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GLOBAL FORESTRY IMPACTS OF REDUCING SOFTWOOD SUPPLIES FROM NORTH AMERICA

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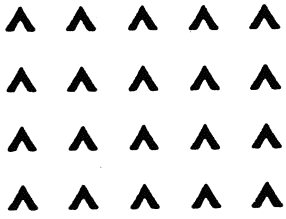

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GLOBAL FORESTRY IMPACTS OF REDUCING SOFTWOOD SUPPLIES FROM NORTH AMERICA

Executive Summary

The reduction in timber supply in the US Pacific Northwest region to protect the northern spotted owl is just one of a number of similar, ongoing adjustments in timber supply globally. The rapid rise in wood product prices experienced within the last 12 months--an increase of 100 percent--is suggestive of a substantial supply reduction rather than a cyclical housing recovery impacting demand. As such, the price adjustment in the wood products markets is forcing a permanent change in wood flow, rather than the cyclical changes associated with demand fluctuations. The reductions in timber supply will continue to impact market prices until adjustments of wood flow in world markets are complete. Many global producers will expand their production with higher wood prices. One result is that international producers benefit while consumers must pay the higher prices.

Supply reductions are not limited to US Pacific Northwest regional production but also include hardwoods from the tropics, and, prospectively British Columbian products. Tropical hardwood producers are reducing their harvests to meet sustainable timber harvest targets evolving from International Tropical Timber Organization (ITTO) negotiations. These reductions do cause reactions in US markets. We can expect the substitution of softwood plywood for hardwood plywood in Asian markets since there are relatively fewer alternative hardwood suppliers than softwood. Specification differences in plywood manufacturing are not easily met by North American producers, leading to a pre-disposition of this demand shift to be in logs rather than panels, although manufacturing specifications could also change over time with investments in panel plants dedicated for export markets. As for British Columbia, a provincial "fast track" study is currently underway for each forest planning unit. These studies are expected to recommend lower harvest levels in favor of changing environmental policies of the same magnitude as the spotted owl related reductions in the US Pacific Northwest region.

We have utilized the CINTRAFOR Global Trade Model (CGTM) to analyze the global impacts of these supply reductions. The CGTM is a global forest sector model developed over the last decade at the International Institute for Applied Systems Analysis in Austria and the University of Washington. This model has been used most recently to understand the impacts of constraining tropical timber production in Asia in studies commissioned by the World Bank and the London Environmental Economics Center for ITTO.

This report analyzes the supply impacts on prices, who pays, who benefits, and what may be the broader environmental implications of new supplies replacing previous supply

patterns through changes in international trade flows. The study also examines the implications of greater exports from Russia, the only country with a substantial inventory of mature softwoods.

Major conclusions from the analysis are:

- The cumulative impact of a 33 million cubic meter supply reduction--while only 4.5 percent of the global supply--is significant. It produces observable responses from other regions to offset the decline in harvests, including a 16 percent redirection of trade flows.

- The reduced timber production in the constrained region is redistributed among major competitors around the globe. Major gains are made by higher-cost forest producers as log prices allow marginal producers to expand their production.

- Reduced product supply is substantial, leading to a 30 percent reduction in product demand by 1995 as a result of higher prices. While this analysis does not directly address the impacts of this demand reduction on non-wood product consumption, one can expect a greater use of energy-intensive non-wood substitutes to replace the loss in wood product demand.

- Over the short term, higher-cost producers harvest more area to offset the timber supply reduction. Anywhere from 1.12 to 1.61 hectares are harvested for every one hectare preserved. The range depends on estimates of timber stocking levels on the replacement hectares. The harvested area ratio increases to a range of 1.59 to 1.91 if Siberia were to expand its timber harvest levels.

- Over the longer term, these impacts are exacerbated as higher productive forest lands in the Pacific Northwest and British Columbia are replaced by less fertile forest lands. The annual loss in forest land productivity is estimated between 17 and 44 percent, depending on stock level assumptions and the response from Siberia. These annual productivity losses are cumulative and will add to the ratio of harvested to preserved area as high-volume, old growth stocks are replaced by lower-volume, second growth timber with longer rotations. In addition, these high-cost producers are likely to have limitations in their processing infrastructure, leading to additional waste both in the mill operation and at the forest harvest level.

- Consumers are the major losers. They pay $2.5 billion dollars as a result of the timber supply reduction. Mill operators also lose. Gains by southern mills are only 20 percent of the losses to mill operators in the west. Timber producers gain $1.4 billion dollars. These impacts are reduced substantially if Siberia expands its timber harvest levels.

Concerns over wetlands, other species preservation, federal below-cost timber sales, and sustainable harvest levels in other regions will add further strains on global wood supplies and cause a greater shift in regional timber production as other areas will respond to offset any timber supply reduction. Additional supply constraints will magnify the impacts with more wood demand shifting to non-wood substitutes.

Environmental tradeoffs may be counterproductive through increased harvest acreage. While timberland is preserved in the US Pacific Northwest westside region and British Columbia, greater areas in other producing regions are harvested to offset only 60 percent of the timber production decline. The shift from high to low productive areas may well result in new environmental problems. Non-wood substitution will increase carbon dioxide emissions, for example.

While current short-term market conditions show US prices well above those implied in this analysis, economic theory and the CGTM would suggest these prices will come down as international markets adjust and international consumers absorb a portion of the cost. However, there are many reservations as to the desirability of increasing harvests in other regions, which may result in institutional constraints around the world. The process of globalization of timber shortages may become more difficult to address than is evident from historical experience.

GLOBAL FORESTRY IMPACTS OF REDUCING SOFTWOOD SUPPLIES FROM NORTH AMERICA

Introduction

Recently, timber supply in the US has decreased dramatically, primarily due to environmental regulations. The most affected area has been the US Pacific Northwest region where the northern spotted owl and other endangered or threatened species have provoked the withdrawal of millions of hectares of public timberlands from harvest consideration. Sales of federal timber from this region have declined by 44% during the period from 1990 to 1992 from an expected level of 36.6 million cubic meters when Forest Service plans were first drafted (Warren 1993). While many sales are currently locked up in the courts with the possibility that they may be allowed to proceed in the future, there are other areas being impacted as well, suggesting a substantial, permanent, undetermined contraction in the availability of timber from public lands, both federal and state, in this region. The result of this contraction of the regional timber supply has caused a sharp decline in log inventories held by mills within the region, with a subsequent increase in log cost, mill shutdowns, and the search for alternative sources of raw materials. The entire effect of the contraction in timber supply has yet to be realized as the search for alternative sources continues.

It is important to note that there are many players impacted by the reduction in timber harvest in the US West region besides domestic mill owners and timber producers. Logs produced on private lands in the Pacific Northwest westside region are sold in log markets around the broader Pacific Rim region. Logs harvested from private lands in this region, and, previous to 1992, logs harvested from Washington State lands, are shipped to Japan, Korea, Taiwan, and China, as well as filling the domestic needs of local mills. In 1990, log exports were 18.3 million cubic meters, approximately 16 percent of the total harvest from the US West region (Warren 1993).

Recognizing these linkages between domestic and international markets is important in assessing the full impacts of regional policies and, in this instance, the impacts of a contraction in timber supply in the US West region. The shortage of logs to the domestic market caused by the withdrawal of public timber sales diverts a share of logs from international outlets to these domestic mills through its upward pressure on log prices in the region. Economic theory predicts a shift in log flows from the international to the domestic market to the extent that higher domestic log prices will narrow the gap between domestic and international log prices. The extent of this shift will depend on the domestic log price response relative to the international price response, the amount of domestic logs harvested, and any change in international specifications for import logs induced by a shortage of logs traded in international markets. There will be upward

pressure on international log prices as log inventories in importing countries decline due to the diversion in international log flows.

While timber produced in the US Pacific Northwest westside region is consumed around the Pacific Rim, so are other forest products from other major producers in this basin. Both the Pacific Northwest westside region and Canada export lumber to Pacific Rim consumers, as well as providing lumber to Canadian and other US regions. In contrast to the US, however, Canada does not allow any export of logs unless they can be shown to be surplus of their domestic needs. While constrained in the log market, Canada is linked to the Pacific Rim markets through lumber products. These connections link the North America and the Pacific Rim lumber and plywood markets. In a similar manner, the European markets are also linked to North American markets.

Other major softwood participants in the Pacific Rim markets include the emerging plantation regions of Chile and New Zealand. Extensive areas of radiata pine were established in these countries and are now becoming available for market. Both Chile and New Zealand have increased their harvest levels and have experienced an increase in log prices since 1985, evidence that log inventories are being depleted in the international markets. Chile and New Zealand have also expanded their share of log markets in the consuming countries of the Pacific Rim.

Traditionally, the far east region of Siberia has been an important participant in the large consuming markets of Japan, Korea and China. The proximity of these markets to Siberia's forests presents an opportunity to develop these wood resources as a substitute to replace the declining harvests in other regions. Lack of planning and political stability have constrained Siberia's participation in the Pacific Rim wood market recently. The future is, at best, uncertain with respect to the potential of the Siberian forests to provide wood products to the Pacific Rim countries. However, one can expect interest in the region's timber potential to grow as resource scarcity in the major consuming markets continues to exist.

The wood consuming markets of Japan, Korea, Taiwan and China are also experiencing a shortage in hardwood logs. Recent harvest constraints have reduced the supply of tropical hardwoods from Malaysia and Indonesia, the two principal producers in the region. Trade restrictions have reduced and prevented log exports from portions of these regions as well. Largely, the impacts from these restrictions have been to restructure the hardwood log markets by shifting plywood processing capacity to the log producing region (Perez-Garcia and Lippke 1992).

The restructuring by hardwood-producing and -consuming countries has implications for softwood producers, particularly log producers. The shortage of hardwood logs will reduce capacity utilization, particularly in plywood manufacturing in the log importing countries. The demand for softwood logs will increase to the extent that processing

capacity can be modified to accept softwood logs. The recent opening of Korea's first coniferous plywood mill provides some support to this hypothesis.

As one can see, the potential list of those impacted by a reduction in the timber harvest from the US Pacific Northwest sector is large and extends beyond the domestic market; the linkages provided by open markets transfers these impacts to other market participants. These linkages work through both the lumber and plywood markets as well as the log market in the Pacific Northwest region.

In addition to timber reductions in the US Pacific Northwest region, there are growing indications that similar reductions in allowable cut will take place in British Columbia. The reduction in British Columbia's allowable cut will further reduce global wood supply. Studies are currently underway for each of BC's forest planning units. A first such study for the Kalum North region of British Columbia reduces its allowable cut projections by 10 percent per decade over the next several decades (B. C. Ministry of Forests, 1993).

The integrated impact of these several global timber supply changes is the focus of this paper. An economic assessment is provided for a reduction in timber supply from the US Pacific Northwest public sector and British Columbia, while also considering the potential impacts from a reduction in hardwood timber harvests in Southeast Asian markets. While there exist other regions with potential supply restrictions of equal magnitude arising from changes in forest practices legislation, efforts to regulate wetlands use, conservation of other species, and the elimination of below-cost timber sales, the intention of the study is to demonstrate the likely effects of timber supply reduction in one region on other regions through trade linkages. The objective of this exercise is to characterize the likely response of alternative suppliers, including US regions other than the Pacific Northwest, as well as foreign countries, to a contraction in the global timber supply. It is shown that these impacts are significant.

The US markets are closely linked to global markets through log and lumber trade, and the responses of all supply regions are impacted by trade flows. Since these economic trade linkages alter production patterns across the globe, they also have environmental consequences. The economic results are extended to characterize several impacts on environmental measures.

The Concept of a Spatial Equilibrium

In economic terms, trade linkages between any two (or more) log and commodity (such as lumber and plywood) markets establishes an equilibrium where the amount of logs and commodities supplied by one market is equal to the amount of logs and commodities imported by the second market. In the Pacific Northwest there exist equilibria in *both* the log and commodity markets since trade linkages exist for both of these markets.

What Is an Equilibrium?

To illustrate the economic concept of a market equilibrium consider Figure 1. This figure illustrates a supply and demand curve for lumber in the upper portion, and a supply curve for timber in the lower portion. An equilibrium is defined as the point where the amount supplied is equal to the amount demanded; point **L1** in Figure 1. At equilibrium **P4 - L1** of lumber in log equivalent units is produced at **O - P4** prices. To produce **P4 - L1** of lumber, **PO - TO** of timber is required. The demand for timber then is **PO - TO**, which at equilibrium is supplied at **O - PO** price. Note that for convenience, without affecting our example, we have labeled our quantity axis in log equivalent units to be able to represent the amount of lumber and logs produced and consumed on the same graph.

What is a Global Equilibrium?

How does the market equilibrium portrayed in Figure 1 differ from a global equilibrium? Consider Figure 2. While this figure represents a more complicated process, several important points are illustrated. First, to simplify the problem of illustrating the spatial equilibrium without any loss of information, the figure illustrates the globe (defined here as two markets) where the demand and supply for lumber is drawn in the upper portion, and a timber supply curve is illustrated in the lower portion. Both regions produce both lumber and logs. Second, a global equilibrium point can be defined because the higher price in market B allows lumber to be imported from market A (**P6** is greater than **P4**). A higher log price in market B also allows logs to be imported from market A (**P3** is greater than **PO**), net of transfer costs. The amount of lumber that market A will export to market B will be equal to the amount of lumber demanded in excess of domestic production (**L2 - L3** is equal to **L6 - L4**) in equilibrium. This equilibrium is reached when excess supply from market A is equal to excess demand from market B (**P5 - L5**), illustrated by the intersection of the excess supply and demand curves (heavy lines) in Figure 2. This similar logic--the price differences between markets A and B--leads to an equilibrium in the log markets where the excess supply of logs in market A is equal to the excess demand in market B (**P2 - T4**). From Figure 2 we also note the following. First, prices are higher for the exporter (**P5 > P4**) and lower for the importer (**P5 < P6**) under the spatial equilibrium. Second, log production is higher for the exporting region by an amount **T6 - T8**. This higher production level is comprised of a higher demand to produce more lumber (**T5 - T8**) and export logs (**T6 - T5**). Lastly, the returns to timber producers are higher (log prices are higher) because of the log exports in market A (**P2** is greater than **P1**). A global equilibrium--commonly referred to as a spatial equilibrium--is the point where the amount supplied by several markets (considered the globe) is equal to the amount demanded by all consumers. This framework provides a convenient method to measure the impacts from a

Figure 1. Market equilibrium

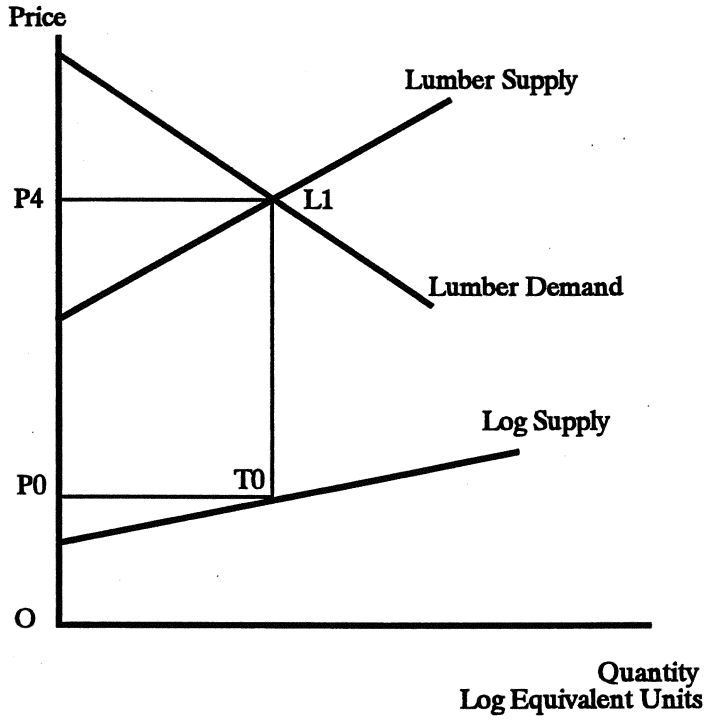
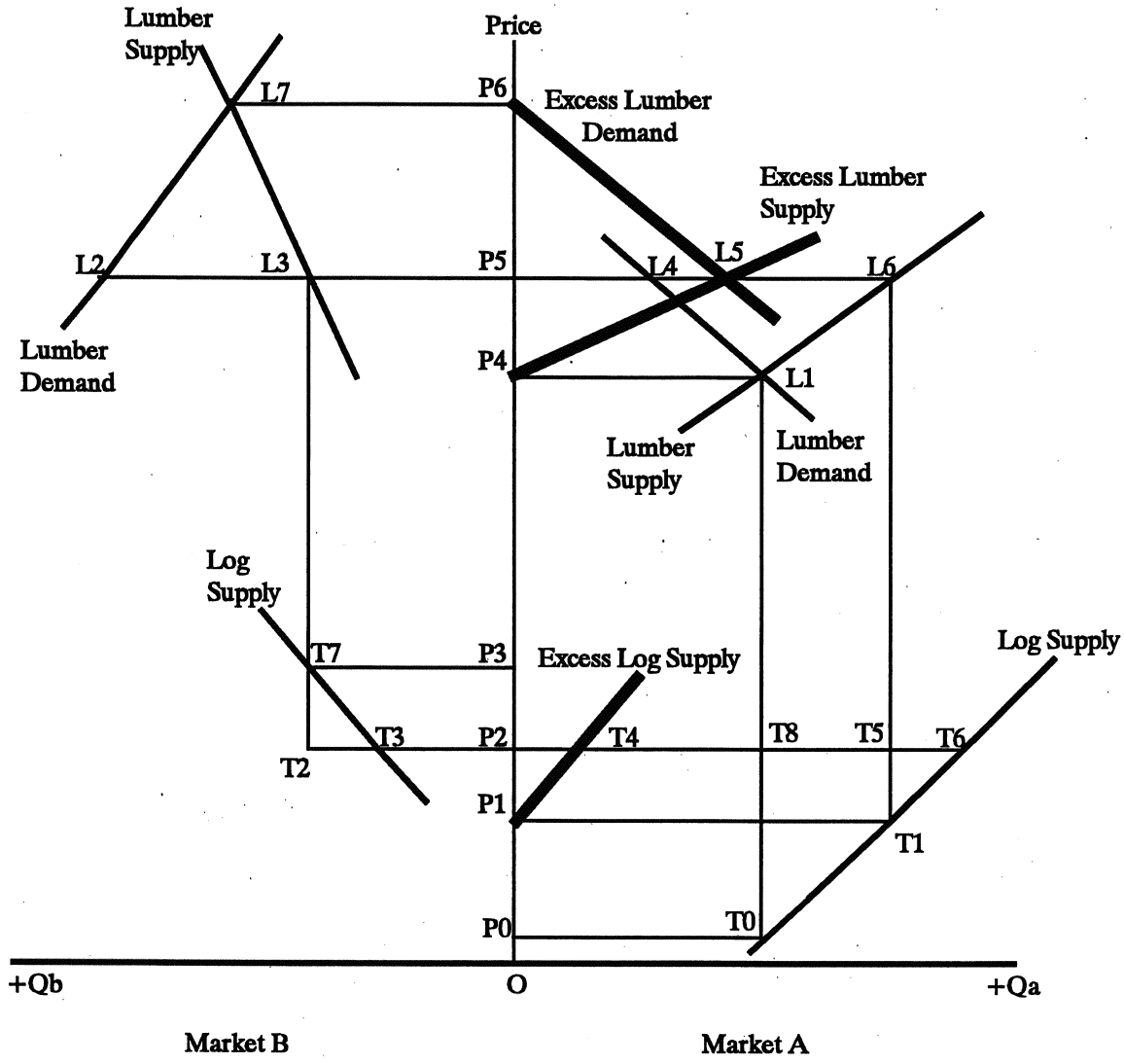


Figure 2. Spatial equilibrium



LOG MARKET
O-P1 = Domestic Price in Market A
O-P3 = Domestic Price in Market B
O-P2 = Equilibrium Log Price
P2-T6 = Domestic Log Production in Market A
P2-T3 = Domestic Log Production in Market B
P2-T5 = Log Demand in Market A
P2-T2 = Log Demand in Market B
T5-T6 = Excess Log Supply =
T2-T3 = Excess Log Demand =
P2-T4 = Quantity Logs Traded.

O-P0 = Closed Market Log Price
P0-T0 = Closed Market Log Production.

LUMBER MARKET
O-P4 = Domestic Price in Market A
O-P6 = Domestic Price in Market B
O-P5 = Equilibrium Lumber Price
P5-L6 = Domestic Lumber Production in Market A
P5-L3 = Domestic Lumber Production in Market B
P5-L4 = Lumber Demand in Market A
P5-L2 = Lumber Demand in Market B
L4-L6 = Excess Lumber Supply =
L3-L2 = Excess Lumber Demand =
P5-L5 = Quantity Lumber Traded.

P4- L1 = Closed Market Lumber Production.

contraction in timber supply (a shift in the timber supply curve) in forest products markets linked through trade of lumber and logs.

A Global Model of the Forest Sector

The CINTRAFOR Global Trade Model (CGTM) projects production, consumption, prices and trade of eight forest products in 43 timber supply regions which comprise the globe (see Cardellichio et al., 1988, 1989). Table 1 provides the timber supply regions included in the CGTM. The regional breakdown of the model is the most complete for a global forest sector model, with the majority of the detail in the Asia-Pacific-American region. There are 33 final product demand regions around the globe. A large number of these regions have estimated demand functions for sawnwood and plywood. Data used to estimate the structural equations of the model have recently been updated to 1990.

The CGTM is useful to illustrate the impacts of the policy decisions since it provides a rigorous tool based on economic theory to describe market behavior spatially and over time. An important advantage of using the CGTM model is that it provides future forecasts of market behavior considering timber resource and production capacity constraints: that is, timber must be available to produce forest products and cannot exceed the total global resources, and production must occur within the defined capacity. The need for future forecasts is evident, as policy impacts require time periods greater than a year to become fully realized.

Measuring the Impacts

Public harvest levels for the US Pacific Northwest and Interior regions in our BASE CASE are defined at the levels in Forest Service (R-6) and BLM (Oregon and California) plans. This base case reflects the pre-1990 timber situation and includes a modest reduction in harvesting due to spotted owl habitat areas.

Two alternative scenarios are defined. Our first alternative scenario--PRESERVATION ALTERNATIVE CASE--includes the reduction of approximately 20 million cubic meters (4 billion board feet) in Allowable Sales Quantities (ASQ) in the US West; the reduction in approximately 20 million cubic meters (4 billion board feet) in Western Canada; and an increase of approximately one percent per year in softwood plywood consumption in Japan resulting from a reduction in tropical timber harvests under a sustainable harvest limit of 4 million cubic meters for West Malaysia and 12.5 million cubic meters for East Malaysia. The one percent per year increase in softwood plywood consumption implies that this market will capture approximately 50 percent of the current hardwood plywood market in Japan by 2015, an increase in softwood log consumption of 7.4 million cubic meters. A second alternative scenario--SiberiaN RESPONSE ALTERNATIVE CASE--examines the sensitivity of our results to a potential increase in log exports from Siberia.

The Timber Supply Shortage in North America Impacts the Global Forest Sector

The timber supply shortage is characterized by a shift inward of the timber supply curve in Figure 2. The impact of this inward shift is to increase the log costs to mills and importers through an increase in log prices in these regions. Other regions are then faced with a greater demand for timber, a movement along their timber supply curves as they partially offset the decline in the constrained regions. Higher prices induce greater harvest levels in the regions that face a higher demand for their timber. The effects of the contraction in timber supply and consequent price movements are discussed below.

All Regions Experience Higher Log Costs

Globally, the net effect is for higher log prices to occur prompting higher-cost producers to expand their production levels. Since these prices are the result of a shift in timber supply, they will result in permanent upward shifts in log prices. These price escalations further augment the projected growth of log costs in the BASE CASE, which includes a modest reduction in planned timber sales. Under the BASE CASE scenario, prices increase by 20 percent for the Pacific Northwest regions, 60 percent for the US South, 90 percent for Interior British Columbia and 20 percent for Chile by 2030. Prices increase further under the Preservation ALTERNATIVE CASE. In both the Pacific Northwest regions prices grow an additional 30 percent; in the US South, 70 percent; in Interior British Columbia, 40 percent; and in Chile prices grow an additional 25 percent more than BASE CASE levels. Price projections for these important regions are presented in Figure 3.

The price simulations characterize new global market equilibrium levels and may differ substantially from short-term price fluctuations. In the short term, before global adjustments have been made, local price changes are expected to be much larger, since it takes longer for the global suppliers to respond. As the global supply response contributes to relieving local shortages, local prices should be expected to move towards the longer-term equilibrium conditions implied in the Preservation ALTERNATIVE CASE.

Producers Around the Globe Intensify Harvests As a Result of Higher Prices

The regions most closely linked to the affected timber markets through trade flows will expand their production levels until constrained by their available commercial timber volume. These regions are the next least-cost regions substituting for the timber supply shortage; that is, they have higher production costs than the supplying regions they replace. As a result, markets shares are redistributed around the globe at a higher cost to

Table 1. Timber supply regions in the CGTM

US:
- US West
  - US Pacific Northwest
    - **Westside***
      (Western Washington & Western Oregon)
    - **Eastside***
      (Eastern Washington &Eastern Oregon)
  - **Interior Region***
  - Alaska
  - California Redwood
- **US South**
- **US North**

CANADA:
- **B. C. Coast**
- **Interior B. C.**
- **Eastern Canada**

CENTRAL AMERICA

SOUTH AMERICA:
- Brazil
- Rest of North
- **Chile**
- Rest of South

EUROPE:
- **Finland**
- **Sweden**
- **Rest of Western Europe**
- Rest of Eastern Europe

ASIA:
- **Japan**
- **South Korea**
- **Indonesia**
  - **East Malaysia**
- **West Malaysia**
  - **Papua New Guinea**
- **Philippines**
- China
- Taiwan-Hong Kong
- Indochina
- India
- Middle East

USSR:
- Western USSR
  (Europe and West Siberia)
- Eastern USSR
  (East Siberia and Far East)

AFRICA:
- North
- East
- South
- West

OCEANIA:
- Australia
- **New Zealand**
  - Rest of Oceania

Bold type indicates endogenous regions; * indicates a separate public and private supply region has been specified.

processors and some level of future harvest is foregone as these regions augment present production levels.

By 1995, with the full effect of the log shortage in place, the global response is to substitute from other regions nearly 60 percent of the harvest reduction. Within the US West region, the private sector augments its harvest levels by 7 million cubic meters, one-fifth of the reduction in US Pacific Northwest public and Canadian harvests. An additional 5.2 million cubic meters is harvested in the US South and North combined, accounting for nearly 16 percent of the reduction. The total US response is to replace one third of the reduction in US and Canadian timber supply. This response compares to a 24 percent increase in harvest when only the US timber preservation impacts were evaluated (Perez-Garcia, 1991). A larger response is observed primarily as a result of the reduction in supply from Canada. There is no certainty that these private responses will actually occur as the private sector is also being impacted by new forest practices act regulations and endangered species conservation that may preclude this price response.

The European regions, Finland, Sweden and Western Europe, augment their harvest levels by 6.8 million cubic meters, making up 20 percent of the harvest reduction. The Canadian response is 4 percent, from Eastern Canada. Japan increases its harvest amount by 2 percent (0.7 million cubic meters). One-fifth of the reduction in timber supply from North America is offset by overseas wood suppliers. The total international response compares to 21 percent when only the US timber land preservation impacts are analyzed. Figure 4 illustrates the distribution of reduced harvest impacts among the major regions in the globe for 1995.

Nearly 38 percent of the reduced harvest is not captured by any region, a permanent reduction in timber output. Under the previous analysis of only US timber land withdrawals cited above, the demand loss was estimated to be 10-14 percent.

The majority of the reduction in timber demand--66 percent--is the result of Canada's closed log markets. That is, little wood substitution can occur in these log markets for the simulated reduction in British Columbian supply. Therefore, a contraction in timber supply in Canada translates directly to a reduction in lumber and plywood production.

Concerns over the Sustainability of Alternative Suppliers

A second impact on log markets is for the Pacific Northwest west region private suppliers to reduce future harvest as present harvests are substituted for future production (see Figure 5). Over time, Pacific Northwest West region private producers can not sustain the higher harvest levels induced by shortages and higher log prices and are forced to decrease harvests. By 2000, harvests in the private sector of the PNW Westside region decline to BASE CASE levels. By 2040, the harvest levels have declined 27 percent from the BASE CASE cut levels. The impact of more constraints from the Forest

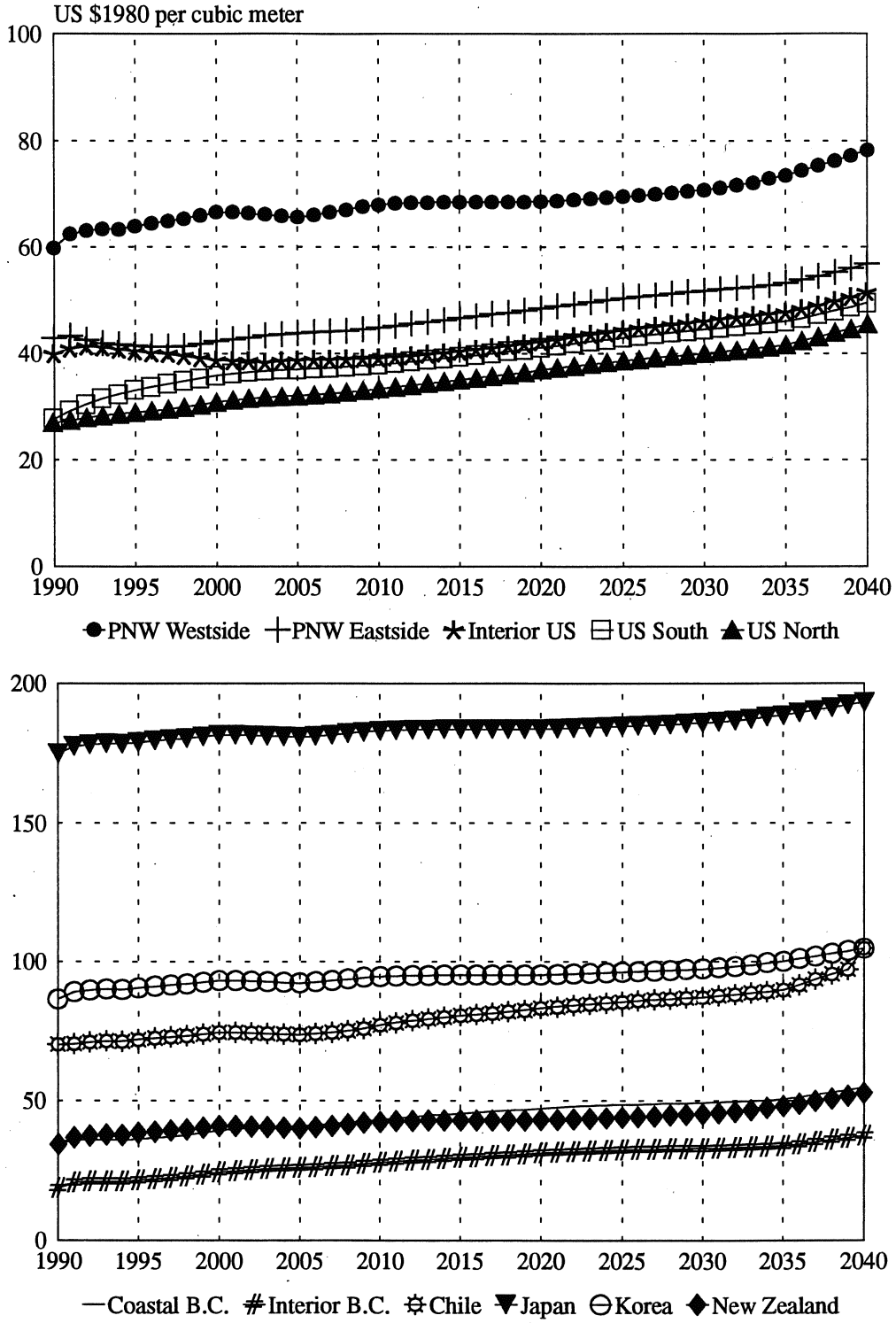


Figure 3a. Sawlog price projections for the BASE CASE

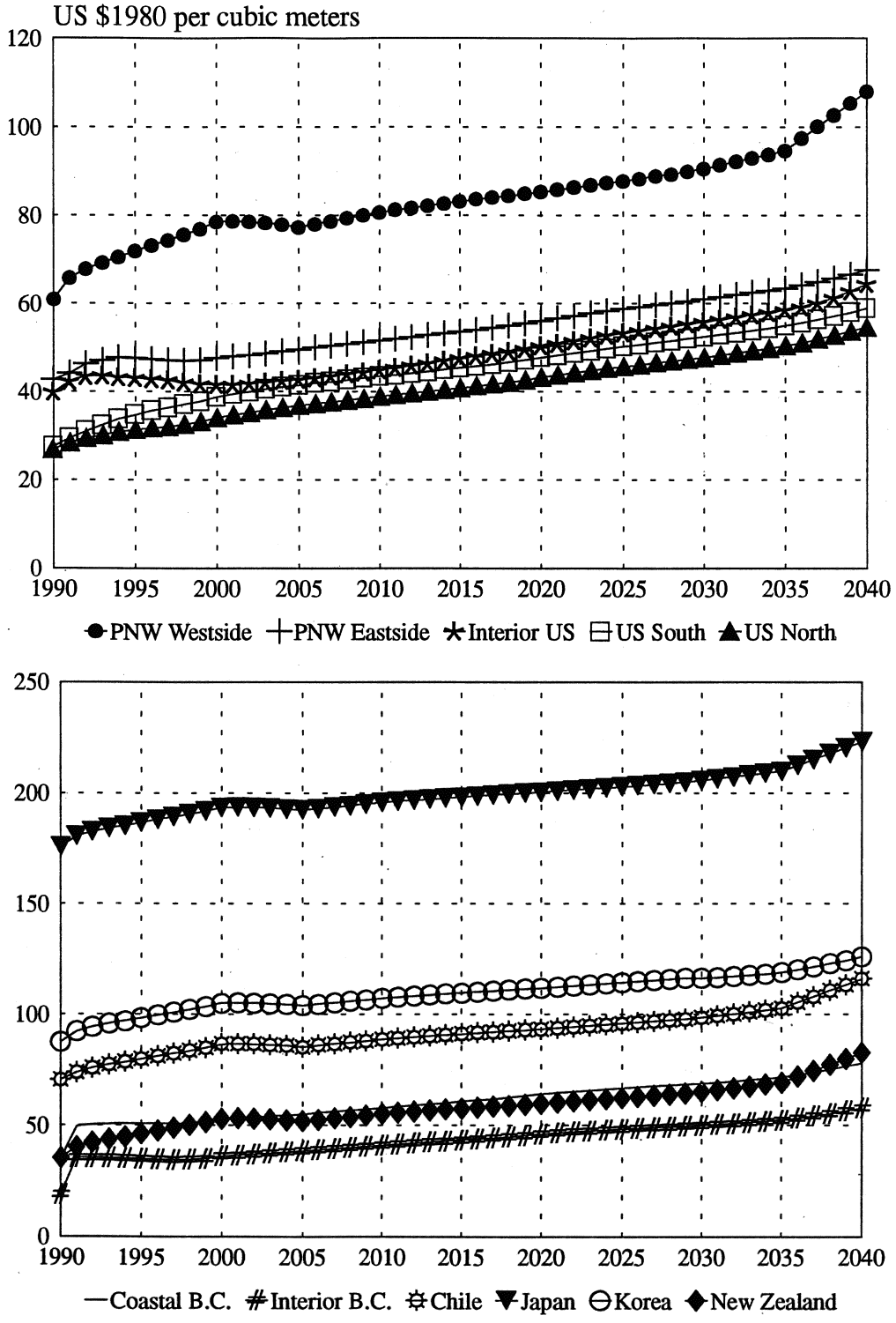


Figure 3b. Sawlog price projections for the PRESERVATION CASE

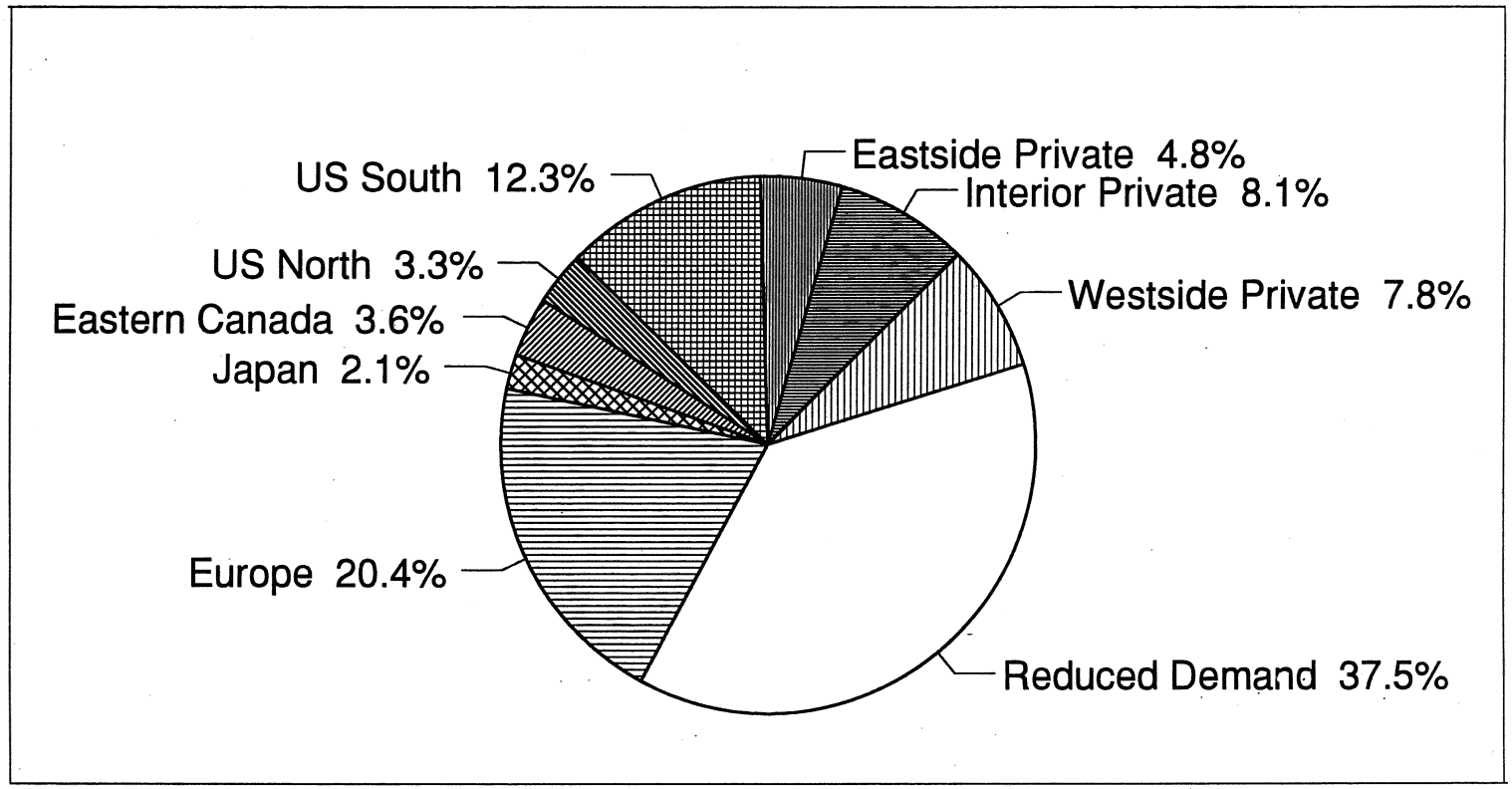


Figure 4. Global response to habitat preservation for 1995. Regional production increase to offset 33.3 million cubic meters in softwood production decline (as a percent of the decline)

Practices Act and preservation on owl conservation areas within private forests may preclude much of the private response shown prior to the year 2000.

A similar concern exists about expanding sustainable harvest levels in the US South. Harvests from the US South's forest land can increase only so long as these levels are sustainable. While data in the CGTM supports a large inventory of coniferous growing stock for the South, there is a growing concern that the South's ability to grow the timber to support an expansion in sustainable harvest is overestimated by our growth projections (Colberg 1992). Concerns over the impacts of wetlands preservation and new endangered species may further constrain the South's ability to respond.

Siberia Has the Potential to Offset a Large Share of the Decline in Harvests

The global response to timber preservation is sensitive to the levels of harvests and exports from Siberia. Regional responses to timber preservation policies change substantially with a 7.7 million cubic meter increase in Siberian harvest by 1995 as shown in the Siberian Response ALTERNATIVE CASE. The offset from US timber producers declines to 23 percent. International producers offset the decline in timber production by 50 percent, nearly half of this attributed to the increase in Siberian harvests. The loss in timber demand is reduced to 34 percent of the timber supply reduction under the Siberian Response ALTERNATIVE CASE. Figure 6 illustrates the shares of timber reduction offset associated with this higher Siberian production scenario.

Lumber Market Offsets, Efficiency Gains and Market Demand Decline

There is a decline in 10.8 million cubic meters in lumber production as a result of the reduction in timber supply. Nearly three-quarters of the decline is in British Columbia where no alternative log sources exist to offset their timber supply reduction. Chile also experiences a large reduction in its domestic production of lumber; fourteen percent of the decline in global production occurs in Chile as more logs enter the Asian log market. Eastside and Westside regions of the US West (Washington and Oregon States) together account for nearly 6 percent of the decline. The Asian markets likewise contribute roughly 6 percent of the decline.

Approximately 70 percent of the lumber production decline is compensated by increased lumber production in other regions (Figure 7). The US West Interior region contributes 5.5 percent, making the US West region--the Westside, Eastside and Interior sub-regions--on the whole maintain their BASE CASE level of lumber production. The elimination of below-cost timber sales on Forest Service land and other environmental pressures in the region may of course prevent this expansion response within the Western US Interior region.

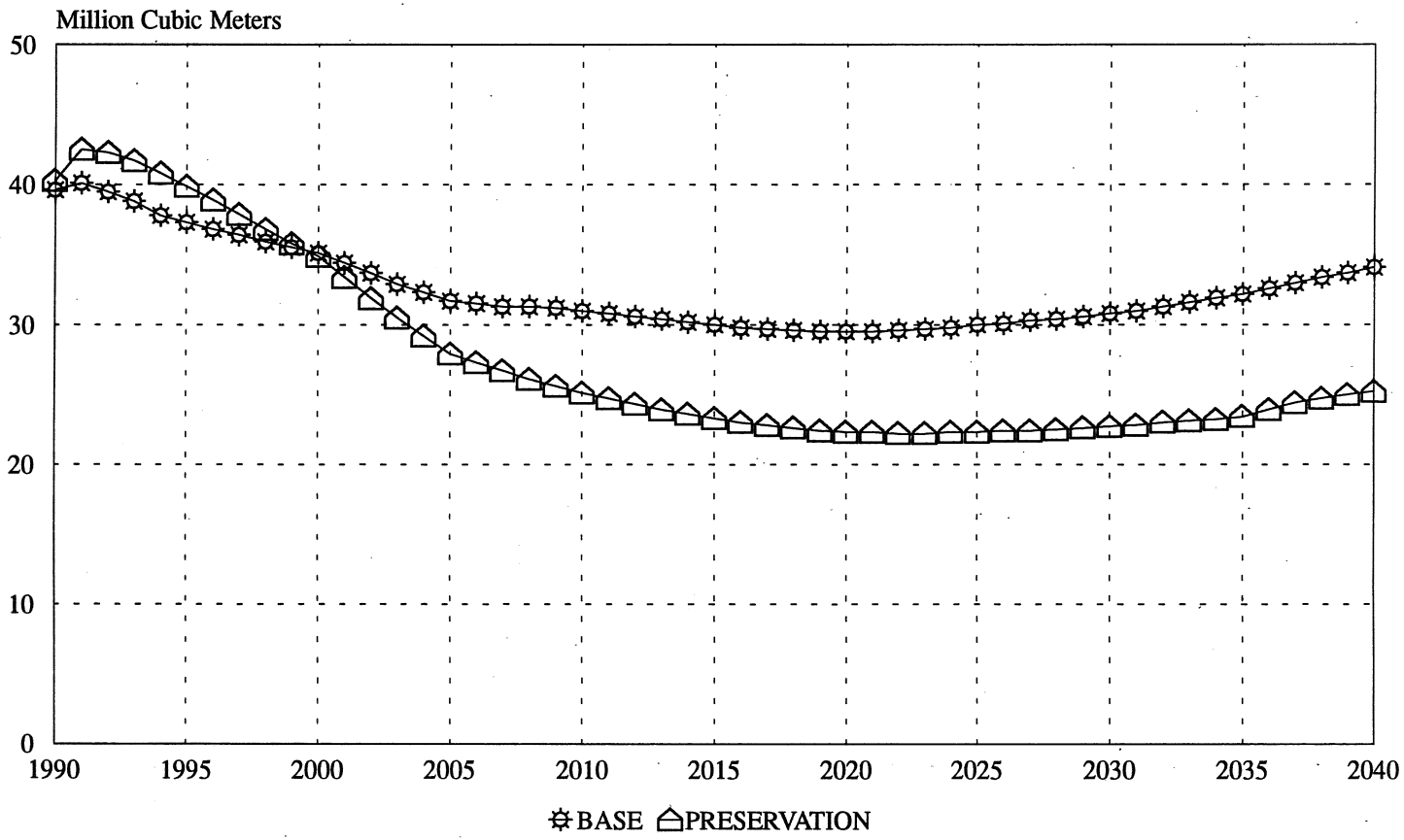


Figure 5. Timber harvest projections from PNW Westside private ownership.

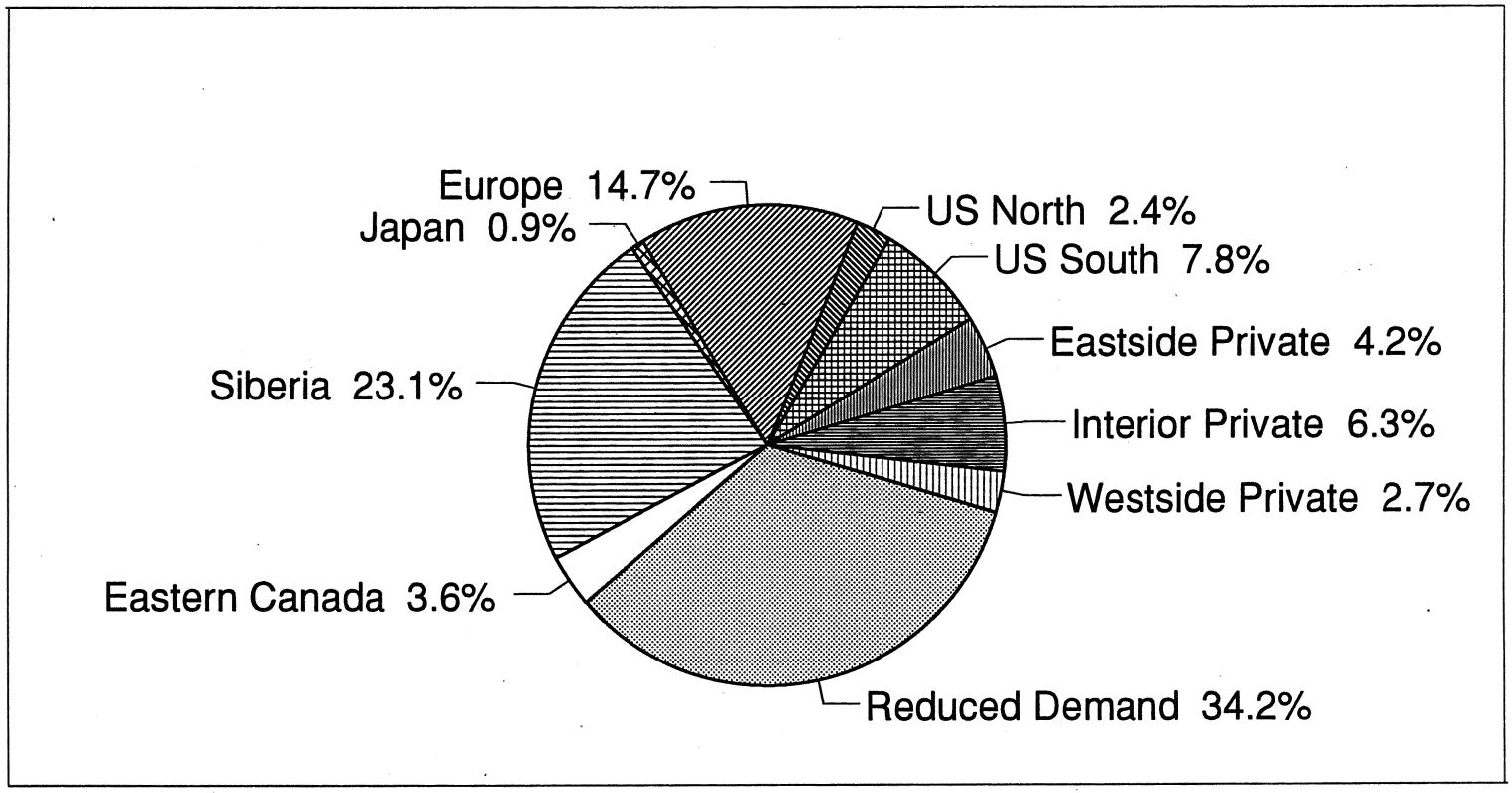


Figure 6. Global response to habitat preservation for 1995 with higher production from Siberia. Regional production increase to offset 33.3 million cubic meters in softwood production decline (as a percent of the decline)

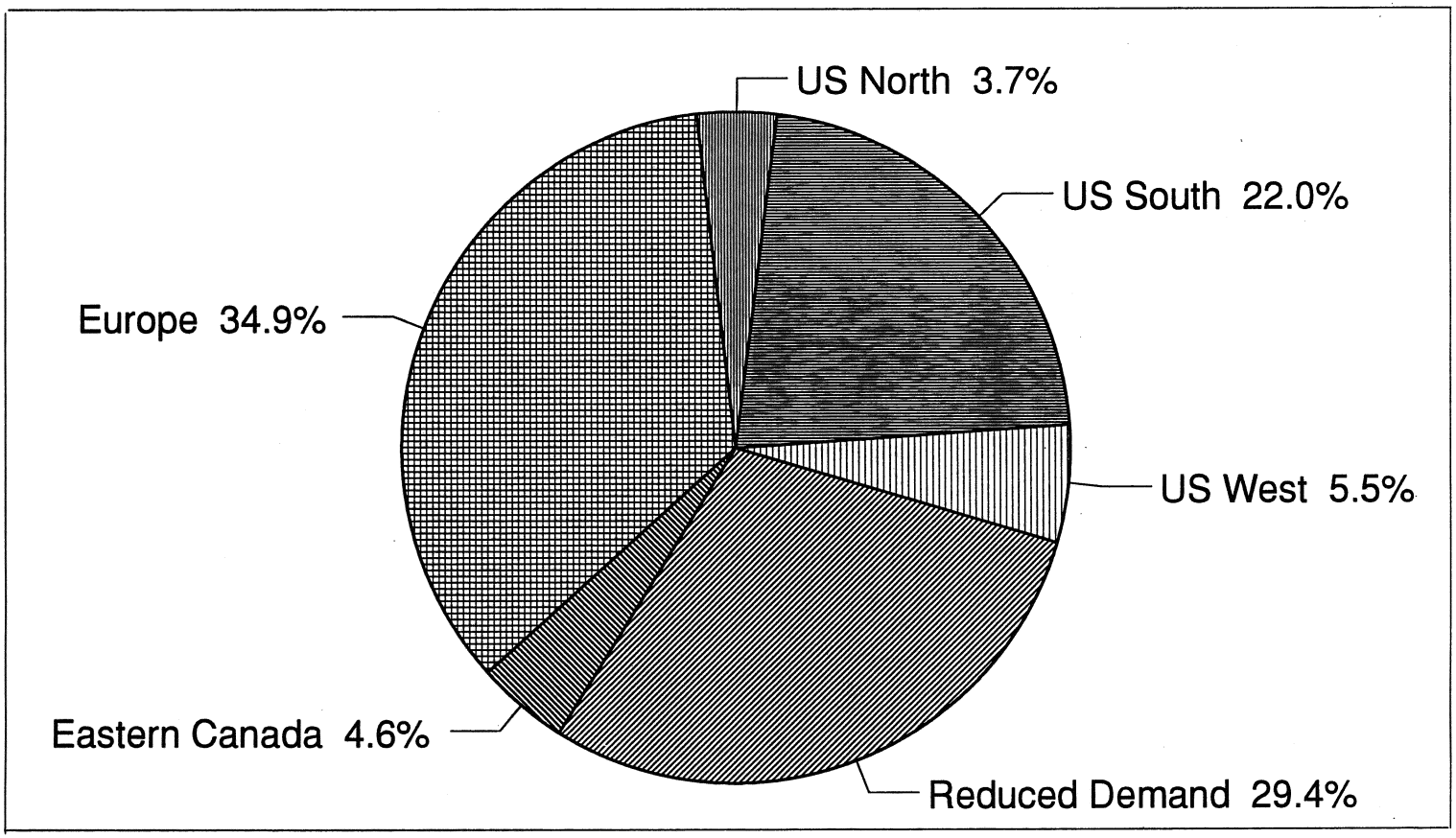


Figure 7. Regional distribution of lumber production increase to offset 10.8 million cubic meters of softwood decline in 1995.

The US South and North compensate for one quarter of the reduction. The European regions increase their lumber production by over one-third of the decline in lumber production. Thirty percent is lost by a decrease in lumber demand which may be compensated by the use of non-wood resources.

Why is the demand loss for lumber less than the demand loss for timber? Related to this question: How do the lumber manufacturers in the US West maintain their BASE level of production, while log producers offset harvest decline only by 21 percent? First, log harvest declines are offset by increased production from the private sector and a redirection of export logs to domestic mills. Mill operators are faced with a 13 million cubic meter reduction in log supply within their region. Of this, 7 million cubic meters are produced from the private sector to offset the reduction (21 percent of the US and Canadian reduction) and an additional 4.2 million is diverted from export markets. Second, while lumber production remains the same in the US West, log consumption drops by 1.8 million cubic meters. This drop in consumption reflects a gain in lumber manufacturing efficiency as more processing occurs in the US West Interior region which is more efficient in converting logs to lumber than the US West Eastside region. An overall gain in efficiency for the region is reflected in the decrease in log consumption, since the more efficient mill processors in the Westside region decrease their output only slightly as log export diversions benefit these processors. Using a similar argument, logs shipped from Chile to the Asian markets reflect a gain in manufacturing efficiency as the Asian mills utilize logs more efficiently in producing lumber than mills in Chile. The Asian markets' share of timber consumption reduction was 8.4 percent with only a 6.5 percent share of lumber production decline.

Two further points deserve mention. Even with the partial offset provided by an expanded private harvest and log export diversion, mill producers in the US West suffer net operating loses because of higher log costs. Higher-priced lumber only partially compensates the mill operator for increased log costs. Second, Asian markets remain competitive log purchasers. Log exports from the US West decline by 4.2 million cubic meters by 1995, but are still higher than 1990 levels. This strong demand for logs is driven primarily by the assumption that China's log demand will continue to increase until 2000. Strong economic growth in China is assumed to increase wood demand relative to a stable supply much as has already been occurred in Japan, Korea and Taiwan.

There is some loss in lumber production efficiency as the US South (less efficient) picks up more processing capacity to replace Canadian (more efficient) lumber market shares in the US North. This loss is more than compensated by increases in the efficiency in other regions, including European mills, as they expand production capacity. The overall effect, however, is for lumber demand to decrease by nearly 30 percent, with much of this drop likely to be substituted by non-wood products.

Lumber Production Will Expand in the US South and Europe If Higher Log Production Levels Are Sustainable

As a result of the shortage of timber in US West and Canadian domestic markets and the subsequent rise in log costs, the US South is able to increase its share of the US lumber market (Figure 8). The US South is a big winner, along with the European regions, only if it is able to increase its sustainable harvest levels. As Figure 8 illustrates, the US South is projected to increase lumber production by nearly 12 percent throughout most of the forecast period over the BASE CASE, reaching 60 percent over the 1990 levels by 2040. A recent analysis by Colberg (1992) draws attention to concerns that the inventory to sustain a higher level of log production in the South may not exist.

A similar concern can be expressed for the European regions, with the exception of Finland and Sweden which presently have excess timber supply. The European regions, however, are being faced with several environmental concerns that have affected the growing capacity of the forests (Nilsson et al., 1992). Therefore the substitutions implied by the model might be considered an upper bound for available wood, with possibly greater non-wood substitution taking place if these regions with projected expansions in lumber production capacity, are not able to increase their sustainable harvest levels.

Trade Diversions: Asian Markets Continue with a Strong Demand

The log export market in the Pacific Rim is also impacted because of the log trade linkage to the Pacific Northwest log market. Three of the four major log exporters, the US Pacific Northwest, Chile and New Zealand, are able to adjust log exports due to shifts in log costs. All exports in the PRESERVATION ALTERNATIVE CASE remain lower than the BASE CASE levels.

Growth in Chinese demand primarily drives the increase in log exports in both the BASE and Preservation ALTERNATIVE CASE as evidenced in Table 2. Supply constraints cause log exports to decline 5 percent by 1995; 8 percent by 2000 and 23 percent by 2040 as compared to the BASE CASE levels.

Figures 9 and 10 display regional flows and changes in log and lumber trade flow impacts by 1995. Figure 9 depicts the trade levels of logs and lumber under the BASE CASE. Exports are illustrated as positive numbers, while imports are denoted by negative numbers. The major log importers are the Asian markets of Japan, Korea and China. The major lumber importers are the US North and West Europe. The US West is the major log exporter while Canada and the Scandinavian countries are the major lumber exporters. Figure 10 illustrates how these trade flows are impacted through a reduction in timber supply from North America. This figure denotes differences from the BASE case. Positive numbers indicate either a reduction in imports or

Table 2. Log exports under the BASE and PRESERVATION CASES (million m^3)

	1990	1995	2000	2040
		BASE CASE		
US PNW	14.1	19.6	22.7	17.4
Chile	0.0	1.9	4.5	0.0
Siberia	5.3	3.0	3.0	0.0
New Zealand	1.6	6.7	9.3	12.4
TOTAL	**21.0**	**31.2**	**39.5**	**29.8**
		PRESERVATION CASE		
US PNW	13.5	15.2	17.5	10.0
Chile	0.0	4.6	6.8	0.2
Siberia	5.3	3.0	3.0	0.0
New Zealand	1.9	6.9	9.0	12.7
TOTAL	**20.7**	**29.7**	**36.3**	**22.9**

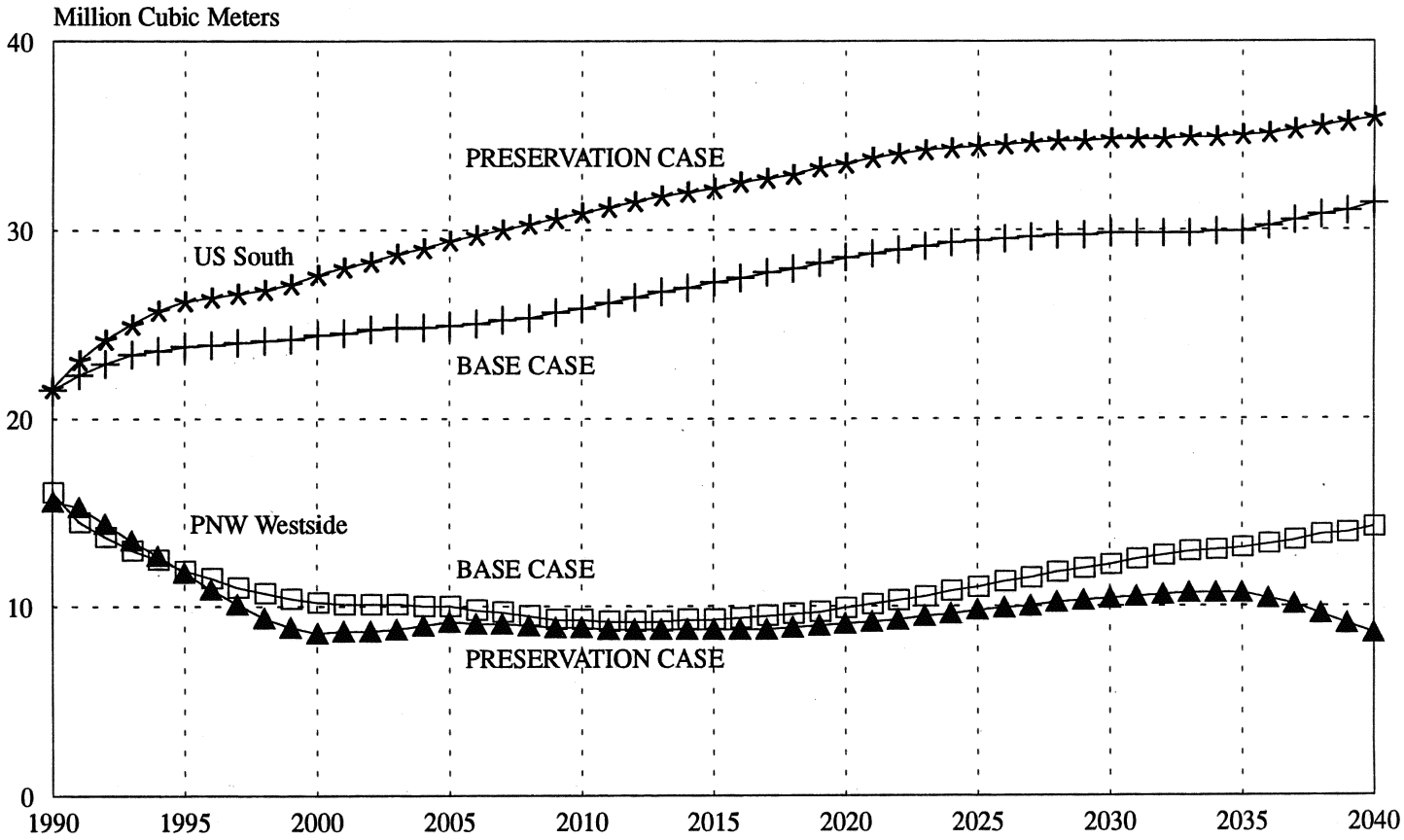


Figure 8. Lumber production projections in the US South and PNW Westside regions.

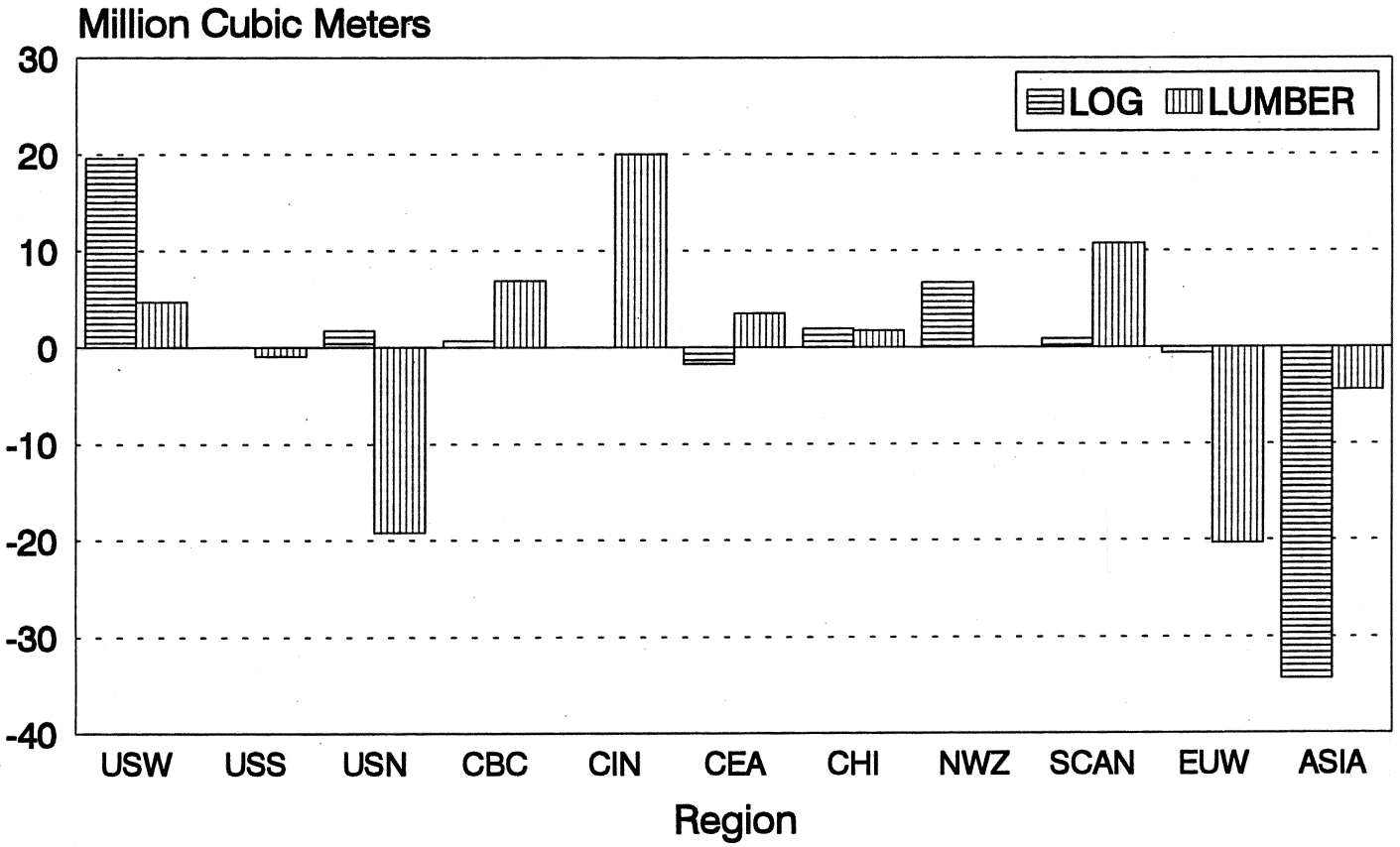


Figure 9. Log and lumber trade flows for 1995. Positive number indicates exports, negative numbers indicate imports.

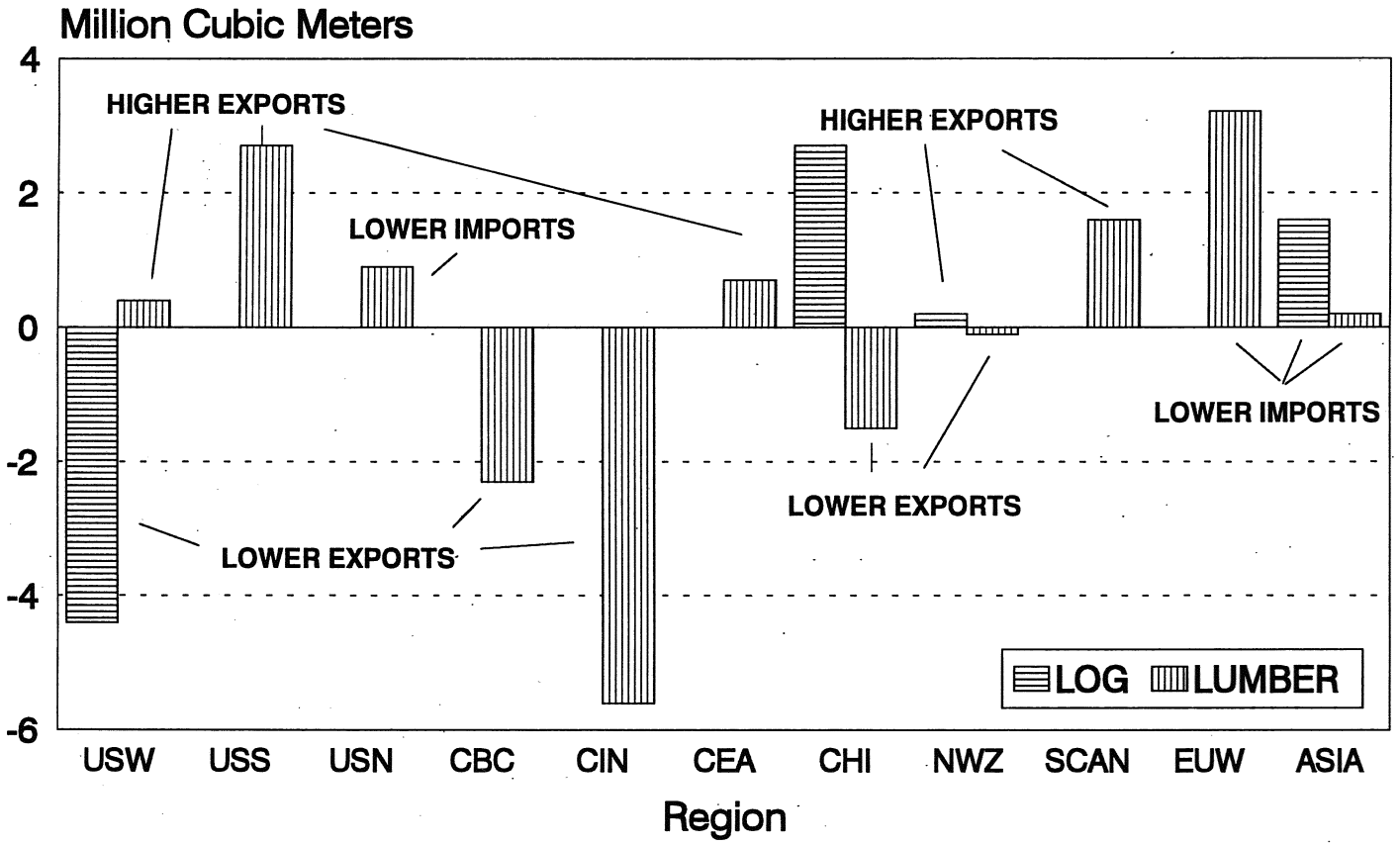


Figure 10. Changes in log and lumber trade flows (BASE - PRESERVATION CASE) for 1995. Positive numbers indicate higher exports or lower imports, negative numbers indicate lower exports or higher imports.

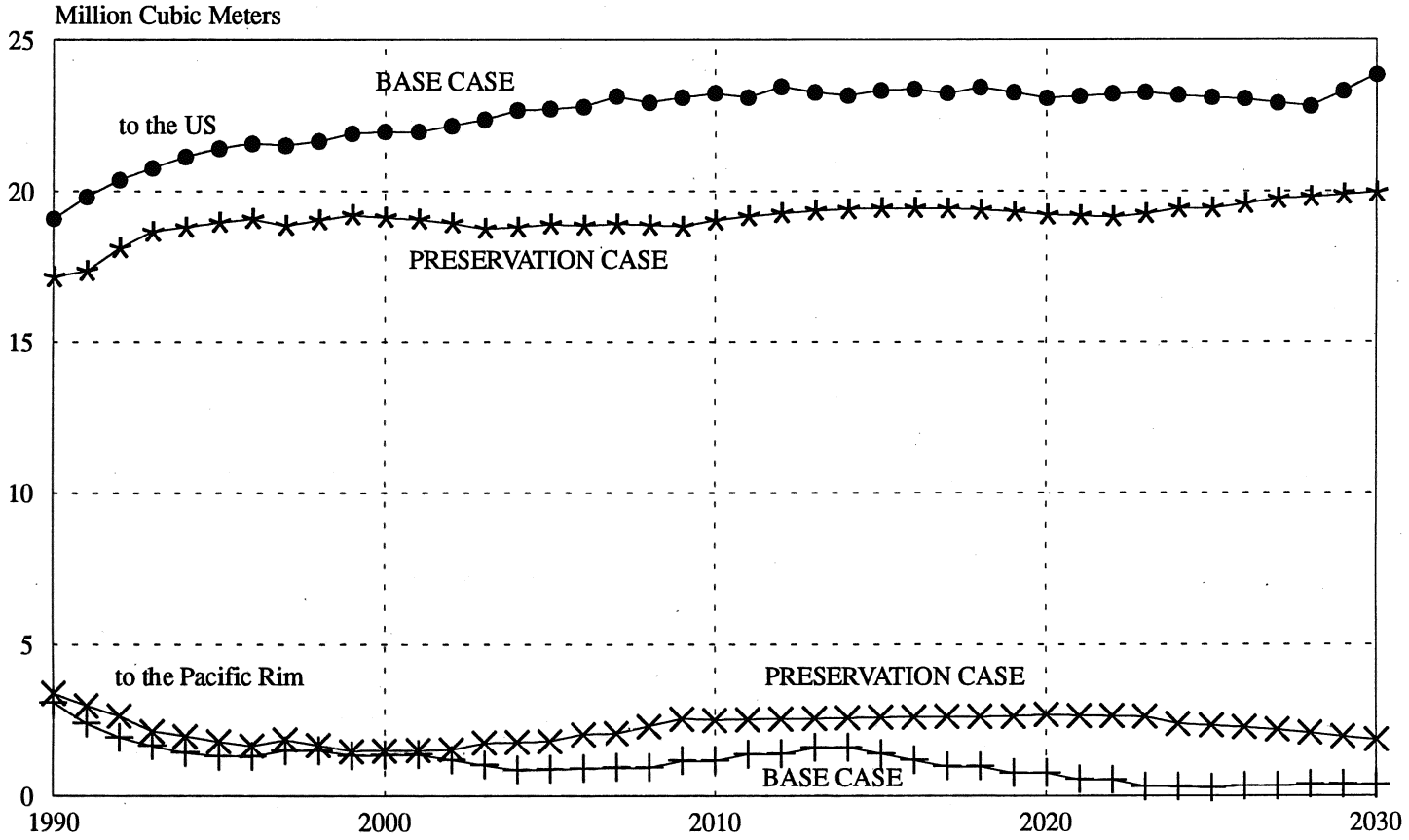


Figure 11. Canadian lumber exports to the US and Pacific Rim markets

greater exports: negative numbers indicate lower exports. As a result of timber preservation, the US West lowers log exports, while increasing slightly its level of lumber exports. Canada also lowers its lumber exports, while the US South increase lumber exports, mainly to the US North. The US North is still able to lower its lumber imports through an expansion in lumber manufacturing. Other points illustrated in the figure are: Chile reduces lumber exports in favor of log exports, Scandinavia increase its lumber exports, West Europe decrease its lumber imports, and Asia lowers imports of logs and lumber. The decline in lumber imports in Asia is a result of lower export levels from Canada.

Although its lumber exports are down, Canada's response is to provide a greater share to Pacific Rim markets over US markets. The projected shares of Canadian lumber exports to the US and Pacific Rim markets are depicted in Figure 11. Under the BASE CASE scenario, lumber exports from British Columbia to the US increase 15 percent, while exports to the Pacific Rim decline 47 percent. Comparing the ALTERNATIVE PRESERVATION CASE scenario with the BASE CASE, lumber exports to the US are down 15 percent by 1995, while exports to the Pacific Rim expand 40 percent. Overall there is a 16 percent change in trade flow relative to the original trade flow volume from an approximately 5 percent change in global supply.

Who Gains, Who Loses

We have already provided some evidence on winners and losers under timber preservation policies in the US West and British Columbia in our discussion of lumber milling efficiencies above. Table 3 presents a complete tabulation of the economic welfare changes by 1995 associated with a decline in timber harvests in all major markets. Among the log producers, the US, on total, loses welfare. Gains in the private sector in the US West, US South and US North from price and volume increases are not enough to compensate welfare losses sustained by the US public sector in the West. Mills also lose wealth in the US on average. Small wealth gains by the US South do not compensate the larger loses sustained by the mills in the US West. Lumber consumers in the US also pay more: $970 million.

The wealth losses to consumers in the US are due in part to the decrease in the Canadian supply. While mill producers in Canada also sustain net losses, higher gains to these processors due to higher lumber prices are paid mostly by US consumers, particularly the US North: US North consumers pay $306 million, while Canadian consumers pay $141 million compared to gains by mill producers of $49 and $510 million respectively. The decrease in the Canadian supply results in the substitution of higher-cost materials in the US markets. Globally, the net effects are for timber producers to gain $1,359 million, lumber mill operators to lose $880 million, and consumers to pay $2.5 billion annually.

Table 3. Welfare changes associated with timber supply reductions in billion dollars. Lumber mills purchase logs (as consumers) and sell lumber (as producers). The total loss is the sum of greater log consumption costs minus greater lumber prices.

Region	Log Producers	Lumber Mills			Lumber Consumers
		consumers	+ producers	= total	
US West	$0.718	-$0.632	$0.361	-$0.271	-$0.327
US West Public	-$1.150				
US South	$0.283	-$0.289	$0.343	$0.054	-$0.337
US North	$0.053	-$0.048	$0.049	$0.002	-$0.307
TOTAL US	-$0.096	-$0.969	$0.754	-$0.215	-$0.971
Canada	$0.318	-$1.209	$0.512	-$0.697	-$0.141
Asia	$0.257	-$0.601	$0.425	-$0.176	-$0.258
Europe	$0.584	-$0.601	$0.826	$0.225	-$0.631
Chile and New Zealand	$0.261	-$0.097	$0.081	-$0.016	-$0.468
ALL MAJOR MARKETS	$1.358	-$3.476	$2.598	-$0.879	-$2.469

These welfare changes are substantially impacted by Siberian expansion of harvest levels. Table 4 provides a tabulation of these results. US losses to consumers decline 32 percent. Globally, lumber consumers losses drop to 64 percent ($1.6 billion) compared to the PRESERVATION ALTERNATIVE CASE. The lumber impacts are less significant, with most of the decline in timber costs transfered directly to lower costs for consumers since the Siberian supply is in log form.

These wealth transfers are estimated after global supply patterns adjust. In the short term US prices can be observed far above prices projected by these scenarios. US consumer losses in mid-1993 are well above those shown here, but they should decline as global markets adjust and world consumers are impacted.

Greater Areas of Harvest Occur to Offset Timber Preservation

Table 5 presents a summary of estimated changes in harvest areas in response to greater timber production offseting timberland preservation. The information provided in Table 5 indicates how short-term harvest expansion is met by utilizing existing inventories and provide a lower bound on how longer-term land use changes might occur. Longer-term responses require that we consider changes in the timberland productivity.

The table presents estimated stocking levels for regions which are impacted by timber land preservation, changes in the harvests associated with each region, and the impact on harvested area. This information is summarized in the lower portion by considering the area saved through preservation, the increase in harvest areas in other regions to offset the timber supply reduction and the net effect on area harvested. Two ratios are presented. The first ratio indicates that for every hectare of timber land preserved, 1.12 hectares are harvested elsewhere. The second ratio defines the number of additional hectares required to compensate for the total timber supply reduction. In this case 1.8 hectares are required to replace every hectare preserved by the 33.3 million cubic meter reduction in timber harvest.

The estimated ratio of increased harvest area to area saved depends on the stocking level. The stocking levels presented in Table 5 reflect current levels on harvestable acreage. However, as more area is harvested in each region, the inventory stock per hectare declines. The ratio of increased harvest area to area saved expands to 1.6 when using estimated volumes of timber on marginal area to be harvested (not shown on Tables 5 and 6). Therefore a reasonable range of short-term impacts of timberland preservation is from 1.12 to 1.61 hectares harvested to area preserved.

The number of hectares required to offset the timber production decline is substantially greater when considering the impacts of an expanded harvest from Siberia (see Table 6). Nearly fifty thousand additional hectares are required to supply the timber harvest offset. That is, 1.6 hectares are harvested for every hectare preserved. This ratio increases to 2.5

Table 4. Welfare changes associated with timber supply reductions WITH HIGHER PRODUCTION FROM SIBERIA in billion dollars. Lumber mills purchase logs (as consumers) and sell lumber (as producers). The total loss is the sum of greater log consumption costs minus greater lumber prices.

Region	Log Producers	Lumber Mills			Lumber Consumers
		consumers	+ producers	= total	
US West	$0.417	-$0.430	$0.251	-$0.179	-$0.223
US West Public	-$1.185				
US South	$0.176	-$0.178	$0.231	$0.053	-$0.230
US North	$0.037	-$0.032	$0.033	$0.001	-$0.209
TOTAL US	-$0.556	-$0.641	$0.515	-$0.125	-$0.663
Canada	$0.183	-$1.076	$0.347	-$0.727	-$0.096
Asia	$0.138	-$0.333	$0.291	-$0.041	-$0.175
Europe	$0.423	-$0.431	$0.555	$0.125	-$0.429
Chile and New Zealand	$0.142	-$0.064	$0.043	-$0.020	-$0.227
ALL MAJOR MARKETS	$0.355	-$2.545	$1.755	-$0.790	-$1.590

Table 5. Implications of timber supply reductions on harvested areas.

	Stocking Level (m^3/ha)	Change in Harvest (million m^3)	Change in Area Harvested (hectares)
US West (Private)			
Westside	492	2.6	5,285
Eastside	296	1.6	5,405
Interior	237	2.7	11,392
US South	228	4.1	17,982
US North	200	1.1	5,500
US West (Public)			
Westside	530	-8.4	-15,849
Eastside	296	-3.3	-11,149
Interior	258	-1.3	-5,039
Coastal B.C.	424	-5.5	-12,972
Interior B.C.	370	-14.8	-40,000
Eastern Canada	200	1.2	6,000
Japan	107	0.7	6,542
Finland	183	2.3	12,568
Sweden	209	0.7	3,349
West Europe	176	3.8	21,591
AREA OF HABITAT PRESERVED:			85,008
AREA HARVESTED TO PARTIALLY OFFSET REDUCTION IN TIMBER SUPPLY:			95,615
RATIO OF AREA HARVESTED TO AREA PRESERVED:			1.12
TOTAL AREA REQUIRED TO COMPENSATE FOR THE FULL REDUCTION IN TIMBER SUPPLY:			153,077
RATIO OF AREA HARVESTED TO AREA PRESERVED: (for full compensation of timber reduction)			1.80

hectares to replace the full timber supply reduction or to 1.9 when marginal stocking levels are considered.

Timber Production Efficiency Losses

While Tables 5 and 6 make a point on how the short-term response to changes in timber supply may impact the distribution of timber growing stock, they do not reveal the much larger long-term impacts associated with changes in the use of different timber land productivity classes. As in the case of the changing efficiencies associated with milling lumber, there are also corresponding changes in timber production associated with productivity differences among the many responding regions. Over the longer term, the longer rotation of higher cost timber becomes more important and the area harvested will be in direct relation to land productivity.

Substitution by alternative, higher-cost wood suppliers will require more area harvested. If these areas contain old-growth, it will be depleted first then additional area will be harvested to maintain the cut level. The alternative of substituting harvests from low-productivity forests like Siberia or even northern Canada for preservation of higher-productivity forests has a second impact on harvest area over time. Each year for perhaps 150 years, a new area will be harvested in Siberia to produce substitute product probably with large waste inflating the area. In comparison, for highly productive lands such as Chile, New Zealand or even the US South, in 25 years the harvest would be repeated as a second generation harvest on the same land area. That is, the total area represented for harvests on low productivity land may be 6 times larger based on rotation length and perhaps twice as large or more on the basis of utilization efficiency.

Information on growth and yield of forest lands from various substitute regions is used in order to gain an understanding of annual impact of this shift in land productivity. There is an annual loss of 17 to 44 percent in timber productivity. That is, it requires from 17 to 44 percent more area to maintain timber productivity each year. The long-term effect is for 7.65 times as much land to be harvested over a 45 year rotation to maintain the productivity of the timber lands being withdrawn from production.

Non-wood Substitution

The substantial reduction in demand for timber will be largely replaced by non-wood substitution, although some of this reduction may result in conservation and lower usage. Every wood product has non-wood substitutes; recent studies suggest the substitution may be quite large as relative prices change (Moffett 1993). If the 38 percent reduced demand for timber or 12 million cubic meters is replaced by non-wood substitutes, an 18 million ton increase in carbon dioxide emis-sions might be expected through greater usage of fossil fuels associated with the production of non-wood substitutes (Koch 1992).

Table 6. Implications of timber supply reductions on harvested areas WITH A SIBERIAN RESPONSE.

	Stocking Level (m^3/ha)	Change in Harvest (million m^3)	Change in Area Harvested (hectares)
US West (Private)			
Westside	492	0.9	1,829
Eastside	296	1.4	4,730
Interior	237	2.1	8,861
US South	228	2.6	11,404
US North	200	0.8	4,000
US West (Public)			
Westside	530	-8.4	-15,849
Eastside	296	-3.3	-11,149
Interior	258	-1.3	-5,039
Coastal B.C.	424	-5.5	-12,972
Interior B.C.	370	-14.8	-40,000
Eastern Canada	200	1.2	6,000
Japan	107	0.3	2,804
Finland	183	1.7	9,290
Sweden	209	0.5	2,392
West Europe	176	2.7	15,341
SIBERIA	112	7.7	68,750
AREA OF HABITAT PRESERVED:			85,008
AREA HARVESTED TO PARTIALLY OFFSET REDUCTION IN TIMBER SUPPLY:			135,400
RATIO OF AREA HARVESTED TO AREA PRESERVED:			1.59
TOTAL AREA REQUIRED TO COMPENSATE FOR THE FULL REDUCTION IN TIMBER SUPPLY:			205,882
RATIO OF AREA HARVESTED TO AREA PRESERVED: (for full compensation of timber reduction)			2.42

Conclusion

The cumulative impact of a 33 million cubic meter supply reduction--while only 4.5 percent of the global supply--is significant. It produces observable responses from other regions to offset the decline in harvests including a 16 percent redirection of trade flows.

Reduced product supply is also substantial, leading to energy intensive non-wood substitutes. As the impacts of preservation grow, the share of supply offset by non-wood substitutes will also grow as prices increase.

Consumers are the major losers. They pay $2.5 billion as a result of the timber reduction. Mill operators also lose. Gains by southern mills are 20 percent of the losses to mill operators in the West. Timber producers gain $1.4 billion around the globe with slight losses in the US. These impacts are reduced substantially if Siberia expands its timber harvest levels.

Major gains are made by high-cost forest producers. These high-cost producers harvest more area to offset the timber supply reduction. For every one hectare preserved, 1.12 to 1.61 hec-tares are harvested. This ratio increases to 1.6 to 1.9 if Siberia expands its timber harvest levels.

The impacts of greater area harvested understate the longer-term consequences of substituting higher-cost timber producers. Rotation age and waste differences are substantially larger for these producers than the stocking volumes of old growth. Annual productivity declines range from 17 percent to 44 percent with the higher estimate associated with the use of low-productivity lands in Siberia.

Environmental tradeoffs may be counterproductive through increased harvest acreage and increased carbon dioxide emissions. While timber land is preserved in the US West and British Columbia, greater areas are harvested to offset only 60 percent of the timber production decline. The shift from high to low productive areas may well result in new environmental problems.

Additional supply constraints are expected beyond those characterized in the report and will magnify the impacts with more wood demand shifting to non-wood substitutes. Concerns over wetlands, other species preservation, federal below-cost timber sales, and sustainable harvests level in other regions will add further strains on global wood supplies and cause a greater shift in regional timber production to higher-cost producers.

While current short-term market conditions show US prices well above those implied in this analysis, economic theory and the CGTM would suggest these prices should come down as international markets adjust and international consumers absorb a portion of the cost. However, there are many concerns about the sustainability of harvests in other

regions which may result in institutional constraints. The process of globalization of timber shortages may become more difficult to address than evident from historical experience.

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