Age Class	(2) Volume	(3) Cum. Volume 1	(4) Target	(5) Cum. Volume 2	(6) Growth Rate	(7) Previously Used Rate	(8) Hectares	(9) Hectares	(10) Lt. Grey	(11) Dk. Grey
0-4	25	25		28	5	4	251,139	440,907	11	6
5-9	75	100		100	15	8	327,093	507,020	38	25
10-14	80	180		171	16	16	319,591	286,074	23	26
15-19	75	255		243	15	32	163,337	134,004	10	12
20-24	100	355	450	347	20	35	53,632	138,217	14	5
25-29	155	510		514	31	28	17,378	116,192	18	3
30-34	160	670		673	32	22	15,022	27,626	4	2
35-39	30	700		700	6	20		15,395	0	
40-44	0	700		700	0	0		9,270		
45-49	0	700		700	0	0		2,415		
50-54	0	700		700	0	0				

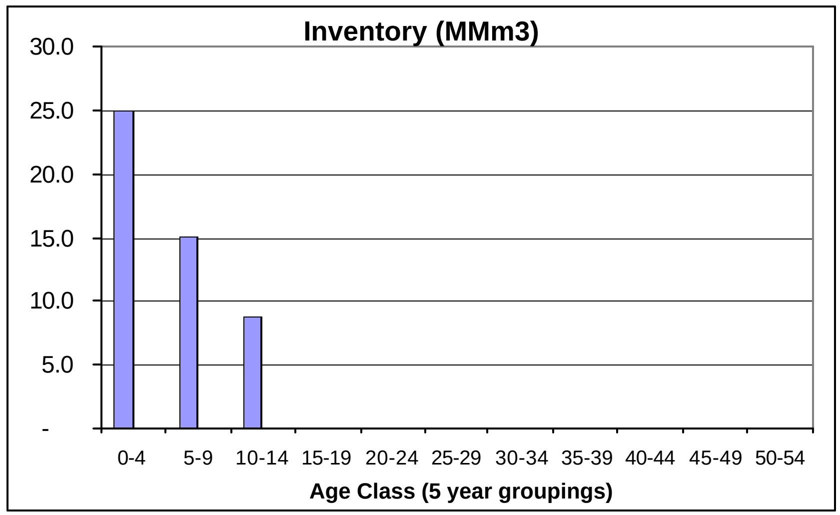




A5. China Industry

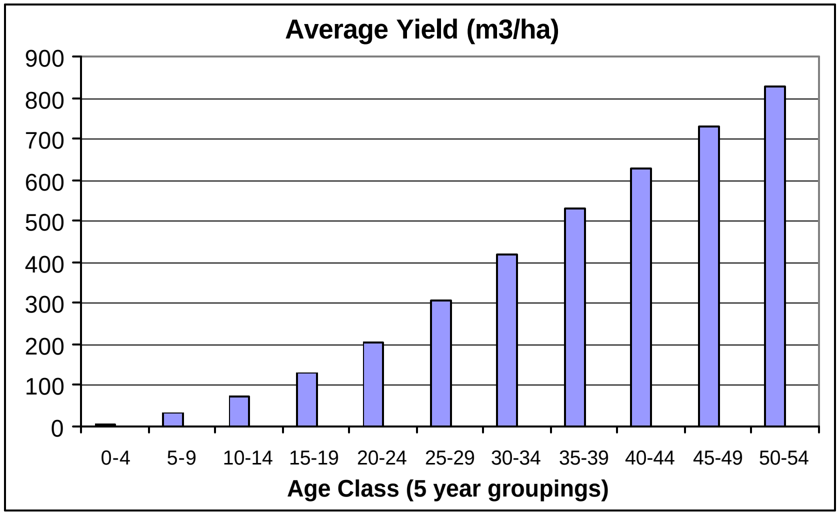
(1) Age Class	(2) Volume	(3) Cum. Volume 1	(4) Target	(5) Cum. Volume 2	(6) Growth Rate	(7) Previously Used Rate	-8 Hectares	-9 Hectares	-10 Lt. Grey	-11 Dk. Grey
0-4	2.5	2.5			0.5	5		10,015,029	25	
9-May	3	5.5			0.6	15		5,000,232	15	
14-Oct	3.5	9			0.7	16		2,485,550	8.7	
15-19	4	13			0.8	15		13,668	0.1	
20-24	4.5	17.5			0.9	20		3,713	0	
25-29	5	22.5			1	31		401	0	
30-34	6	28.5			1.2	32		3	0	
35-39	7	35.5			1.4	6		3	0	
40-44	8	43.5			1.6	1		-		
45-49	9	52.5			1.8	1		-	-	
50-54	10	62.5	55		2	1		-	-	

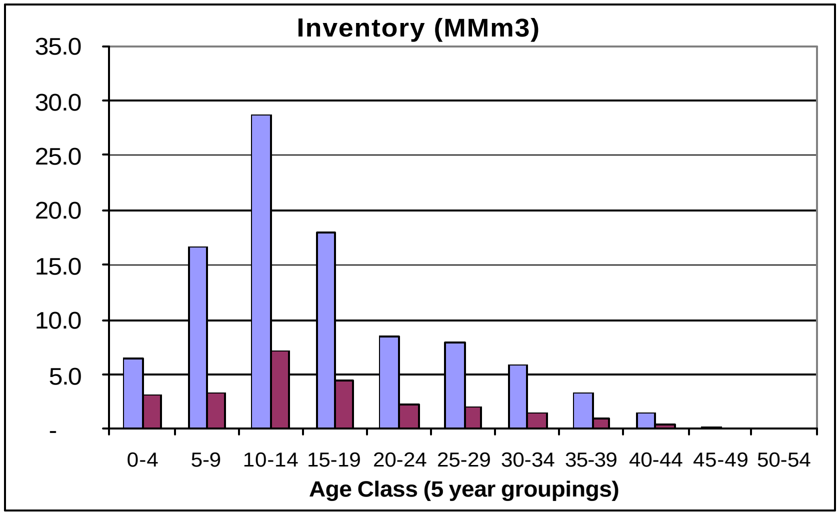




A6. Indonesia Industry

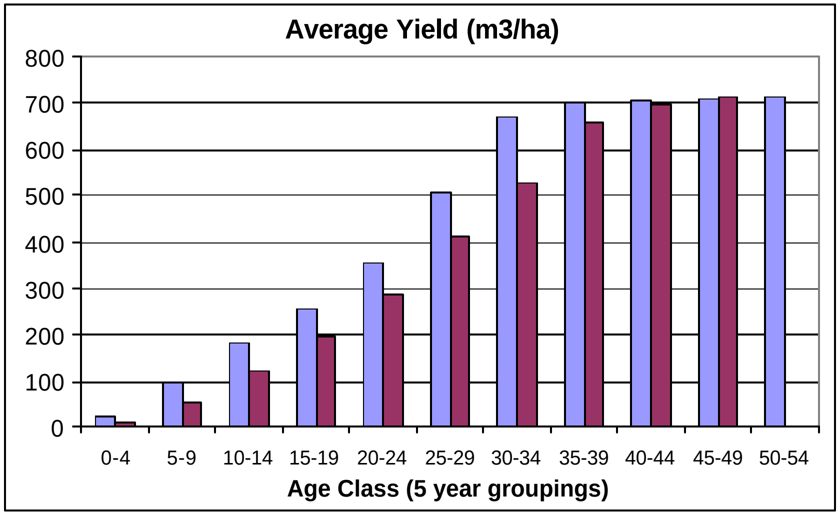
(1) Age Class	(2) Volume	(3) Cum. Volume 1	(4) Target	(5) Cum. Volume 2	(6) Growth Rate	(7) Previously Used Rate	(8) Hectares	(9) Hectares	(10) Lt. Grey	(11) Dk. Grey
0-4	10	10			2	1		642,952	6.4	3
5-9	25	35			5	1		669,748	16.7	3
10-14	40	75			8	2		715,806	28.6	7
15-19	60	135			12	3		301,358	18.1	5
20-24	75	210			15	4		114,168	8.6	2
25-29	100	310	300		20	5		80,605	8.1	2
30-34	110	420			22	6		52,710	5.8	2
35-39	110	530			22	7		30,008	3.3	1
40-44	100	630			20	8		14,557	1.5	1
45-49	100	730			20	9		1,769	0.2	0
50-54	100	830			20	9		-	-	-

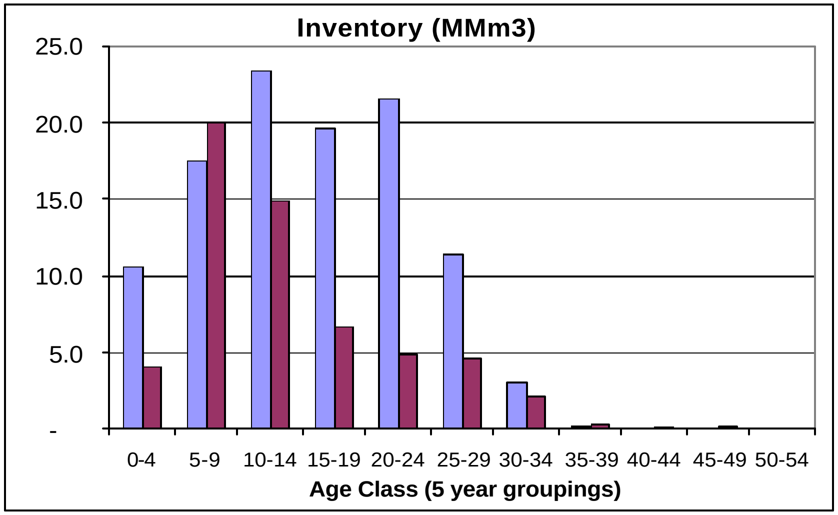




A7. New Zealand Industry

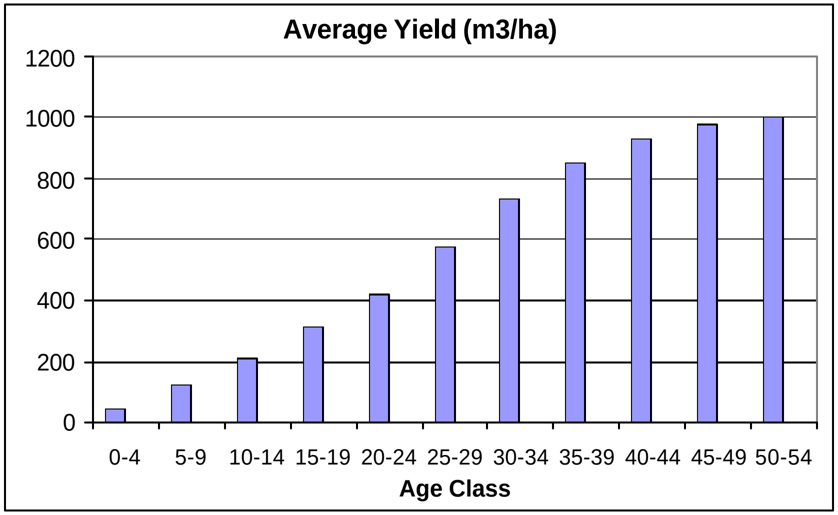
(1) Age Class	(2) Volume	(3) Cum. Volume 1	(4) Target	(5) Cum. Volume 2	(6) Growth Rate	(7) Previously Used Rate	(8) Hectares	(9) Hectares	(10) Lt. Grey	(11) Dk. Grey
0-4	25	25		11.8	5	4	160,380	424,855	10.6	4.0
5-9	75	100		57.0	15	8	267,191	233,610	17.5	20.0
10-14	80	180		120.3	16	16	185,605	292,409	23.4	14.8
15-19	75	255		197.5	15	32	88,365	261,697	19.6	6.6
20-24	100	355	450	288.7	20	35	48,502	214,900	21.5	4.9
25-29	155	510		413.5	31	28	29,983	73,679	11.4	4.6
30-34	160	670		528.7	32	22	13,098	19,050	3.0	2.1
35-39	30	700		658.4	6	20	9,987	6,578	0.2	0.3
40-44	5	705		695.7	1	0	18,354	2,460	0.0	0.1
45-49	5	710		712.0	1	0	38,332	246	0.0	0.2
50-54	5	715			1	0		10,568	0.1	

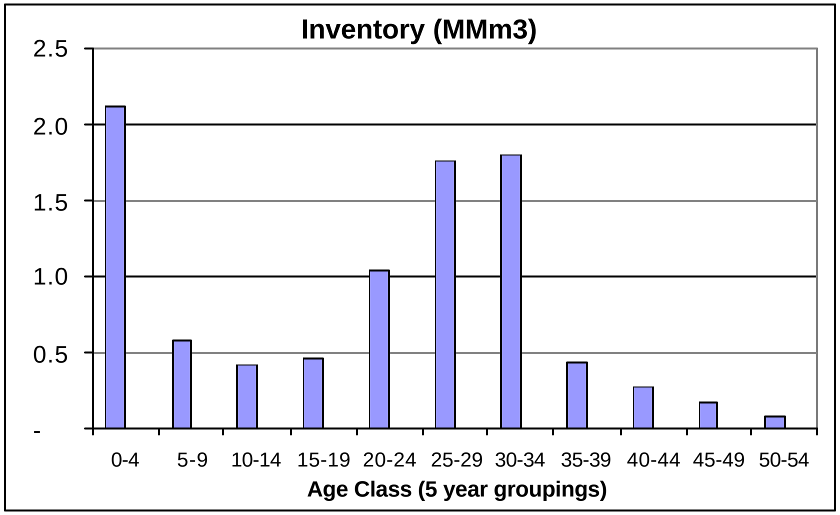




A8. Uruguay Industry

(1) Age Class	(2) Volume	(3) Cum. Volume 1	(4) Target	(5) Cum. Volume 2	(6) Growth Rate	(7) Previously Used Rate	(8) Hectares	(9) Hectares	(10) Lt. Grey	(11) Dk. Grey
0-4	40	40			8	5		53,046	2.1	
5-9	80	120			16	15		7,298	0.6	
10-14	90	210			18	16		4,627	0.4	
15-19	100	310			20	15		4,633	0.5	
20-24	110	420	450		22	20		9,463	1.0	
25-29	155	575			31	31		11,367	1.8	
30-34	160	735			32	32		11,186	1.8	
35-39	120	855			24	6		3,667	0.4	
40-44	75	930			15	1		3,611	0.3	
45-49	50	980			10	1		3,556	0.2	
50-54	25	1005			5	1		3,546	0.1	





APPENDIX 2. PULP PROJECTION (MM METRIC TONS)

Period	USA	US West	US South	US North	Coastal BC	Canada Interior
81-85	247.5	39.8	167.1	40.6	17.5	14.2
86-90	286.3	46.6	195.9	43.8	23.3	18.6
91-95	298.0	48.6	204.0	45.4	26.4	21.1
96-00	316.5	51.6	216.7	48.2	28.1	22.5
01-05	341.7	55.7	234.0	52.0	30.3	24.3
06-10	367.6	60.0	251.7	56.0	32.6	26.2
11-15	398.2	64.9	272.6	60.6	35.4	28.4
16-20	430.7	70.2	294.8	65.6	38.2	30.7
21-25	469.2	76.5	321.2	71.5	41.7	33.4
26-30	510.3	83.2	349.3	77.7	45.3	36.3
31-35	558.5	91.1	382.4	85.0	49.6	39.8
36-40	609.1	99.4	417.0	92.8	54.1	43.4

Period	Canada Eastern	Central America	Brazil	South America North	Chile	South America South
81-85	68.2	2.5	15.5	0.6	3.9	2.4
86-90	79.5	3.6	21.1	1.3	4.6	3.5
91-95	90.5	4.3	36.6	2.6	8.5	4.7
96-00	96.4	4.6	43.3	3.1	9.7	5.2
01-05	104.1	4.9	46.8	3.4	10.5	5.6
06-10	112.0	5.3	50.3	3.6	11.3	6.1
11-15	121.4	5.7	54.5	3.9	12.3	6.6
16-20	131.2	6.2	59.0	4.2	13.3	7.1
21-25	143.0	6.8	64.3	4.6	14.4	7.7
26-30	155.5	7.4	69.9	5.0	15.7	8.4
31-35	170.2	8.0	76.5	5.5	17.2	9.2
36-40	185.6	8.8	83.4	6.0	18.8	10.0

Period	Finland	Sweden	Europe West	Europe East	Japan	Korea
81-85	37.2	44.6	56.9	18.2	44.5	1.2
86-90	44.2	51.7	53.7	20.4	57.5	1.9
91-95	50.8	53.6	42.7	21.2	72.4	3.1
96-00	56.9	56.8	45.9	22.5	79.1	3.5
01-05	61.4	61.3	49.6	24.2	85.4	3.8
06-10	66.1	66.0	53.4	26.1	91.9	4.1
11-15	71.6	71.5	57.8	28.2	99.5	4.4
16-20	77.4	77.3	62.5	30.6	107.6	4.7
21-25	84.3	84.2	68.1	33.3	117.3	5.2
26-30	91.7	91.6	74.1	36.2	127.5	5.6
31-35	100.4	100.2	81.1	39.6	139.6	6.2
36-40	109.5	109.3	88.4	43.2	152.2	6.7

Period	China	Taiwan Hong Kong	Malaysia West	Indonesia	Indochina	India
81-85	6.1	1.2	0.1	0.4	0.1	3.7
86-90	8.5	1.8	0.6	1.6	0.2	4.4
91-95	9.3	2.2	0.6	2.9	0.3	3.6
96-00	9.8	2.4	0.6	3.0	0.3	3.8
01-05	10.6	2.6	0.7	3.2	0.4	4.1
06-10	11.4	2.8	0.7	3.5	0.4	4.4
11-15	12.3	3.0	0.8	3.8	0.4	4.8
16-20	13.3	3.2	0.8	4.1	0.5	5.2
21-25	14.5	3.5	0.9	4.4	0.5	5.6
26-30	15.8	3.8	1.0	4.8	0.6	6.1
31-35	17.3	4.2	1.1	5.3	0.6	6.7
36-40	18.9	4.6	1.2	5.8	0.7	7.3

Period	Middle East	USSR	Africa	Australia	New Zealand
81-85	1.6	48.6	7.4	3.9	5.6
86-90	2.6	55.1	9.9	5.5	6.4
91-95	3.6	55.8	11.6	6.4	7.2
96-00	4.0	58.8	12.4	6.7	7.6
01-05	4.3	63.5	13.4	7.3	8.2
06-10	4.7	68.3	14.4	7.8	8.8
11-15	5.0	74.0	15.6	8.5	9.5
16-20	5.4	80.0	16.8	9.2	10.3
21-25	5.9	87.2	18.4	10.0	11.2
26-30	6.5	94.8	20.0	10.9	12.2
31-35	7.1	103.8	21.8	11.9	13.4
36-40	7.7	113.2	23.8	13.0	14.6