REGIONAL FORUM V

3I Technological Flexibility in the North American Forest Sector

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3I.I Background

Technological flexibility in the North American forest sector is exemplified by significant changes during recent decades. Significant changes include intensified timber management and improved timber growth (particularly for softwood timber), development of modem mechanized timber harvesting systems, improved sawmill technology, changes in wood panel technology, changes in construction engineering and materials, and adjustments in papermaking and recycling. All these changes may be explained as behavioral responses to unique market opportunities or economic constraints. Cumulative effects of these changes include significant adjustments in patterns of wood use and timber markets and greater ability to sustain biological and economic growth in the forest sector.

The objective of this article is to make observations based upon these changes a-B to trace the origins of these changes in human behavior and the effects of these changes in terms of forest resource demand. The purpose is to convey an understanding that technological progress is both a behavioral response to resource conditions and a major contributing factor behind the ability to sustain resource supply while demand grows for forest products. These factors are relevant because they broaden the issues and concerns of forest sustainability. The goals of forest sustainability, which are to preserve biological systems and satisfy fundamental human needs, are dependent upon rational human responses to resource conditions (as evidenced by structural changes in production and technology).

3I.2 Origins of Technological Change

Throughout the latter half of the 20th century, the North American forest sector has experienced largely unabated growth in demand and production of forest products. This period has been characterized by long run economic adjustment to markets through product and material substitution, intensified timber management, shifts in regional production capacities, and improvements in technology.

Most of the profound technological changes in the North American forest sector originated as responses to market conditions, involving solution to market dilemma or exploitation of market opportunity. Markets were characterized in recent decades by growing product demands, with limited supplies of certain categories of wood resources and relatively abundant supplies of certain other materials. From 1980 to 1996, the combined U.S. and Canadian output of nine principal categories of forest products increased by 47%, from 148 to 218 mill. tonnes (dry weight basis). (The author's estimates are based on production data for nine principal categories of industrial wood products including paper, paperboard, market pulp, particleboard, medium-density fiberboard (MDF), oriented strandboard (OSB), softwood plywood, softwood sawnwood, and hardwood sawnwood.) In the same period, consumption of pulpwood, wood residues, and recycled fiber increased faster than consumption of sawlogs and veneer logs. Earlier expansion of production had contributed to market dilemmas, such as escalating prices of sawlogs and increased waste disposal costs, and those dilemmas were subsequently ameliorated by material substitution and recycling.

Technological change has arisen also partly as a result of environmental policy and legislation. Increased prices for sawlogs and veneer logs, especially for softwoods, resulted not only from increasing demand but also from reduced timber harvests on public forests due to policy adjustments aimed at preserving old-growth forest habitat for endangered species. Increased waste disposal costs were due not only to increasing levels of waste disposal but also in part to environmental legislation and increased regulation of waste disposal in landfills.

31.3 MARKET-DRIVEN CHANGE

Perhaps the most profound market dilemma that has faced the North American forest sector in recent decades has been long-term escalation of real prices for sawlogs and veneer logs, particularly in the United States. This trend was driven by increased demand for sawnwood and plywood, beginning in the 1970's and continuing into the 1990's. The forest sector faced a short run market dilemma – as sawnwood and plywood demand increased, with fixed technology and limited industrial roundwood supplies, sawlog and veneer log raw material prices increased as well. In the short-run, immediate alternatives included higher product prices or declining industry profits. The solution to the short-run market dilemma was found in long-run adjustments, including investments in new and more efficient technology and intensified forest management. Thus, short-run market conditions fostered investment in sawmill and plywood mill efficiency improvements. The market dilemma coincided also with a new opportunity to exploit relatively abundant pulpwood and wood residue supplies. Intensified forest management resulted in increased abundance of plantation grown timber and pulpwood, and supplies of wood residues increased along with sawnwood and plywood production. These conditions fostered ongoing expansion in composite wood panel output, most notably particleboard, OSB, and MDF, substituting for sawnwood and veneer products.

increased paper recycling in North America ***is*** another example of market-driven change in technology. By the 1980's, expanded consumption of paper products in North America had contributed to increased waste disposal costs, fostering expansion in collection and recovery of paper for recycling. Increased collection and recovery of paper for recycling flooded the market with low cost recovered fiber in the early 1990's, leading to expansion in recycling capacity within the paper and paperboard industry.

31.4 IMPROVED TIMBER MANAGEMENT AND HARVESTING SYSTEMS

The relative economic abundance of pulpwood (smaller diameter and younger age classes of timber) resulted from gains in timber growth and improved harvesting systems. In the United States, the area of land planted annually with softwood timber increased by more than fivefold from the 1950's to 1980's (presently more than one mill. ha per year), and the land area planted annually with softwood timber in the southern United States alone currently exceeds that of any other country in the world (Sharma 1992; Powell et al. 1993; Moulton et al. 1995). Intensified softwood timber management in North America, as exemplified by plantations, occurred because softwoods had higher anticipated demands and higher stumpage market values than hardwoods. However, because of shorter rotations required to grow timber for pulpwood, intensified forestry and increased plantations in recent decades have had more immediate effects on boosting pulpwood supply than sawlog or veneer log supply.

Modem mechanized harvesting systems have been developed and applied widely in the past 50 years, largely as an economic response to rising labor costs, increased demands for timber, and changes in timber management. Mechanized timber harvesting systems have been employed in North America for more than 100 years, going back to large steam-powered devices used for removing logs from forests in the 19th century. However, timber harvesting remained very labor intensive well into the 20th century. The advent of portable gasoline-powered chain saws for felling and cutting trees, diesel-powered tractors for hauling logs from the forest, and trucks for hauling wood to mills resulted in significant displacement of human labor and draft animals in the 1920's and 1930's. More specialized and more powerful equipment for harvesting of trees and removal of wood began to be widely adopted in the 1950's and 1960's, including mechanized feller-bunchers, skidders, and whole-tree chippers. In part, development of such equipment was fostered by increased use of small diameter timber (pulpwood, small sawlogs, and plantation timber) more suitable to modem mechanized harvesting systems.

31.5 Improvements in Sawmill and Sawnwood Technology

Because of higher softwood industrial roundwood prices, there was strong incentive to improve wood use through advances in sawmill technology and modem sawnwood grading systems in North America. Use of more stable and precise sawing equipment, laser-guided sawing, computerized log breakdown systems, and improved drying systems enabled sawmills in North America to steadily increase recovery of sawnwood from logs and to optimize recovery of sawnwood from small diameter logs. These changes resulted in a regional shift of the North American sawmilling industry from predominantly western regions, based on more expensive large diameter timber (e.g., west coast Douglas-fir), to eastern regions with low cost small diameter timber resources, particularly the southern United States and eastern Canada. Softwood sawnwood production in North America has been split fairly evenly between the United States and Canada for decades, but since the early 1980's, production in the southern United States has grown from around 13% to around 23% of the North American total. More precise sawnwood grading systems, including nondestructive mechanical stress rating systems, have also enabled sawnwood to be used more efficiently. With improved grading, designed structural performance has been more closely matched to actual structural performance limits of the sawnwood (as in engineered wood trusses). Consequently, engineered wood roof trusses and small dimension sawnwood (chiefly “2 by 4“ sawnwood) have become almost universally used in housing and light commercial construction, replacing wide dimension softwood sawnwood.

31.6 Expansion of Composite Wood Panel Technology

Wood panel production capacity growth in recent decades has shifted toward expansion in the composite wood panel industry, which includes particleboard, MDF, and OSB. For example, OSB is rapidly replacing softwood plywood in construction markets. Also, OSB is used in engineered wood products such as I-joists (which replace wide dimension softwood sawnwood in construction). In recent years, I-joists have reportedly taken over a growing share (probably more than 10%) of the wood floor framing market in the United States, a market once occupied solely by wide dimension sawnwood. United States and Canadian output of OSB panels increased from around 0.8 mill. m^3 in 1980 to 13.5 mill. m^3 in 1996 (Figure 31.1). United States and Canadian output of softwood plywood peaked in 1987 at around 22.5 mill. m^3 and declined to around 18.8 mill. m^3 by 1996 (Figure 31.2).

Economic factors that have led to the rapid expansion of OSB production include generally low mill labor costs (relative to plywood) and the fact that OSB is made from cheap small diameter pulpwood (including hardwoods) compared with the increasingly expensive softwood veneer logs and sawlogs required for softwood plywood and sawn-

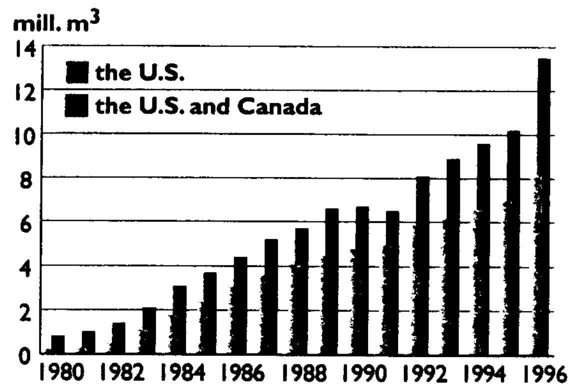

Figure 31.1: Oriented strandboard (OSB) production in the United States and Canada, 1980-1996 (Adair 1995)

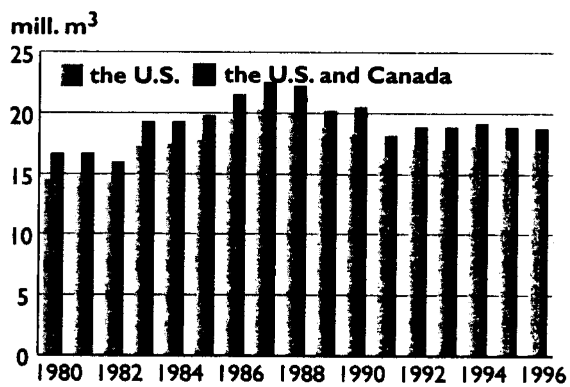

Figure 31.2 Softwood plywood production in the United States and Canada 1980-1996 (Adair 1995)

wood (Spelter 1996). The OSB industry began to grow most significantly in the 1980's immediately following a period of escalation in softwood industrial roundwood prices in the late 1970's. This trend was accelerated in the late 1980's by environmental restrictions on harvests of old-growth softwood timber from publicly owned forest lands in the western United States. The OSB industry has expanded mainly in the eastern United States and in Canada, making use of low cost hardwoods such as aspen *(Populus* spp.) and pulpwood-type raw materials and reducing the use of softwood veneer logs.

31.7 Paper Recycling

Paper recycling rates have increased substantially in the United States and Canada since the 1980's, driven by increased supply of recovered paper and production cost savings (particularly in newsprint and containerboard grades). In the 1980's, costs of waste disposal escalated rapidly in North America. In the United States, costs of waste disposal in landfills increased from less than USD 10 per tonne to USD 50 per tonne or more (in densely populated states in the northeastern part of the U. S., disposal costs reached more than USD 100 per tonne by the late 1980's). To avoid rapidly increasing disposal costs, many municipalities and businesses began to recover more materials from waste for recycling. By the early 1990's, markets were flooded with recovered paper at very low prices. In addition, many states passed legislation of various forms to promote demand for recyclable materials, making it more feasible for municipalities and others to avoid costly waste disposal in landfills. Driven by the market force of cheap fiber supply from recovered paper as well as by legislative incentives, the paper and paperboard industries added recycling capacity. From the 1980's to mid- 1990's, the recovered paper utilization rate increased from 23% to 37% in the U.S. and from less than 10% to 24% in Canada (Figure 31.3). Utilization rates are the average ratio of recycled paper input to paper and paperboard output in the paper and paperboard industries. During the same period, recovery rates (ratios of paper recovery to total paper consumption) increased in the U.S. from 26% to 45% (one sixth of paper recovery in the U.S. is exported) and in Canada from 20% to 41%.

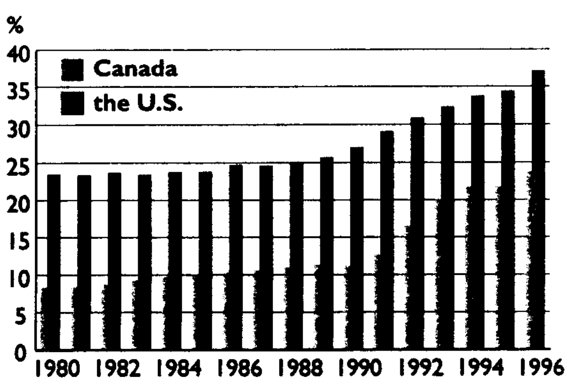

Figure 31.3: Recycled paper utilization rates in the United States and Canadian pulp and paper sectors, 1980-1996 (AFPA 1996; CPPA 1997)

However, increased paper recycling has not been accompanied by a decline in pulpwood harvest in North America. In the United States alone, production of paper and paperboard increased by 14% between 1990 and 1995, stimulating an increase in overall demand for fiber (AFPA 1996). From 1990 to 1995, the U.S. domestic consumption of paper and paperboard increased by about 11% and the U.S. exports of paper and paperboard products increased by 58% (AFPA 1996). Thus, production increased and an increasing share of production was for export. Consumption of recovered paper at domestic paper and paperboard mills increased by 48% (from 19.7 mill. tonnes in 1990 to 29.2 mill. tonnes in 1995). Wood pulp production increased by only 6%, and yet pulpwood harvest increased by nearly 970. The smaller gain in wood pulp production relative to paper and paperboard production is attributable to the increase in paper recycling. The larger gain in roundwood pulpwood harvest relative to wood pulp production is attributable to decreased supply of wood residues (less production of sawnwood and plywood) and an increased share of lower yield bleached kraft pulp in overall wood pulp production.

Unlike the Scandinavian countries of Europe, for example, high yield mechanical pulping technology has not gained significantly in proportion to total wood pulp production in North America. This is undoubtedly due to the fact that pulpwood remains relatively cheap and abundant in North American markets, reducing the incentive to shift from low yield chemical pulps (such as kraft pulp) to mechanical pulp grades. This is also due in part to the higher electrical energy input required in mechanical pulping (which helps explain why mechanical pulping has gained more in Canadian regions with lower cost electrical energy than in the United States). In the long term, however, if pulpwood supplies are constrained or pulpwood prices increase, mechanical pulping technology may be more widely adopted.

31.8 Economic Implications for Sustainability

An important implication of improved forest management, efficiency gains, material substitution, and enhanced recycling is that these changes effectively create a larger, more sustainable, and more economical resource base, which will economically sustain higher levels of production. For example, pulpwood harvest in the southern United States has more than doubled since the early 1960's, and southern pulpwood has been used increasingly for structural product applications (such as OSB) as well as for pulp and paper products. However, intensified forest management, expanded forest plantations, gains in production efficiency, and recycling have helped maintain affordable and stable economic supplies of southern pulpwood. Adjusted for economic inflation, the average real price of Southern Pine pulpwood delivered to mills in late 1996 was precisely the same as 20 years earlier in 1976.

Intensification of timber management has had a notable impact on forest resource sustainability as shown by timber inventory data in the United States since the early 1950's. The national average softwood net annual growth per hectare increased by nearly 75% between the 1950's and 1980's (Ince et al. 1989). Even though total timber cut (including all growing stock and non-growing stock harvest and logging residues) increased by more than 70% between the 1950's and 1980's, the volume of standing softwood timber in the U.S. was sustained at a level between 12.2 and 13.2 bill. m^3 during the past 50 years (most recently, it has been around 12.7 bill. m^3) through improved forest productivity.

Finally, the North American experience helps provide some insight to future markets and future technologies. Generally, certain resources may become more expensive through relative scarcity (such as large diameter softwood timber in the western United States in the 1980's and 1990's for example) and when that happens, industry and society will seek technology capable of using alternative lower cost or more abundant resources (such as small diameter timber in the eastern United States, low cost hardwoods, or recycled fiber). No resource is infinitely abundant, and ultimately any resource may become scarce, but if solutions to future problems of resource scarcity exist, they will most likely be found in the realm of human ingenuity, increased productivity, and technological flexibility.

31.9 Advantages of Flexibility

The forest sector has gained in technological flexibility as hardwoods have become suitable raw material for construction via technologies such as OSB, as pulp logs have become suitable for sawnwood production via small log sawmill technology, and as recycled fiber has become more broadly suitable for papermaking via advances in recycling. Flexibility to substitute one form of resource, which may be temporarily abundant, for another form, which may be temporarily limited in supply, helps avoid scarcity and enhance sustainability.

The technological and structural flexibility of recent decades has shown significant advantages for sustainability of the forest sector in North America. These advantages include: (i) averting a timber resource crisis, which could have been catastrophic to the North American forest sector, by means of material and product substitution along with regional shifts in production capacity; (ii) enhancing global competitiveness and securing a larger role in world trade by developing a stable and more flexible resource supply base; and (iii) sustaining growing demands for forest products, despite constraints of a finite land base, through gains in forest resource productivity along with material substitution and recycling, which enable more complete and efficient use of wood resources.

31.10 Effects on Society and Environment

One corollary to the role of technology in securing forest resource sustainability is society's increased dependence on technology to sustain demands. The current level of demands for wood products in North America simply could not be sustained economically without the kind of technological advances and changes in production that occurred during the past several decades. For example, as late as 1962, all structural wood panel production of the United States was concentrated in the West (primarily in the Pacific Northwest and primarily based on old-growth Douglas-fir). Western softwood plywood was the only technology available at that time for production of structural grade wood panels in the United States. By 1996, consumption of structural wood panels in the United States (including softwood plywood and OSB) attained a level more than three times greater in volume than in 1962 (when production was entirely concentrated in the West). By 1996, Southern Pine plywood production exceeded western plywood production. and OSB production accounted for about one third of total structural wood panel production. It would be virtually impossible to economically sustain today's level of structural panel demand in the United States with production of softwood plywood in the West alone. The advent of small-log Southern Pine plywood technology, OSB technology, and shifts of production capacity from West to East were thus essential ingredients in responding to and sustaining high levels of demand. Likewise, increased paper recycling, new composite wood panels, and engineered wood products are all examples of how society has evolved a growing dependence on technology to sustain its demands.

31.11 Conclusions

Technological flexibility of the forest sector in North America has been a vital contributor to forest resource sustainability during the current era of growing demand for forest products. One cart expect a continued pattern of shifts in production technology and resource use with time, as society and industry adjust to market conditions through long-run technological change and shifts in production capacity. This is a predictable behavioral pattern as long as technology, resources, or geographic location afford a means of obtaining comparative advantage. In addition, the long-run consequence of greater flexibility and substitutability among resource options is the ability to sustain a higher level of production in the forest sector.

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