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The global wood market, prices and plantation investment: an examination drawing on the Australian experience

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Summary

A global wood shortage generating real inflation-adjusted price increases for wood has been a long and widely-held expectation. This paper assesses the validity of this view by examining global trends in wood and wood-products consumption, developing a model to explain movements in wood prices and testing it empirically. No evidence was found of increasing real prices for wood over the long-term, indicating that there is no looming global wood shortage. A global wood shortage is not predicted because technology is increasing resource productivity, enabling wood products to be made using less wood, and also increasing wood supply. It is superficial to interpret this to mean that there is little to worry about from a native forest biodiversity perspective. The analysis presented in this paper suggests that real prices for wood are likely to continue to fall. This will discourage commercially-driven investment in plantation establishment on existing agricultural land. But industrial pressure will continue for a wood resource that is attractive in cost and quality terms, increasing the risk of biodiversity loss through intensification of native forest management and clearing of native forests for plantations. It is prudent to consider approaches that encourage plantation investment on existing agriculture land using the price mechanism. Currently, much private sector plantation investment is based on price expectations derived from an incorrect view of an imminent global wood shortage. Withdrawing old-growth forests from commodity wood supply is likely to increase wood prices in line with widely-held, though apparently false, expectations and also deliver an absolute best ecological outcome. As increasing volumes of wood become available from maturing plantations, government policy changes will be required to ensure that levels of logging in native forests actually decline rather than new markets being found for native forest wood. Despite its strategic commercial importance, little is known about the potential of the existing global plantation estate to supply wood. Addressing this information gap is a timely task that would enhance industry policy and clarify future plantation investment requirements.

Keywords : wood prices, global wood deficit, wood consumption projections, plantations, forest conservation, old-growth forests

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Introduction

Some analysts forecast a global wood shortage (Simons Consulting Group 1994; Apsey & Reed 1994). They consider that population and per caput income growth will continue to drive up wood demand, particularly in developing regions, whilst wood supply is constrained by the catch-up effects of unsustainable logging and deforestation and increasing conservation demands. Forecasts of global wood shortages fuel expectations of increasing real (inflation adjusted) prices for wood. In contrast, other analysts cast doubt on the likelihood of a looming global deficit in wood, finding scant evidence of increasing real prices for wood in global markets (Sedjo & Lyon 1990; FAO 1997).

An expectation of increasing real prices for wood stimulates investment in plantations that compete against native forests as a source of wood. If these price expectations are unrealized because a global wood shortage has been incorrectly forecast, investment in plantations could collapse.

The aim of this study was to examine the evidence for a looming global wood shortage and to explore the implications of the findings for plantation investment and native forests. Trends in global consumption of wood and wood products are reviewed, specifically incorporating the effects of technological change embodied in new products and processes. Projecting consumption by extrapolating past trends, a widely-practised methodology, means that the effects of technological change on wood demand and supply cannot fully be captured. The study presents a theoretical model to explain long-term movements in wood prices that is tested empirically.

The following terminology will be used in this paper:

- Wood is the fibre under the bark of trees. In this paper, ‘wood’ refers to logs and particles of wood that are used to make industrial wood products, namely sawn timber, wood-based panels and paper. Wood used for fuel has been excluded from the analysis presented in this paper.
- Plantations are trees that are planted and managed in an agricultural context where wood production is the major objective. Other multi-purpose tree crops (for example

Table 1 Growth in global wood and wood products consumption in developed and developing countries. Source: FAO (1999*a*). Paper consumption data expressed in tonnes have been converted to m^3 assuming 1 m^3 of paper weighs on average 0.75 tonnes.

Product	*Volume (m^3) growth 1968 to 1998 (% per annum)*			*Developed countries' consumption share 1998 (%)*	*Total world consumption 1998 (million m^3)*	*Total world consumption 1998 (US$ billion)*
	Total world	*Developed countries*	*Developing countries*			
Paper	3.2	2.4	7.1	72	386.1	231
Sawn timber	0.3	−0.4	3.3	73	434.6	90
Wood-based panels	2.5	1.7	8.3	76	153.1	48
Wood for the above products	0.8	0.1	3.5	72	1539.9	145

rubber, oil palm, coconuts and fruit trees) also contribute to wood supply but wood production may not be their primary objective. This paper focuses on trees planted primarily for wood production.
- Native forests are forests in which the plant species are predominantly native to the locality in which the forest occurs and where natural regenerative processes operate either fully or in part for the recovery of canopy structure following natural or artificial disturbance.
- Growth rates over long periods have been calculated using ordinary least squares regression incorporating all annual data over the period as specified. This removes the distortions of compound growth rate calculations based only on end-point data.

Consumption of wood and wood products

Demand for wood is derived from the demand for paper, wood-based panels and sawn timber. These wood products compete against non-wood products in the market for packaging, communication, personal care, shelter and decoration (Sedjo & Lyon 1990; Lippke 1994; Clark 1995*a*).

This section describes trends in wood and wood products consumption and examines the technology-driven changing relationship between finished wood products and wood input. Consumption was calculated using Food and Agricultural Organization (FAO) data by deducting exports from production and adding imports. Changes in stock levels cannot be allowed for because stocks data were not available. FAO time-series data used in this paper incorporate preliminary data for 1998 (FAO 1999*a*).

Paper

Paper is made predominantly from wood pulp and recycled paper. Non-wood pulp, made from fibrous vegetable materials other than wood, accounted for 7% of fibre input for paper production in 1998 (FAO 1999*a*). Paper is the highest value and fastest growing sector of the global wood products industry (Table 1). The US$ value of paper, and other wood products consumed, was calculated by applying unit price import data for each product to the volume of product consumed.

Developed countries still consume the major share of world paper. This dominance is declining with developing countries accounting for more than half of the volume increase in global paper consumption during 1988–1998. A priority in developing countries for increased health standards is evident in the relatively high growth in consumption of wrapping and packaging papers and household and sanitary papers (Fig. 1). These papers are made predominantly from long-fibred softwoods to capture their strength properties and recycled paper to avoid the cost of wood pulping. Printing and writing paper is the slowest growing paper market in developing countries.

Wood requirements for global paper production are stagnating. This is because pulp made from wood is becoming less important in paper production. Wood pulp accounted for 81% of the fibre input for global paper production in 1968; 30 years later it accounted for 56%. Growth in global paper consumption is increasingly being met by recycled paper and

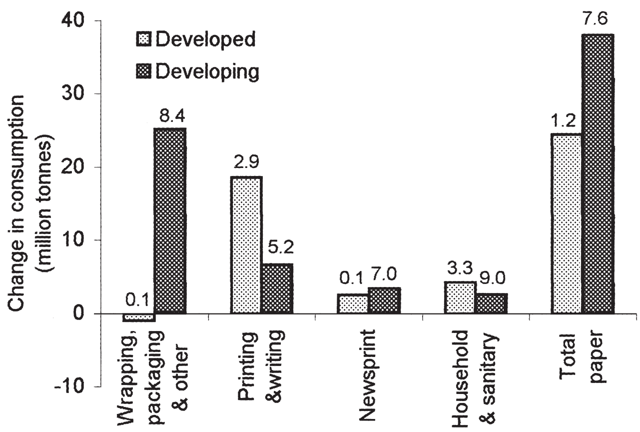

Figure 1 Absolute change in global paper consumption, 1988 to 1998. Numbers above the bars are % per annum growth rates over 1988 to 1998. Source: FAO (1999*a*).

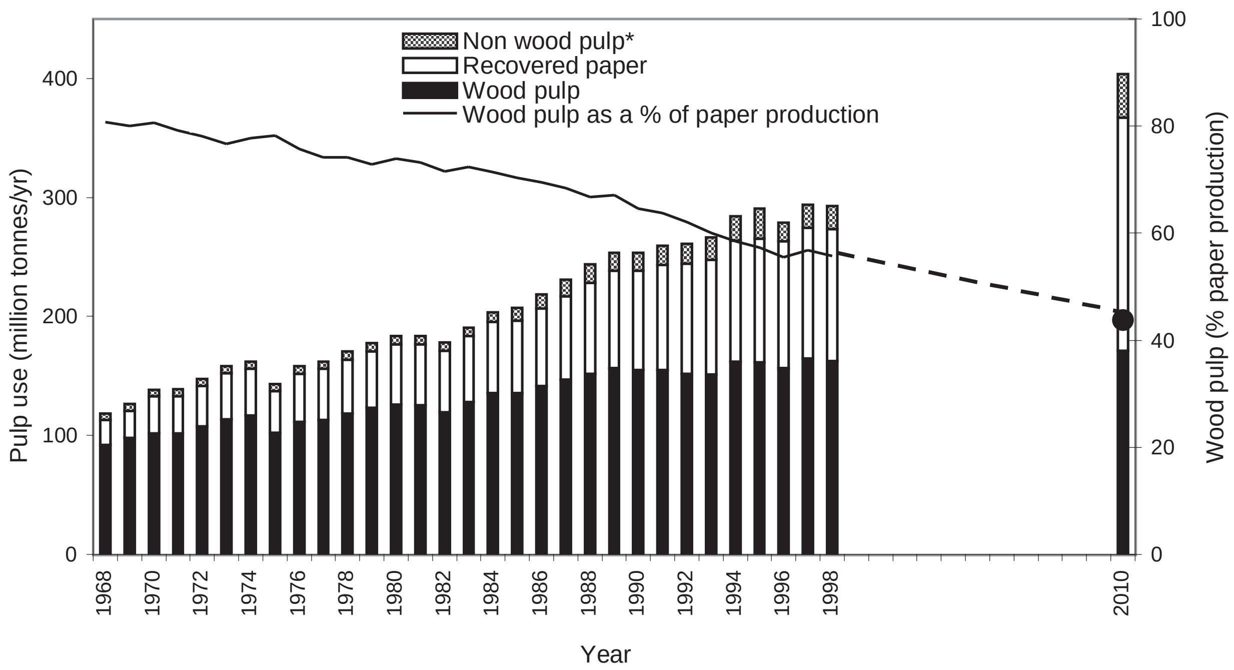

Figure 2 Use of wood pulp in global paper production. *An unstated proportion of non-wood pulp is used for fibreboard production. Sources: FAO (1999*a*); Zhu *et al.* (1998).

to a lesser extent non-wood pulp, instead of pulp made from wood (Fig. 2).

The uncoupling of paper from wood pulp has intensified during the 1990s. Global paper consumption increased by an average 2.9% per annum over 1990 to 1998, but the use of wood pulp to meet this paper consumption grew by only 0.8% per annum over the same period. The use of recycled paper grew by 3.7% per annum and non-wood pulp by 2.7% per annum over the same period. The FAO expects these trends to continue, with projected consumption of wood pulp growing by only 0.6% per annum over 1997 to 2010 and wood pulp declining to 44% of the material input for paper production by 2010 (Zhu *et al.* 1998).

New, relatively high yield pulping technologies further weaken the linkage between paper and wood. Sedjo and Lyon (1990) note the adoption of wood-saving technologies such as chemi-thermo-mechanical (CTM) pulping which almost doubles traditional chemical pulp yields per unit of wood input.

Tree selection and breeding associated with plantation programmes complement wood-saving pulping technologies. Macrae *et al.* (1999) report 20% reductions in wood input per unit of pulp output using selected species in plantation growing regimes.

In combination, the projected increased use of recycled paper and continuing investment in wood-saving pulping technology will significantly constrain growth in wood input for paper production. Wood input required for wood pulp used in global paper production is likely to grow at less than 0.6% per annum.

Sawn timber & wood-based panels

The solid wood products market has seen a flow of new products such as particleboard, medium density fibreboard (MDF) and more recently oriented strandboard (OSB). Much of this new product development has worked to displace existing wood products rather than expand the overall market for wood and wood products (Apsey 1986; Nelson & Kelly 1998; von Weizsacker *et al.* 1997).

The traditional sawn timber product has borne the brunt of this competition (Table 1). Wood-based panel production has been stimulated by the increasing scarcity of large logs relative to small logs, scale economy attractions of large processing complexes, and on-going new product development to increase their application and market range.

The displacement of sawn timber by wood-based panels such as particleboard and MDF saves wood. The FAO (1999*b*) notes that the wood recovery rates for such wood-based panels are typically higher than for sawn timber and plywood. Ellis (1995) presents wood recovery rates for particleboard approximately 15-35% higher than sawn timber and plywood. Less wood will be used per unit of finished product as the global market share of wood-based panels continues to increase from its current low base (Fig. 3).

This changing product mix appears not to have been fully factored into the FAO's latest consumption projections (Zhu *et al.* 1998) which show an abrupt decline in the market share of wood-based panels in 2000 (Fig. 3). It has been claimed that the FAO has persistently over-estimated sawn timber consumption relative to wood-based panels consumption

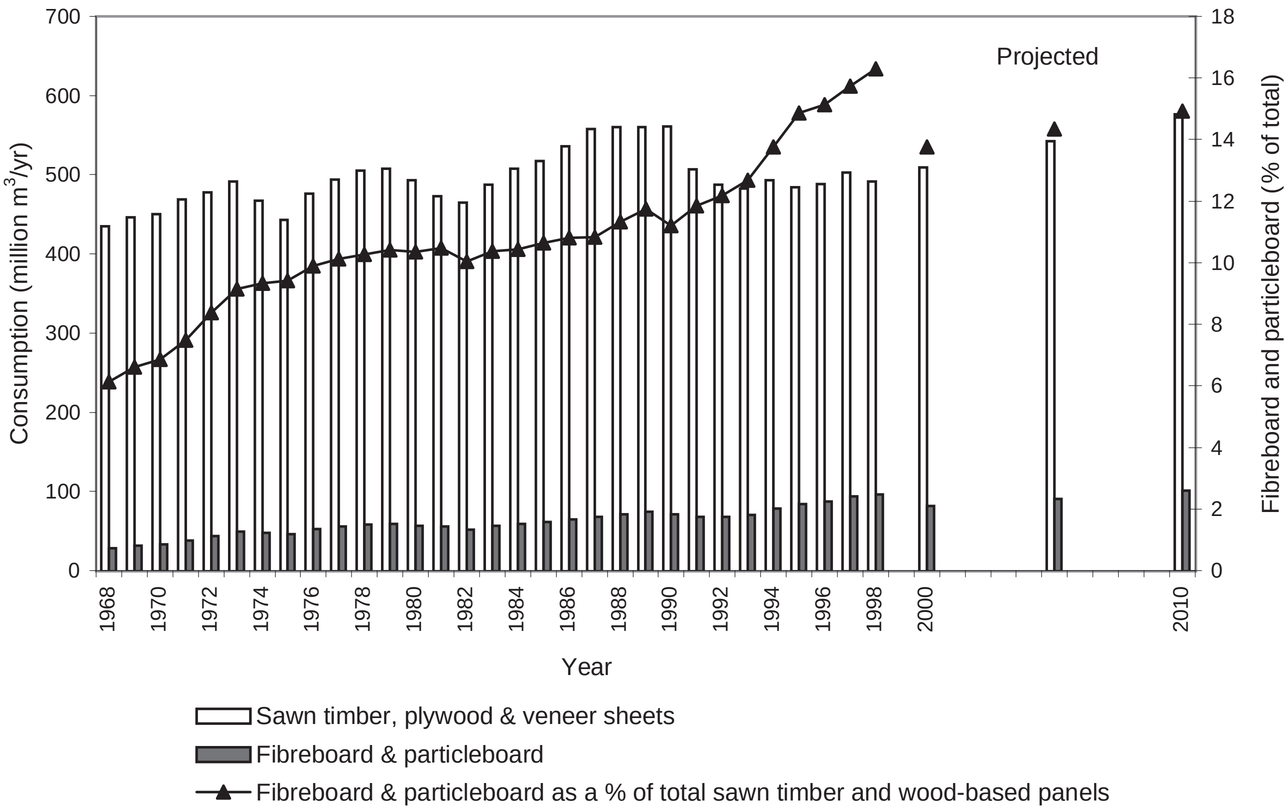

Figure 3 Global consumption of sawn timber and wood-based panels. Sources: FAO (1999*a*) for actual consumption from 1968 to 1998; Zhu *et al*. (1998) for projected consumption in 2000, 2005 and 2010.

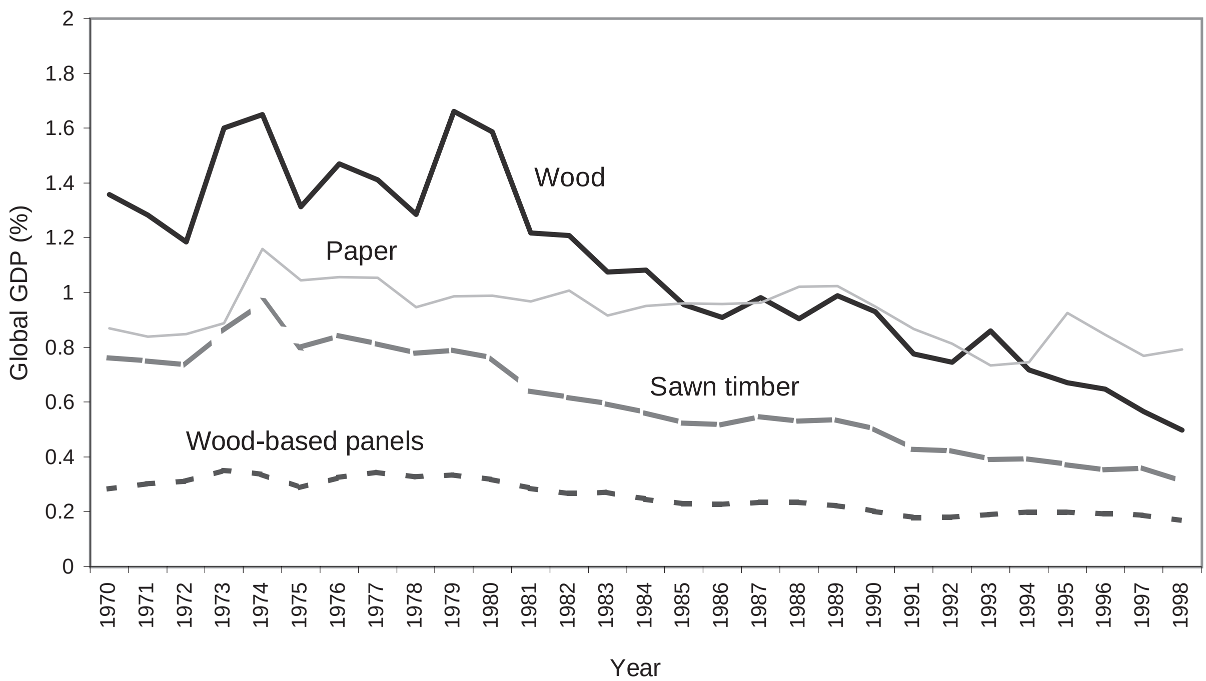

Figure 4 Contribution of wood and wood products to global GDP. Sources: FAO (1999*a*), International Monetary Fund (1999).

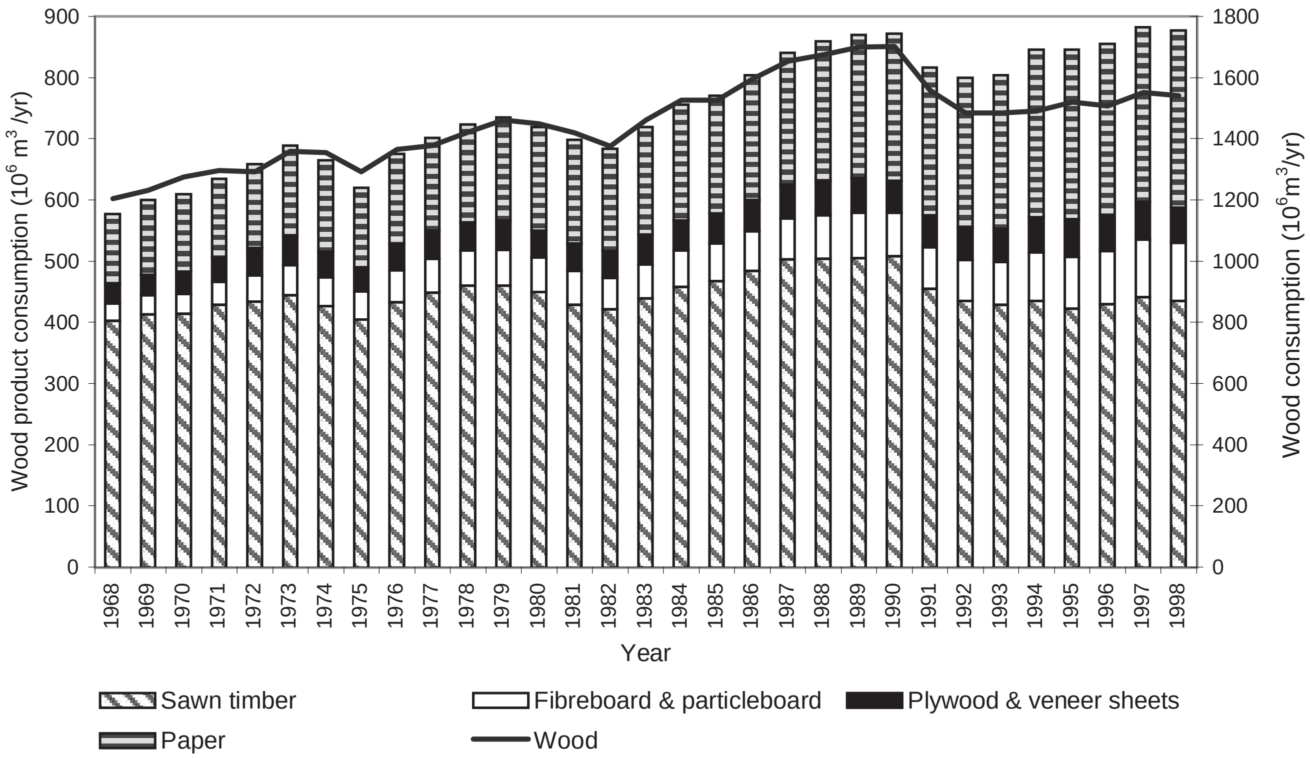

Figure 5 Consumption of global wood and wood products. Paper consumption data measured in tonnes have been converted to m^3 assuming 1 m^3 of paper weighs on average 0.75 tonnes. Source: FAO (1999*a*).

(A.J. Leslie, personal communication 1997). This apparently incorrect product mix will generate over-estimates of future global wood requirements.

Wood : used to make sawn timber, wood-based panels and paper

Global wood production is growing relatively slowly in US$ value and volume terms. We can estimate the growth in the US$ value of global wood production relative to total world economic activity (measured by gross domestic product, GDP) by applying the FAO's import price data to their wood production data and comparing this series with International Monetary Fund data on world GDP. This exercise shows that global wood production maintained a reasonably steady contribution to global GDP of an average 1.4% during the 1970s. Since then the US$ value of global wood production has grown at only one third the growth in global GDP. By 1998, wood production accounted for only 0.5% of world economic activity (Fig. 4).

Processed wood products have fared much better, with the exception of sawn timber. Sawn timber production accounted for 0.8% of global GDP in the 1970s. Since then its contribution has steadily declined and by 1998 it accounted for only 0.3% of global GDP. This contrasts with paper and wood-based panels that have experienced only moderate declines in their share of global economic activity (Fig. 4).

The declining economic significance of wood production is caused by falling wood prices relative to prices for all other goods and services (examined later in this paper) and low rates of growth in the physical amount of wood used. The volume of wood used globally for paper, sawn timber and wood-based panel production increased by only 0.8% per annum over the 30 years ending 1998 (Table 1).

The derived demand relationship between wood and finished wood products has been gradually separating. The separation has intensified during the 1990s (Fig. 5). Over the six years 1992–1998 the volume of finished wood products consumed globally increased by an average 1.8% per annum, but global wood consumption increased by less than half this rate, namely an average 0.8% per annum. Paper recycling, the dominant wood-saving action, has been complemented by other wood-saving product and process developments (Sedjo & Lyon 1990; FAO 1999*b*).

Projected wood consumption

The FAO dominates global wood consumption projection work, but the projections have been criticized for the significance of revisions (usually down) and the persistent over-estimation of sawn timber consumption (A.J. Leslie, personal communication 1997). The first FAO projections of global wood consumption in 2010, published in 1993 (FAO 1993), were revised down by 30% in 1999 (Fig. 6). In addition to being optimistic in early projections, the FAO has

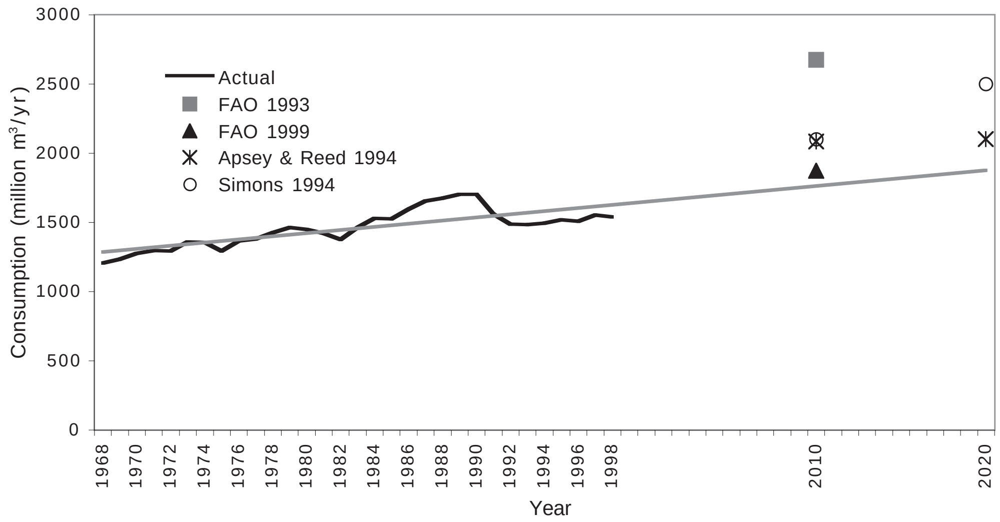

Figure 6 Actual and projected global wood consumption. Trend line is a continuation of the growth rate over 1968 to 1998 of an average 0.8% per annum. Sources: FAO (1993, 1999*a*, *b*); Apsey and Reed (1994); Simons Consulting Group (1994).

not realistically tracked wood-saving technology. The FAO recognizes the systematic errors in its methodology and has embarked on extensive re-modelling work (FAO 1997).

Dissatisfaction with FAO wood consumption projections has led to many analysts simply assuming a consumption growth rate. In Australia, the projections of global wood consumption prepared by Apsey and Reed (1994) and the Simons Consulting Group (1994) have been widely used in policy formulation (Cameron 1996; Centre for International Economics 1997; Ministerial Council on Forestry, Fisheries and Aquaculture *et al.* 1997). Both sets of projections appear to over-estimate consumption significantly. Simons Consulting Group (1994, p. ii) justify using a 1.4% per annum long-term growth in wood consumption based on an undocumented 'consensus of international experts polled by the consultant'. Apsey and Reed (1994, p. 4) justify using an average 1.5% per annum long-term growth in wood consumption because it is 'realistic on a world wide basis'. Their projections were revised down by 13% (Apsey & Reed 1998) due solely to commencing the assumed 1.5% per annum compound growth from a later year.

Continuing growth in global wood consumption requires high rates of economic growth in developing countries to offset stagnating wood consumption in developed countries and the effects of wood-saving technology.

Wood supply

Knowledge of global wood stocks and flows is seriously deficient. The years of debate and concern about forest resources have not generated a reliable global wood supply inventory. Recent calls for more reliable data and analysis of global wood sources has encouraged the FAO to undertake more extensive and ongoing work to develop an inventory of global wood supply. This work is proceeding (FAO 1999*b*) and is starting to fill some gaps in some regions, but it will be some time before a realistic global wood supply inventory is available and even longer for reliable projections of global wood supply to be made.

In the absence of reliable wood inventory data, industry analysts will continue to generate projections of wood supply to compare with the demand outlook. In these circumstances, it is impossible to generate precise long-term projections of global wood supply and demand. These projections provide a single point estimate of the difference between wood supply and demand (Apsey & Reed 1994; Simons Consulting Group 1994) that must be considered a notional deficit. However, projections of wood deficits create expectations of increasing real prices for wood.

Expectations of real price increases for wood are one of the most encouraging signals to invest in plantations. This is clearly observable in Australia, where government policy strongly supports a major increase in private sector plantation establishment (Tuckey 2000). Both the Australian government and the plantation wood growing industry are encouraged by projections of global wood deficits and expectations of increasing real prices for wood. An examination of private sector prospectuses to raise funds during the 1990s for plantation establishment in Australia shows that all have expectations of a global wood deficit. Most prospectuses examined assume future real prices for wood on the stump (prices before logging) that are significantly higher than current (native forest) wood prices after allowing for a quality differential (see for example Timbercorp Eucalypts Ltd 1999; Pacific Forest Corporation Ltd 1999). Part of the optimism may be attributed to an unrealistic expectation that the commercial benefits of public subsidies on native forest wood can be shifted from processors to private growers.

Expanding the global plantation estate could enable significant environmental and industry gains, but the risk exists of a collapse in plantation investment if price expectations, based on heroic projections of global wood deficits, are not realized over the next decade. A greater theoretical understanding of wood price trends is required to assist in evaluating this risk. The following section presents a theoretical model of movements in wood prices that is then tested using the empirical evidence.

Wood price trends : some theory

Long-term movements in wood prices are determined by the commodity nature of wood and technological change. Commodities are homogenous products that usually meet established product standards. Commodity producers therefore compete mainly on price which is the factor that distinguishes, for buyers, one company's product from others. Individual commodity producers are focused on selling their products at attractive prices to capture more sales. This means that there is constant downward pressure on prices. To maintain profit levels, commodity producers adopt a complementary on-going strategy of cost reduction. Technological change is the means by which this is achieved over the long term.

The price effect of technological change in commodity markets can be examined using the traditional supply and demand price model (Fig. 7). The model has been simplified to focus on capturing the relationship between the consumption of wood and wood products, wood supply and technological change. Linear supply and demand schedules are presented and the effect of competition from non-wood products has not been incorporated. Competition from non-wood products works to constrain wood price increases (Lippke 1994). Classification of the effect of technological change on wood demand and supply was based on Sedjo and Lyon (1990).

D_{wp1} is the demand schedule for wood products in time period one, and it shows the relationship between the price

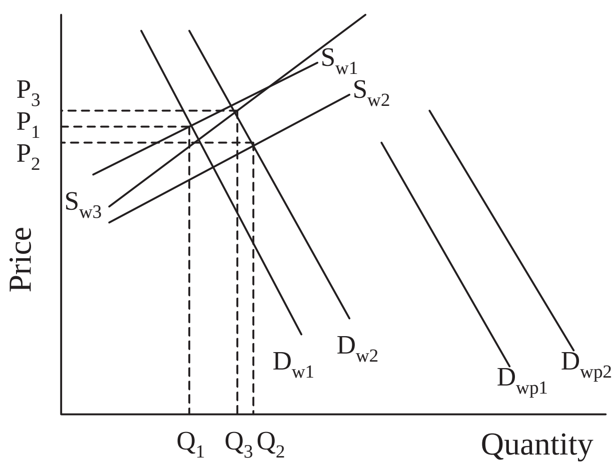

Figure 7 Wood price model. (See text for a description of the variables.)

for wood products and the quantity demanded and how sensitive demand is to changes in price (Fig. 7). D_{w1} is the corresponding derived demand schedule for wood. S_{w1} is the supply schedule for wood in time period one. The interaction of supply and demand generates a wood price at P_1 with Q_1 of wood consumed in time period one.

An increase in income will shift the demand for wood products to D_{wp2}, but the derived demand effect on wood is moderated by on-going wood-saving technology (for example higher yielding pulp technology, recycling, increased market share of wood-based panels). The demand schedule for wood shifts out to D_{w2}; this is a smaller shift than that of the demand schedule for wood products (Fig. 7).

Wood-extending technology works to shift out to the right the wood supply curve. Such technology, again stimulated by cost-conscious commodity producers, includes new products or processes to take advantage of cheaper resources that previously were not viewed as part of the wood base. It also includes yield-enhancing technology such as native forest intensification and increasing plantation wood yields through productivity enhancement. Cost reducing strategies in the logging industry make previously inaccessible and sub-marginal forest areas feasible to log and also work to shift out the wood supply curve. S_{w2} represents the wood supply schedule at time period two (Fig. 7).

At time period two, one possible outcome is that the derived demand for wood increases from Q_1 to Q_2 with the price for wood falling from P_1 to P_2. (The supply schedule S_{w3} and associated P_3 and Q_3 will be used in the discussion section of this paper.)

The direction of wood price movements depends on the relative slopes of the supply and demand schedules (depicting the responsiveness of supply and demand to changes in price – price elasticity) and their shifts. The demand for wood is highly price inelastic (FAO 1997; Zhu *et al.* 1998); demand is not particularly sensitive to price fluctuations. This is shown by the steepness in the slope of the demand schedule (Fig. 7). In contrast, wood supply is more price elastic and the supply schedule is flatter. Wood supply can be more responsive to price changes because of the significance of native forests that have not previously been commercially logged and also the capacity for regional shortfalls in wood to be accommodated through trade. The FAO estimates that undisturbed native forests, with their built up stocks of wood, currently account for 43% of the area of forests available for global wood supply (FAO 1999*b*). This analysis implicitly supposes that sustainable wood yield logging schedules are often not adhered to (Dauvergne 1997).

The model presented above showed the conditions for wood prices to decline. If this were the case it implies that there is no wood shortage in the particular market. What is the empirical evidence for declining wood prices? The following section examines four long-term trends in wood prices in widely differing circumstances.

Figure 8 Real price for global exports of wood. Wood exports comprise wood in the round, chips, particles and wood residues. fob = free on board and is the price excluding customs, insurance and freight costs. Prices deflated by US CPI (Consumer Price Index) 1990 = 100. Sources: FAO (1999*a*); Reserve Bank of Australia for US CPI.

Wood prices: the empirical evidence

Global wood export market

Global exports of wood have increased by an average 1.0% per annum over the 30 years ending 1998 (Fig. 8). Real prices for wood show an underlying downward trend, which was broken for a period by the oil shock followed by the early 1980s economic recovery. This price trend gives no support to the view that there is a global wood shortage, however the past does not necessarily reflect the future. The next decades may see significant conservation gains for native forests that trigger price spikes and expectations of on-going moderately high prices (Lippke 1994).

New Zealand radiata pine (*Pinus radiata*) log export prices

The United States' decision to protect spotted owl habitat triggered a price spike and delivered significant financial benefits to exporters of radiata pine plantation sawlogs from New Zealand. Export prices for high-quality pruned radiata pine logs peaked in the September quarter of 1993, when prices were 135% higher in real terms than those in the September quarter of 1992 (Fig. 9). Within a year, real prices for pruned logs plummeted and have continued on a fairly steady downward path. By June 1999, export prices for pruned radiata pine logs were no different in real terms to those before the price spike. Real prices for all lower quality radiata pine

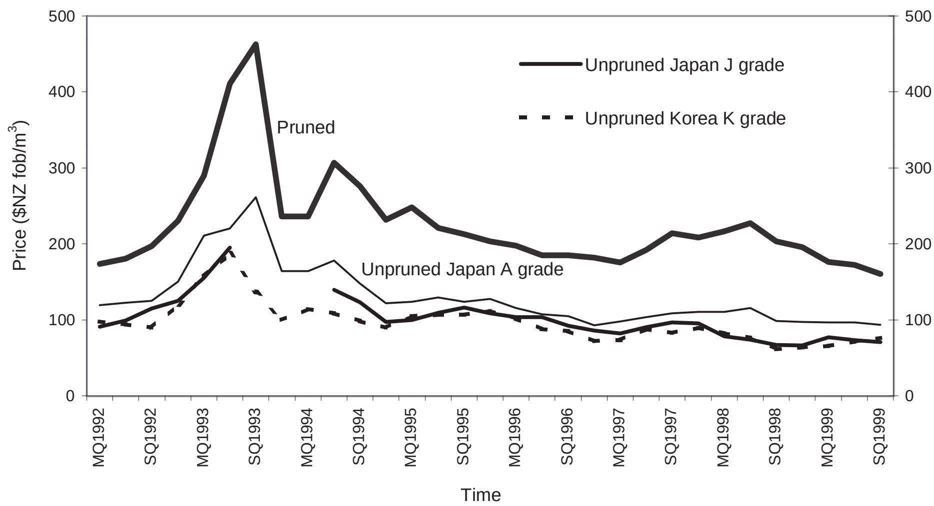

Figure 9 Real prices for New Zealand radiata pine log exports. fob = free on board and is the price excluding customs, insurance and freight costs. Prices deflated by NZ CPI December quarter 1993 = 1000. MQ = March quarter, SQ = September quarter. Sources: New Zealand Ministry of Agriculture and Forestry (1999); Reserve Bank of Australia for NZ CPI.

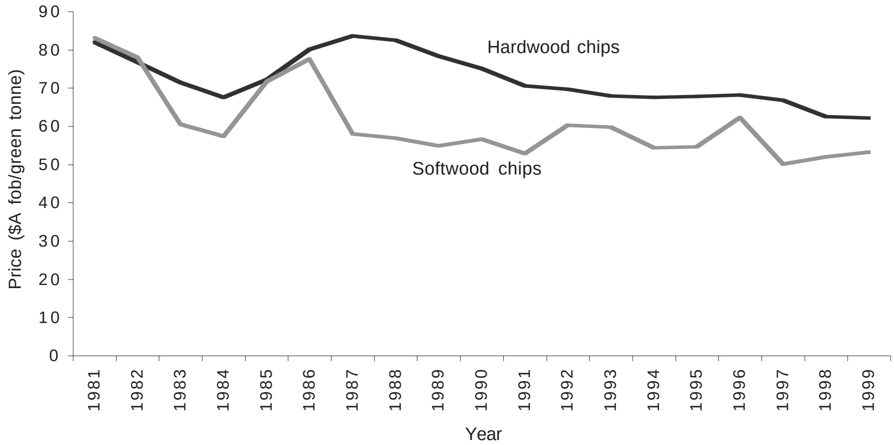

Figure 10 Real prices for Australian chip exports. fob = free on board and is the price excluding customs, insurance and freight costs. Green tonne is the weight of the chips before drying. Prices deflated by Australian CPI 1989/90 = 100. Sources: Australian Bureau of Agricultural and Resource Economics (1998, 1999).

export logs have tended to decline since the September quarter of 1993. Real prices for these logs in September 1999 were nearly 30% lower than their pre-spike prices.

Australian eucalypt export woodchip prices

The importance of price expectations for plantation investment decision-making is clearly evident in Australia's eucalypt plantation programme targeted for the global chip market. Australia is a major player accounting for 25% of global softwood and hardwood chip exports (FAO 1999*a*). The annual rate of new, first rotation, eucalypt plantation establishment in Australia increased by 343% between 1995 to 1999 (Bureau of Resource Sciences 2000). The majority of these plantations have been financed through private sector prospectus-based investment (Kohler 2000; Cummine 2000). All prospectuses referred to looming global shortages of hardwood. Most prospectuses incorporate significant price increases for wood stumpages relative to native forest stumpage prices. The price data indicate no tightening of the global hardwood chip market. Real prices for hardwood chips exported from Australia declined by an average 1.1% per annum over the period 1981 to 1998 (Fig. 10).

Chip import prices for the high growth Asian region

Increasing real prices for wood could be expected in countries with high economic growth in the Asia-Pacific region, if domestic wood supplies cannot meet strong growth in wood products consumption. Importing chips has accommodated most of the wood deficit. The volume of chips imported into the ASEAN (Association of South East Asian Nations) region, China, Japan and Korea increased by an average 12.3% per annum over the period 1964 to 1998. Despite this strong growth, real import prices for chips showed no underlying upwards trend (Fig. 11).

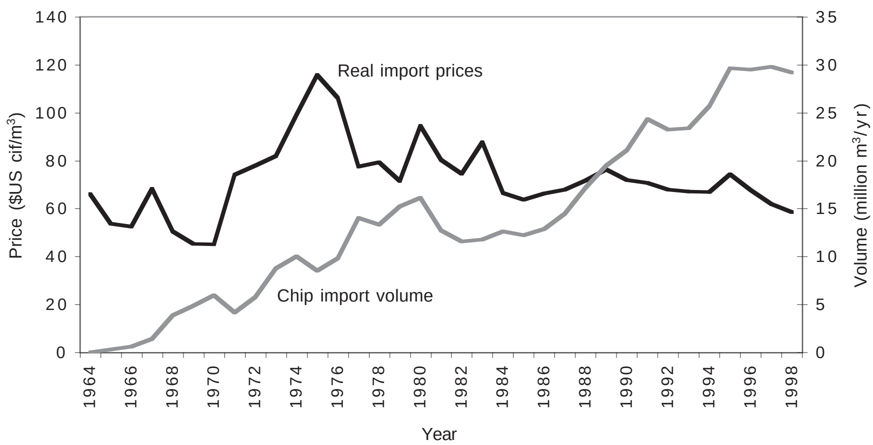

Figure 11 Real prices for chip imports to the ASEAN, Japan, China & Korea. cif = price including customs, insurance and freight costs. Prices deflated by US CPI 1990 = 100. Sources: FAO (1999*a*); Reserve Bank of Australia for US CPI.

The wood price data examined in this paper cover a wide set of circumstances, namely the aggregated global wood market, a regional market exposed to and benefiting from a wood supply shock, a market with expectations of wood chip shortages, and a high-growth regional market with short to medium-term wood shortages. No evidence was found to support the argument that real prices for wood increase over the long term. On the contrary, in three of the four examples, real prices for wood showed a long-term downwards trend. The most optimistic price trends were for the high-growth Asian countries. Despite the significant increase in the volume of chips imported by high-growth Asian countries over the last three decades, average real import prices for chips during the 1990s were virtually no different to the prices paid during the 1960s.

These findings are consistent with the FAO (1997) which reported no evidence, based on real prices, of increasing scarcity of wood during the past 30 years. The FAO expects no long-term real price increases for wood because their supply and demand analysis suggested that forests and plantations together with other fibre sources would be sufficient to meet demand in the foreseeable future (FAO 1997, 1999*b*). Sedjo and Lyons (1990) also found no evidence of increasing real prices for wood and concluded that increasing global wood consumption has been matched by an outward shift in the wood supply schedule.

Discussion

That the world is experiencing, or soon will experience, a wood shortage is a widely held view. It generates expectations of increasing real prices for wood. However, as has been shown here and elsewhere, there is no evidence of increasing real prices.

Both forest conservation and utilization advocates re-enforce the expectation of increasing real wood prices in advancing their differing interests. Forest conservationists argue that over-consumption and unsustainable deforestation and logging are likely to increase wood prices (Greenpeace 1999). Increasing prices for wood are a desirable, but incomplete, correction mechanism. The native forest-logging industry argues that global wood shortages are imminent and that protecting more forest areas from logging to meet conservation objectives will increase wood prices (National Association of Forest Industries 1990, 1995). Promoters of plantation investment are encouraged by studies showing global wood shortages. Such studies create expectations of increasing wood prices which generate greater (false) confidence in investment.

Many factors, working on demand and supply, are averting a global wood shortage. There has been negligible growth in wood consumption in developed countries over the past three decades (Table 1). This is because sawn timber consumption has flattened as population levels and house building have stabilized and paper recycling has increased. Developed countries account for slightly over 70% of global wood consumption. Static, possibly in the near future declining, wood consumption in developed countries has helped to accommodate necessary consumption increases in developing countries without generating real price increases for wood.

Wood-saving technologies are increasing resource productivity, enabling the same volume of wood products to be manufactured but with less wood. As has been shown in this paper, global wood use in more recent years has been increasing at only half the rate of consumption growth in wood products. In 1990, 1.8 m^3 of wood was used to make 1 m^3 of wood products, but by 1998, wood-saving technologies reduced this to 1.6 m^3 of wood to make 1 m^3 of wood products (Fig 5). Paper recycling has been the most significant wood-saving technology adopted to date. Others include high yield pulping and substituting sawn timber with more resource-efficient wood-based panel products and timber-engineered products. Technological change is also increasing wood supply through the intensification of native forest management, logging cost reductions that widen the commercially viable wood catchment and productivity enhancement in plantations.

It would be incorrect to interpret the absence of a looming global wood shortage to mean that there is little to worry about from a conservation perspective. The outcome with respect to native forest conservation depends on what land base (forested land or already cleared agricultural land) will be used for the intensification technologies that enable on-going wood cost reductions to be made through growing wood as an agricultural crop. It also depends on the extent to which native forest logging pressure is actually reduced as plantation-grown wood becomes available for processing.

Declining real prices for wood increases the risk that plantations will not be established on existing agricultural land with commercially-driven investment. Instead, the attraction of immediate cash flow from logging native forests on what is often subsidized public land means that plantation establishment is more likely to be focused on clearing native forests or intensively managing native forests. Intensification practices include reducing rotation periods, increasing wood yields using agricultural technology, and selecting non-indigenous tree species for replanting. Intensification of native forest management threatens biodiversity in natural ecosystems (Ehrlich 1996; Lindenmayer 1996; Norton 1996).

One option for addressing this biodiversity threat is to accredit industry players that source their wood from ecologically sustainable native forest logging. Accreditation may, for example, be based on the Montreal Process (Montreal Process Implementation Group 1998) or the principles established by the Forest Stewardship Council (World Wildlife Fund 1998). Accreditation, by not recognizing the commodity nature of the wood and wood products industry and the reality of global trade, will deliver a second-best ecological outcome. Accreditation will encourage commodity producers to relocate to regions where they can avoid wood growing and logging practices that add to their costs.

A long-lasting solution means accepting that commodity wood production and ecologically sustainable native forest logging are incompatible (Clark 1994). It is this incompatibility that makes the option of growing trees in an agricultural context on existing agricultural land appealing from both an ecological and economic perspective. The challenge lies in attracting investment in plantation establishment on existing agricultural land. One option is to use the provisions of the Kyoto Protocol of the 1997 Framework Convention on Climate Change that recognized the carbon sink value of afforestation and agreed to the development of a system of trading in emission credits. However considerably more detailed analysis and policy debate remains on the issue of emissions from combustion of fossil fuels, forests as sources and sinks and an effective policy mix (Hamilton 1998).

With these uncertainties, it is prudent to consider approaches that encourage plantation investment on existing agriculture land using the price mechanism. Currently, much private sector plantation investment is based on price expectations derived from an incorrect view of an imminent global wood shortage. Withdrawing old-growth forests from commodity wood supply is likely to increase wood prices in line with widely held, though apparently false, expectations and also deliver an absolute best ecological outcome. Old-growth forests have dampened price increases when regional wood shortages have arisen because they contain large volumes of mature wood that can be quickly brought into production. The price effect of withdrawing old-growth forests from commodity wood supply has been shown theoretically (Fig. 7). It would shift the wood supply schedule up and also increase its slope (S_{w3}) as wood supply became less responsive to changes in price. The price for wood increases to point P_3 (Fig.7).

Native forest logging levels will not automatically fall as increasing volumes of wood become available from maturing plantations. The Australian experience illustrates the significance of the point. Plantations now account for half of Australia's wood base following a four-fold increase in plantation wood supply since the 1970s. Wood supply from native forests has remained unchanged over this 30-year period at around 10 million m^3 per annum (Australian Bureau of Agricultural and Resource Economics 1998). Plantation products have displaced large volumes of native forest sawn timber (Australian Bureau of Agricultural and Resource Economics 1999 and earlier volumes), but new markets for native forest wood, principally the global chip market and more recently the expectations of major biomass use for 'renewable' electricity generation, are working to maintain logging levels in Australia's native forests. Significant volumes of plantation wood have remained unused with large areas of plantations not thinned as scheduled and remaining unlogged despite reaching their clear-fell harvest age (Clark 1995*b*). Government policy settings skewed to the interests of the long-established native forest industry can undermine the emerging competing plantation processing industry (Clark 1995*a*).

Little is known about the global plantation estate, despite its strategic commercial importance. Unresolved operational definitions that distinguish a plantation from a native forest frustrate the compilation of comprehensive data on plantations. Developed countries account for most of the area data deficiencies. We do not know what plantations currently contribute to global wood supply (FAO 1999*b*) and comprehensive projections of global plantation wood supply are non-existent. Allocating more resources to address these information gaps is a timely task that would assist in developing appropriate industry policies and determining future plantation establishment rates.

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