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Forestry Expansion –
a study of technical, economic and ecological factors
The Long Term Global Demand for and Supply of Wood

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INTRODUCTION

As the United Kingdom depends on imports for a very large part of its supplies of wood and wood products, decisions about future domestic production will be influenced by the way in which global demand and supply evolve. The purpose of this paper is to review long term studies of demand for and supply of wood and wood products in the world as a whole, and in the regions which are most likely to influence supplies to the United Kingdom, in order to explore likely future trends in supplies and prices.
In this first section of the paper the present and historical patterns of production and trade are briefly reviewed, and the position of the United Kingdom within this trade is evaluated. The two following sections examine trends in demand and supply, and the final section examines the evolution of the balance between the two, and the implications for future trade and prices.

Present production patterns and trends

Global production of wood in the period 1985/87 is estimated to have averaged 3255 million m^3 annually, of which 1350 million m^3 was wood for industrial processing (saw and veneer logs and pulpwood)*. The pattern of production of the main categories of industrial wood and wood products is shown in Table 1.

Nearly three-quarters of industrial wood output occurs in the countries of the north temperate zone, with roughly 40% in North America and 20% in Europe. The USSR and the tropical zone each account for about 15% of total output, and the south temperate zone for about 8%.

*As fuelwood, and "other industrial wood" (principally poles), are traded in only very small quantities, they are considered in the rest of this paper only to the extent that they affect supplies of categories of wood and wood products which are traded.

Table 1 Global annual production of industrial wood and wood products 1985/87 (million units)

	Saw and veneer logs	*Pulp wood*	*Sawn wood*	*Veneer and ply*	*Particle board*	*Fibre board*	*Wood pulp*
	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(m^3)	(mt)
North America	372.0	168.1	154.2	22.3	11.6	6.1	73.2
Europe	155.8	114.6	83.3	4.8	23.7	4.2	34.3
USSR	159.6	39.7	100.4	2.7	7.0	3.6	10.4
Japan	19.0	12.1	29.2	7.4	0.9	0.9	9.4
Other Asia	149.0	10.0	70.9	11.6	1.2	1.4	3.7
Latin America	63.9	31.6	28.5	1.9	1.8	1.0	6.0
Africa	21.7	7.1	7.9	1.2	0.5	0.2	1.7
Oceania	16.0	11.6	5.5	0.2	0.9	0.3	2.0
TOTAL	957.0	394.7	479.8	52.1	47.7	17.5	140.6

Source: ECE/FAO, 1989

More than 70% of all wood for industry that is harvested at present is in the form of saw and veneer logs, of which more than 70% is harvested from coniferous species*. However, over the past decade output of non-coniferous logs has grown faster than output of coniferous logs, and production of pulpwood has grown twice as fast as production of logs.

Over the 10 years to 1985/87 global production of industrial wood grew by 13%. Growth in production in most regions has been at similar rates, except in the USSR and Japan where it has been slow and in the south temperate belt where it has been rapid. Broad geographical patterns have therefore not been changing significantly.

The patterns of production of processed products (Table 1) largely reflect those of roundwood production, and of wood products consumption. North America has accounted for much of recent growth in production of sawn softwood and softwood plywood, and tropical Asia for the expansion in output of sawn hardwood and hardwood plywood. Growth in wood pulp production has been concentrated in North America and Europe, and in some of the south temperate countries. Growth in particle board output has been largest in North America and the USSR; and growth in production of fibreboard in the USSR, Asia and Latin America (FAO, 1989).

*In the report the term softwoods is used interchangeably with coniferous products and hardwoods with non-coniferous.

Present trade patterns and trends

In terms of wood raw material needed to produce them, the volume of wood and wood products entering trade is roughly equivalent to a third of world production of industrial wood. Trade is predominantly in processed products, with a steadily increasing proportion of the output of most of the main wood products being traded. Trade in roundwood is mainly between countries around the Pacific rim and within and into Europe, and is increasingly in the form of pulpwood rather than logs (FAO, 1989).

Table 2 World Trade in Forest Products, 1980 (million m^3 roundwood equivalent)

From:	*Canada*	*Nordic region*	*Other Europe*	*USA*	*USSR*	*SE Asia*	*Other*†	*Total*
To:								
Other Europe*	21	65	67	17	20	6	13	209
USA	79	1	-	-	-	2	1	83
Japan	9	1	-	24	7	28	2	71
Developing countries	7	9	3	14	3	20	4	60
Other	3	14	7	8	6	3	6	46
Total	119	90	77	63	36	59	26	471

Source: ECE/FAO, 1989

*Excluding Nordic countries

†Of which 22 million m^3 from Africa and Latin America

Table 2 summarises the principal trade flows. At this level of aggregation the pattern of trade has not changed radically over a period of at least 20 years. Trade is heavily concentrated within three intra-regional flows: from Canada to the United States, from the Nordic countries to the rest of Europe, and within the rest of Europe. This group of European countries is by far the largest net importer, accounting for nearly a half of all imports over the past 20 years, and the United States and Japan are the second and third largest. Canada is the largest exporter, in terms of equivalent volumes of roundwood, followed by the Nordic countries, the United States and the countries of Southeast Asia. Together, they account for 70% of the total wood volume traded. With the exception of the United States, a very large proportion of their production enters trade. These regions are therefore of particular importance when looking at future supplies.

The United Kingdom is the largest importer in Europe of sawnwood, plywood, particle board, wood pulp and newsprint and the second largest importer of printing and writing paper and other paper and paperboard. Its imports of coniferous and non-coniferous sawnwood account for a fifth and a tenth respectively of the regional imports of these products, and its share of imports of panel and pulp and paper products ranges from a fifth to a third. United Kingdom imports are thus a major component of some of the main trade flows, underlying the sensitivity of the country's supply situation to developments in global trade in these products.

Predicting future trends and patterns of demand and supply

Attempts to project future events over such lengthy periods as are necessary in forestry are by their very nature extremely precarious. Demand for the products of forestry largely depends on the evolution of economic activity, which itself cannot be predicted with any degree of confidence for other than short periods ahead. Technological change, which constitutes the other main demand shifting factor, is even more difficult to forecast.

Analysis within the forest sector, even over the short run, faces a number of other problems. For much of the global forestry estate even basic information on forest inventory and growth is lacking, so that the scope for global analysis is restricted. Even in the better researched and documented regions the information needed to translate physical into economic relationships is weak or absent.

Most forecasting even in the main producing areas still rests on separate projections of consumption and removals. Some national and regional studies have recently moved to the stage of simulating market equilibrium, but with trade still treated as exogenous to the model (e.g. USFS, 1989). A start has also been made to try to develop spatial equilibrium models which simulate trade as well as production and demand, notably the Global Trade Model (Kallio *et al.*, 1987) developed at the International Institute for Applied Systems Analysis (IIASA) and the Timber Supply Model (Sedjo and Lyon, 1990) from Resources for the Future (RFF).

However, it is important in interpreting what is available from these exercises to recognise that they are designed not to provide forecasts, but for system analysis – to explore how a system would deviate from a base scenario under particular circumstances; the base scenario being usually essentially an extension of past trends. It is also necessary to emphasise that they are first generation models. Work under way to refine them* should not be expected to provide anything more than some broad indications of the possible direction of future changes†.

*Much of the second generation work starts from the IIASA model and is developing analytical models tailored to the situation of particular countries and regions. Two which are of particular interest in the present context, because they are developed within a global framework, are the CINTRAFOR Global Trade Model (Cardellichio *et al.*, 1989) being developed at the Center for International Trade in Forest Products, University of Washington, primarily to analyse forest products markets in the Pacific Rim region, and the MESTA model developed at the Finnish Forest Research Institute to study the implications for the Finnish forest sector of market and production developments elsewhere in the world (e.g. Seppala *et al.*, 1990).

†The limitations that will remain, even after further work has been well summarised, is as follows: there will always be unrealistic features of the model structure and assumptions; the underlying data are of poor quality or non-existent in many regions of the world; the model cannot be statistically validated; many economic relationships defy quantification; and structural change remains difficult to model and even more difficult to predict (Cardellichio and Adams, 1988).

FUTURE DEMAND

Trends in consumption of wood

For the world as a whole, and for each of the main industrialised regions, the rate of growth in consumption of industrial wood has been slowing down – worldwide from 3.5% annually during 1950/60 to 2.2% in 1960/70, and 1.1% in 1970/80 (Sedjo and Lyon, 1990) though the late 1980s was a period of more rapid growth in use. This long term reduction in growth in consumption reflects, in addition to changes in economic growth rates, a number of long term trends.

One is that wood products are used in applications and markets where their use appears to have been approaching maturity – such as housing in much of Europe, North America and Japan. A second is improvements in the durability, quality and efficiency of wood products which extend their useful life so that replacement is required less often. A third is technological change in processing and manufacture which results in less material being needed for a unit of product, or for a particular application. A fourth is substitution. Wood industries have been as successful as most in enhancing the properties and competitive position of their products, but advances in market share of particular wood products have usually been at the expense of other wood products.

In part such changes reflect and are dictated by changes in the user industry. For example, the shift in the main user countries to mechanised and automated manufacturing, in order to control labour costs, favours dimensionally stable and easily machined products such as plywood and particle board over products such as sawnwood which have to be hand finished or fitted in many applications. Other changes have their origins within the wood products sector. Thus, the continuing diversification and improvement of fibre and particle based products in part reflect pressures to take advantage of lower cost raw materials.

The net result of these trends is a progressive shift in the structure of wood products consumption from solid wood to reconstituted wood and wood fibre products. In aggregate, consumption of sawnwood is growing only slowly; with per capita use falling in most of the developed world. Growth in consumption of panels has been rapid, but has slowed down in high per capita use countries. Consumption of paper and paperboard on the other hand continues to grow strongly.

In general these trends are expected to continue. However, the scope for substitution of sawnwood by wood based panels in North America and Western Europe has already been largely exploited, so that use of both of these products may grow in future more in line with change in the user sectors. Within the panel sector it is expected that there could be considerable shifts, with flakeboard and other reconstituted products making inroads into structural plywood use in the United States, and medium density fibreboard capturing market share from other wood products in Europe. Consumption of plywood is therefore expected to grow more slowly than consumption of other panels.

Because of technical change in the wood products sector, consumption of wood raw materials has grown less rapidly than consumption of the processed products. A particularly important development in this respect has been the rapid progress in most industrialised countries in raising the proportion of the raw materials for reconstituted

wood products industries that comes from logging, sawmilling and other residues, and from recycling of paper.

In the United States, the proportion of softwood growing stock left in the forest as logging residue fell from 37% in 1962 to less than 10% in 1986. Similarly, the proportion of pulpwood consumed which was provided by residues and chips grew from 29% to 38% between 1970 and 1980 (USFS, 1989). In Europe during the same period the share of pulpwood supplies coming from these sources rose from 22% to 29%, and recycling of waste paper raised the proportion of paper-making fibres provided in this way from 26% to 32% (ECE/FAO, 1986).

There are many parts of the world where this shift towards full use of the available wood and fibre base has yet to happen, including major users such as the USSR. However, in both the United States and Europe it appears that most available residues are by now in use. It must therefore be expected that a much greater proportion of future growth in raw material needs must be met from roundwood harvesting. Thus, the CINTRAFOR global projections show residues falling from 29 to 21% of pulpwood supplies between 1985 and 2000 (Cardellichio *et al.*, 1989); and the forecasts for the United States (Table 4) show the use of residues declining not only as a proportion of pulpwood consumption from 39% in 1985/86 to 21% in 2040), but also in absolute quantities – due to only limited growth in sawnwood and veneer/plywood production, and increasing competition for residue use as fuel as real energy costs rise (USFS, 1989)*.

However, in the mid 1980s only half as much waste paper was being recycled in the United States as in Europe or Japan. As pressures rise to make it mandatory for environmental reasons, recycling in the United States is expanding rapidly, and it is expected that it will rise towards the levels of nearly 50% in Japan and 51% in the EEC. This could result in growth in demands on pulpwood harvests in North America being significantly less than was projected in the study reported on immediately above (ECE/FAO, 1990). At the global level, though, it has been projected that in the period to 2000 consumption of pulpwood would grow nearly three times as fast as use of saw logs (Cardellichio *et al.*, 1989).

Another important shift in the demand for wood raw materials is that towards greater use of lower grade and size material, and towards hitherto lesser used species. This is largely due to the shift from solid to reconstituted wood products, and within the latter towards fibre and particle based products. However, for some products, notably sawnwood, the use of lower quality raw material is causing a reduction in yields.

Technological advances in the pulp, as well as the panel industries, have broadened the range of use of hardwoods, and advances in sawmilling have expanded their use in that industry. As a consequence, in most industrialised countries consumption of non-coniferous roundwood has recently been growing faster than that of coniferous wood, and this trend is expected to continue in the future. At the global level, the

*Real energy costs are projected to grow fivefold by 2040 in the United States in the US Forest Service outlook study (USFS, 1990).

CINTRAFOR study has predicted that in the period to 2000 average annual growth rates for consumption of non-coniferous roundwood will be more than three times as fast for sawlogs, and nearly twice as fast for pulpwood (Cardellichio *et al.*, 1989).

Demand forecasts

Demand for forest products is determined principally by change in population, income and price, and by technological change. As each of these parameters can have markedly different impacts in the main use sectors – construction, furniture, packaging, etc. – it is preferable to carry out the analysis separately for each. However, past consumption can be disaggregated to end uses only in the more developed countries, and even in these useful forward estimates of likely change in the end use, sectors exist or can be developed for only short periods into the future. The usual approach to estimating future demand in the long term is consequently to relate aggregate demand of a product to change in just population and income, through application of income elasticities derived from analysis of past change. Price elasticities adjust the estimates for price effects, and further adjustments are made for anticipated future technological change.

The precision of such forecasts is therefore heavily dependent on the availability and accuracy of data for the base period, on the capacity of the analytical model to correctly represent the relationships between consumption or demand and the underlying parameters, and on future population and economic change following the paths anticipated in the projections. Experience even over the short term shows that this cannot be assumed. Thus the ECE/FAO forecasts developed in the early 1970s of European consumption in 1980 fell short of actual consumption in that year by 25% for fuelwood and 3% for sawnwood, and exceeded consumption by 28% for panels and by 14% for paper and paperboard (ECE/FAO, 1986). A 1973 government forecast of 1983 total wood products consumption in Japan exceeded actual consumption by 44%, and a revised 1980 projection for 1986 by 25% (Nectoux and Kuroda, 1989). When carried through the 50 years of long term forecasts, such weaknesses in simulation or projection exercises can lead to forecasts which differ from each other, and actual performance, by very large margins – as is demonstrated by some of the results reviewed in this paper.

As has been noted earlier, it is important to keep in mind, in interpreting the forecasts and projections reviewed below, that they are based on different assumptions about the underlying parameters and different analytical methods and models. The forward estimates from the different studies therefore cannot be compared directly with one another.

In the United States, the long run demands for all major wood products are projected to grow over the next five decades (Table 3). Projected consumption of sawn softwood will be 1.2 times higher than consumption in 1986 by 2010 and 1.3 times higher by 2040. Consumption of sawn hardwood is projected to go up by margins of 1.7 and 1.8 times over the same periods. Consumption of paper products, fuelwood and pallets is expected to grow particularly rapidly. Within the panels group, fibre based products are expected to grow most strongly until 2010, when consumption of softwood plywood, which is expected to decline in the near future, begins to rise again (USFS, 1989).

In Europe, consumption of paper and paperboard and of wood-based panels is expected to grow about twice as fast as consumption of sawnwood over the period 1980 to 2000

(Table 4)*. Consumption of sawn hardwood grows considerably faster than sawn softwood; particle board is the fastest growing panel (and fibreboard the slowest); and printing and writing paper grows much faster than newsprint or other paper and paperboard (mainly packaging). Consumption of fuelwood also grows, particularly in northern Europe. Growth in the other products is fastest in southern Europe (ECE/FAO, 1986).

Table 3 US forest products consumption in 1986 with projections to 2040
(million m^3)

	1986	*2000*	*2020*	*2040*
Sawnwood				
Softwoods	110.4	106.9	128.1	133.1
Total	131.5	130.7	156.7	164.3
Structural panels				
Softwood plywood	18.2	15.0	17.6	20.1
Total	21.3	22.4	29.1	34.2
Pulpwood				
Softwood roundwood	128.0	176.9	209.2	241.8
Total roundwood	207.0	305.2	391.9	451.7
Total	338.6	406.4	515.5	574.9

Source: USFS, 1989

Table 4 Consumption of forest products in Europe in 1979-81 with estimates to 2000 and 2020
(million units)

	1979-1981	*2000*		*2020*	
		Low	*High*	*Low*	*High*
Sawnwood (m^3)	102.3	119.0	140.8	123.0	148.0
Wood-based panels (m^3)	35.6	49.6	58.5	52.0	60.0
Paper and paperboard (m^t)	49.2	67.2	92.0	68.0	95.0

Source: ECE/FAO, 1986

In the USSR, the period to 2000 is expected to be one of rationalisation and intensification in order to increase the productivity of wood use. A much larger proportion of the wood harvest is used as fuel or in solid form (sawnwood) than is the case in most other industrial countries.

*The projections to 2025 shown in the table simply extend the per capita consumption levels estimated for 2000, and apply them to population forecasts for 2025 (ECE/FAO, 1986).

Consumption of both has been declining for some time, and change in the structure of wood use in the direction of replacement of sawnwood by panels and paperboard, increased use of residues as industrial raw material and further reduction in the use of roundwood as fuel, is expected to continue to the end of the century (ECE/FAO, 1989).

In Japan, consumption of wood peaked in 1970, dropping subsequently by about 10% to the level of about 90 million m^3 at which it has remained through the 1980s. In the latest Forestry Agency projections (MAFF, 1987), it is projected to grow (in roundwood equivalent terms) to a level 7% higher than in 1986 by 1994 and 15% higher by 2004 (Table 5). In the more recent CINTRAFOR Pacific Rim study, a somewhat faster growth in consumption is forecast – 20% from 1986 to 2000 (Cardellichio *et al.*, 1989). All the projected growth is in panels and paper and paperboard, reflecting shifts away from the traditionally heavy use of sawnwood in housing and other construction.

Table 5 Forecast of Japan's demand for wood products to 2004
(million m^3 roundwood equivalent)

	1984	*1994*	*2004*
Sawnwood	45	43-45	42-45
Plywood and panels	15	17	19
Pulpwood	31	35	40
Other	4	4	5
Total	94	99-101	104-108

Source: MAFF, 1987

The projections reproduced in Table 6 show substantial increases in consumption in the developing regions of Africa, Asia and Latin America in the period 1986 to 2000. Consumption, and growth in consumption, of all main products is concentrated in South America, the Far East and China, but growth rates in all developing regions exceed those in the industrial regions. In the period 1986 to 2000, this group of countries as a whole could account for more than a half of the projected increase in world sawnwood consumption. Growth rates in developing country consumption are projected to be fastest for panels and slowest for sawnwood (FAO, 1988).

The results of four recent global projections of demand are summarised in Figure 1. As is to be expected, the results show a very considerable spread, with consumption of industrial wood growing from less than 15% to about 40% over the period from about 1985 to 2000, and from a third to three-quarters over the period 1985 to 2030 or 2040.

Table 6 FAO global forest products consumption outlook projections to 2000 (million units)

	Sawnwood and sleepers (m^3)		*Wood-based panels* (m^3)		*Wood pulp* (mt)	
	1986	*2000*	*1986*	*2000*	*1986*	*2000*
North America	139.9	142.2	42.4	66.8	65.6	84.7
Europe	95.3	111.3	36.3	58.8	36.9	49.2
USSR	91.2	109.8	12.6	19.8	8.7	12.5
Japan	34.3	36.6	9.7	17.2	11.3	18.0
Other Asia	67.5	114.5	9.8	22.1	5.5	9.1
Latin America	29.7	52.5	5.0	12.4	5.3	9.0
Africa	10.5	14.0	2.0	3.4	0.9	1.4
Oceania	6.8	7.7	1.4	2.3	1.8	2.3
Total	475.2	588.6	119.3	202.7	136.0	186.2

Source: FAO, 1988

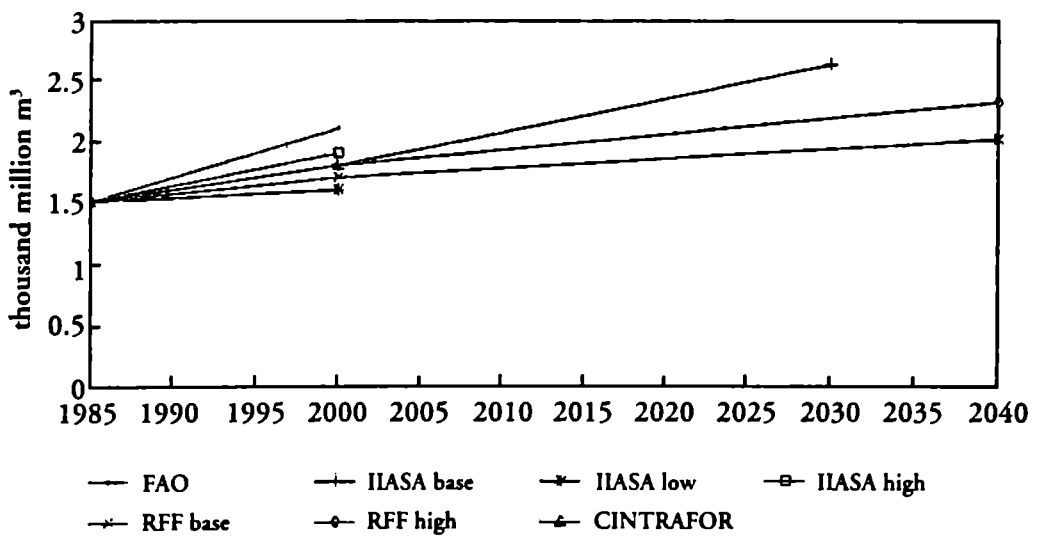

Figure 1 Trends in global consumption. (Comparison of long term projections.)

Sources: derived from: FAO, 1988; Kallio *et al.*, 1987; Sedjo and Lyon, 1990; Cardellichio *et al.*, 1989

Only two studies estimate global demand over 50 years. The IIASA model (Kallio *et al.*, 1987) projects a quite high rate of growth in demand throughout the period*. Because it incorporates rates of change which are rising exponentially in the latter part of the model run, the estimates of demand for 2030 are probably on the high side of possible outcomes. The RFF model (Sedjo and Lyon, 1990) projects past growth trends in aggregate consumption, subsuming the effects of change in income, technology, etc. into a single relationship, which is applied to projections of population change. Growth in demand is assumed to decline steadily, to zero by 2040, from an annual rate of 1.0% in the base scenario and 2.0% in the "high" scenario. Even the latter gives slow growth over the latter part of the period, and the long run estimates could therefore be towards the low end of possible outcomes.

Though there is thus a great deal of uncertainty about rates of growth in consumption or demand beyond the end of the century, a number of features of the future can be discerned with reasonable confidence. The first is that there is no evidence to suggest that there will be fundamental changes in the place of the main wood products in the economy. None is likely to be displaced from its principal end uses, nor are there likely to be major breakthroughs which would radically alter the patterns of use. Secondly, with so much of consumption occurring in the mature markets of the industrialised regions, growth and change is likely to be moderate; with much of such growth as does occur likely to happen in the developing regions. Thirdly, the continuing shift from solid to reconstituted products, towards greater input flexibility in processing technology, and towards increasing the efficiency with which raw materials are used, and reused, will all continue to reduce the need for roundwood for a given end use and to extend the range of available wood biomass which can be used.

FUTURE SUPPLY

Trends in production

The half of the world's forests which lie in the north temperate zone, and which presently supply more than four fifths of the world's output of industrial wood, have been broadly stable for a considerable period. Though there have been significant fluctuations back and forth in the use of land at the interface between forestry and agriculture these have roughly balanced out. Loss of forest land to urban and infrastructure developments, and increasing allocations to non-timber uses such as protection and recreation, have been reducing the timber production potential in some areas. On the other hand, increased investment in planted forest and in silvicultural interventions, and the growing availability of relatively productive land withdrawn from agricultural use, have been increasing timber production potential elsewhere. Throughout the north temperate zone net increment exceeds removals and the volume of growing stock has been increasing.

*The "low" growth projection shown in Figure 1 assumes per capita incomes grow at only one half rate assumed in the base projection; the "high" growth projection assumes per capita incomes in developing, but not developed, countries grow at rates 50% higher than those in the base scenario.

The reverse is the case, however, in the tropical regions. The area of forest is being rapidly reduced through clearance and transfer to agricultural uses, and there is little investment taking place in increasing productivity on remaining forest areas or in creating planted forests. In the south temperate zone, in contrast, investment in forests has taken place on a large scale.

During the future period being considered here, there will be a major shift in global production from old growth to planted and managed forests. Old growth resources which have been important sources of production to date, notably those on the west coast of North America and in the tropics, will be worked out, and large planted resources in the south and west of the United States, western Europe, Japan, Oceania and the southern parts of Latin America will be brought into production, together with second growth resources such as the hardwoods of the northern United States.

These shifts will have implications for the quality of wood supplies. Forests under management are seldom grown with premium wood quality as an objective; most are directed towards quantity rather than quality. It is unclear what the impact upon markets and users will be of the resulting decline in supplies of the best qualities of timber, veneer, etc.; or what the acceptability of some of the plantation supplies will be.

The shift to greater dependence on planted forests raises other issues. One is the long term availability of the land on which planting is taking place, or is planned to take place. In North America and Europe much of the new planting is taking place on sites previously used for agriculture or pasture. Though the pressures to limit production of agricultural products in some areas, and to put land under tree cover for environmental reasons in others, presently point firmly towards the trends towards transfer to forestry use continuing and even accelerating (for example see CEE, 1988), in the long period being considered here circumstances could arise which could reverse these trends.

Growing demands for environmental and other non-wood outputs of the forest estate are also likely to constrain wood production in many parts of the world, as logging is prohibited in some areas and others become subject to more complex and costly silvicultural and management requirements. As is noted below, the latest United States Forest Service projections already assume that environmental uses will have priority over wood production on all public forest land (USFS, 1989).

Another factor that could affect future supplies is related to ownership. A large part of the resource in such major producing areas as north Europe and the eastern United States is in the hands of non-industrial owners (as is the case elsewhere, e.g. in Japan). The predicted increases in output are therefore sensitive to the behaviour of such owners. Until relatively recently these were mainly farmers, who worked their forest holdings as part of the farm household enterprise, but changes away from these ownership patterns have been occurring. In Sweden, for example, where it is estimated that annual production from non-industrial private forests could be increased by 10 million m^3 within present sustainable yield limits, the proportion of holdings apparently operated as part of a farm enterprise dropped from nearly 70% in 1951 to 33% in 1981 (Eriksson, 1989). Non-farmers have been found to have less economic and financial inducements to cut, and they account for most of the untapped potential harvest (Lonnstedt, 1989).

In addition to these economic issues, uncertainties exist about a number of factors bearing on the biological productivity of the forest resource. A shift to large scale single species planted forests increases the danger of disease or pests on an epidemic scale. Of more concern, because of their potential magnitude, are the possible effects of atmospheric pollution and of global warming. As their impact is best considered in terms of comparison with the present production potential, it is discussed later in the section, following the review of the base case projections.

Production forecasts and projections

Most studies model timber production from growing stock inventory data, adjusting starting values to take account of growth and removals in each future period. They therefore in effect shift a short-run supply curve through time in response to adjustments in the level of timber inventory. Very little of what has been attempted, and is summarised below, addresses longer term timber supply problems, such as those associated with transition from old growth existing natural stocks to managed and planted forests. Also, few studies have been able to develop economic supply curves; most are limited to predicting physical availability. For substantial parts of the world's forests, lack of information has prevented the development even of usable physical production estimates, so that they have to be dealt with outside the models.

Figure 2 summarises results from recent national and regional studies which have attempted production projections for the regions in which the main increases in output are expected* .

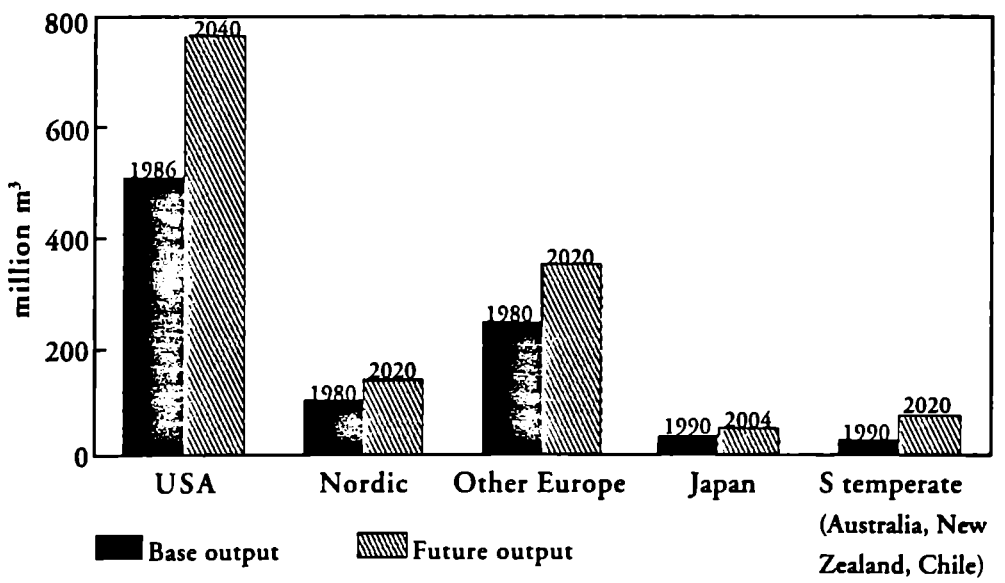

Figure 2 Future roundwood ouput (selected regional projections).

Sources: derived from USFS, 1989; ECE/FAO, 1986; MAFF 1987

*As was noted earlier, the different studies employ different methodologies, and are based on different assumptions about the evolution of demand, costs, and other supply-shifting factors. The projections for the different regions are therefore not necessarily comparable with each other.

In North America, net growth presently exceeds removals, in hardwoods by margins of more than 100%. In both the United States and Canada net loss of forest land is occurring, and other areas are being withdrawn from wood production for environmental, recreation and other reasons, but in the United States new planting on a very large scale is adding to net growth.

Because of environmental and other non-market constraints on use of public forest land, it is assumed in United States projections that all growth in output must come from private forest areas. By about the turn of the century the remaining United States old growth softwood resource in the west will have been harvested, and further expansion of production will have to come from the predominantly planted resource in the south and west, and the very large inventory of predominantly hardwood second growth volume which has built up in the north and east. It is projected that softwood harvests will rise from 331 million m^3 in 1986 to 445 million m^3 in 2040, an increase of 36%, and that hardwood harvests will increase from 178 to 320 million m^3 (79%). The largest increases will be in the south (USFS, 1989).

In Canada, in contrast to the United States, the greater part of the resource continues to be in the form of old growth stands, with the proportion being highest in the far west and lowest in the east. It appears that increases in production of softwoods from public lands could be achieved in much of the east only in conjunction with greater silvicultural intervention, or a revision of allowable cut levels to draw in more of the resource currently classified as economically inaccessible. In the central prairie provinces, in contrast, there are large surpluses of both softwood and hardwood available.

The situation in British Columbia is less clear. Current harvest levels are close to the prevailing level of allowable cut, implying very little surplus. However, the allowable cut is calculated on a resource base from which more than half of the forest land has been excluded primarily on the basis of economic judgements (e.g. an assumption that there would be no future demand for hardwoods). Sensitivity analysis indicates potential increases in harvest over 20 years of about 24% through increased utilization of the resource base (ECE/FAO, 1990). Nevertheless, the consensus of opinion appears to be that, in the near future at least, there will be little if any increase in output in the province. At the national level, the most recent projection predicts further growth in Canada's roundwood harvests, mainly in the central region, with the rate of increase dependent on demand and price (ECE/FAO, 1990).

In Europe the forest resource continues to increase. In the region as a whole, forest area grew by about 2.5% in the 1970s net annual increment by 8.9% and growing stock by 12.3%. The increases were concentrated in the Nordic countries and in the countries along the western edge of the region where investment in plantation forests has been heavy (France, Ireland, Spain and the United Kingdom), but all countries recorded some growth. Continued planting in forest areas, natural extension of forest areas and the growth in planting outside forest as land is taken out of agricultural use, are expected to result in continued increases in the region's production potential. Europe's net annual increment on exploitable closed forest has been predicted to grow from 504 million m^3 in 1980 to between 540 and 566 million m^3 by 2000, and by a further 24 to 48 million m^3 by 2020 (ECE/FAO, 1986).

Removals have been forecast to rise from 350 million m^3 (under bark) in 1985 to between 391 and 438 million m^3 by 2000, and between 431 and 490 million m^3 by 2020. The growth in harvests is concentrated in those parts of the region, identified immediately above, where the resource has been expanding most strongly. As this resource expansion is predominantly in coniferous species, the latter account for much of the increase. Nevertheless, in Europe as a whole, hardwood removals are predicted to grow as rapidly, maintaining its one-third share. Much of the growth in hardwood production is in southern Europe (ECE/FAO, 1986).

In a subsequent study by IIASA it has been estimated that the sustainable potential biological harvest in Europe would be 534 million m^3 (over bark) from the present forest area, and 564 million m^3 if the forecast expansion of forest area to 2020 is taken into account (Nilsson *et al.*, 1990). The latter level would allow harvests to be raised by up to about 140 million m^3 above the level of actual output in 1987, an increase similar to the higher level ECE/FAO forecast.

Growing stock is also reported to be increasing in the USSR. Annual roundwood production peaked in 1975, and in 1985 at 368 million m^3 was no higher than it was in 1960, seemingly largely because of problems in the logging and transport industries. However, the proportion of hardwoods in the harvest has grown, and the proportion of fuelwood has fallen sharply. A recent sector study by the Soviet authorities (ECE/FAO, 1989) predicts that the volume of wood harvested annually will not change greatly in the period to 2000. However, within the total output of industrial wood, it is predicted to rise by more than a quarter between 1985 and 2000. Considerable increases are also planned in output of processed forest products, based on increased use of residues, better allocation of the roundwood available and other measures to increase productivity and efficiency. Production from Siberia and the Soviet Far East has been growing in recent years, but it is predicted that in the period to 2000 output will continue to be concentrated in the European and Uralian regions. Whether there will be a substantial rise in the longer term in output from the large resources in the far north and northeast, where transport, environmental and productivity problems have been encountered in the past, is not clear.

In Japan, a heavily forested country, investment in plantations in the 1950s and 1960s on a large scale has created a very substantial resource from which domestic production could be expanded in due course. The Forestry Agency (undated) has estimated that in 20 years time the potential output from these long rotation planted forests will have reached 89 million m^3. Much of the resource is in private ownership, and high costs and low prices in markets which continue to be dominated by imported supplies have not yet made production of other than high quality timber attractive. However, though domestic output is bound to remain responsive to such factors as the impact of exchange rates on the cost of imports, the presence in the sawlog resource of a growing share of the large sized high quality timbers required in traditional construction, and pressures on the pulp industry to limit its dependence on external raw material supplies, are likely to result in increased domestic production in the future. In the government's 1987 Basic Plan for Japan's Forestry Resources, the country's production is predicted to increase from recent levels of between 30 and 35 million m^3 to between 40 and 43 million m^3 by 1994, and up to 52 million m^3 by 2004 (MAFF, 1987).

The situation in the tropical regions is very unclear. The data base is very poor or non-existent, and the heterogeneous structure and selective felling form of harvest practised in most tropical closed forests do not permit the use of models developed elsewhere. It has been estimated by FAO/UNEP that in 1981-85 about 11.3 million ha were being deforested annually in the tropics, of which some 7.5 million ha were closed forest (Lanly, 1982)*. The same source estimates that about 20% of the remaining closed forest has been subjected to clearing under shifting cultivation in the past, and a further 20% has been logged over. In Africa and Asia the two are linked; the road infrastructure created for harvesting also creates access for slash and burn farmers. In those two regions most deforestation is thus occurring in forest areas of commercial value. In Latin America clearing of forest is primarily to create pasture for livestock production.

The lack of reliable data severely hampers the task of analysis and projection for the tropical resource. An early attempt to try and model and project long term tropical wood production resulted in projections of decline in output in Asia from the 1990s, but a rapid increase in production in Africa and Latin America to several times 1980s levels by 2000, followed by a steady fall in output in both regions (Grainger, 1986). More recent studies have produced much lower projections. In the CINTRAFOR study, it is estimated that in the period to 2000 production from the existing forest resources in most of the main producing areas in Southeast Asia will be no more than maintained at present levels, that output in West Africa will also remain at about present levels, but that production will grow by about 20% in Latin America (Cardellichio, *et al.*, 1989). Production from existing tropical resources is expected to decline in the early decades of the next century, but the main Asian producers expect recent and planned investments in planted forests to support a renewed growth in production, as does Brazil, but this will be a quite different resource to the old growth forests on which the trade in tropical hardwoods has been based.

Particularly fast rates of growth in output are expected in the south temperate zone, based on the large areas of high yielding plantations which have been established and are continuing to be established – in particular in Chile, New Zealand and Australia. Over the past decade, output of industrial wood from the south temperate zone grew by nearly 50%, by far the fastest rate of growth of any region. Recent forecasts predict a growth in output of industrial wood from plantations between 1990 and 2020 by two- and-a-half times in Chile to 29 million m^3, by a similar margin in New Zealand to an output of 25 million m^3, and a more than doubling of Australia's plantation output to about 20 million m^3. Considerable uncertainty still attaches to both quantities and quality, and the acceptability of what will be predominantly utility grades of radiata pine lumber in the market, and recent forecasts have tended to revise projected outputs downward (Hunter, personal communication). Nevertheless, it is quite clear that even the already existing planted resource will become a major source of supply in the period under review.

*Preliminary results from a more recent FAO study have produced much higher estimates; 52 countries in which the annual rate of deforestation had been estimated to be 9.2 million ha in the earlier assessment show a rate of 16.8 million ha in the more recent study (Dembner, 1991).

Possible impacts of atmospheric pollution and global warming

As is discussed by Cannell and Cape, (1991), much uncertainty surrounds the possible impacts of atmospheric pollution on forest productivity. It is unclear to what extent various pollutants, which could be harmful to trees, are actually affecting forests, and if they are, what orders of magnitude of decline in productivity result, or could result.

The impact of damage on supplies is likely to be twofold: short term disruptions to wood markets, as production from salvage and sanitation fellings is added to supplies, and a longer term reduction in sustainable output. In a recently completed study by IIASA the impact of sulphur and nitrogen compounds on sustainable output from forests in Europe was explored. This was based on the extent of forest areas with deposits in excess of 'target loads', and on what is known about damage cycles at higher levels of deposit for different species, age classes, etc. For Europe as a whole, this resulted in an estimate of long term loss of potential wood supply of about 85 million m^3 (over bark), equivalent to a reduction of 15% in the base case rate of increment. The extent of the decline varied considerably within Europe, from 8% of the rate of increment in the Nordic countries to 25% in eastern Europe (Nilsson *et al.*, 1990).

However, an analysis of the possible consequences of a range of forest damage scenarios for western Europe, using the Finnish global simulation model, found that even major changes in increment or sanitation/salvage fellings are likely to have only modest impacts on production, trade and use of forest products. The results indicated that a 50% reduction in increment by 2010 would reduce harvests in the region in that year by only 10%. A 100% shift in the supply curve of coniferous timber in western Europe, due to mortality and damage, increased coniferous roundwood harvests by only 14% by 2000, and output of processed coniferous products by considerably less (Seppala *et al.*, 1990).

A number of factors contribute to this. The effects of pollution take effect only progressively. Sanitation fellings are substituted for scheduled removals, roundwood imports into the region are reduced, and increased consumption and export of forest products in response to the lower prices resulting from the supply increase help absorb increased industrial production. Trade therefore diffuses and dampens the effects of the change in supply in one region, by absorbing some of the impact in other regions. This is illustrated in Table 7, which summarises the estimated changes in production which result under the scenario with the greatest increase in supply in western Europe.

Table 7 Projections of changes in coniferous roundwood harvests and processed product output by 2000 as a result of severe acid rain damage in Western Europe* (million units)

	Coniferous harvest (m^3)	*Coniferous sawnwood production* (m^3)	*Paper and board production* (tons)
Western Europe	+12.7	+1.2	+3.6
Finland	- 1.0	+0.2	-0.3
Sweden	- 0.9	-0.2	-0.7
North America	- 4.9	-2.2	-2.3
Latin America	- 1.5	+0.1	-0.2
Rest of World	- 0.5	+2.6	-0.1

Source: Seppala, *et al.*, 1990

*The scenario assumes that damage results in a 100% shift in the supply of coniferous timber in the region.

As is noted in Paper 2, global warming is likely to be generally beneficial in terms of improved forest growth. However, drier summers and other effects of climatic change could produce undesirable effects on growth of some species, and the shifts in the climatic boundaries within which particular species will grow could adversely effect production in a given country or region.

Again the high degree of uncertainty as to the magnitude or timing of global warming, and about the climatic changes that could result in different parts of the world, have prevented any meaningful work on the possible impact on wood supplies. An analysis as part of the IIASA Global Trade Model study (Kallio *et al.*, 1987), which assumed that the effect of warming would be confined to the boreal forests, that it would have a pronounced effect on growth in these forests, and that this effect would have fully worked its way through to increased production within the next 50 years, produced a predictable projection of lower prices, increased global consumption and lower production outside the boreal zone. However, as the authors point out, this is an extreme scenario, and it is likely that in reality any impact on existing forest yields over the time horizons being considered in this study would be small. However, if planting of trees was adopted on a large scale, in order to take up and store $C0_2$, as has been under consideration in the United States, it might significantly affect wood availability before the end of the period (Kaiser, personal communication).

FUTURE BALANCE BETWEEN SUPPLY AND DEMAND

Supply and demand are brought into balance through the effects of price changes; rising prices dampening demand and stimulating output, while falling prices have the reverse effect. Trade is of course a key component of this balancing process. In this section these dimensions are examined first through the global wood supply-demand simulation models, and then by examining trade and price trends separately in some more detail.

Simulation of global wood supply-demand relationships

The projections under the base case scenario in the IIASA model (Kallio *et al.*, 1987), which is associated with a relatively high growth in demand, show global output rising to about 2.6 thousand million m^3 annually by 2030. A very large part of the growth in removals in this estimate is accounted for by the United States and Canada, which by 2030 account for 45% of industrial wood removals. Non-coniferous species account for a large part of United States growth. Growth is also faster than average in the south temperate regions (Brazil, Chile and Australia-New Zealand). In all other regions removals increase only moderately. Under a lower growth scenario (with a growth rate of income per capita 50% lower than in the base case scenario) growth in removals is about one third less than in the base scenario. This is reflected in roughly similar reductions in the main industrial categories, with the exception of non-coniferous sawlogs which show much less decrease.

Under the RFF model* (Sedjo and Lyon, 1990), which assumes a relatively slow growth in demand, global supply rises to about two thousand million m^3 by 2040. Under this model the largest increases in industrial wood removals come from the United States (predominantly from the south) and the south temperate zone, which by the end of the 50-year period is second only to the southern United States in magnitude of production. Canada shows an overall decline, with western Canada declining substantially over the first 30 years but increasing again later. In the Nordic region of Europe removals expand initially but fall back later. Southeast Asia maintains its level of removals.

Under a higher demand scenario (demand growing initially at 2.0% rather than 1.0% annually but still declining, gradually, to zero by the end of the period), which involves twice as large an increase in global removals over the period, to 2.3 thousand million m^3, production in eastern and western Canada and in north Europe is considerably higher, as higher prices extend the margins of what is economically accessible. Production in the United States also grows more rapidly and to higher levels.

Comparison of these projections with each other, and with the regional and national forecasts examined earlier, predictably again shows considerable differences in the magnitudes involved. For example, in the base case projections from the IIASA and RFF global models roundwood supply in the southern region of the United States grows to levels far above that arrived at in the much more detailed study by the United States Forest Service (USFS, 1989). Nevertheless, the broad patterns of change are essentially similar – the main increases in supplies are accounted for by areas with maturing planted or second growth forests, but most of the regions with large resources of natural forests continue to be major producers and account for the greater part of the additional increases in output that would be called forth by a more rapid growth in demand and prices.

Future trade trends

Trade is the most difficult component of the supply/demand balance to analyse and predict. It has not proved possible to model and project trade separately; in most exercises it is treated as a residual, to be adjusted subjectively in the light of the results of separate production and consumption projections. The global simulation models developed to study trade in conjunction with production and demand have not yet reached the stage where they produce useful estimates of particular trade flows; but are of considerable value in exploring how total exports, patterns of supply, and prices might change under different conditions.

The results from the IIASA model show the shares of Canada and the Nordic producers in sawn softwood trade increasing, while the United States becomes a major exporter of

*This model incorporates only some of the producing regions, which together presently account for somewhat more than half of global output of industrial wood. Output in the remaining "non-responsive region" – which includes western Europe and most of the tropical producers as well as the centrally planned countries – is assumed to grow initially at a rate of 0.5% annually, gradually falling to zero after 50 years (Sedjo and Lyon, 1990).

sawn hardwood and of plywood/veneer. The United States and south temperate countries gain share in pulp exports, Canada in newsprint, the Nordic countries in printing and writing papers, and the United States in packaging paper and paperboard. Western Europe's imports of most product groups decline, the exception being printing and writing paper (other than newsprint).

The recent joint study for North America by the United States and Canadian forest services (ECE/FAO, 1990) forecasts net outflows from that region in the period to 2005 (Table 8). Substantial increases in exports of sawn softwood, paper and paperboard and building board are predicted, and the United States also expects exports of softwood plywood to develop as supplies from tropical producers diminish, and exports of sawn hardwood as production of this product expands in the east of the country. The large export of roundwood at present is expected to decrease, as the west coast old growth resource is worked out. However, the CINTRAFOR projections indicate increased pulpwood flows within North America, from Canada to the United States (Cardellichio *et al.*, 1989).

Table 8 Forecasts of North American exports to 2005*
(million units)

	1985	*1995*	*2000*	*2005*
Coniferous logs (m^3)	16.9	14.6	13.5	13.5
Coniferous sawnwood (m^3)	10.6	12.6	13.7	15.1
Non-coniferous sawnwood (m^3)	0.7	1.2	1.2	1.2
Coniferous plywood (m^3)	0.7	1.0	1.1	1.2
Paper (tonnes)	1.6	2.9	3.3	3.4
Paperboard (tonnes)	2.8	3.8	3.9	4.1

Source: ECE/FAO, 1990.

*Exports of the USA and Canada to the rest of the world (i.e. excludes trade between the two countries).

The main recent outlook study for Europe, the European Timber Trends Study, estimated that the region's net imports would grow by a margin equivalent to 25-45 million m^3 of wood between 1980 and 2000, but that it would be unlikely to grow further by 2020 unless demand expanded considerably faster than postulated in the base scenario (ECE/FAO, 1986).

Subsequently, a number of studies in the Nordic countries have been exploring how the region's trade, within Europe as well as into it, is likely to develop. A Finnish study (Seppala *et al.*, 1990) predicts declining trade in sawn softwood after 2000 as self-sufficiency within western Europe increases, a rapid rise in Nordic exports of printing and writing papers to the rest of the region, but a decline in the intra-regional flows in newsprint, as Canadian imports gain share, and in other paper and paperboard in which the United States is expected to increase its share of the European market. Intra-regional

trade in pulp also declines as Nordic producers add value by concentrating on paper and board production (Bystrom and Lonnstedt, 1989).

A continued rise in Europe's trade in roundwood in the near future is also predicted (Seppala *et al.*, 1990), based on outflows from Eastern Europe and the USSR. However, the economic changes now taking place in these countries clearly could alter their supply availability for export. The CINTRAFOR study forecasts declining roundwood outflows from the USSR and Eastern Europe, as growing demand for pulp and declining residue availability increase pressures on pulpwood supplies everywhere, and predicts that the diversion of sawlogs to pulp use which is already taking place in some countries could continue, possibly curtailing Nordic exports of sawn softwood (Cardellichio *et al.*,1989).

Japan plans to reduce its imports, both as a share of aggregate consumption and in absolute terms, in favour of domestic output. As was noted earlier, this shift has not yet started to take place. However, its import pattern has recently been radically restructured, following the reduction in availability of tropical roundwood supplies, primarily towards roundwood from North America. As supplies of roundwood from old growth resources on the west coast of North America diminish, a shift towards a greater share of processed products within the import total is expected. Already Japan has become a large importer of tropical hardwood plywood, and North American analysts expect it to become an importer of pulp and paper on a much larger scale than at present (ECE/FAO, 1990). However, the phasing of such a shift is uncertain, because of the potential availability of coniferous pulpwood from Chile, New Zealand and the far eastern region of the USSR; and of hardwood chips from a number of sources. As in the recent past, the balance between raw materials and processed imports is likely to be materially affected by exchange rate fluctuations.

The future evolution of tropical forest products exports is particularly difficult to predict. Aggregate trade is presently about one-quarter lower than it was at its historical peak in 1979. The sharp fall thereafter was partly due to depressed demand at the beginning of the 1980s in the main importing countries, and partly to the restrictions in log exports by some of the main producers, which sharply cut back imports into Japan (by far the largest importer). Exports of processed products have been growing, but face limited market prospects in the main user regions. Tropical hardwood sawnwood is mainly used in Europe and North America in applications such as joinery in which it faces keen competition from both temperate sawn hardwoods and sawn softwoods. The largest user of tropical hardwood plywood has been the United States where the market for the product peaked in the 1970s and has been declining since. Japan, another major user of non-coniferous plywood (manufactured in Japan from imported logs) has expanded its imports as tropical hardwood roundwood supplies have declined, but is also shifting away from its use.

It therefore seems likely that present outflows to industrialised country markets will be reduced largely to higher quality woods in the course of the future period being considered here. If environmentally inspired consumer boycotts of produce from "unsustainable" sources were to take effect even this trade could decline. Recent studies suggest that, even in the period to 2000, the bulk of tropical hardwood production is likely to be increasingly directed to domestic consumption and to exports to other developing countries. The CINTRAFOR study predicts that in this period only Brazil

among the major suppliers will significantly expand its exports, with outflows from the main producers in Southeast Asia being maintained at about present levels under the stimulus of rising prices, and exports from West Africa declining as domestic consumption grows (Cardellichio *et al.*, 1989). In the longer term, Southeast Asia producers expect to be able to expand exports of plantation grown wood products.

Much of the greatly increased output from the planted forests in the south temperate zone should be exported. As was indicated earlier, they are expected to become a major source of pulp, or pulpwood, and probably of coniferous sawnwood as well.

To sum up, it appears likely that in future trade will play a declining role in the supply of sawnwood in the industrialised regions, given mature markets and growing self-sufficiency, but will become more important for some fast growing developing country users, such as China. Trade in the more highly valued pulp and paper products, on the other hand, should continue to increase its share of the principal supply patterns, with the trade structure evolving to reflect both changing raw material availability and shifts in the product strategies of the major producers. However, as was pointed out in the discussion of the possible impacts of heavy damage from atmospheric pollution, changes in trade are likely to be the main way in which unexpected disruptions of supplies, or markets, are absorbed. Therefore trade could show greater deviations from what has been predicted than production or consumption.

Price trends

At the global level, the base scenario in the RFF projections shows a very gradual rise in real prices of roundwood (aggregate of sawlogs and pulpwood) over the 50 years to 2040, at an average rate of just under 0.2% annually. Under the high demand scenario this rises to 1.2% (Sedjo and Lyon, 1990). The base scenario in the IIASA projections to 2030 shows real prices rising globally more rapidly, as is consistent with the faster growth in demand assumed. Prices of sawlogs rise faster than prices of pulpwood, but prices of processed products rise very little (with the lowest rises being in pulp and paper products). In the low demand scenario even the prices of roundwood are almost constant over time (Kallio *et al.*, 1987). The CINTRAFOR global projections to 2000 highlight relatively faster rises in prices for coniferous pulpwood and non-coniferous sawlogs. Again product prices are broadly stable over time (Cardellichio *et al.*, 1989).

The evolution of real prices has been most extensively documented and analysed for the United States softwood resource. A number of recent studies for the pine resource in the US south, the largest supply region, indicate that prices there will increase during the next 30 years, but at a decreasing rate and at rates that will be lower than those that occurred in the past. It has been argued that the historical and forecasted changes in these prices are consistent with a shift from mining old growth timber to investment in forest management as prices rise to a level at which forestry is profitable because of wood production alone (Binkley and Vincent, 1988).

In the most recent United States Forest Service study (USFS, 1989), the real price of coniferous sawlogs in the United States south grows at an average of 1.03% annually to 2030, and at 1.14% in the west, with much of the rise expected to happen in the period immediately after the turn of the century as supply shifts from old growth to plantations. Non-coniferous sawlog prices grow more slowly initially but are expected to rise after

2000, as hardwood stocks are brought into use (with quality hardwoods attracting higher prices throughout). Pulpwood prices rise more slowly than sawlog prices, because of the expected substantial increase in the recycling of paper.

There is less information about expected future prices in Europe. The evidence in the ECE/FAO study seems to indicate that, in general, in contrast to the United States, real prices for forest products did not rise in Europe between the mid 1960s and the early 1980s (ECE/FAO, 1986). A recent study using the revised Finnish global model (Seppala *et al.*, 1989) predicts for the period to 2010 increasing real prices in western Europe for coniferous pulpwood, because of the slow growth in supplies of residues, but declining prices of coniferous logs. Real prices of processed products increase only very slowly (with the fastest rises being for construction panels and sawn hardwood). Nordic country analysts point to the growing supplies of roundwood in parts of Europe without corresponding processing capacity, the growing use of roundwood imports to achieve flexibility of supply at a given price level, and continuing technical development towards wood and fibre saving in the processing industries, as pressures likely to keep roundwood prices from rising (Lonnstedt, personal communication).

There is thus predictable variation among the price projections and forecasts reviewed. These vary with the underlying assumptions about the rate of growth in demand, and with differences in the forecasts about such factors as the extent to which increased recycling of paper will limit increases in demand for pulpwood, and the speed with which depletion of old growth resources will limit the supplies of woods of particular qualities and characteristics. However, none of the studies suggests that on average real prices are likely to grow at rates in excess of those in the past; indeed most suggest lower rates of growth. Moreover, with further technological advances and improved efficiency at the harvesting, processing and distribution stages of production, delivered prices for wood are likely to continue to grow more slowly than stumpage prices, and product prices more slowly than wood prices – which should exhibit little if any growth.

CONCLUSIONS

As has been pointed out throughout this paper the basis for drawing any conclusions about the long term future of wood supplies is extremely weak. Nevertheless, a number of broad trends and conclusions do emerge from the main studies that have been reviewed here. These are summarised in Table 9.

In brief, the evidence, such as it is, suggests that, if demand continues to grow at rates consistent with historical growth in consumption, supplies are likely to expand without appreciable real increases in prices. Moreover, it suggests that, even if demand were to grow relatively rapidly, requiring more substantial increases in prices of **roundwood** in order to stimulate sufficient supplies of wood, prices of **processed products** – which is the form in which the United Kingdom imports its wood – would rise very little, if at all.

This evidently is at variance with the widely held view, which also permeates many official reports on the subject (for example CEE, 1988), that the world is facing a growing shortage of industrial wood. It is possible that this view has been too much

influenced by the decline in the tropical resource, and underestimates the contribution of the stable and growing temperate resources. The importance of technical change in extending the resource and containing increases in costs is also widely underestimated.

Table 9 Summary of projected long term trends.

Demand

- Global demand for industrial wood has been projected to grow by margins of 15% to 40% over 15 years, and from 35% to 75% over 50 years.

- Consumption will continue to be concentrated in the developed world, but a substantial part of the increase in consumption will occur in the developing countries (in particular in sawnwood).

- Continued shifts from solid to reconstituted products will contribute to sawnwood exhibiting the slowest, and pulp and paper products the fastest, growth in consumption.

- Demand for roundwood will grow more slowly than demand for products as technology and increased processing efficiency continue to extend its use.

- Use of non-coniferous species will grow faster than coniferous species.

Production

- Though the tropical resource will continue to decline, the much larger and expanding temperate resources can support expansion of supplies in line with projected global demand without appreciable real increases in prices.

- There will be a major shift from old growth to planted and second growth resources: the tropics and the west coast of North America will become less important in the global total, and planted resources in the southern United States and in the south temperate zone (and in the EEC and Japan), and the second growth hardwood resource of the north-eastern USA, more important.

- Large resources in central Canada, northern Europe and the far eastern regions of the USSR can also support expanded production if demand dictates.

- Even if the rate of growth in demand results in increasing real prices of roundwood, there is likely to be little if any rise in product prices.

Trade

- The two largest importing regions of western Europe and Japan could become more self sufficient; and parts of the developing world less sufficient.

- Import of roundwood is likely to decline as a share of supply, but pulpwood trade could increase where wood residue supplies tighten.

- Import of sawnwood is also likely to become less important in developed world supplies but more important in the developing world, absorbing much of declining tropical wood exports.

- Trade in pulp and paper is likely to become more important in global supplies, with north America, northern Europe and the south temperate zone accounting for much of the expansion in exports.

- Adjustments through trade are likely to diffuse and dampen the impacts of even large adverse disruptions in supply or demand, such as might occur due to damage to forests from atmospheric pollution.

As has been noted earlier, there are a number of possible outcomes which could bear adversely on supply, such as damage from atmospheric pollution. Nevertheless, exploration of the sensitivity of the supply situation to changes of different kinds which has been carried out in several of the studies reviewed suggests that even large adverse disruptions would not result in appreciable long term increases in costs and prices. This is because adjustments through trade tend to dampen and smooth the impacts of change, with roundwood production and the processing industries able to adjust to much of the rest of the consequences of even major changes.

A final point that should be made is to note the extent to which the strong supply situation is the result of past investment in wood production. A continued growth in the sector at the same pace beyond the 50-year period cannot be assumed unless there is a continued inflow of capital into managed resources able to provide wood and fibre without substantial rises in real costs. Also, much of the additional roundwood supplies which will become available over the next decades, even in western Europe, is in regions where there is not at present a corresponding industrial processing capacity. The pattern of supply and use, and to some extent of price, is therefore likely to be affected by the extent to which investment is made in processing and manufacturing to complement the changing structure of roundwood supplies.

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'FORESTRY EXPANSION: A STUDY OF TECHNICAL, ECONOMIC AND ECOLOGICAL FACTORS'

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