Adapting to global supply constraints

or: Timber famine and six reasons why it won't occur

Clark S. Binkley

Abstract

As global population and incomes increases, so too will the demand for wood increase. At the same time, the supply of timber from many traditional sources is declining, and the increased supply from such "emerging" regions as New Zealand and Chile is probably not adequate to offset the reductions elsewhere in the world. Increased demand will confront constrained supply, setting the stage for "timber famine" or, in economic terms, increases in timber prices. These prospective price increases will induce changes in both timber supply and timber demand that will tend to offset the effects of increased scarcity. This paper focuses on changes in timber demand.

For an economist, price increases produce substitution and income effects. In this case, substitution effects include 1) substitution of domestically grown wood by imports; 2) substitution of capital and labor for timber in wood processing; 3) substitution of technology for wood in wood products; 4) substitution of nonwood products for wood products; and 5) substitution of high wood-consumption life-styles for ones that require less wood. Even after all of this substitution occurs, higher timber and product prices will reduce consumer welfare. Economists call these losses in consumer welfare "income effects."

Each of these adjustments carries economic and environmental costs. The net effect, however, will be a significant abatement of the latent demand for wood inferred from population and income data alone. Despite these adjustments, timber demand is apt to increase faster than supply, and some real price increases can still be anticipated. These increases will reduce consumer welfare but will also create opportunities for profitable investment in timber production, in process improvements, in new product development, and in the R&D that supports these new businesses.

The author is Dean, Faculty of Forestry, Univ. of British Columbia, Vancouver, B.C., Canada.

Introduction: the ingredients for timber famine?

> "If we accept the larger estimate of annual growth and apply it to the present rate of consumption, the result shows a probable duration of our supplies of lumber of not more than 33 years...[It] is certain that the United States has already crossed the verge of a timber famine."
>
> *Gifford Pinchot, 1907*

Despite a doubling of population and a seven-fold increase in economic activity, the United States has somehow avoided Pinchot's dire prediction. But now humans have pushed into nearly every corner of the world, and our high income levels have fueled massive increases in the consumption of wood products. The productivity of our forests seems to be threatened by regional air pollution and global climatic change. Demands for the important environmental services that forests provide increasingly constrain their capacity to produce industrial products. Are we now on the verge of a real timber famine?

As global populations increase, so too will the latent demand for wood. By applying estimates of the current per-capita consumption of industrial roundwood to widely accepted forecasts of population growth, Sutton (20) concluded that the world will need about 75 million m^3 of additional industrial timber supply each year for the next two decades. As a point of reference, British Columbia — one of the world's largest suppliers of softwood timber — has an annual allowable cut of about this same amount.

Sutton's forecasts ignore the increases in consumption associated with increases in income. For many forest products, the income elasticity of demand is greater than one, so an increase in income has more than a proportionate increase in consumption (21). For example, when restated using purchasing power parity exchange rates, the average income level in the People's Republic of China is now about $2,500, with the high population coastal areas having a level of income about twice that. If the rapid economic development there continues, within two decades a large fraction of that country will possess a standard of living equivalent to that in Japan, Germany, or the United States today — and conceivably the same high levels of wood-products consumption.

Because of its importance to long-term industrial planning, many researchers have studied the prospective demand for wood products. Table 1 shows the estimates of industrial timber consumption in the year 2000 from seven such studies. Not surprisingly, there is considerable range in the estimates. The median growth rate reported by these studies (1.7% per year) suggests that timber consumption will rise by about 30 million m^3 per year. Sutton's forecasts lie on the high end of the range, but even the median estimate implies that substantially more wood will be required every year. Will timber supply expand accordingly?

Perhaps not. At the same time that the underlying factors driving demand — population, income, and economic activity — head upward, economic and environmental factors constrain timber supply in many parts of the world. Table 2 shows one estimate of future timber supply in the major regions of the Pacific Basin.

Table 1. — Forecasts of industrial timber consumption, 2000.

Study	Forecast consumption	Growth rate from 1985
	(billion m^3)	(% per year)
Food & Agriculture Organization (1982)		
High demand scenario	2.6	4.0
Low demand scenario	2.3	3.2
Food & Agriculture Organization (1979)	1.8	1.6
SRI (1979)	1.9	1.9
World Bank (1978)	2.8	4.5
Kallio, Dykstra, and Binkley (1987)	1.8	1.6
Sedjo and Lyons (1990)		
Base case scenario	1.7	1.2
High demand scenario	1.8	1.6
Cardellichio et al. (1988)	1.8	1.7
Median projection for 2000	**1.8**	**1.7**

Both British Columbia and the U.S. Pacific Northwest have increasingly restrictive environmental regulations that are likely to force significant reductions in harvest levels. In British Columbia, the current round of timber supply reviews is likely to conclude that current harvest levels are 20 to 25 percent above the levels that can be sustained in perpetuity. However, these timber supply reviews reflect neither the provincial government's stated objective of doubling the areas of parks and preserves nor some of the more restrictive environmental constraints contained in the provincial Forest Practice Code that has recently been released for public comment. Completing the Protected Areas Strategy could conceivably reduce harvest levels by an additional 6 percent, although the actual impact is apt to be less. Recent analyses of the constraints contained in the proposed Forest Practices Code (e.g. reduction in size of clearcuts, mandatory green-up periods before adjacent cutblocks can be harvested, networks of old-growth reserves within the working forest, cover constraints to retain at all times a significant area of old-growth forests within the working forest) found significant reductions in all areas studied, ranging from 29 percent in the coastal Tsitika and interior Tangiers drainages to 65 percent on coastal Hardwick Island (11,12).

Some Indonesian analysts forecast that, as a consequence of forest depletion and expanded domestic consumption, Indonesia could become a net importer of timber by 2000 (18). Poor infrastructure, institutional uncertainty, and depleted forests limit supply increases from the Russian Far East (3). Timber supply will increase in New Zealand and Chile, but these increases are not sufficient to fully offset reductions elsewhere.

In short, we seem to have the basic ingredients in the recipe for timber famine of the kind Gifford Pinchot heralded 85 years ago. But instead of timber famine, we are apt to see a host of offsetting adaptive responses.

Table 2. — Timber harvests from Pacific Rim supply regions (1).

Supply regions	1990	1995	Change
	(million m^3)		
U.S. Pacific Northwest	81.0	65.0	(16.0)
British Columbia	78.3	65.0	(13.3)
Russia	100.0	97.0	(3.0)
Malaysia and Indonesia	66.0	61.3	(4.7)
New Zealand	13.0	14.0	1.0
Chile	16.5	18.2	1.7
Total	354.8	320.5	(34.3)

Adaptive responses to timber scarcity

For an economist, timber scarcity means rising timber prices. Rising timber prices induce responses in both supply and demand. Considerable attention has been paid to supply-side responses (16). These include shifts in the extensive margin as places previously too remote or rough to log become economically attractive, increases in management intensity to grow more wood per unit area, reduction in timber rotations, and increases in plantation area. These effects can be powerful. For example, plantations established to absorb carbon are one possibility for incremental supply that many analysts commonly ignore. Such plantations are a cost-effective method of CO_2 abatement (17). Haynes et al. (6) has estimated that a 6-million-acre afforestation program would provide enough timber supply to drive prices down to "stabilize at a low level" by 2040.

This paper focuses on the demand-side responses that are not well understood. Economists decompose price-induced reductions in demand into substitution effects and income effects.

Five kinds of substitution effects will tend to limit the impact of timber scarcity:

1. Changes in trade flows to substitute timber from places where it is relatively abundant for timber from places where it is comparatively scarce.
2. Greater use of capital and labor in processing facilities to substitute these inputs for timber and to economize on wood consumption.
3. Incorporation of higher levels of knowledge per unit of product to substitute technology for wood while meeting customer needs with less fiber.
4. Increased use of aluminum, plastics, and steel to substitute nonwood products for wood products.
5. Cultural changes to substitute new ways of living for old ones requiring more wood.

Even once the full latitude for substitution has occurred, consumers are likely to still be worse off than they were when timber was more abundant. This residual loss of consumer welfare is called an income effect: Higher prices reduce the income consumers have to spend on other goods and services. Because the demand for some wood products is fairly inelastic, the income effects associated with higher timber prices may be significant.

Let us examine each of these substitution and income effects in greater detail.

Changes in trade flows

Every since deforestation in the Mediterranean forced the Greek navy to import cedar for its triremes, timber trade has moved wood from places of relative abundance to places of relative scarcity. Wood products remain one of the world's most heavily traded goods.

By making timber from one region available to consumers in another, trade offsets the effects of local scarcity. Indeed, some environmentalists decry trade precisely because it permits importing countries to "live beyond their means." Conversely, restrictions on trade exacerbate local imbalances between supply and demand. For example, the propensity to restrict log exports when local timber supplies decline is nearly universal. This misguided policy reduces the value of local forests and thereby thwarts some logical responses to increased scarcity such as improved processing efficiency or reduced demand (22). Such restrictions also drive up consumer prices, exacerbating the global welfare losses associated with rising timber prices. Non-tariff barriers to trade such as the current limitations on the import of unpasteurized Canadian lumber into Europe produce similar pernicious effects.

Perez-Garcia (13) analyzed the impacts on forest products trade on the likely reductions in timber supply in the U.S. Pacific Northwest (20 million m^3) and in British Columbia (13.3 million m^3) due to environmental restrictions. Figure 1 shows that 65.8 percent of the reduction in harvests in these northwest coastal regions of North America are sim-

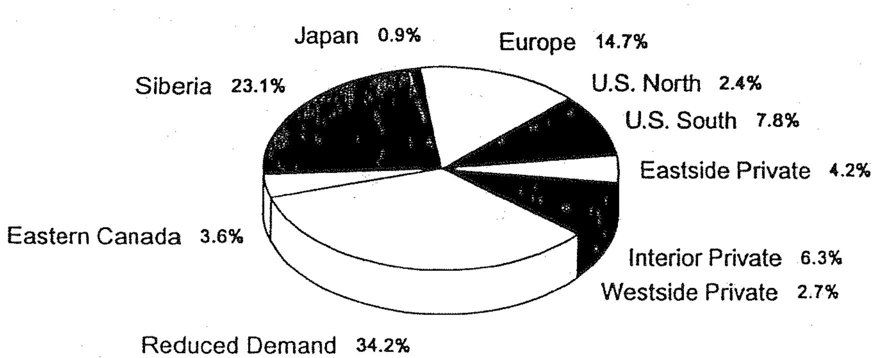

Figure 1. — Changes in regional production due to reduced northwest coastal North American timber harvests (13).

ply redistributed among other regions. Because most of the world's forests carry lower timber volumes than do those of the Northwest, the *area* harvested annually would actually increase by 12 to 61 percent, depending on the precise assumptions used. As a consequence, it is not clear that — when viewed from a global perspective — harvest restrictions in the U.S. Pacific Northwest and in British Columbia produce net positive environmental effects for the world as a whole.

Improved processing efficiency

Gifford Pinchot's predictions were not realized, partly of because steady improvements in the technical efficiency of wood processing. Using standard econometric techniques, the rate of technical improvement is difficult to measure, but the trend probably lies in the range of 1 to 2 percent per year for many wood products manufacturing activities (7).

Two examples drawn from sawmills in the British Columbia interior provide some insight into the nature of technological progress. Figure 2 shows that a typical British Columbia interior sawmill has increased lumber recovery by 12.8 percent as a result of capital investments taken over the last few years. Even at current factor and output prices, these investments all carried high internal rates of return, so the firm readily chose to make them. With increased timber prices, the incentive to invest in such technology would be even greater. Put another way, ordinary market forces make it economical to offset a significant reduction in log supply.

Such anecdotes about individual mills tell little about overall market impacts. To reflect on these market effects, Figure 3 shows the lumber-recovery factor for northern interior sawmills in British Columbia between 1986 and 1992. Note first that the interquartile range varies between 7.6 percent and

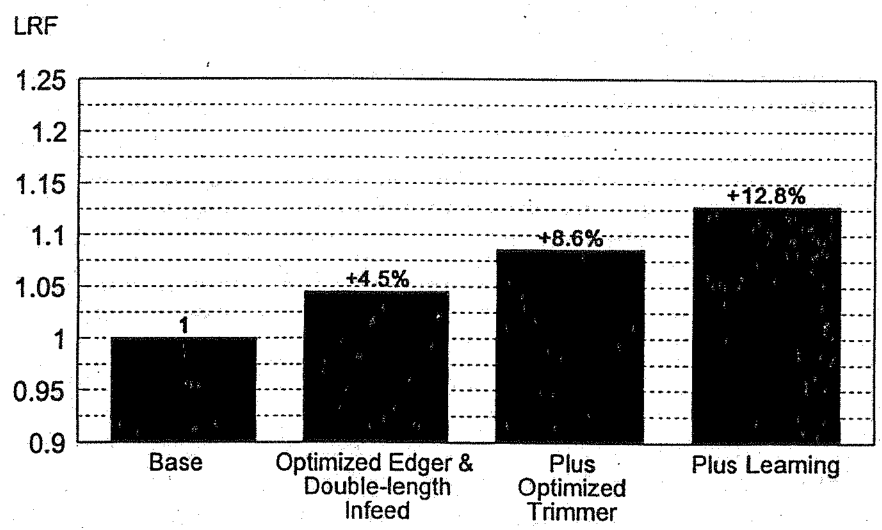

Figure 2. — Capital-time substitution in an interior B.C. sawmill (LRF is scaled so the pre-investment level equals 1.00).

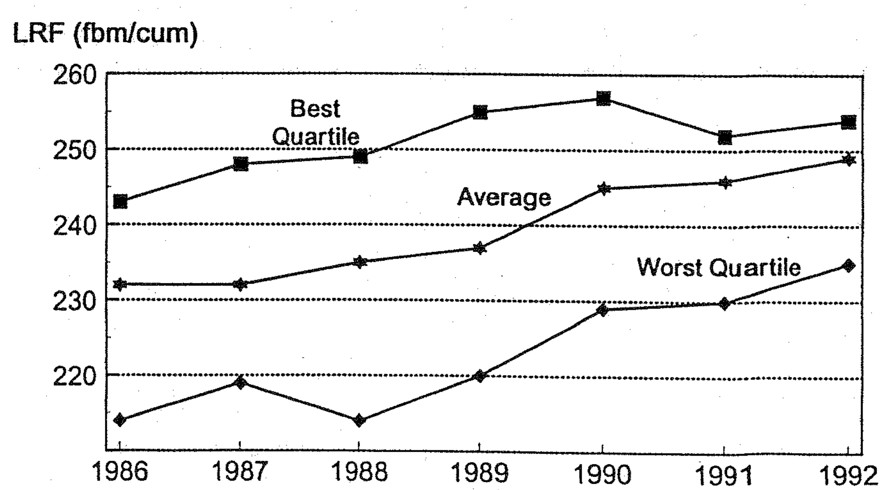

Figure 3. — Trends in lumber recovery for interior B.C. sawmills.

12.5 percent of the average. As a consequence, there is considerable room for industry-wide improvement in technical efficiency if the worst mills came up to the standard set by the best ones. Second, interior sawmills face similar factor prices and produce similar products (mainly SPF dimension lumber for U.S. markets). Lumber recovery is therefore a good proxy for production costs. Since prices are set by the marginal production cost of the least efficient mill, all of the mills that are more efficient generate profits (or what economists call "quasi-rents") equal to the difference between their own production costs and those of the least efficient mill. The data in Figure 3 suggest that adoption of the technology that is most efficient at one point in time continues to produce quasi-rents for at least 7 years. These quasi-rents have persisted despite the fact that the spread in lumber recovery between the least and most efficient mills has narrowed over time. These persistent excess returns to technology provide a powerful economic incentive to invest in more efficient processing technology, and thereby to reduce timber demand.

Technologically advanced wood products

Increases in timber prices provide an incentive to develop new products that provide similar performance characteristics to the old ones but use less wood. Such developments substitute technology for wood. Examples of such engineered wood products include laminated veneer lumber, Trus-Joist/MacMillan's Parallam, and older products such as oriented strandboard (OSB).

The case of OSB is instructive. In many applications OSB can be substituted for plywood, and consumers choose between the two products largely on the basis of comparative costs. The relative cost of the two products depends heavily on the price of peeler logs, the most important single cost of producing plywood. Figure 4 shows the growth of OSB's share of the U.S. panel market as the price for peeler logs rose. Even though the technology to produce OSB became commercial in the 1960s, only the timber shock of the 1970s created an adequate incentive for consumers to adopt OSB. As scarcity drives timber prices up, there is probably considerable capacity for new, higher technology wood products to substitute for old ones.

Wood-nonwood substitution

Increases in timber prices will tend to drive up the prices of products manufactured from timber. These increases in product prices provide an incentive for consumers to use formerly more costly nonwood products with similar performance characteristics in place of their wooden counterparts.

Table 3 shows that there is considerable room for price-induced substitution between wood and nonwood products. For example, a 1 percent increase in the price of softwood lumber will increase the consumption of structural steel by 0.32 percent. Indeed, the recent run-up in SPF lumber prices caused some homebuilders to look for alternative materials. *The Economist* (19 June 1993, p. 68) noted this effect, and reported that "a typical home built [as suggested by steel producers] would contain between four and five tons of hot-dipped galvanized steel doing the work of about 20 tons of timber." As scarcity

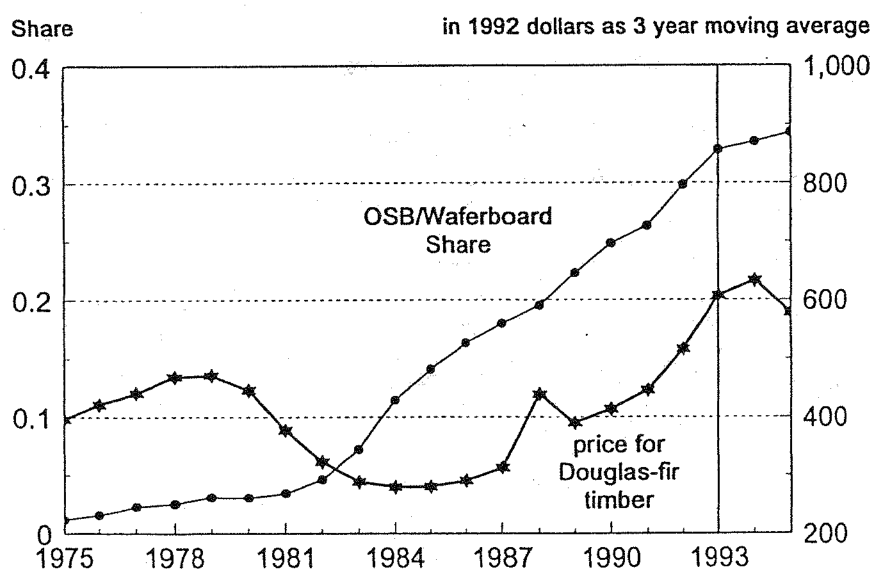

Figure 4. — Increase in OSB/waferboard share of U.S. panel markets (RISI, personal communication).

pushes up the prices of wood products, consumers will buy products manufactured from other materials to satisfy the demands formerly met by wood. This process of substitution reduces the impact of timber scarcity on consumers.

Of course, the nonwood substitutes for wood products may produce deleterious side effects that warrant policy attention. For example, cement production is second only to fossil fuel consumption as a source of CO_2 emissions in Canada. Using the elasticities of substitution reported in Table 3, Prins (15) estimated the amount of other materials that would be substituted for SPF lumber produced in Canada if the price of SPF doubled. He then computed the amount of additional energy that would be required to manufacture these other materials, and estimated that energy consumption would increase by the equivalent of 3.4 million barrels of oil/year to offset the reduction in Canadian lumber production alone. Similarly, Perez-Garcia (13) estimated that wood/nonwood substitution associated with the 33.3 million m^3 timber harvest reduction anticipated in the northwest coastal region of North America would release 18 million tons of additional CO_2 into the atmosphere each year.

One policy to control pollution calls for internalizing the cost of environmental damage into the price of the products that cause it. This could be accomplished, for example, through a carbon tax, through mechanisms such as tradable effluent permits, or through regulations. Timber-supply restrictions occasioned by tightened environmental constraints internalize the costs of these environmental concerns into the price of wood products. If the environmental costs of the substitute nonwood products were incorporated into the price of those products, then wood products would compete more effectively against them. Wood-products manufacturers might therefore be well advised to demand — in the interest of both equity and environmental objectives — that the prices of *all* products should carry the burden of the environmental damage caused by the product.

Cultural changes

The Knight-Ridder newspaper company is experimenting with electronic tablets to replace newspapers (*The Economist*, 10 July 1993, p. 77). Adoption of this technology will require a change in the culture of newspaper reading. But even without high technology, consumption of wood products varies dramatically among countries and among individual households within a country. It is apparently possible to maintain a high standard of living with widely differing levels of wood-products consumption.

Figure 5 shows the per capita apparent consumption (i.e., production plus imports minus exports) of newsprint and printing and writing papers in six industrialized countries. Each of these countries enjoys a very high material standard of living. Yet people in such places as Canada apparently consume over three times as much newsprint as do others

Table 3. — Elasticities of substitution (9,10,15).

Wood product	Non-wood product	Elasticity
Wood windows	Aluminum windows	1.7
Softwood lumber	Bricks	0.51 to 0.79
Softwood lumber	Cement	0.15
Softwood lumber	Structural steel	0.32

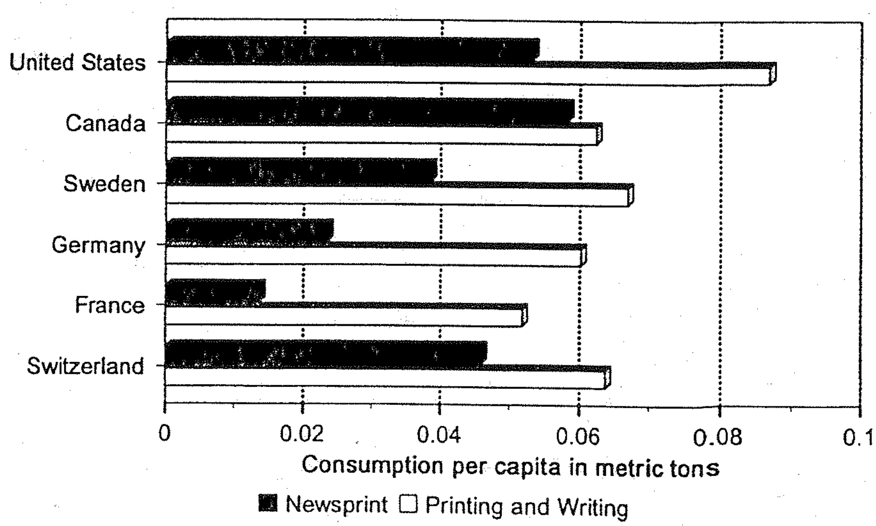

Figure 5. — Annual per capita consumption of paper in selected industrialized countries.

in such places as France. Although the variation in consumption of printing and writing papers is much less, there is obviously considerable room for reducing paper use while maintaining a high living standard. As timber becomes more scarce, consumers of wood products will have an incentive to adopt lifestyles that economize on wood use.

Increased prices and loss of consumer welfare

Increased timber prices will tend to increase the prices of intermediate and final products that contain wood. Increased product prices will provide an incentive for consumers to reduce their consumption of wood products by finding suitable substitutes. To the extent that consumer needs can be well met by these substitutes products, there is no loss of consumer welfare. However, the substitute products generally carry higher prices or poorer performance characteristics. As a consequence, price-induced substitution generally hurts consumers by taking away some of the income that they would otherwise have had for purchasing other products or for saving. Assuming that all of the environmental costs of alternative products are fully recognized in their prices, this income effect is a good measure of the social cost to consumers of increased timber scarcity.

In his study of harvest reductions in the northwest coastal regions of North America, Perez-Garcia (13) estimated this income effect — the loss of consumer welfare due to the higher product prices associated with a reduced timber harvests. The total loss amounts to nearly \$2.5 billion per year, or about \$75 per m^3. Figure 6 shows how this total will be distributed around the world. About 40 percent of the total impact will fall on the regions where the harvest reductions occurred (the United States and Canada). The remainder will hit consumers throughout the world as product prices rise everywhere.

Conclusions: timber famine or not?

Physical depletion of timber, conversion of forest land to other uses and environmental restrictions on timber harvesting in the remaining forested areas will limit future timber supply from many regions that have traditionally produced much of the world's timber. Fast-growing plantations established in the low and middle latitudes will not fully offset the reductions in timber harvest in the traditional supply regions. At the same time, rising population and per capita income insure that the demand for wood products will grow. Estimates of the additional demand range from about 20 to 125 million m^3 per year, with the median lying nearer the low end of the range at about 30 million m^3 per year.

The confluence of rising demand and limited supply will induce a variety of adaptive responses. Timber and wood products prices will rise, especially in the short run. These price increases will induce some short-term increases in timber supply, particularly as areas that were previously too expensive to log become economically attractive, and as rotation ages and growing-stock inventories are reduced. In the longer run, higher timber prices will provoke new plantations and more intensive timber management.

Society can use wood more efficiently in many ways. The forest sector has successfully developed many new products and processes that reduce wood consumption while meeting consumer needs. Accelerating the pace that we create these new knowledge-intensive wood products and processes remains

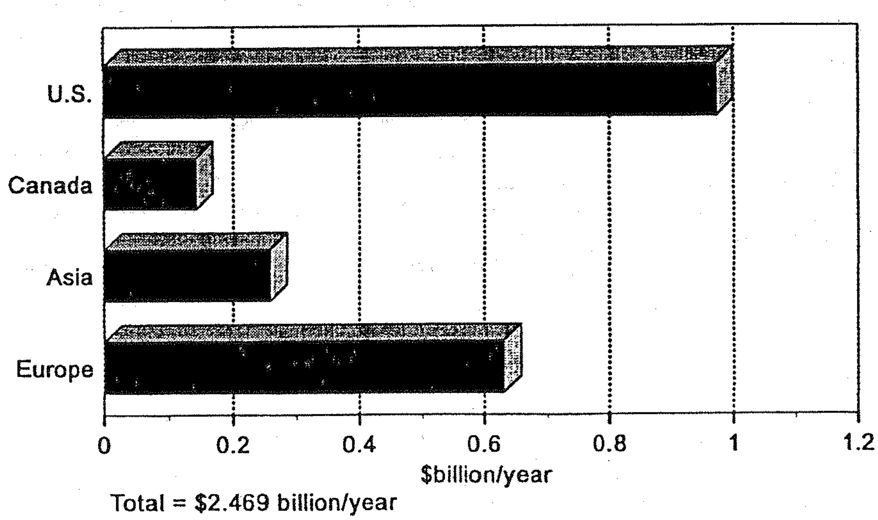

Figure 6. — Loss of consumer welfare due to reduced northwest coastal North American timber harvests (13).

a major challenge for governments, industry, and research institutions.

Other kinds of adjustments carry economic, environmental, and social costs. Substituting such energy- and pollution-intensive materials as concrete, steel, and aluminum for wood will exacerbate local, regional, and global environmental problems.

Despite the wide latitude for adapting to increased timber scarcity, timber demand will still grow more rapidly than supply. Even the most conservative estimates suggest that timber demand will grow by 20 million m^3 per year (16). Such increases will strain the capacity of the world's forests. As a consequence, timber prices are apt to continue their long-term upward real trend, albeit at a rate less than modern-day Gifford Pinchots would have us think.

Manufacturers of wood products will be squeezed between a rising floor of increased raw-material costs and a fixed price ceiling for traditional products set by the cost of available substitute wood and nonwood products. Improved technology in wood products and production processes is the only way to sustain profitability in the face of the these twin pressures. The critical need for improved technology raises important questions concerning appropriate strategies and expenditure levels for R&D, but those are stories for another day.

Literature cited

1. Boyd, C. 1992. Pacific Rim timber supply. Presentation in Santiago, Chile.
2. Cardellichio, P.A., Y.C. Youn, D.M Adams, R.W. Joo, and J.T. Chemelik. A preliminary analysis of timber and timber products production, consumption, trade and prices in the Pacific Rim until 2000. CINTRAFOR Working Paper 22. Univ. of Washington, Seattle, Wash.
3. ________, C.S. Binkley, and V.K. Zausaev. 1990. Sawlog exports from the Soviet Far East. J. Forestry 88:12-36.
4. FAO. 1979. FAO world outlook for timber supply, phase V. FAO, Rome, Italy.
5. ________. 1982. World forest products: demand and supply, 1990 and 2000. Forestry Paper 29. FAO, Rome, Italy.
6. Haynes, R.W., R.J. Alig, and E. Moore. 1992. Alternative simulations of forestry scenarios involving carbon sequestration options. Draft rept. USEPA, Washington, D.C.
7. Hyde, W.F., D.H. Newman, and B.J. Seldon. 1992. The economic benefits of forestry research. Iowa State Univ. Press, Ames, Iowa.
8. Kallio, M., D.P. Dykstra, and C.S. Binkley. 1987. The global forest sector: an analytical perspective. John Wiley, London, England.
9. McKillop, W.L., T.W. Stuart, and P.J. Geissler. 1980. Competition between wood products and substitute structural products: an econometric analysis. Forest Sci. 29:813-822.
10. Moffett, J. 1993. A comparison of product diffusion and distributed-lag models for estimating wood/nonwood substitution in the U.S. window market. CINTRAFOR Working Paper 42. Univ. of Washington, Seattle, Wash.
11. Nelson, J.D. and J.S. Hackett. 1993. An economic analysis of timber harvesting regulations for coastal British Columbia. Univ. of British Columbia Forest Economics and Policy Analysis Unit Working Paper, Vancouver, B.C., Canada.
12. ________ and C. Winsor. 1992. The effects of harvesting guidelines on timber supply and delivered wood costs in the Tangiers drainage. Contract report for the Revelstoke (B.C.) forest District, 24 December.
13. Perez-Garcia, J.M. 1993. Global forestry impacts of reducing softwood supplies from North America. CINTRAFOR Working Paper 43. Univ. of Washington, Seattle, Wash.
14. Pinchot, G. 1907. Conservation of natural resources. The Outlook. 12 October 1907.
15. Prins, R.G. 1993. The economic and environmental impacts of reduced timber harvest and increased softwood lumber prices. Working Paper 29. Forestry Canada, Economic Studies Div., Ottawa, Ont., Canada.
16. Sedjo, R.A. and K.S. Lyons. 1990. The long-term adequacy of world timber supply. Resources for the Future, Washington, D.C.
17. ________ and J. Wisniewski. 1993. Managing carbon via forestry: an economic synthesis. Draft MS.
18. Sidabutar, H.P. and C. Chandrasekharan. 1992. Outlook for the Indonesian forestry sector. *In:* Forest sector analysis for developing countries. R. Haynes, P. Harou, and J. Mikowski, eds. CINTRAFOR Special Paper SP 10. Univ. of Washington, Seattle, Wash. pp. 180-195.
19. SRI International. 1979. The outlook for the world's forest products industries. Palo Alto, Calif.
20. Sutton, W.R.J. 1992. The world's need for wood. Paper presented at Maruia Society meeting "New Zealand and the World's Forests," Wellington, N.Z.
21. Uutela, E. 1984. Income and price elasticities of demand for paper and board. Inter. Working Paper WP-84-102. Inst. for Applied Systems Analysis, Laxenburg, Austria.
22. Vincent, J.R. and C.S. Binkley. 1992. Forest-based industrialization: a dynamic perspective. *In:* Managing the World's Forests, N.P. Sharma, ed. Kendall-Hunt, Dubuque, Iowa.
23. World Bank. 1979. EIS Paper 98. IBRD, London, England.

a major challenge for governments, industry, and research institutions.

Other kinds of adjustments carry economic, environmental, and social costs. Substituting such energy- and pollution-intensive materials as concrete, steel, and aluminum for wood will exacerbate local, regional, and global environmental problems.

Despite the wide latitude for adapting to increased timber scarcity, timber demand will still grow more rapidly than supply. Even the most conservative estimates suggest that timber demand will grow by 20 million m^3 per year (16). Such increases will strain the capacity of the world's forests. As a consequence, timber prices are apt to continue their long-term upward real trend, albeit at a rate less than modern-day Gifford Pinchots would have us think.

Manufacturers of wood products will be squeezed between a rising floor of increased raw-material costs and a fixed price ceiling for traditional products set by the cost of available substitute wood and nonwood products. Improved technology in wood products and production processes is the only way to sustain profitability in the face of the these twin pressures. The critical need for improved technology raises important questions concerning appropriate strategies and expenditure levels for R&D, but those are stories for another day.

Literature cited

1. Boyd, C. 1992. Pacific Rim timber supply. Presentation in Santiago, Chile.
2. Cardellichio, P.A., Y.C. Youn, D.M Adams, R.W. Joo, and J.T. Chemelik. A preliminary analysis of timber and timber products production, consumption, trade and prices in the Pacific Rim until 2000. CINTRAFOR Working Paper 22. Univ. of Washington, Seattle, Wash.
3. ________, C.S. Binkley, and V.K. Zausaev. 1990. Sawlog exports from the Soviet Far East. J. Forestry 88:12-36.
4. FAO. 1979. FAO world outlook for timber supply, phase V. FAO, Rome, Italy.
5. ________. 1982. World forest products: demand and supply, 1990 and 2000. Forestry Paper 29. FAO, Rome, Italy.
6. Haynes, R.W., R.J. Alig, and E. Moore. 1992. Alternative simulations of forestry scenarios involving carbon sequestration options. Draft rept. USEPA, Washington, D.C.
7. Hyde, W.F., D.H. Newman, and B.J. Seldon. 1992. The economic benefits of forestry research. Iowa State Univ. Press, Ames, Iowa.
8. Kallio, M., D.P. Dykstra, and C.S. Binkley. 1987. The global forest sector: an analytical perspective. John Wiley, London, England.
9. McKillop, W.L., T.W. Stuart, and P.J. Geissler. 1980. Competition between wood products and substitute structural products: an econometric analysis. Forest Sci. 29:813-822.
10. Moffett, J. 1993. A comparison of product diffusion and distributed-lag models for estimating wood/nonwood substitution in the U.S. window market. CINTRAFOR Working Paper 42. Univ. of Washington, Seattle, Wash.
11. Nelson, J.D. and J.S. Hackett. 1993. An economic analysis of timber harvesting regulations for coastal British Columbia. Univ. of British Columbia Forest Economics and Policy Analysis Unit Working Paper, Vancouver, B.C., Canada.
12. ________ and C. Winsor. 1992. The effects of harvesting guidelines on timber supply and delivered wood costs in the Tangiers drainage. Contract report for the Revelstoke (B.C.) forest District, 24 December.
13. Perez-Garcia, J.M. 1993. Global forestry impacts of reducing softwood supplies from North America. CINTRAFOR Working Paper 43. Univ. of Washington, Seattle, Wash.
14. Pinchot, G. 1907. Conservation of natural resources. The Outlook. 12 October 1907.
15. Prins, R.G. 1993. The economic and environmental impacts of reduced timber harvest and increased softwood lumber prices. Working Paper 29. Forestry Canada, Economic Studies Div., Ottawa, Ont., Canada.
16. Sedjo, R.A. and K.S. Lyons. 1990. The long-term adequacy of world timber supply. Resources for the Future, Washington, D.C.
17. ________ and J. Wisniewski. 1993. Managing carbon via forestry: an economic synthesis. Draft MS.
18. Sidabutar, H.P. and C. Chandrasekharan. 1992. Outlook for the Indonesian forestry sector. *In:* Forest sector analysis for developing countries. R. Haynes, P. Harou, and J. Mikowski, eds. CINTRAFOR Special Paper SP 10. Univ. of Washington, Seattle, Wash. pp. 180-195.
19. SRI International. 1979. The outlook for the world's forest products industries. Palo Alto, Calif.
20. Sutton, W.R.J. 1992. The world's need for wood. Paper presented at Maruia Society meeting "New Zealand and the World's Forests," Wellington, N.Z.
21. Uutela, E. 1984. Income and price elasticities of demand for paper and board. Inter. Working Paper WP-84-102. Inst. for Applied Systems Analysis, Laxenburg, Austria.
22. Vincent, J.R. and C.S. Binkley. 1992. Forest-based industrialization: a dynamic perspective. *In:* Managing the World's Forests, N.P. Sharma, ed. Kendall-Hunt, Dubuque, Iowa.
23. World Bank. 1979. EIS Paper 98. IBRD, London, England.