A Look At The World's Timber Resources and Processing Facilities

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Abstract

Sustainable development has become the umbrella objective for forest management in many countries of the world, and managers are increasingly faced with the challenges of balancing environmental and economic health in their forest management and resource utilization decisions. It can no longer be assumed that abundant raw materials are available simply for the taking. Changing times require that we change how the forest resource is managed and used. As we look to the future, we must develop a better understanding of the complex interactions of wood use and the resultant social and ecological considerations. This paper addresses the value of wood in human societies, provides a brief review of the world's forest cover, discusses worldwide links and expectations, makes the case for forest products technology, discusses global trends in forest products, discusses future supply and demand for industrial roundwood and wood products, and examines ways to meet future challenges.

Keywords: Forest management, Sustainable development, Forests, Value, Forest products **technology**

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Introduction

A world without forests would be a world that is completely alien to the one we know today. Forests provide a wide range of benefits at the local, national, and global levels. Some of these benefits depend on the forest being pristine or subject to minimal interference. Others can only be realized through well-planned disturbances such as harvesting for wood and other products. The shrinking forest base and growing human population have heightened the challenge for forestry and forest products utilization to produce the needed types and quantity of trees and to prevent conversion of forestland to nonforest uses.

The concept of sustainability is central to sound forest management, and defining what it means is the subject of much current debate. Sustainability in all of its facets-ecological, economic, and social-is important today and will become increasingly important for stewardship of the world's forests. The benefits of forests are wide-ranging and diverse. These benefits include clean air and water, productive soils, biological diversity, goods and services, employment opportunities, community benefits, recreation, animal habitat, and naturalness. Forests also provide intangible benefits such as beauty, inspiration, and wonder.

This paper will address the value of wood in human societies. It will provide a brief review of the world's forest cover and discuss worldwide links and expectations, make the case for forest products technology, discuss global trends in forest products, discuss future supply and demand for industrial roundwood and wood products, and examine ways to meet future challenges.

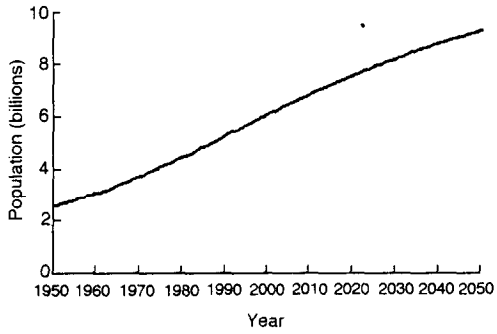
Value of Wood in Human Societies

A critical consideration in any discussion of future industrial raw materials demand is human population growth. All projections indicate a continuing increase in global population in the future. One way to view this is that a child born today will live in a world where the population will double during his or her expected lifetime. The greatest growth in population is likely to occur where the

standards of living are also expected to show the greatest rise. The result is a world economy that will grow even more rapidly than the population. This means that demands for resources, which are already high on a per capita basis, will rise even higher.

The historical record of world population growth is dramatic (Fig. 1). World population doubled between 1850 and 1950 and then doubled again between 1950 and the present (Bowyer 1995). During each of the next four to five decades, global population is expected to increase by approximately 900 × 10^6. These figures make it dramatically clear that the world of tomorrow will place even more pressure on forests and forest resources.

Figure 1—World population 1950—2050 (From Youngquist and Hamilton 1999).



Tremendous quantities of wood are consumed each year throughout the world. Schulz (1993) reports that the world harvests approximately 3.5 × 10^9 m^3 of wood annually, with slightly more than half of this used as fuelwood. Approximately 63% of the annual harvest is comprised of hardwoods, which are mostly used for fuel in the developing countries of the world, The world's softwood use is primarily industrial. Sutton (1993) reports that the global per capita consumption of wood is approximately 0.67 m^3 per year, a figure that has remained largely unchanged since 1960 (Schulz 1993). This means that growth in world wood demand is closely following the growth in world population. With the assumption of a continuation of per capita consumption trends, population increases alone will add approximately 60 × 10^6 m^3 annually to world wood demand (Bowyer 1995).

The World's Forest Cover (FAO 1999)

Information on the status of the world's forests, their extent, location, type, and condition, is important for efforts to improve forest management worldwide and for assessments of the ability of the forest to provide the goods and services demanded of them. The area of the world's forests, including naturally occurring forests and forest plantations, was estimated to be 3,454 × 10^6 ha in 1995, or about one-fourth of the land area of the Earth. About 55% of the world's forests are located in developing countries, with the remaining 45% in developed countries (Fig. 2). The world's forests are almost equally divided between tropical-subtropical forests and temperate-boreal forests. Only about 3% of the world's forests are forest plantations. The remaining 97% are natural or seminatural forests. Data published in FAO (1997) provide a picture of the trends in forest cover for a 15-year interval (1980—1995) and allow a comparison between the 1980—1990 and 1990—1995 periods.

Between 1980 and 1995, the extent of the world's forests (including both natural forests and forest plantations) decreased by some 180 × 10^6 ha, or about 5% of the total forest land base. There was a net increase of 20 × 10^6 ha in developed countries but a net loss of 200 × 10^6 ha in developing nations. The change in forest area by region between 1980 and 1995 is shown in Figure 3.

Between 1990 and 1995, there was an estimated net loss of 56.3 × 10^6 ha of forests worldwide. This represented a decrease of 65.1 × 10^6 ha in developing countries and an increase of 8.8 × 10^6 ha in developed countries. Although the global loss of forests was very high, the figures suggest that the rate of deforestation might be slowing.

Figure2—Forest areas by main regions in 1995. (From FAO 1999)

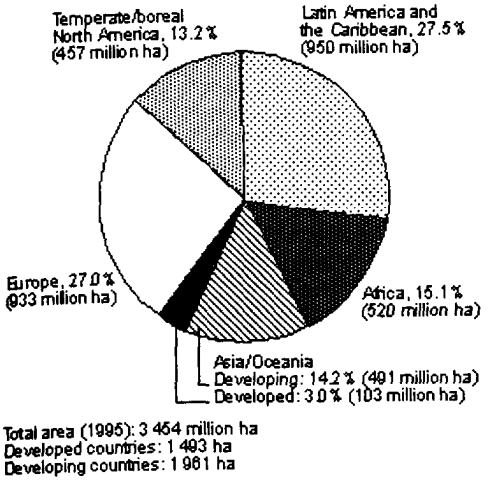
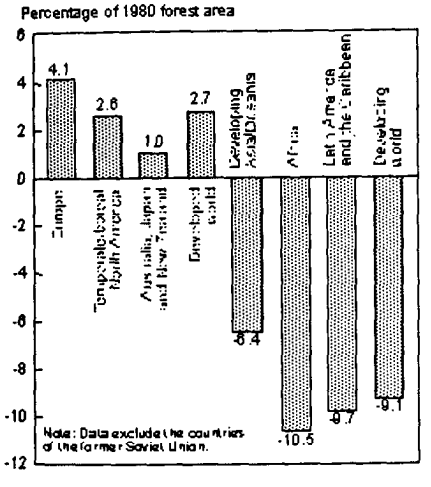


Figure 3—Forest area in 1995 as compared with 1980 (From FAO 1999.)



The estimate of forest cover change in natural forests of developing countries (which is where most deforestation is taking place) was a loss of 13.7 × 10^6 ha of forests per year between 1990 and 1995 compared with a 15.5 × 10^6 ha loss per year during the decade of 1980 to 1990. The major causes of change in forest cover in the tropics appear to be expansion of subsistence agriculture in Africa and Asia and large economic development Programs involving resettlement, agriculture, and infrastructure in Latin America and Asia (FAO 1996). The net increase in forest area in developed countries is largely a result of afforestation and reforestation, including natural regrowth on land abandoned by agriculture. This increase has more than compensated for the clearing of some areas of forest in various developed countries, which is mainly due to urban expansion and infrastructure development.

The Approach to Environmental, Social, and Economic Concerns

Environmental, social, and economic concerns must be considered together. Ecological sustainability must provide a foundation upon which forest management worldwide can contribute significantly to economic and social sustainability. Conservation and wise management of forests can promote sustainability by providing for a wide variety of uses, values, products, and services and by enhancing society's capability to make sustainable choices. In a like manner, social and economic sustainability provides a foundation for ecological sustainability by broadening forest management perspectives through improved standards of living.

When the concept of sustainable development was presented in 1987 by the United Nation's World Commission on Environment and Development (United Nations Commission 1987), attention shifted to environmental concerns. However, the concept was one of balance-the environment and the economy cannot be treated separately. Material needs must be met in ways that preserve the biosphere, and concern for the biosphere must recognize material needs. Another important concept imbedded in this strategy is recognition of both the short and long term. The Commission's report clearly stated that sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

Worldwide Linkages and Expectations

The question of conservation and utilization of forest resources must be balanced and is at the very essence of the work of all of us who are

concerned with the management and utilization of natural resources for sustainable development. The discussion of conservation and utilization must focus on how the needs for conservation and utilization can be combined harmoniously to derive the maximum benefits for present and future generations.

Finally, the theme of worldwide linkages and expectations means that the way that wood is processed and used must be developed in a global context to achieve success in sustainable development. Local decisions on timber harvest and use have clear implications for other countries. In developed countries, with rising demand, local decisions not to harvest create a higher economic incentive to harvest elsewhere. In countries where natural forests are not managed for regeneration, short-term harvest decisions can affect the availability of all forest resources in the long term.

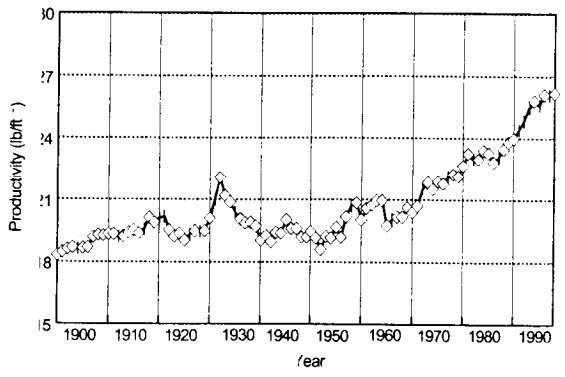
The Case for Forest Products Technology

Given this changing context, what roles will forest products play in relationship to forests and forestry? In our opinion, forest product technology will play a central role in meeting these challenges for the following reasons:

- Management is and will continue to be necessary to achieve desired forest conditions.
- Management that includes wood removal is a cost-effective way to achieve ecosystem health.
- Wood technology will help provide choices for the management and use of the forest.
- Sustainability must recognize the interdependence of the environment and the economy.
- Management for wood fiber will maintain prominence but not dominance.
- We need to understand and embrace the values the public is not willing to forego.
- Forest products can help forest lands compete economically, thus making their conversion to nonforest uses a much less viable option.
- Conservation of wood fiber, not competition of wood with other raw materials, must be the focus of wood products research.

A brief historical review is appropriate as one way of pointing out how a decline in wood resource availability can be at least partially offset by increasing efficiencies in the use of the wood resource. For example, in the United States, product output per unit of wood input has risen by about 40% during the past half century (Fig. 4) (Ince 2000).

Figure 4 — U.S. Product output per roundwood input (From Ince 2000)



Global Trends in Forest Products (FAO 1999)

To meet the needs for wood and nonwood products and, at the same time, fulfill demands for environmental and social services from forests is a challenge now facing the forest sector. Efforts to find an acceptable balance between production and protection and between use and conservation drive much of the debate surrounding the forest sector today.

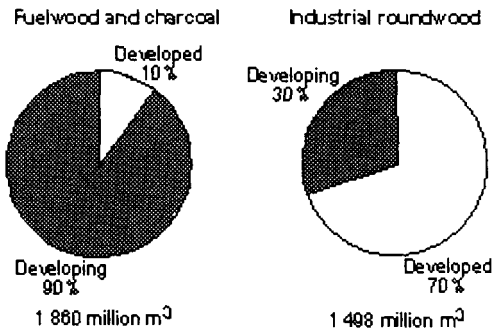
The overall patterns of production and consumption of wood products are very different between developed and developing countries. Developed countries account for 70% of the total world production and consumption of value-added industrial wood products. Developing countries, on the other hand, produce and consume about 90% of the world's fuelwood and charcoal, which are the major household energy sources in many of these nations (Fig. 5). More fuelwood and charcoal are consumed each year in the world than industrial roundwood. Demand for fuelwood is expected to continue to increase at a rate of about 1.1% per year between now and 2010, while demand for industrial roundwood is expected to increase at a rate of about 1.7% per year during the same period.

Factors that are expected to influence the ability to meet increasing demand include increased sources of wood (e.g., plantations and trees outside forests), technological improvements in wood processing, which will increase the efficiency of raw material use, and increased use of recovered and nonwood fiber. Trade will continue to help balance geographical wood deficits in one place with surpluses elsewhere.

While wood is the predominant commercial product from forests, increased attention is being paid to the actual and potential economic role of nonwood forest products (NWFPs). The importance of NWFPs to household and local economies, particularly among the poor in developing countries, is increasingly recognized, as is the need to consider them in forest management planning and in forest policy in many countries.

Wood energy is another area that is raising new interest. While fuelwood and charcoal remain significant sources of energy in developing countries, especially for domestic use, their potential to contribute to the modem energy sector as an alternative to fossil fuels is being investigated in several countries.

Figure 5—Production and consumption of wood products in 1996 (From FAO 1999).



Trade and Trends in Forest Products (FAO 1999)

According to the United Nations Food and Agricultural Organization, growth in the production of tropical forest products has slowed during the past 3 to 5 years. The export of most products has followed a similar trend; export volumes of tropical logs, sawn wood, and wood-based panels have decreased. Some of the trends reflect major structural changes that are unlikely to be reversed, while others are a response to normal short-term changes in market conditions. Factors influencing the changes include

- increasing domestic consumption in important developing producer countries;
- reduced harvest levels because of both environmental concerns and export market conditions;
- a shift in exports from logs, and to a lesser extent sawnwood, toward export of higher value products; and
- most recently, marked reductions in demand in Asia, especially in Japan.

Certification for sustainably produced forest products continues to be a high profile and often controversial subject in the forest sector. In addition, initial efforts are being made to extend certification to nonwood forest products, which will raise new issues. Certification systems are based on evaluating the standard of forest management being practiced.

Accurate statistics on the area of forests and volume of wood certified are difficult to obtain, and the figures are often difficult to interpret. The Forest Stewardship Council (FSC) reports that about 10.3×10^6 ha of forestland have been certified by FSC-accredited certifiers. It is significant that 90% of this area is in temperate developed countries, largely in Europe and North America. Sweden and Poland alone account for 58% of the total. Only a minor part is in tropical countries, where the problem of deforestation is greatest. The volume of certified wood involved and the volumes entering or about to enter the market are unknown but are still insignificant in global and regional terms. The area of forests certified is not a sound indicator of the volume of wood entering the market, since parts of the certified areas may not be of harvestable age, may not contain commercial species, or in extreme cases may not even have trees growing on them.

Certification efforts are being made at many levels. International efforts include those of FSC and the International Organization for Standardization (ISO). Regional initiatives include those of the African Timber Organization (ATO) and the European Union's Eco-Management and Auditing Scheme (EMAS) and Eco-Labeling Scheme. Countries with national programs include Brazil, Canada, Finland, Ghana, Indonesia, and Sweden. In the last 2 years, there have been many new initiatives and a number of additional forests have been certified or are in the process of being certified. Among importing countries, interest continues to be greatest in Europe, especially Germany, the Netherlands, and the United Kingdom. The exporting countries showing the most interest in certification are those whose main export markets share European countries and to a lesser extent the United States; hence the considerable effort Canada, Finland, Indonesia, Malaysia, and Sweden have put into developing national certification systems.

Future Supply and Demand for Industrial Roundwood and Wood Products (FAO 1999)

FAO has recently completed two new global supply and demand studies: the Global Fiber Supply Model (GFSM) (FAO 1998b) and the Global Forest Products Outlook Study (Whiteman 1999). A major and more detailed forestry sector study for the Asia and the Pacific region has also recently been produced (FAO 1998a). Rather than dwelling too intently on market forecasts, which are vulnerable to macroeconomic shifts (such as those recently experienced in Asia), these new studies focus more on the likely policy implications of forest product market developments. The following text briefly describes the main market developments that are expected in the future and discusses the

implications of these developments within the context of sustainable forest management.

Future Forest Product Production and Consumption by Region

The current and projected level of wood production and consumption in 1996 and 2010 is shown by region in Figure 6. From 1996 to 2010, global industrial forest product production and consumption are projected to increase at an annual rate of about 1.7%, from $1{,}490 \times 10^6$ to $1{,}870 \times 10^6$ m^3. Thus in 2010, output will be about one-quarter higher than it is at present. It will, however, only be about 10% higher than the peak in production ($1{,}700 \times 10^6$ m^3) around 1990. Growth will vary between regions, with Asia and Oceania likely to show the highest rates of expansion. Slow growth in consumption is expected for Africa and South America, and slow growth in both consumption and production is expected for North and Central America. North and Central America will, however, remain by far the largest producing and exporting region in the world. Europe, Asia, and North and Central America will account for about 85% of production and more than 90% of consumption in 2010 (roughly the same share as in 1996). However, within this group, it is expected that during this period of growth, a small share (about 5%) of global consumption will shift from North and Central America to Asia.

Future Forest Product Production and Consumption by Product Category

Current estimates and future forecasts of global forest product production and consumption by product category are shown in Table 1. As in the past, the market for paper and paperboard is expected to have the most rapid growth, at an annual rate of 2.4%. In contrast, production of pulp for paper is expected to grow by only 1.1% per year, reflecting an expected increase in the recycling of recovered paper in the total fiber furnish in the future. Moderate growth is expected in solid wood product consumption, at annual rates of 1.1% for sawn wood and 1.3% for wood-based panels. Most of the growth in the production and consumption of wood-based panels is expected in the reconstituted wood panels sector rather than the plywood sector.

Forecast Wood and Fiber Production Compared with Production Potential

A comparison of projected roundwood production levels in the Asia and the Pacific region with production (or estimated biological) potential shows that, in general, future wood demand could easily be met within the region. In certain countries and for certain types of wood (e.g., sawlogs), however, supplies are going to become increasingly scarce in the future.

FAO does not yet have sufficient data to make an accurate assessment of the production potential for the whole world. The Global Fiber Supply Model (GSFM), for example, covers a large part of the world but excludes the important contribution of trees outside forests. However, GFSM can be used to compare projected levels of production (Fig. 6) with supply potential from the forest and from recovered and nonwood fiber sources across some regions (Table 2).

As Table 2 shows, forecast production levels are well within the projected limits of production potential in South America and Oceania but approach the limit in Asia and exceed it in Africa. The results of the fifth European Timber Trends Study (Joint ECA/FAO Agriculture and Timber Division 1996) suggest that Europe should also have adequate wood supplies to meet production requirements in the near term. However, two points are worth noting. First, the GFSM projections should be considered as the absolute maximum amounts. The cost of accessing increasingly marginal areas, which are included in the GFSM analysis, may prevent the total potential supply presented in Table 2 from being realized in the near future. Second, it should be remembered that, while supplies may be plentiful at the broad regional or country level, there may continue to be local scarcity, which could put forestry policy makers under pressure to release natural forest resources for timber harvesting.

Figure 6—Forecast industrial roundwood production and product consumption in 1996 and 2010 (From FAO 1999).

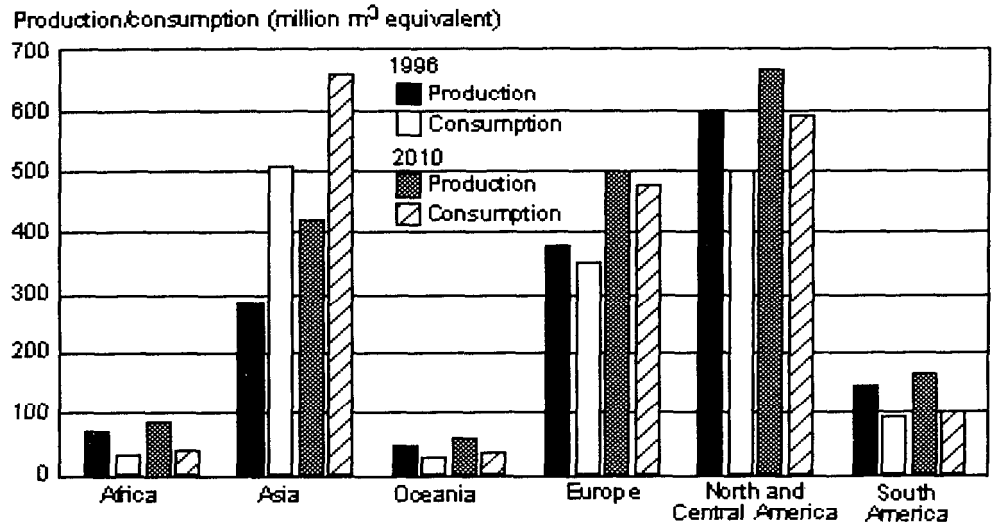


Table l-Current and forecast global forest production/consumption by product category, 1996 and 2010[a]

Product	Production/consumption 1996	Production/consumption 2010	Total growth 1996—2010 %	Annual growth 1996—2010 %
Industrial roundwood (million m^3)	1,490	1,872	26	1.7
Sawnwood (million m^3)	430	501	17	1.1
Wood-based panels (million m^3)	149	180	20	1.3
Pulp (million tones)	179	208	16	1.1
Paper and paperboard (million tones)	284	394	39	2.4

In regions such as Africa and Asia, where supplies (particularly of large logs) from forests are coming under pressure, consumers of wood and fiber will increasingly have to look to other sources to meet the demand (as they already do in Asia) if they do not wish to overexploit their forests. Another, perhaps more likely, alternative is that the markets for forest products will continue to move in the direction of substitution of other wood-based panels and engineered wood products for sawn wood and plywood. Wood-based panels and engineered products can be manufactured from small-sized wood or nonwood substitutes.

In summary, the supply and demand analysis carried out by FAO suggests that the capacity of the forest and other sources of fiber will be sufficient to meet demand for the near future. However, the situation will vary among countries and regions. Africa and South Asia will continue to need to use a wide range of nonforest supply sources to meet their consumption demands. The demand for higher quality sawlogs will also approach or even exceed the production capacity of forests and plantations in Africa, Southeast Asia, and the Pacific Islands.

Table 2—Forecast production potential from forests and recovered and nonwood fibre sources and forecast production of wood and fibre in 2010 (million m^3 equivalent)[a]

Region	Forecast production in 2010			Total potential fibre availability in 2010[b]
	Industrial roundwood	Recovered and nonwood fibre	Total	
Africa	84	2	86	81
Asia	421	222	643	729
Oceania	54	0	54	80
Europe	502	133	632	893
North and Central America	658	147	805	835
South America	153	2	155	225
World total	1,872	506	2,375	2,843

[a]From FAO 1999. [b]From GFSM (FAO, 1998a) or official government estimates.

However, it is expected that product prices will not rise significantly during the projection period. Many of the world's regions have ample or excess wood product manufacturing capacity. The current worldwide economic slowdown has further mitigated pressure on consumer prices for the time being. In selected cases, there may be upward pressure on the prices of certain types of roundwood (typically the higher grades), but price increases will be restrained by the availability of lower value wood and nonwood substitutes. Trading patterns are not expected to change significantly, apart from the continuing trend toward more in-country processing of wood raw materials. This should lead to less trade in semiprocessed and commodity-grade wood products and more trade in higher value products.

Possible Future Market Developments

Wood Supply

The sources of wood and other fibers used in production are likely to change in the future. It is expected that in most countries, there will be a move away from the use of forest resources for wood and fiber production and towards a greater reliance on other sources of supply. The greatest change by far will be the increased use of wood processing residues and recycled fibers in the product input mix. The use of such secondary sources is likely to continue to expand in the more developed parts of North America, Europe, and Asia, while trees outside forests are likely to have an increasingly important role as forest resources decline in some of the less developed regions of the world.

Within the forest, supply patterns are also likely to change in the future. The next decade or so will see large areas of commercial short-rotation plantations (for pulpwood) become available in the southern hemisphere. Greater areas of older plantations established for the production of sawlogs will also start to be harvested in countries such as Australia, Chile, New Zealand, South Africa, the United Kingdom, and the United States. These plantations will provide the greatest share of the expanded wood production potential expected in the future. In contrast, very few countries are likely to be able to expand production sustainably from the natural forest without considerable investment in silviculture.

Greater areas of natural forest are likely to be legally protected. Many of the areas that are likely to be chosen for preservation are not currently harvested and are considered unexploitable for economic reasons (physical constraints, transport limitations, low timber value). A decrease in harvesting intensities in the exploitable natural forest would have a greater impact on future supply potential than

would an increase in the amount of legally protected forests.

Technological Change

Technological change has been incorporated in this supply and demand analysis only in the pulp and paper sector, where it has been assumed that current trends in the use of recovered paper in the total fiber furnish will continue in the future. For example, 1 ton of paper and paperboard in 1970 was made up of more than 80% wood pulp. By 1997, this figure had dropped to 56%, and by 2010, it is expected to fall to below 50%. This trend is partly a result of the increased use of recovered paper but is also a result of shifts in market shares, whereby the proportion of printing and writing papers (which have a lower fiber content) in the overall market has increased and is expected to continue to do so.

Other technological changes that are not included in the model may also occur in the future. First, improvements in harvesting practices could increase log recovery and reduce logging residues in many of the world's forests. Many developing countries have substantial room to increase their log recovery rates. Even a modest increase in log recovery rates in countries with high annual felling levels could increase production and contribute significantly to meeting the projected growth in industrial roundwood demand.

More efficient conversion and use of mill residues and better mill recovery rates have significant effects by reducing the amount of roundwood required to manufacture products. In addition, residues could be used more effectively to meet the demands of other wood processors. Not much is currently known about the utilization of mill residues outside a few of the large developed countries. However, it is suspected that large volumes of residues are wasted or left unused. As FAO (1998a) has shown, all of these sources could make a significant contribution to wood supply.

A third technological change that might occur is a move towards greater use of reconstituted panels because of two factors: upward price pressure resulting from the increasing scarcity of large-diameter logs and technological developments in construction and other wood-using industries, which would allow the use of such products where only plywood or sawn wood are currently used. This shift will also have the effect of extending the use of resources (recovery rates for reconstituted panels are typically higher than for sawn wood and plywood) as well as providing a ready market for residues from other industries.

Technological developments in wood processing continue to keep pace with market, environmental, and raw material resource trends. The increased production of reconstituted panels such as oriented strandboard and medium-density fiberboard and developments in the manufacturing of engineered wood products will continue to increase the efficiency of using more diverse raw materials. Engineered wood products increase opportunities for using small-diameter logs of lower quality and less-used species. The use of microprocessors in almost every step of the production cycle increases product quality and minimizes the amount of residues generated. Much of the technological development in wood processing is currently concentrated in industrialized countries, and the extent to which the technologies are used in nonindustrialized countries is not known. Wider adoption of current technologies and development of new ones that increase processing efficiency could help slow the increasing demand for raw materials to supply finished wood-based products.

Use of the Changing Wood Resource

Tomorrow's wood product manufacturers will face a distinctly different resource than that available today. The character of the wood supply varies with the forest management regime. Plantation-grown trees are likely to be single species, even age, even size class, relatively uniform, and genetically improved. Trees produced under sustainable forestry principles are likely to be more diverse-of mixed species, uneven aged, and mixed size classification. As the concepts of sustainable forestry and sustainable development move into practice, industry will most likely find itself needing to utilize a much more diverse raw material supply than it has in the past. In contrast, industrial processes and products usually benefit from a uniform, stable raw material supply because they can be optimized

more readily. In addition, product variability is generally reduced and processes are more stable with a uniform supply. With a more diverse raw material supply, new technologies will be needed to overcome the problems of product and process variation. Today, technologies such as composite products, nondestructive evaluation, mechanical grading systems, and engineered wood products play an increasingly important role in adapting to a changing timber resource.

Composite technologies are generally more flexible in type and quality of material used than are solid lumber wood products. One composite experiencing remarkable growth is oriented strandboard (OSB), a product made from wood particles aligned to obtain the best engineered properties. OSB is being used as a replacement for plywood because of the difficulty of getting veneer-grade logs and because it can be made from a variety of tree species and size classes. OSB now represents more than 25% of the structural panel market, and the demand continues to grow. The raw materials for many OSB manufacturing plants in North America are underutilized species like aspen and yellow-poplar.

Another technology that has allowed the use of different tree species and size classes is nondestructive evaluation (NDE) technology. NDE can be used to determine the stiffness and strength of individual pieces of lumber, reducing dependence on visual grades (which are species dependent) in favor of mechanical grading (which is species independent). Mechanical grading can allow a wider range of species to be substituted for structural applications, as long as certain stiffness and strength requirements are achieved. Mechanical grading uses static bending techniques, vibration techniques, or stress waves to determine stiffness. Research has demonstrated a direct relationship between the bending stiffness of lumber and its bending strength. The only way to determine the actual bending strength of a board is to break it. Since that is not practical, the next best available method is to measure the board's stiffness, compute the modulus of elasticity, and then predict the bending strength. Such procedures produce a mechanically graded lumber that is accepted by regulatory agencies and all major building codes, provided that production follows approved grading agency certification and quality control procedures.

Meeting the Challenge

Forests are being squeezed between expanding needs and a shrinking resource base. The pressure being placed on the resource also pushes technological developments to help divert those pressures. Historically, technology has aided conservation by making more efficient use of resources. That trend will need to accelerate to meet the challenges of today and tomorrow. Key areas for research and development are use of the changing wood resource, extension of the resource, and environmentally friendly technologies.

Sustainable development must be based on the interdependence of the environment and the economy. Wood technology is essential to this integration. Some specific areas for research and development include

- determining new, more efficient, and environmentally friendly ways to extract, reduce, and convert virgin wood raw materials to useful products,
- developing technologies to allow the re-use of materials and products to the maximum extent possible,
- making sure that the latest technologies for extracting, reducing, converting, using, and re-using wood raw materials are transferred to developing nations as quickly as possible,
- developing methods to ensure that renewable resources of all kinds, e.g., wood and agricultural crop residues, are converted to value-added uses like advanced consumer and engineered wood products, and
- developing technologies that do not produce harmful by-products during the manufacture of wood products.

This list represents just a few of the areas that hold promise for advancing wood utilization activities to meet the needs of society while keeping a well-tuned balance between the ecological, economic, and social aspects of sustainable forest management.

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