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AN ASSESSMENT OF THE MARKET FOR SOFTWOOD CLEARWOOD LUMBER PRODUCTS

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EXECUTIVE SUMMARY

The purpose of this project was to assess market opportunities for second-growth clearwood lumber by identifying industry segments that currently utilize clearwood lumber and determining whether alternative markets will continue to exist for clearwood lumber produced from intensively-managed forests in the Pacific Northwest. The historical lumber price data was analyzed and industry segments that have traditionally utilized clearwood lumber were surveyed.

Survey Results

Of survey respondents 33% were moulding manufacturers, 14% were millwork manufacturers, 10% produced doors, 8% made windows and 23% made other products such as furniture, cabinets, crafts, paneling, stair parts, and other specialty products.

The use of individual species was often associated with specific industry segments. Approximately 81% of the ponderosa pine was used in the production of mouldings and windows. Douglas-fir was primarily utilized in the manufacture of doors (49%) and other products (29%). Southern pine was used primarily in structural products, although 15% was used for mouldings and 11% was used for doors. Approximately 87% of the radiata pine was used for the production of moulding and millwork.

The geographic location of the survey respondents was: 33% from the northeast, 26% from the Pacific Northwest, 25% from the southwest, and 16% from the southeast. On average, most of the firms that participated in the survey could be classified as small- to medium-sized. While respondents' average annual purchase of softwood lumber was reported to be 5,800,000 board feet, the median volume purchased was just 700,000 board feet. Similarly, while the median sales revenue reported by respondents was $2.8 million, average sales revenue was more than three times that amount. Roughly 50% of the respondents reported total sales revenue of less than $2.5 million.

Concerns regarding the ability of plantation-grown timber to substitute for old-growth lumber products may be exaggerated. The study found that the two most important lumber attributes were reliability of supply and price. The least important attributes were identified as being mechanical strength and vertical grain.

Based on a factor analysis, the original sixteen lumber attributes were reduced to four factors: timber quality, manufacturing properties, mechanical properties, and price/supply. The results of the survey suggest that many manufacturers in industry segments that have traditionally relied on clearwood lumber as a raw material input have successfully substituted lower-grade lumber (*e.g*., shop grade lumber), non-traditional species, and non-wood products to offset reduced supplies and price increases.

In 1989, 58% of respondents indicated that raw material substitutes had replaced 31% of the softwood lumber volume previously used in their production process, although the median volume was only 5%. By 1994 however, 83% of respondents reported that they were substituting 36% (median of 24%) of their softwood lumber with other raw materials. This is a statistically significant increase. The top three reasons that respondents indicated were important considerations in their decision to utilize a substitute product were the price of the substitute, product availability, and reliability of supply. Reduced environmental impact was reported to be the least influential attribute.

Those manufacturers who did use substitute products in their manufacturing process tended to have higher sales revenue and employed twice as many people as firms that did not use substitute products. Approximately 60% of moulding manufacturers indicated that they used a raw material substitute for softwood lumber, while 77% of millwork manufacturers, 83% of window manufacturers, 62% of door manufacturers, and all of the structural product manufacturers reported using some raw material substitutes in their manufacturing processes.

Price Trends

Analysis of prices for softwood lumber products at the producer wholesale level (based on bi-weekly spot prices) indicate that, while lumber is a semi-homogeneous product, there are important and persistent differences in value based on species and grade. The user survey results suggest that price is an important variable in the purchase decision and likewise in decisions to utilize substitute raw materials, including non-wood materials.

There is a definite structure of nominal and real (inflation-adjusted) prices in the softwood lumber market, indicating that buyers purposefully differentiate lumber on the basis of perceived attributes associated with the intended end use. Lumber grades, which seek to specify broad groups of product attributes, are imperfect. Lumber products can frequently be downgraded to lower end uses and potentially upgraded through reprocessing, for example, by removing knots to produce short clear pieces of lumber. However, price trends indicate that lumber grades are a useful basis for differentiating products and to measure how prices perform in both a relative and absolute sense over time.

Relative price analysis indicates that clearwood grades of softwood lumber command a significant premium relative to the overall market, as indexed using Douglas-fir Standard & Better 2x4's as the baseline commodity index. The aggregate softwood lumber market is sensitive to macro-economic factors linked to business cycles, particularly to residential construction. As such, considerable fluctuation in aggregate lumber prices can be expected, with the overall vector of product prices moving somewhat in tandem. Nevertheless, movements in relative prices can and do occur, leading to potential substitution between clearwood lumber grades and other, less expensive lumber grades and non-wood substitutes.

The price analysis confirmed that Shop, C & Better selects, and Moulding & Better grades of Douglas-fir, ponderosa pine, and southern pine lumber command significant relative price premiums over the common and structural softwood lumber grades. Shop grades of Douglas-fir commanded an average premium of 43% while ponderosa pine #3 Shop commanded a premium of 85% relative to the baseline commodity index. C & Better Select lumber exhibited an even larger relative premium, 125% for southern pine and 474% for ponderosa pine. Moulding and Better lumber demonstrated relative premiums of 214% for Douglas-fir and 356% for ponderosa pine. These relative price premiums were quite stable over the 1989-1995 data period, with long-term trends slightly upward with respect to the relative prices for ponderosa pine C & Better Selects and Moulding & Better grades.

Increasing relative prices, however, provide incentives for buyers to consider substitute products. While the trends estimated in this study are not strongly upward, taken together with the results of the industry survey, the producers of clearwood lumber grades should be aware of the growing potential for substitute products capable of meeting end user demand and which are price competitive. In the short-term, considerable relative price instability was evident in response to business cycles, with the consequences being that end users frequently experience rapid increases and decreases in the relative prices of clearwood lumber grades which do not reflect longer-term trends but are perceived as indicators of significant market shifts. As measured by the standard deviation of relative prices around the long-term price trend, clearwood grades of lumber typically had variations three to eight times greater than commodity structural lumber grades.

Markets respond to changes in perceived relative prices, whether generated by a change in the product's own price or from a change in the price of a competitive product. The analysis of price elasticities (own-price and cross-price) was limited by the availability of relevant price and consumption information at a disaggregated level. The review of the economic literature indicates that softwood lumber is generally price inelastic in both the short- and long-run. Given the niche nature of markets for clearwood lumber grades, it might be expected that the demand will be somewhat more inelastic, indicating that the quantity of clearwood consumed is less responsive to relative price changes in the short-term, but also that prices will be more sensitive to structural market shifts. Timber supply shifts likely account for much of the relative price instability observed for the higher-valued clearwood lumber products.

In addition to the movements of relative prices, this study found that the price premiums paid for clearwood grades of lumber (in 1995 dollar terms) were substantial and quite stable when measured as the prevailing differences from the overall softwood lumber market. In real terms, average price premiums for #3 Shop grade lumber over the baseline product ranged from $159/mbf for southern pine and $166/mbf for Douglas-fir to $280/mbf for ponderosa pine. Real price premiums for C & Better Select lumber averaged $405/mbf for southern pine and $1,563/mbf for ponderosa pine. Finally, real price premiums for Moulding grade lumber were $692/mbf for southern pine and $1,196/mbf for ponderosa pine. For all the clearwood lumber species/grades combinations with sufficient price data, the real price differences were found to increase modestly over time, with the exception of Douglas-fir Moulding and Better grade lumber, where a slight downward trend in real price difference was observed for a shorter, three-year data period. The persistence of these price differences over the 1989-95 market cycles and abnormal supply disruptions would indicate that clearwood grades of softwood lumber are effectively differentiated in the perception of end users and the price differences are not a simple result of transient market disruptions.

The analysis also determined the spread of real prices between commodity and clearwood lumber grades within individual species of lumber. Where it is possible to alter the grade yields through intensive forest management, the spread of real prices is highly relevant as more clearwood replaces lower-valued grades in the total lumber recovery volume. Real price spreads remained stable during the 1989-95 period for the clearwood grades, with slightly positive trends observed for all products with the exception of Douglas-fir Moulding & Better grade lumber.

Conclusions

This study found that clearwood lumber is a differentiated product for which end users are willing to pay a substantial premium. Those respondents who utilize clearwood lumber as a raw material input in their manufacturing process indicated that they value reliability of supply, price, and price stability over timber quality. This would seem to indicate that manufacturers cannot, or will not, continue to accept higher relative prices and rapid price fluctuations. The lumber price trend data indicate that softwood lumber products are highly differentiated in terms of perceived market value, reflecting the unique attributes of specific lumber grades that are valued by end users. The price analysis supports the conclusion that price-induced substitution is an important driver behind the convergence in relative prices between the higher grade ponderosa pine lumber products and the overall softwood lumber market, but that clearwood grades of lumber have generally maintained their relative price differentials. However, the price analysis and industrial survey results suggest that, for more and more manufacturers, clearwood lumber attributes may be available from lower grade lumber products and substitute products. The survey results clearly indicate that many manufacturers are switching to substitute products to meet their raw material needs and provide price stability for their manufacturing operation.

Based on these results, lumber producers and plantation managers can better assess whether to adopt management practices that emphasize the production of clearwood lumber for high-value niche markets, or whether they might be better off focusing on the production of commodity grade products. Given the significantly different cost structure associated with each of these production strategies, the results of this study can help managers determine which strategy is the most cost effective based on the characteristics of the market segments they are serving.

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INTRODUCTION

What is Clearwood?

Until recently, value-added forest products manufacturers in the US have relied upon the readily available, high quality, large diameter, old-growth timber which produces high yields of defect-free, straight-grained lumber. The historic availability of high quality softwood lumber, often referred to as clearwood, has influenced the perceptions of manufacturers as well as the production techniques used in many value-added segments of the wood processing industry. As the structure of the forest resource changes, however, value-added forest products manufacturers are encountering increasing difficulty in obtaining reliable supplies of clearwood lumber products.

Historically, clear softwood lumber has been defined as knot-free, straight-grained wood with narrow growth rings, suitable for both appearance and structural end-use applications (Anon. 1992b). However, in recent years the perception of clearwood has been changing, reflecting the evolution of the structure of forests in the Pacific Northwest from an old-growth resource to a second-growth plantation resource. In comparison to old-growth forests, plantation grown timber is characterized by wide growth rings, more knots, and different physical and mechanical properties. These differences can be attributed to the faster growth rates of trees in plantations, different earlywood-latewood ratios, and a higher proportion of juvenile wood. The differences between old-growth timber and plantation timber extend beyond appearance to include strength properties, physical properties, and processing characteristics. As a result, the clearwood resource derived from second-growth forests differs substantially from the old-growth resource of the past.

The Clearwood Resource Supply

Recent court decisions and federal legislation have resulted in a substantial decrease in the total volume of timber harvested from public forest lands in the Pacific Northwest. These court decisions as well as federal legislation related to the forest resource in the Pacific Northwest have been influenced by both political and environmental interest groups, either to preserve endangered species habitat or to foster multiple use regimes. As a result, federal court decisions in the late 1980's and early 1990's have effectively halted the harvest of most federal timber sales that had been under contract but not yet harvested (Anon. 1991c). For example, the total volume of timber harvested from federal forest lands in Washington and Oregon between 1988 and 1994 declined by 36% and 70%, respectively, accounting for the dramatic decline in timber harvest experienced in these states (Figure 1).

The combination of federal harvest restrictions, adverse court decisions, and other economic and political factors has contributed to price instability, characterized by drastic price fluctuations for lumber products at the national level (Anon. 1994b, Irland *et al*. 1993). For example, recent data indicates that the price of Douglas-fir structural timber increased 58% between 1988 and 1993, while ponderosa pine No. 2 5/4 Shop grade lumber increased 59% over the same period (Warren 1995). Although lumber prices have since declined as the market adjusted to supply uncertainties, the expectation of future price instability provides an opportunity for alternative timber species and substitute materials to gain a foothold in the US marketplace.

To compensate, wood processors in the Pacific Northwest have been forced to increase their reliance on timber harvested from private forest lands. Private timber harvests (as a percentage of the total harvest) in Washington and Oregon increased from nearly 50% in 1988 to 67% in 1994 (Warren 1995). In recent years, private timber owners have increased their harvest levels in response to higher log prices, increased demand, and the fear of future legislative restrictions on private timber harvests. For example, Oregon's 1993 private timber harvest volume recorded its highest level since 1971 (Anon 1995a). Since most private forest land in the Pacific Northwest has been silviculturally managed for relatively short rotations with minimal silvicultural improvements prior to harvest, logs obtained from these forests tend to be smaller in size and of lower quality than those obtained from public forests (Robinson 1992, Tomasko 1992, Mitchell *et al*. 1989, Flora 1986).

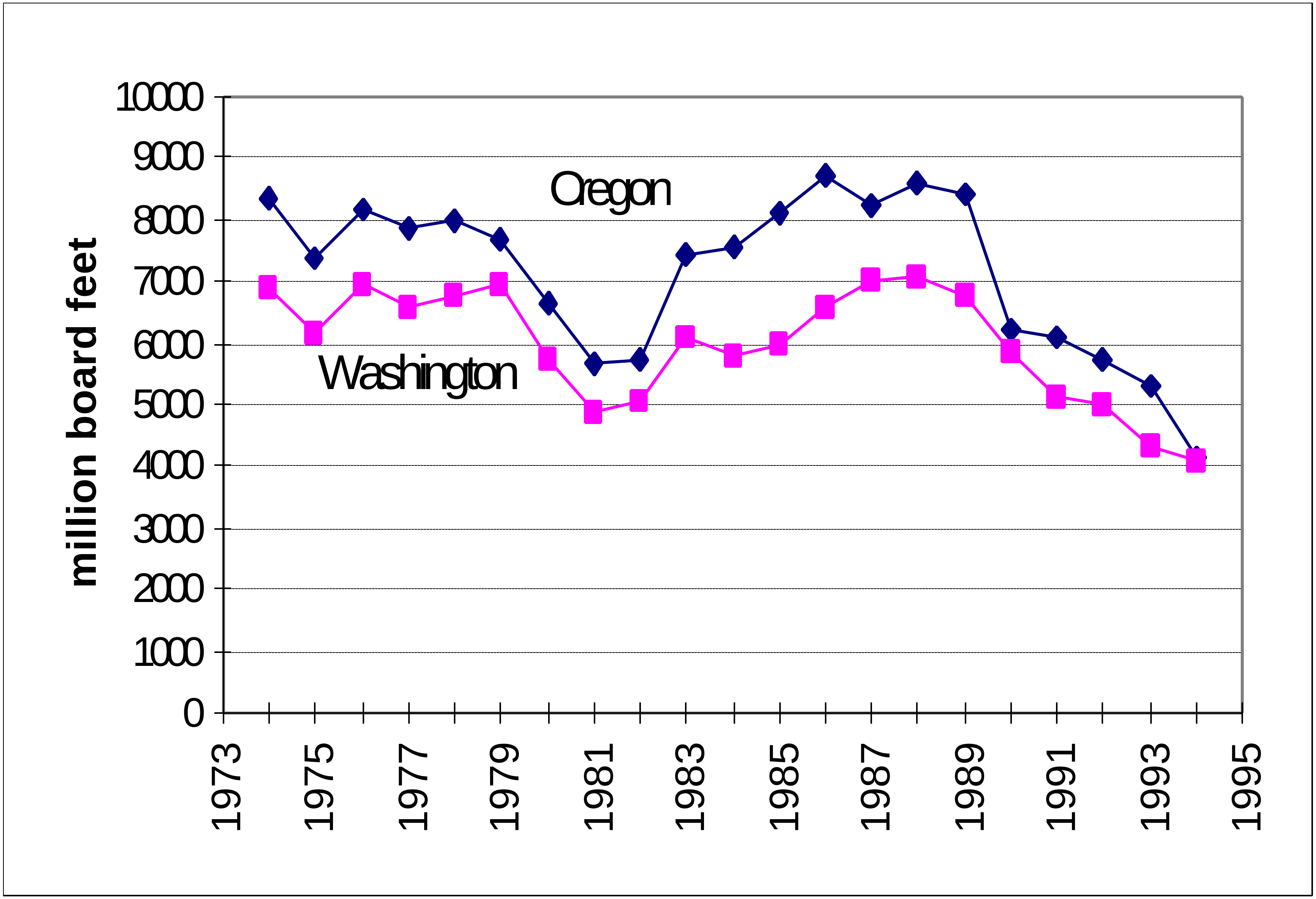

Figure 1. Total timber harvest volumes in Washington and Oregon, 1974-1994.

Contributing further to the supply uncertainty is the fact that harvest restrictions are occurring in other timber supply regions. For example, US manufacturers have traditionally relied on softwood lumber from Canada to supplement domestic lumber supplies. However, a recent study conducted by Price-Waterhouse forecasts a 17% reduction in British Columbia (BC) harvest levels, while the recent US-Canada lumber tariff agreement will further reduce lumber imports from Canada (Anon. 1995c).

The removal of over 50% of federal and state timber from the market in the US and the anticipated decline in harvest levels and lumber exports from BC has had a significant impact on the forest products industry in the Pacific Northwest. Mill closures rose from 8 in 1988 to 54 in 1990, with a subsequent cumulative loss of 9,300 mill jobs (Ehinger *et al*. 1994). The reduction in timber harvests in the Pacific Northwest has left the region's wood processing industry searching for alternative sources of raw material.

The Role of Silvicultural Stand Management in Increasing Clearwood Yields

To better meet the needs of the wood processing industry, foresters in the Pacific Northwest are currently assessing whether intensive silvicultural treatments such as thinning and/or pruning represent a viable economic strategy for producing increased volumes of clearwood lumber. Recent research indicates that intensive forest management is probably the best method for improving the quality of timber derived from forest plantations, potentially increasing the gross value of the resource, and perhaps generating a higher net return on forest investments (Fight *et al*. 1993, Haynes and Fight 1992, Fight *et al*. 1992, Cahill 1991, Cahill *et al*. 1988, Cahill *et al*. 1986).

There are different strategies for increasing wood quality and gross timber value through intensive forest management. For example, establishing a relatively dense forest stand promotes rapid crown closure and can reduce limb size. Thinning promotes an increased growth rate, producing larger diameter trees by removing nearby competing trees (Briggs 1995). Finally, a combination of thinning and pruning can produce wood with smaller and fewer knots--two characteristics which are important attributes in the lumber grading process. Pruning also encourages clearwood to form sooner and induces a tree to produce more wood than would an unmanaged tree in the same stand over the same period of time.

Despite the advantages of pruning and thinning regimes on forest growth rates and lumber quality, it is not readily apparent that these silvicultural practices would always increase the rate of return from private forest land investments in the Pacific Northwest. The decision to adopt intensive silvicultural practices is influenced by: 1) whether foreign competitors can obtain better results at lower costs, 2) the stumpage price when the timber is harvested, 3) how long it takes for the trees to reach a harvestable age and, 4) what timber attributes are valued by end users and to what extent they are willing to pay a higher price for these attributes (Briggs 1995, Fahey and Willets 1995, Horgan 1992).

Some indication of the financial implications of intensive forest management practices can be derived from the experiences of countries such as New Zealand and Chile, where they have been intensively managing radiata pine forest plantations for over thirty years (Eastin 1993, Anon. 1991b, Carson 1988, Kininmonth 1986, Mishiro *et al*. 1986). Similarly, southern pine forest managers in the US are improving their management practices to increase timber yield and quality. These non-traditional species are beginning to gain market share in industry segments once dominated by old-growth clearwood by taking advantage of technological innovations, efficient resource use, attention to quality and uniformity, and aggressive marketing (Flora 1995, Cox 1993).

In addition to their experience with intensive silvicultural management regimes, New Zealand and Chile forests have substantially shorter rotations than those observed in the Pacific Northwest. While intensively managed radiata pine forests can produce high quality timber in rotations as short as 24 years, Douglas-fir forests in the Pacific Northwest have a minimum rotation of 45 years when intensively managed (Oliver *et al.* 1986). In addition, the growth rates for softwood plantations in New Zealand and Chile are much higher than in the US. For example, the mean annual increment of radiata pine in New Zealand and Chile averages 24 m^3/ha/yr and 20 m^3/ha/yr, respectively, while it is 12 m^3/ha/yr for southern pine in the US south and 10 m^3/ha/yr for Douglas-fir in the Pacific Northwest (NZ FOA 1995).

The Nature of Old-Growth and Second-Growth Clearwood

Certainly, fast-grown plantation timber is not a direct substitute for old-growth clearwood lumber due to the different physical and mechanical properties of the two products. For example, fast-grown plantation timber has a lower density, wider growth rings, a higher percentage of juvenile wood, and different processing characteristics. Hence, plantation-grown lumber may not always compete with high quality old-growth lumber in all industry segments because it does not possess the technical characteristics desired by manufacturers in specific industry segments or other users. For example, wide growth rings and a high proportion of juvenile wood reduces strength properties and adversely affects machinability and the ability of the wood to accept paints and stains evenly. A higher proportion of juvenile wood adversely impacts the dimensional stability and drying characteristics of plantation grown timber as well (Briggs 1995, Fahey and Willets 1995).

Species selection can also influence the level of quality and the economic incentive to utilize intensive forest management methods. Fight *et al*. (1993), using a price premium analysis, found that differences in timber quality exist between different species receiving the same silvicultural treatments. For example, they found that although pruned second growth Douglas-fir forests generated a higher rate of return than did second growth ponderosa pine forests receiving a similar silvicultural treatment, Douglas-fir was more susceptible to problems regarding appearance and machinability.

When considered together, these factors have contibuted to concerns regarding the quality and acceptability of plantation clearwood as a direct substitute for old-growth clearwood in some end-use market segments. Are the attributes associated with old-growth clearwood necessary to achieve the end-use values in changing markets? Perhaps such specifications are not adequate to differentiate raw materials in today's markets. Timber supply shortages, actual and perceived, are forcing industry managers to reevaluate their perceptions of lumber quality and value, with the result that the lumber attributes associated with old-growth clearwood might not be an appropriate indicator of the lumber attributes that are valued today.

Market Trend Towards Wood and Non-Wood Substitutes

Increasing price trends for clearwood lumber products suggest that greater returns might be derived from the application of intensive forest management practices in the Pacific Northwest (Fight *et al*. 1993, Mitchell and Polsson 1993, Somerville 1988). While technological innovations have increased the recovery of clearwood lumber (Wagner 1993, Anon. 1992a, Baldwin 1992, Cown *et al*. 1988, Park 1985), new methods of grading lumber and predicting clearwood removals have been adopted to further increase the yield of clearwood lumber (Park 1994, Barrett and Kellogg 1991). Despite this, questions remain as to whether manufacturers and consumers are willing to accept fast grown plantation clearwood as a direct substitute for old-growth clearwood and whether past price premiums for the higher grades of softwood lumber will likely be maintained.

Non-traditional timber species and non-wood substitute materials are becoming more competitive as a result of the increasing price trends of clearwood lumber products (Baldwin 1992, Tomasko 1992, Anon. 1991a, Cahill 1991). Manufacturers who have traditionally relied on old-growth clearwood as a raw material input for their manufacturing processes are now turning to substitute materials such as hardwood lumber, finger-jointed lumber, LVL, edge-glued panels, medium density fiberboard, and high density foam products. It would appear that the challenge confronting value-added forest products manufacturers who have traditionally relied on an old-growth clearwood resource is to either identify new sources of clearwood lumber that possess acceptable attributes or identify substitute products that provide similar processing and end-use characteristics. The changing pattern of prices within softwood lumber species and grades, as well as between wood and non-wood products, will to some extent determine the degree to which clearwood lumber will maintain a favored market position.

RESEARCH OBJECTIVES

The purpose of this project was to assess changing market opportunities for clearwood lumber by identifying industry segments that currently utilize clearwood lumber and determine whether markets for clearwood lumber are changing with respect to relative price differentiation and quality premiums. In particular, this project was designed to address the following research objectives:

1. Identify those segments of the forest products industry that utilize clearwood lumber as a raw material input for their manufacturing process.
   ? What clearwood attributes are perceived to be important by manufacturers within each industry segment?
   ? What timber species are being used within each industry segment?
   ? Which grades of lumber are being used within each industry segment?

2. Identify those clearwood lumber attributes that are perceived to be important by managers.

3. Identify what products are being used as substitutes for clearwood lumber within each industry segment.
   ? What non-traditional timber species are being substituted for clearwood?
   ? What wood-based materials are being substituted for clearwood?
   ? What non-wood materials are being substituted for clearwood?
   ? What product attributes are perceived to be important factors in influencing the use of substitute materials?

4. Compile a time series of price trends for clearwood products.
   ? How do prices for clearwood products compare to the prices for non-clearwood products?
   ? What are the relative and absolute price differences for non-clearwood products competing in the same product market?
   ? What are recent trends in both relative prices and price premiums for clearwood grades of softwood lumber in comparison with the broader aggregate softwood lumber market?

5. Assess the competitiveness of substitute materials with respect to clearwood lumber.
   ? What are the estimated cross-price elasticities of traditional clearwood lumber species with respect to non-traditional clearwood lumber species?
   ? What is the cross-price elasticity of clearwood lumber products with respect to other wood and non-wood substitutes?

6. Assess alternative sources of clearwood products, both foreign and domestic.
   ? Where are plantation grown clearwood products being produced?
   ? What is the current and future supply situation for clearwood products?

LITERATURE REVIEW

Defining Old-Growth Clearwood

The forest product industry in the Pacific Northwest has traditionally relied upon the old-growth resource as a raw material supply for its manufacturing operations. The high quality, large diameter old-growth resource in this region produces high yields of clearwood lumber, defined as knot-free, straight-grained wood with narrow growth rings suitable for both appearance and structural end-use applications (Anon. 1992a).

Horgan (1992) estimated that the industrial demand for clearwood lumber, both softwood and hardwood, exceeded 59 million m^3 in 1992, approximately 38% of which was for softwood species. However, government regulations, court injunctions, and political, economic and environmental pressures have substantially reduced the available supply of public timber, forcing manufacturers in the Pacific Northwest to utilize substitute products and species. One implication of this changing resource base is that clearwood lumber today differs substantially from what was considered to be clearwood lumber just ten or twenty years ago.

In a substantive sense, clearwood as a product is poorly defined despite the highly detailed rules used to specify clearwood lumber grades. Although grading rules are highly specific, they do not provide a definition of clearwood because they fail to take into account many of the attributes that are important to manufacturers in different industry segments. The idea that the definition of clearwood is based on a set of attributes that varies by industry segment greatly increases the difficulty of defining clearwood. Yet the determination of a definition of clearwood lumber is important to forest managers as they develop forest management regimes to produce high quality logs (Horgan 1992). For example, lumber length is an important factor which differs between industry segments based on the end product and the manufacturing process. If the moulding and millwork industry requires a minimum clearwood length of 2 to 2.4 meters, plantation managers need to take this requirement into account when designing their management regimes. Conversely, if the target market for clearwood lumber is furniture and furniture component manufacturers, then almost any length could be regarded as clearwood.

Industries Using Clearwood

Forest products firms are often segmented into two industry groups based on the type of product being manufactured. These industry segments, while encompassing a wide range of products, generally produce non-appearance (structural) products and appearance products. Non-appearance products are generally used in structural applications where they are covered by other materials and, thus, their visual characteristics are important only to the extent that they might affect their structural integrity. Examples of structural products would include wall studs, floor and ceiling joists, sub-flooring panels and exterior sheathing.

In contrast, appearance products are used in end-use applications where visual aesthetics are important. Clearwood lumber is often used to manufacture appearance products because of the requirement that the raw material should possess few visual defects. The industries that typically utilize clearwood lumber as a raw material input include moulding, millwork, doors, windows, stairs, flooring and cabinets. In addition to using clearwood lumber, manufacturers of appearance products frequently utilize Shop grade lumber as well. Shop lumber is graded based on the quantity and size of clear cuttings that can be obtained from a board, with the higher grades tending to produce longer clear cuttings (Fahey and Willets 1995). The strategy of utilizing both high grade clearwood lumber and lower cost Shop grade lumber enables a manufacturer to reduce raw material costs.

While many industry segments are able to incorporate factory lumber into their raw material mix, other industry segments, such as the moulding industry, have traditionally relied on the higher grades of clearwood lumber as a raw material input because of the availability of long clear lengths. A recent study identified a number of lumber characteristics that were reported to be important to moulding and millwork manufacturers (Columbia Information Systems 1991). The most important lumber characteristics were found to be a uniform grain pattern, absence of knots, ease of machining, dimensional stability and smooth surface texture. Characteristics such as straightness of grain, ease of gluing, nail holding ability, paintability, ease of pressure treating, ease of drying and earlywood/latewood color differences were of lesser concern.

The Columbia Information Systems study also found that two-thirds of millwork manufacturers relied primarily on a single species as a raw material input, with 60% favoring ponderosa pine, 18% Douglas-fir, and 8% sugar pine. This finding coincides with the results obtained from a national study of the moulding and millwork industry conducted by CINTRAFOR (Briggs *et al*. 1994). While many millwork manufacturers expressed concern regarding future raw material supplies, most continue to rely on a single species and 68% of the respondents had not even considered using a substitute product.

However, the Columbia Information Systems study did find that 28% of millwork respondents are exploring ways to extend their clearwood resources. Strategies for maximizing the clearwood resource supply included using thinner veneers (61%), combining species in the raw material mix (8%), and introducing new processing technologies (8%). A further 13% of respondents reported implementing changes in the manufacturing process to allow the use of finger-jointed lumber, glue laminated lumber, or lower grades of lumber. Finally, some moulding and millwork manufacturers reported shifting to non-traditional species out of necessity. Jaenicke (1992) observed that the millwork industry's raw material supply has begun to include such non-traditional species as low density hardwoods (*e.g*., western red alder and yellow poplar), southern pine, and imported radiata pine.

Alternative Softwood Timber Species

Another strategy for addressing the reduced availability of clearwood lumber involves the substitution of non-traditional timber species. While there are always a few innovative manufacturers willing to evaluate and adopt new species and products, it generally requires some type of radical, discontinuous change within the business environment to provide the impetus for widespread change at the industry level.

Perhaps the most effective impetus for change within the forest products industry would be a reduction in the resource availability from traditional resource supplies, exactly the situation that exists in the Pacific Northwest. Manufacturers in this region, who have traditionally relied upon the high quality pine, hemlock, and Douglas-fir resource, are now being forced to consider alternative resource supplies. While many manufacturers have already begun to utilize non-traditional domestic softwood species (*e.g*., southern pine, spruce and fir), others have begun to evaluate low density hardwood species such as yellow poplar, western red alder and aspen. In addition, some manufacturers have begun to utilize imported softwood species, a trend that reflects the increasingly global nature of the forest products industry. Given the resource situation in the Pacific Northwest, including British Columbia, offshore suppliers of wood products have a tremendous opportunity to increase market acceptance for their products in the US.

The global softwood plantation resource

A substantial area of forest plantations, estimated to total approximately 95 million hectares, has been established globally (Laarman and Sedjo 1992). However, there are only a few countries where plantations represent an important component of the total forest resource and where there is substantial export potential, Table 1. The most widely known softwood species is radiata pine which is grown in New Zealand, Chile, Australia and South Africa. However, an equally important species, both in terms of plantation area under cultivation and from a utilization perspective, is southern yellow pine. While southern pine plantations have been established in a number of South and Central American countries, the most important plantation resource is located in southern Brazil and Argentina.

From a resource availability perspective, plantation timber is becoming more and more important as timber harvesting constraints are imposed in the natural forests of the traditional timber supply regions. Not only do the plantations in many of these regions exhibit rapid growth rates, but the combination of high growth rates with improved genetic stock and intensive forest management practices further increase the quality and value of the plantation resource. In most cases, the harvest level from the established plantation resource exceeds domestic consumption requirements. As a result, countries such as New Zealand and Chile have become significant

Table 1. Plantation location, area, and species composition of selected countries.

Country	Plantation area (ha.)	Species composition
Brazil	6,200,000	30% pine, 52% eucalyptus
Chile	1,800,000	79% radiata pine, 14% eucalyptus
New Zealand	1,388,000	91% radiata pine, 5% Douglas-fir
South Africa	1,330,000	51% pine, 39% eucalyptus
Australia	1,105,000	67% radiata pine, 21% other pine
Argentina	880,000	54% pine, 30% eucalyptus, 15% poplar

Sources: Various 1990-1995.

exporters of forest products, while other countries such as Brazil, Argentina, and South Africa are expected to increase their exports substantially in the near future.

The radiata pine resource

Radiata pine has until recently played a relatively minor role in Pacific Rim timber markets. The major timber importing countries in Asia (Japan, Korea, Taiwan and China) have traditionally relied on North America and southeast Asia to supply softwood and hardwood timber products, respectively. However, harvest restrictions in these regions have substantially reduced the availability of timber resources, raising questions regarding the future timber supply. Reduced timber harvest in traditional supply regions provided radiata pine producers with the opportunity to expand their market presence in the Asian markets as well as in the US Pacific Northwest. To the extent that radiata pine is perceived as a reliable resource supply and a credible substitute for traditional softwood species, it represents a significant competitive threat to forest managers in North America.

Despite the fact that extensive radiata pine plantations have been established in New Zealand, Australia and Chile for almost a century, radiata pine remained relatively unknown in the world lumber markets until recently. Perceptions of radiata pine as a low quality timber species have deterred it from gaining widespread acceptance internationally. However, new attention is being focused on radiata pine as the supply of more traditional softwood species becomes restricted and higher priced. As greater volumes of radiata pine appear on world markets, and as end users become more familiar with its technical properties, radiata pine can be expected to gain even greater market acceptance.

Approximately 9 million acres (4 million hectares) of radiata pine plantations have been established worldwide, primarily in the Pacific Rim region. Chile and New Zealand possess the largest radiata pine plantations, with 2.9 and 2.6 million acres (1.3 and 1.2 million hectares), respectively. Australia, with the third largest radiata pine resource, has just over 1.6 million acres (750,000 hectares) of radiata pine plantations. Radiata pine represents the primary plantation species in both Chile and New Zealand, where it comprises over 80% of total plantation area. The establishment of new radiata pine plantations in New Zealand and Chile is substantial, with 120,000 acres planted per year (48,000 hectares/year) in New Zealand and 141,000 acres/year (57,000 hectares/year) in Chile. The establishment of new plantations exceeds the rate of harvest; in Chile plantation establishment exceeds harvest by a ratio of four to one.

Radiata pine plantations have been demonstrated to produce timber much faster than plantations in North America. Managed plantation forests in New Zealand and Chile have mean annual increment growth rates of 24 m^3/ha/yr and 20 m^3/ha/yr, respectively. These values compare favorably with those obtained from plantations in the southern US (12 m^3/ha/yr) and the Pacific Northwest (10 m^3/ha/yr). High plantation growth rates have allowed both Chile and New Zealand to rapidly increase their harvest levels as the plantation resource matures. In Chile, the sustained yield from radiata pine plantations is currently 15 million m^3 per annum and it is expected to increase to 24 million m^3 per annum by the year 2010. A similar situation exists in New Zealand, where radiata pine plantations currently produce 13 million m^3 per annum, with annual production volumes expected to increase to 24 million m^3 by 2010 and 33 million m^3 by 2020. Given the small domestic market for wood products in these countries, the vast majority of their timber harvests will be directed to offshore markets.

In the past, radiata pine plantations have not been intensively managed, resulting in poor quality lumber. As a result, radiata pine has acquired a reputation of poor quality, appropriate for such uses as wood chips for the pulp and paper industry and a raw material for the pallet and container industry. This is particularly true in Japan where it is often referred to as “scrap pine”. Over the past 30 years, however, both New Zealand and Chile have developed improved genetic stocks in combination with intensive silvicultural regimes that emphasize selective thinning in combination with pruning early in the rotation. This silvicultural regime has resulted in increased growth rates that facilitate the production of clearwood. Over the next twenty years the volume of pruned logs is expected to increase substantially in both New Zealand and Chile, exceeding 10 million m^3 by year 2015. Despite its reputation of low quality, pruned radiata pine clearwood compares favorably with domestic US softwoods in the areas of machinability, finishing and treatability.

Both New Zealand and Chile have become significant exporters of radiata pine based on their comparative advantage over other softwood producers. Areas where New Zealand and Chile have an advantage over North American producers include: lower log costs, lower labor costs, higher softwood growth rates, high internal rates of return on investments in softwood plantations, and tax incentives that encourage plantation establishment and promote intensive silvicultural management practices (Gruenfeld 1992).

As these countries continue to develop substantial inventories of mature timber, they have begun developing export-oriented marketing strategies for value-added products such as moulding, millwork and preservative treated timbers in Asian markets. In addition, radiata pine producers have begun to take advantage of high stumpage prices in the Pacific Northwest to develop markets in the US. For example, the Western Wood Products Association estimates that in 1994 radiata pine represented 5% of the raw material utilized by the Pacific Northwest moulding and millwork industry where it competes directly against ponderosa pine (Anon. 1991b). Radiata pine producers expect to see this market grow at a rate of 10% per year throughout the 1990's (Anon. 1991b).

Substitutes for Clearwood Lumber

Wood-based substitutes. The most common substitute for old-growth clearwood lumber is lumber derived from other species of softwood. The reasons for this are obvious: while individual species can be expected to have different physical and mechanical properties, they are far more likely to be reasonable substitutes for each other than would be non-wood materials. One area of concern, however, relates to the fact that plantation species may possess lesser mechanical properties that would reduce their suitability for some manufacturing processes. As Cahill (1991) points out, processing technology may not change quickly enough to allow short-term substitution of lower strength species such as radiata pine. Hardwood species are another substitute for clearwood softwood lumber in a number of wood product industries, including moulding and millwork (Anon. 1993a, Anon. 1993b, Tomasko 1992, Anon. 1991a). There is also a trend towards the utilization of engineered wood products in applications such as doors, windows, paneling, flooring, and some structural uses (Anon. 1994a).

Within the door industry, there have been a number of wood-based materials that have gained acceptance as substitutes for clearwood lumber. Traditionally used in the production of stiles and rails, clearwood lumber is now being replaced by finger-jointed lumber, laminated veneer lumber (LVL) and edge-glued lumber. A recent study conducted by Columbia Information Systems (1991) found that finger-jointed lumber was used by approximately 30% of door manufacturers. Door cores are increasingly being made from medium density fiberboard (MDF), oriented-strand board (OSB), or other wood-based composite materials that may or may not utilize a wood veneer overlay.

A variety of wood-based materials, such as finger-jointed lumber and LVL have been utilized as substitutes for clearwood within the window industry. A new composite product, known as Timberstrand? lumber, has also recently been used in the manufacture of windows. However, the acceptance of these substitute materials does not appear to be as widespread as within the door industry. For example, the Columbia Information Systems study found that only about 5% of window manufacturing firms were using finger-jointed lumber.

The moulding industry has also successfully incorporated wood-based substitute products into its manufacturing processes. For example, mouldings are now being produced from materials such as MDF and finger-jointed lumber. Mouldings made from these substitute products are either primed or wrapped with wood veneers to simulate solid wood. Finger-jointed lumber has had particular success in the moulding industry because it possesses superior characteristics in comparison to clearwood in several respects: it has more uniform strength properties, is more dimensionally stable, has less tendency to warp, and contains virtually no rejects (Anon. 1993b, Anon 1992b). As a result, finger-jointed lumber has increased its share of the mouldings market from 19% in 1965 to 40% in 1991, while the market share of clearwood has declined from 70% to 38% over the same time period (Tomasko 1992).

Non-wood substitutes. Non-wood materials have also begun to gain acceptance as substitutes for clearwood lumber in some industry segments. Aluminum, steel, and plastic (vinyl) have successfully been employed by window manufacturers as a substitute for clearwood for a number of years. For example, in 1988 just 15% of the windows manufactured used wood, while 19% used a wood/vinyl combination, 32% used aluminum and 31% used vinyl (F. W. Dodge, Inc. 1992).

Market acceptance for these substitute materials is often attributed to lower raw material costs and the increased ease of maintenance. Consumer preference has also been an important factor in the acceptance of non-wood substitute products. For example, market research has indicated that most consumers prefer wood windows, and as a result, many manufacturers have developed vinyl windows that simulate the look of wood (Anon. 1993c).

Within the door industry, non-wood substitute materials include steel, polystyrene foam, and fiberglass. From 1984 to 1988, steel doors increased their share of the door market from 43% to 63%. This success has been attributed to lower maintenance costs, increased energy efficiency, lower raw material costs, and increased strength. In contrast, fiberglass doors, made of a compression molded fiberglass-faced panel pressed over a foam plastic core, have experienced difficulty in gaining market acceptance, capturing just 3% of the market in 1992. Despite this, some industry observers expect that fiberglass doors will eventually capture a 25% share of the door market in the future.

Clearwood lumber also faces competition within the moulding and millwork industry from a number of non-wood substitutes. The two most common non-wood substitute materials utilized within the moulding and millwork industry are polystyrene and polyvinyl chloride foams. These high density foam products are manufactured in long lengths and can be machined using existing manufacturing technology. Foam mouldings can be painted or overlaid with a wood veneer to simulate clearwood moulding (Anon. 1992c).

The Role of Prices in Clearwood Lumber Markets

The concept and measurement of prices

An objective of this study was to investigate the trends and performance of softwood lumber market prices, and the degree to which specific grades are differentiated. Clearwood lumber grades can potentially be differentiated within the range of lumber products for a specific species, against the average for the overall lumber market, or against similar grades of clearwood products derived from other species groups. Differentiation of a specific clearwood product can be measured in several ways. Typically, price differences can be expressed in either absolute value terms (*e.g*., actual dollar difference) between two products or as a relative price (price ratio) between a clearwood lumber grade and a baseline, or index, lumber product. Each of these measures is utilized in this study, with the particular measure of differentiation related to the meaning or interpretation of market dynamics.

Although the concept of price is relatively straight-forward, the drivers that affect both absolute and relative price movements can be complex. A common problem in the evaluation of price relationships for a commodity product such as softwood lumber is the necessarily large number of assumptions that must be made in defining the nature of price. Price is the measure of value of exchange between willing buyers and sellers of a product. This exchange is presumed to take place in a specific market and to be inclusive of all buyers and sellers acting independently in their own best economic interest. In practice, many simplifying assumptions are needed in order to specify the relevant end use markets for clearwood lumber, the scope of the product included in that particular market, the nature of demand for the products being considered, and the relevant suppliers. Price is also relevant as a measure of a buyer's perception of marginal value of clearwood lumber as derived from markets for final products and as a measure of marginal revenue as related to supplier's output decisions given their specific competitive factor advantages such as raw material and/or labor costs (Labys 1973, McKillop *et al*. 1980).

The ideal softwood lumber price model would include the most influential factors in defining product/price relationships relative to both consumers (buyers) and producers (sellers), while being able to accommodate dynamic changes in supply and demand conditions over time.

In order to examine the differentiation of clearwood softwood lumber within the aggregate lumber market and to determine the potential changes in differentiation due to the shift from clearwood products derived from old growth and second-growth forests over time, this study utilizes the available data on price as reported by industry sources. However, it is necessary to understand the measurement of price within the lumber market at the wholesale or producer level, and to determine what price actually means to primary and secondary manufacturers in terms of the distinguishing attributes measurable by reported product grades and groupings of products as reflected in available price data. Limitations in the availability of price data, and the nature of the price data, are a constraint on the empirical analysis of how prices differentiate clearwood products over time and the degree to which that differentiation may be changing in response to changing lumber quality, clearwood availability or supply, and the emergence of potential substitutes.

Characteristics of lumber prices

Although the concept of price is easily understood, the measurement of price is complicated by many factors. One of the primary complicating factors is the aggregation of diverse lumber products when reporting lumber prices. For example, softwood lumber prices are often expressed as an average for an aggregation of products, species, and grades. While a composite index price may provide an average price, it also masks the variation that exists between individual softwood lumber products. In other words, a composite price index, while an effective index for macro-trends in the softwood lumber market, can mask the presence of significant and important price variations between individual lumber products. As a result, aggregate prices generally include multiple softwood lumber products, often products with distinctly different attributes (*i.e.*, old-growth and second-growth clearwood). At this macro level, softwood lumber is treated as a homogeneous or non-differentiated product which is assumed to be bought and sold in a single softwood lumber market. In reality, there is a very complex vector of differentiated prices for softwood lumber products with different attributes at any given time. This set of prices represents differentiated products with unique prices which prevail at a given time, and which may well persist over time even as the aggregate market responds to overall economic and market conditions. The set of prices reflects the differentiated, or unique, attributes attached to different products which are important to end users and which reflect conscious choices and preferences for which end users are willing to pay a premium.

Lumber prices, as with many commodity products, are subject to price fluctuations, and tend to be highly seasonal in response to market factors, primarily new housing starts and repair and remodel activity. Prices tend to be higher in the late winter to early summer months, when new housing orders begin to increase and available inventories are low. Lumber markets are also subject to a great deal of volatility, primarily due to cyclical supply and demand. Further, sudden changes in the markets for lumber inputs such as raw material supply shocks like those that resulted from federal regulations and court decisions in the Pacific Northwest, can unexpectedly impact lumber markets through supply shifts. These factors can lead to unanticipated lumber market supply shortages, resulting in short-term price volatility. This market volatility further complicates prices as distribution channel members try to keep inventories low to minimize their exposure to financial risk when prices later stabilize and revert back to more modest levels (Irland 1994a, Prins 1993, Anon. 1992b). Another effect of market instability is that softwood lumber prices tend to be much more volatile than other building materials (Irland 1994a).

Lumber price measurements are also affected by the structural and market complexities within the forest products industry. For example, prices are typically reported as the wholesale mill price, producer price, or FOB price. However, due to the spatial separation of mills from their customers, additional transportation costs are incurred, the magnitude of which depend upon the final destination, mode of transportation, and delivery time. As a result, actual consumer prices, while ultimately determining buyer behavior, are seldom reported and a time series of retail softwood lumber prices by product or grade is not available. Another factor affecting lumber prices are the distribution costs that are passed on to the manufacturer and retailer. Most retailers do not purchase timber directly from the mill, relying instead on a wholesaler, agent, or other intermediary who generally charges a 20-40% margin on the FOB mill price for their services (Irland 1994a).

Determining the market price for a lumber product is a complicated endeavor, particularly since raw material prices do not always follow a cost-plus structure (Lynn 1994). Product prices usually depend on the producer's costs, factors that unpredictably influence the availability of supply, and the customer's willingness to pay for a particular product (Sohngen and Haynes 1994). The prices that remanufacturers are willing to pay for softwood lumber or any other industrial raw material are strongly influenced by their perception of value and their anticipation of short-term market trends (Irland 1994, Roy and Johansson 1993, Prins 1993, Flora 1986, Labys 1973).

Characteristics of clearwood prices

The concept of product differentiation relates to the ability of end users to identify differences between products, which in turn help to distinguish market segments. With respect to clearwood lumber, manufacturers are often willing to pay a higher price in order to obtain specific product attributes, such as no knots, longer lumber lengths, narrow growth rings, or uniform moisture content. The perceived quality of lumber is relative to the consumer's perception of tangible and intangible product attributes. Where differences in price for similar products persist over time, the products are assumed to be at least partially differentiated.

As a consequence of product differentiation, lumber products possessing similar but unique characteristics can command different prices in the marketplace. Individual product attributes may not be equally important for all products, end uses, or markets and the importance of different attributes can vary drastically by end user (Adams *et al*. 1992). Lumber attributes that are perceived differently by manufacturers can lead to different equilibrium prices, reflecting partially differentiated supply and demand conditions. Specific product attributes are assumed to account for most of the price variation within the aggregate lumber market. At any given time there is a range of prices for similar products that defines the price premium. This price premium can be expected to persist between similar products on the basis of species, grade, size class, or product availability (Flora *et al*. 1993). An example of a price premium is the observed price differential that exists between species for similar products of West Coast hem-fir and Douglas-fir. Although the products manufactured from these species have similar attributes and end uses, Douglas-fir has maintained a relative price premium over coast hem-fir due to its superior strength characteristics (Haynes and Fight 1992).

Price differentials between products can vary dramatically over time depending upon changes in prevailing market conditions, as well as intrinsic softwood product attributes and the buyers perceptions of the unique value of these attributes. For example, the prices of softwood lumber products that are relatively scarce with few direct substitutes will react differently to market or raw material supply changes than would more abundant lumber products for which there are abundant substitutes. This is demonstrated by the greater price volatility of higher grade lumber products compared to the price levels of lower grade lumber products (Irland 1994a). Another factor in the volatility of clearwood lumber prices is related to the change in the proportion of high quality lumber in the product mix resulting from the decline in the supply of traditional old-growth timber (Figure 2). For example, the amount of old-growth harvested as a percentage of the total harvest in Washington State has fallen from 56% in 1981 to essentially zero in 1994 (Warren 1995).

Changes in lumber quality can be masked by price indexes that aggregate multiple lumber grades or species. A closer inspection of price and volume production data within a particular product line can help to identify these changes. For example, the production of Douglas-fir select lumber by coastal mills in 1993 declined to just 0.1% of the total lumber volume, down from 2.4% in 1985. Meanwhile, the percentage of Douglas-fir light framing

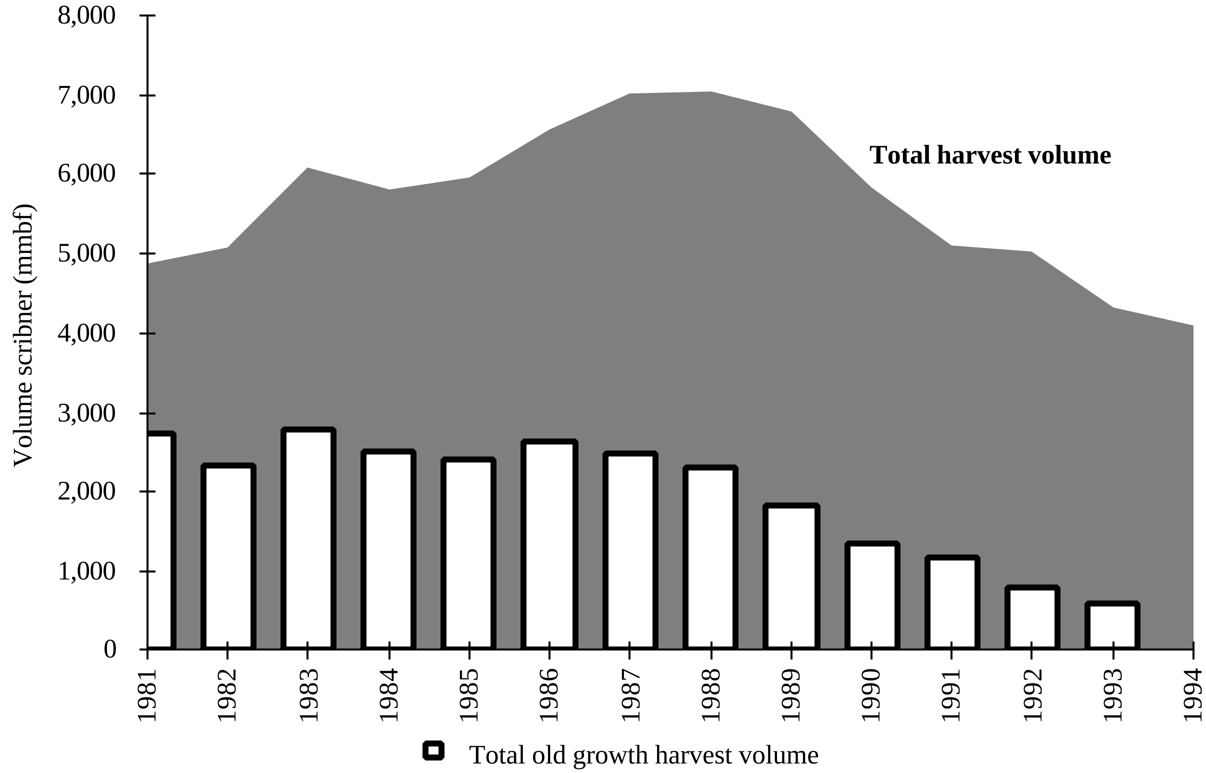

Figure 2. A comparison of the old-growth and total harvest volumes in Washington State.

lumber has increased to 54.7% from 41.8% in 1985 (Warren 1994). This change is not the result of market decisions that reflect end-user preferences, but rather is driven by the changing nature of the available raw material resource in the Pacific Northwest (Warren 1994).

According to Haynes and Fight (1992), the change in the lumber product mix reflects the decline in log quality. Many manufacturers have recognized that the typical log grade available for use in the region's sawmills no longer contains the same quality of wood which could be purchased even a few years ago. For example, the No. 2 & Better log grade now contains more No. 2 lumber than Better (Fryer 1995, Haynes and Fight 1992).

The relative wood quality differentials within a log or lumber grade, however, can be further masked by changes in the purchasing specifications stipulated by lumber buyers, a process known as proprietary grading. Proprietary grading occurs when a lumber buyer specifies that the lumber purchased must meet more specific criteria than those defined by the lumber grading rules. For example, the definition for No. 2 Clear & Better Douglas-fir lumber has fairly specific grade specifications (Table 2). A lumber buyer may request No. 2 Clear & Better Douglas-fir but further specify an average of 8 growth rings per inch and only 2 irregularities on the face of the lumber. While the lumber buyer will certainly pay a higher price for this proprietary grade of lumber, this is seldom reflected in the reported price for the related lumber grade. In addition, the incidence of lumber defects in the remaining lumber is not quantified, although the average quality of the remaining lumber within the grade will be lower.

All of these factors combine to obscure important quality and price information even when specific lumber grade data is available, further complicating the understanding of the selling and buying practices of both producers and consumers of clearwood. Further, other external factors influencing lumber markets also play a role in influencing the price differentials and the changes in relative price over time for clearwood lumber, (*e.g.*, the availability and relative price of substitute products).

The effect of relative price trends on substitution of clearwood lumber

This study seeks to examine the substitutability between clearwood lumber and alternative products, including the potential for using different lumber grades when relative prices favor such products and when the quality attributes are deemed acceptable. Although these products may not necessarily be perfect substitutes, oftentimes buyers do respond to relative price differentials.

An upward trend in absolute clearwood lumber prices, however, does not necessarily lead directly to immediate raw material substitution. Competitive substitution takes a longer time to occur and depends upon the perceived change in the relative price between two products, the likely persistence of the price change, and the transitional costs associated with the raw material substitution process. Drastic relative price disruptions caused by extreme supply volatility, or other unexpected events, which are expected to persist over the longer term can be expected to encourage manufacturers to look for substitutes (Irland 1994, McKillop *et al*. 1980). Other factors, of course, also

Table 2. A comparison of lumber grading rules and proprietary grade criteria.

Douglas-fir No. 2 & Better Export R List Grade Rules	**Hypothetical Proprietary Grade Specifications**
sound timber	sound timber
well manufactured	well manufactured
3 irregularities permitted on face side	*2 irregularities permitted on face side*
4 irregularities permitted on reverse side	4 irregularities permitted on reverse side
average at least 6 annual growth rings	*average 8 annual growth rings*
knots permitted on the reverse face only	knots permitted on the reverse face only

Source: WWPA Vol. 3 Factory Lumber Western Wood Species Book.

affect decisions regarding material substitution and include labor costs, transportation costs, processing efficiencies and/or the additional costs associated with using substitute products (Prins 1993).

Adoption (switching) costs are another factor that affect substitution and maintain price differentials. Adoption costs can be prohibitive in many industries using clearwood lumber due to the fact that different species or other raw materials might not have similar processing characteristics. For example, if a moulding and millwork manufacturer utilizes ponderosa pine in the manufacturing process, it might not be able to switch to southern yellow pine for a variety of reasons, including differences in the machining and kiln-drying characteristics (Anon 1994a). In this case, specific changes in material handling and processing need to be evaluated before the new raw material can be incorporated in the manufacturing process, changes that can be quite costly to a small firm with few slack resources. According to Briggs *et al*. (1994), almost 70% of moulding and millwork plants had fewer than 20 employees in 1987, making the cost of retooling a millwork plant problematic.

Future price trends for clearwood lumber

Due to recent clearwood lumber relative price trends in the US, manufacturers who have traditionally utilized clearwood grade raw materials from the Pacific Northwest have turned to global suppliers to supplement their raw material supply. Competition from global suppliers may dampen relative price movements for softwood lumber in the future, or at least moderate absolute price movements and relative price spikes in the future due to the nature of global trade flows. New suppliers are potentially better able to penetrate US markets given the opening of the former Soviet Republic, the increasing production levels from radiata pine plantations in New Zealand, Chile, and South Africa, and the maturing of southern yellow pine plantations in the southeastern US, southern Brazil, and Argentina. These new suppliers will help to moderate future timber supply volatility and will contribute incrementally to the supply of clearwood products available to secondary wood manufacturers (Sohngen and Haynes 1993).

The globalization of trade, however, will also complicate the general price relations of many products as prices in the Pacific Northwest are simultaneously impacted by production and consumption trends occurring in other global markets. For example, Haynes and Fight (1992) found that in most cases absolute prices increased more for higher grade products than for commodity grades, except in the case of Douglas-fir C Select lumber. They attributed this exception to the reduced explanatory and predictive ability of the hypothesized statistical relationship for C select prices due to assumptions that must be made in determining the nature of market responses within both the export and domestic market for this grade. Overall, the upward trend in absolute lumber prices is expected to continue as wood consumption grows and the global timber supply becomes more limited. However, the future trends for the relative price differentials within the various grades of softwood lumber (including clearwood) are less certain. Potentially, relative prices and price premiums for clearwood lumber could continue to increase relative to lower grade softwood lumber products.

Elasticities of demand and product substitution

This study also investigates the nature of the competitive demand between clearwood lumber products and substitute products as reflected in the economic concept of own-price elasticity of demand and the related concept of cross-price elasticity between potential substitute products. This latter form of price elasticity is different from the more common measurement of own-price elasticity for a specific product, such as clearwood lumber, and conceptually estimates the relative response in the use of one product (*e.g.* clearwood) in response to a change in the relative price of a competitive grade of lumber as well as non-wood substitutes.

In general, the concept of elasticity measures the impact of a small change in the price of a product on the consumption of that product. This own-price elasticity is usually expressed as a proportional change or a percentage. For example, if the price of lumber were to rise by 1%, and lumber consumption subsequently fell by one-half of a percent, the elasticity of demand would be -0.5. More commonly, own-price elasticity of demand is expressed as the absolute value with the implicit assumption that the relationship between price and quantity consumed is negative. This is consistent with normal demand theory whereby the consumption of normal economic goods is inversely related to the price. At higher prices, less of a good will be consumed assuming all other factors influencing demand remain constant, including the price of substitute products. Hence an increase in a product's price is also an implicit increase in that product's relative price in comparison to substitutes.

An own-price elasticity of demand of 0.5 represents inelastic demand. This means that a change in the price of lumber would affect the volume consumed by a proportionately smaller amount. In contrast, an own-price elasticity with a value of greater than 1.0 would represent elastic demand since the percentage change in quantity consumed would exceed the percentage change in price.

A different own-price elasticity may exist depending upon whether the relationship between own-price and quantity is short-term or long-term. Short-run elasticities tend to be more inelastic due to the limited ability of buyers to perceive the change in relative price, to consider the costs of changing inputs and actually adopt substitute materials in the short-term, the limited number of possible substitutes, and/or other limited supply adjustments. The economic short-term is defined as the current market period when all factors influencing markets (both supply and demand) other than price are held constant. This includes the assumption that the availability and price of substitutes remains constant as well as the other factors influencing both demand and supply relationships. As one or more of these short-term constraints is relaxed, the analysis moves towards a long-run perspective with changes possible between comparative market periods. Long-run elasticities are likely to be more elastic (or at least less inelastic) as new substitutes become available and other factors become dynamic.

A related, but conceptually different, measure of elasticity frequently encountered in economic analysis is the cross-price elasticity of substitution. Technically, the cross-price elasticity variable can relate to either substitution or to complimentary relationships between products. In this study, cross-price elasticity refers to the potential for substitution as indicated by a positive sign for the algebraic measure of elasticity. This measure of elasticity relates to the change in the consumption of one commodity (clearwood) in response to a change in price of a competitive and/or substitute product. If the algebraic sign of the cross-price elasticity is positive, then the two products would be considered to be substitutes for one another. For example, the consumption of lumber would be expected to increase if the relative price of plywood increases as users substitute lumber for plywood in some applications. If the cross-price elasticity is negative, the products are considered to be complimentary. For example, the consumption of nails may increase as the relative price of softwood lumber decreases.

It should be noted that cross-price elasticity is intrinsically related to long-term comparative changes in markets due to relative price fluctuations. In the short-run, the prices of all other commodities (substitute or complimentary) are assumed to be constant. The estimation of cross-price elasticity relaxes this short term assumption by allowing the price of a substitute (or complimentary) product to change relative to the price of the specific product under consideration. The measurement of cross-price elasticity is directly linked to a change in relative price. If the price of both goods increased proportionately, the real price relationship (relative price) would remain constant and thus no market response would normally be observed.

If two products are perfect substitutes with no perceived difference in quality or physical attributes between the two commodities, the cross-price elasticity of substitution would be infinite, indicating that as the price of one product rose, consumers would switch to the other product. This situation is applicable to non-differentiated commodities (*e.g.*, commodity grades of lumber or gasoline) where each supplier's product is presumed to be the same. Therefore, if one producer changes their price, consumers would (presumably) immediately substitute less expensive identical goods from other suppliers.

If two products are completely different (unique and fully differentiated) the cross-price elasticity of substitution would be zero, implying that a change in the price of one item would not affect the consumption of the other. Thus, the smaller the absolute value of the cross-price elasticity, the greater the product differentiation between two products. Conceptually, if the price of one good increases, a greater share of income may be devoted to the purchase of that good, reducing the remaining income available for expenditure on the second good. The reverse would be true with a price decrease. Available income is another demand shifter for the product being considered, but this "income effect" is normally assumed to be insignificant where moderate to small changes in relative price and consumption are implied relative to total consumer expenditures.

Price differentials do exist between different types and grades of softwood lumber products precisely as a result of the fact that lumber products are not identical (e.g., grades, species) and are thus partially differentiated in terms of end use demand. Intermediate and secondary producers, as well as final consumers, are willing to pay different prices to obtain a different set of product attributes. The willingness to pay such premiums over time is expressed by the stability in both the absolute and relative premium. A change over time in the relative price indicates a changed willingness to maintain the price differential, either due to a change in the perceived attributes (change in the product quality) or the greater advantage (availability and/or price) of possible substitutes. Relative price changes therefore indicate the extent to which past differentiation may be changing in the face of contemporary changes in softwood lumber markets.

One of the major difficulties in determining price elasticities for lumber products is that short-term price and quantity changes can be due to unexpected supply and demand shifts. Such changes, when experienced, may be perceived as only temporary, with relatively little response, or permanent, leading to a sequence of longer term dynamic adjustments. For large relative price changes, short-term price elasticities might not necessarily be reflective of ongoing market change where demand or supply shifters can be assumed to be dynamic (Irland Group and Joel Popkin and Co. 1993). In such cases, measures of short-term (static) price elasticities may not be very helpful. On the other hand, for long-term elasticities (after market dynamics are allowed), observed market changes may confuse second-order changes for one commodity (own-price elasticity response) with simultaneous substitution changes occurring for other products (cross-price elasticity) as well.

Estimates of price elasticities for softwood lumber

Many studies have sought to examine both own-price and cross-price elasticities of demand for softwood timber and lumber products. These deal with the both short- and long-run relationships between different species groups and/or end-use markets (Hseu and Buongiorno 1993, Phelps 1993, Adams *et al*. 1992, McKillop *et al*. 1980, Waggener et al 1978). Fewer studies have been done concerning the substitution of non-wood products for specific grades of softwood lumber, primarily due to limited prices series for new products, incompatible volume comparisons, or the introduction of new technologies (Moffett 1993, Prins 1993, Adams *et al*. 1992, McKillop *et al*. 1980).

Own-Price Elasticities of Demand. A review of elasticities of demand for softwood lumber products was carried out by Phelps (1993). This research note summarized the findings of many earlier studies conducted in both the United States and Canada regarding both supply and demand elasticities. Domestic demand for both North American and foreign supplies were summarized. Domestic demand related to the demand expressed by users/consumers within North America, explicitly excluding the additional or incremental demand expressed by potential buyers in other countries. Total demand was inclusive, recognizing the combined influence of both domestic and export demand (Table 3).

The studies cited include a wide variety of product classifications, ranging from an aggregation of softwood lumber to separate aggregations for softwood and hardwoods. End uses were identified by some researchers, most commonly utilizing residential and non-residential components, while Mills and Manthy (1974) defined elasticities for primary and secondary uses. Several studies were focused on the demand for a single species of softwood lumber. Unfortunately, in none of the reviewed studies were the product classifications sufficient to derive elasticity estimates for clearwood lumber grades.

The estimates summarized by Phelps most frequently utilized annual data observations, with less frequent observations made on a monthly or quarterly basis. Most elasticity estimates were long-run, implying measured market responses over a defined period of time which exceeded the data period. For example, a long-term estimate may rely on a five year adjustment to annual changes as revealed by the use of annual data.

As noted above, the theoretical definition of elasticity is static; that is, elasticity is defined as the response to a stated price change on the quantity demanded during the fixed market period. The use of long-term elasticities introduces an element of dynamic adjustment, whereby factors other than own-price elasticity can and will impact

Table 3. Elasticities of total demand for North American softwood lumber (Phelps 1993).

Country/region	Elasticity	Short/Long Run	Authors	Comments
Canada	-0.02	LR	Sharma (1986)	Residential construction
Canada	-0.05	LR	Gellner, Constantino, and Percy (1991)	Residential and non-residential construction
US	0.03	LR	Mills and Manthy (1974)	Douglas-fir wholesale price index (primary, secondary)
	-0.08			
US		LR	Mills and Manthy (1974)	Southern pine wholesale price index, primary price index, secondary
	0.51			
	0.44			
US	-0.88	LR	Robinson (1974)	Douglas-fir
US	-0.08	LR	Adams (1977)	Softwood lumber
US	-0.35	LR	Waggener, Schreuder, and Hoganson (1978)	Softwood lumber
US		LR	Adams and Haynes (1980)	Regional
NW	-0.30			
SW	-0.34			
Rocky Mountains	-0.40			
N Central	-0.40			
NE	-0.39			
SE	-0.34			
US	-0.17	LR	McKillop, Stuart, and Geissler (1980)	Softwood lumber
US	-0.91	LR	Rockel and Buongiorno (1982)	Softwood lumber, Douglas-fir
US Pacific NW	-0.36	LR	Merrifield and Haynes (1983)	lumber and plywood (US and Canada)
	0.06			
US	-0.29	SR	Spelter (1985)	Point elasticity
	-0.16			
	-0.13			
	-0.11			
US	-0.88	LR	Spelter (1985)	Point elasticities (period)
	-0.39			
US	-0.17	LR	Adams, McCarl and Homayounfarrokh (1986)	
US	-0.38	LR	Sharma (1986)	Residential construction
US	-0.27	SR	Lewandrowski (1989)	Southern pine
US	-0.04	SR	Lewandrowski (1989)	Douglas-fir, western pine
	-0.22			
US	-0.38	LR	Gellner, Constantino, and Percy (1991)	Residential and non-residential housing
US	-0.60	LR	Seldon and Hyde (1991)	Sawmill and planing mill output
US	-0.13	SR	Adams, Boyd, and Angle (1992)	Residential and non-residential housing
	-0.55	LR		
	-1.15	LR		
US	-0.67	SR	Lewandrowski (1992)	Southern pine
	-0.15			Douglas-fir
	-0.14			Western pine

the quantity demanded. In this sense, long-term elasticity estimates a composite response to own-price elasticity together with a mixture of other factors normally assumed to be constant in the short-run.

The short-run own-price elasticities summarized in Table 3 clearly illustrate the general finding that softwood lumber demand elasticity is highly inelastic. The negative sign on all the measures of elasticity indicate that the change in quantity demanded is inverse to the assumed price change. A rise in price (+) will result in a decrease in quantity demanded (-) assuming all other factors remain constant. The absolute measure of short-term own-price elasticity ranges from 0.035 to about 0.285 with the majority in the range of 0.15 to 0.20. This simply means that for small to moderate price changes, softwood lumber demand is highly inelastic, with proportionately small changes in the quantity of lumber being demanded so long as all other factors remain constant.

The estimates for long-term demand elasticities are more variable. As noted, these estimates attempt to include both the response to own-price changes and the subsequent market dynamics of a longer period as other factors in the marketplace adjust. An important contributing factor is the possible substitution of other products for softwood lumber as users reconsider their decisions in light of changing softwood lumber prices.

The long-term elasticities for softwood lumber summarized by Phelps range from approximately 0.02 to 1.15. The lower of these values approaches the values observed for short-run elasticities noted above. In general, however, the long-term estimates of elasticity reported by Phelps range from 0.45 to 0.60. The higher range estimates, however, indicate considerably more market response, although the absolute values fall below 1.00, indicating inelastic demand. It is not possible here to completely interpret the many different estimates provided, the differences in methodology and estimation techniques, or the different data utilized. Nevertheless, it would appear that long-term elasticities for softwood lumber increase, on average, by approximately 0.30 to 0.65 over short-term estimates. This response in the estimates is consistent with theoretical considerations, whereby other factors impact the quantity of softwood lumber demanded in the long-run, in addition to own-price elasticity.

Cross-Price Elasticities for Lumber Products

By timber species. One aspect of softwood lumber substitution/elasticity research has focused on the substitution between different timber species. Hseu and Buongiorno (1993) found small cross-price elasticities between the various species commonly exported from Canada to the US. Market export price effects existed for all species (large own-price substitution) while substitution effects were found to be species specific.

Sedjo *et al*. (1994), in investigating the radiata pine log market, found that this market was strongly influenced by US log prices. A 4 to 5% increase in radiata pine consumption was associated with each 1% increase in the price of US logs. Among wood based and non-wood substitutes, a doubling in the price of structural softwood lumber was estimated to increase brick consumption by 51%, cement consumption by 15%, and structural steel consumption by 32% (Prins 1993). Cross-price elasticities among wood-based construction materials were estimated to be low but highly significant. (Rockel and Buongiorno 1982).

By end-use market. An analysis of elasticities by end-use market has also been undertaken (Adams *et al*. 1992) The authors studied elasticities for construction end-use markets, where they segmented the repair and remodeling sector rather than treating the construction sector as an aggregate. Although the end-use markets were broadly defined, they found that lumber own-price elasticities varied widely depending on the end-use market. They found significant decreasing cross-price elasticity trends for the residential repair and remodel market since 1950. They attributed this decline to the decreasing share of lumber to total costs and a decreasing own-price elasticity of demand for wood-based inputs. Although other studies appear to indicate a decline in short-term elasticities over time, the studies are not comparable. For the manufacturing sector, the end-use market is so large and heterogeneous that a meaningful aggregate measure of specific raw material inputs is unavailable (Adams *et al*. 1993).

Other conceptual and analytical difficulties also exist for estimation of cross-price elasticities. Earlier studies generally do not allow for quantifying the market responses to technology and policy changes. It is also difficult to differentiate changes in own-price elasticity over time from the cross-price effects which are important for estimating cross-price elasticity (Spelter 1985). It should be noted that many studies of own-price elasticities incorporate time lag variables to allow for measurement of the diffusion of change in consumption in response to price changes. A price change in Period 1, for example, may be related to an observed change in consumption in Period 4, presumably after buyers have had time to observe market changes and adjust their consumption decisions accordingly. While attempts have been made to account for the influence of other dynamic variables, the resulting own-price elasticity estimates obviously include some substitution effects (Waggener *et al*. 1978). Spelter (1985) noted that cross-price elasticities change as the diffusion process proceeds. Adjustments do not proceed immediately, but as markets react to dynamic changes over time (diffusion of adjustments), elasticities decline at a decreasing rate. In general, most elasticity of substitution studies undertaken have focused on structural materials because of the greater availability of composite price series which are available for the substitutes (McKillop *et al*. 1980, Mills and Manthy 1974).

CLEARWOOD SURVEY

Survey Design and Methodology

A mail survey was developed and implemented to identify manufacturers perceptions of clearwood lumber, as well as to assess the importance of various clearwood lumber attributes on the softwood lumber purchase decision. A national survey of clearwood users was carried out in the spring and summer of 1995. An advisory board, comprised of members of the forest products industry, industry associations, and the USDA Forest Service was assembled to provide guidance during the course of the project. The following sections describe the development of the survey instrument, sample frame selection, data collection, assessment of non-response bias, and the statistical analysis of the survey data.

Survey instrument

In order to address the problem of defining clearwood, a set of softwood lumber attributes was developed through a review of the literature and exploratory interviews with managers of firms that utilize clearwood lumber as a raw material input in their manufacturing process. The initial list of attributes was refined by the researchers and submitted to the members of the advisory board for comment. The final list of clearwood attributes was incorporated into the survey instrument where respondents were asked to rate the importance of each attribute in influencing their purchase decision using a seven point Likert-like scale.

Participants were also asked to identify any products that they had used as a substitute for softwood lumber. The list of substitute products was developed from a review of the literature and from advisory board member input. Respondents were next asked to rate the importance of a set of variables in influencing their decision to use substitute products. As with the previous question, importance was measured with a seven point Likert-like scale where a rating of ‘1’ was defined as being not important and a rating of ‘7’ was very important.

In order to aid in the analysis of the data, demographic information was collected from each respondent. At the beginning of the survey, each respondent was asked to provide information on the volume of softwood lumber used in their manufacturing process, the source of their softwood lumber, and the grade of lumber used. In the second section they were asked to identify the species of lumber used in the manufacture of each product line. Finally, each respondent was asked to indicate the firm’s number of employees, location, and gross sales revenue.

The survey instrument was thoroughly pre-tested by industry managers, industry experts, and marketing faculty members experienced in survey methodology. Following modification of the preliminary questionnaire, the revised survey was administered to five industry managers to obtain their comments. To encourage participation, the questionnaire length was kept to minimum.

Census of industrial consumers of clearwood

The population of interest for the survey consisted of secondary manufacturers in those industry segments that traditionally utilize clearwood lumber in their production process. The industry segments of interest included: moulding, millwork, doors, windows, stairs, and flooring. The population of manufacturers was compiled from various industry association directories (*i.e.* Wood Moulding and Millwork Producers Association, Wood Window and Door Association, and the Southeastern Lumber Manufacturers Association) and the *Directory of the Wood*

Products Industry. The final sample frame consisted of 1,719 manufacturers. In order to increase the accuracy of the survey, a census of manufacturers was conducted.

Given the time constraint and large sample size, a mail survey was determined to be the most effective and cost efficient method for collecting data (Dillman 1978). Each participant was sent a survey questionnaire with a stamped, self-addressed, return envelope. A cover letter described the purpose of the study and ensured participants that their responses would be kept strictly confidential. In addition, each participant was offered a copy of the research findings as an incentive to participate in the survey. Follow-up post cards were mailed to each participant at two and four week intervals to increase the likelihood of their participation in the project. Copies of the survey instrument, cover letter and follow-up postcards are presented in Appendix A.

Of the 1,719 questionnaires mailed, a total of 319 responses were obtained, of which approximately half (142) were deemed to be unusable because they were either incomplete or the respondent indicated that they did not utilize clearwood lumber in their manufacturing process. Based on the remaining 177 usable responses, the effective response rate for the survey was calculated to be 11.6% using the following formula:

$$R = \frac{U}{(M - ND - NCU)}$$

where:

R = *response rate*
U = *number of usable responses*
M = *total number of questionnaires mailed*
ND = *number of undeliverable questionnaires*
NCU = *number of firms not using clearwood*

Non-response bias

Non-response bias is a significant concern in the interpretation of survey data because of the possibility that survey respondents may differ in some way from non-respondents (Fowler 1984, Armstrong and Overton 1977). If non-response bias exists, then the information obtained from the survey may not be representative of the population. In order to test for non-response bias, the Armstrong-Overton method for analyzing time responses across early and late respondents was employed. The Armstrong-Overton method uses late respondents as a proxy for non-respondents on the assumption that late respondents are more like non-respondents than are early respondents. Early and late respondents were tested across a number of survey questions and no significant differences were detected, an indication that non-response bias was not a factor in the analysis of the survey responses.

Results and Discussion

Demographic Description of Survey Respondents

This section summarizes the demographic data obtained from the questionnaire. Respondents were asked several questions concerning their manufacturing operation, including the total volume of softwood lumber purchased, their total sales revenue, the geographic location of their manufacturing facility, the number of workers employed, and their primary manufacturing activity. Other descriptive information relates to the source of timber purchases, grade of timber used, and the distribution of species used in their different product lines

The first question of the survey asked the respondent to estimate the total volume of softwood lumber used annually in their manufacturing operations (Table 4). The results of this question indicated that the total volume of softwood lumber utilized by responding firms was approximately 889 million board feet (mmbf). While the average annual volume of softwood lumber used totaled 5.8 million board feet per firm, the median annual volume of softwood lumber used was 700,000 board feet. The average volume used was skewed by a number of large firms that used well over 10 million board feet of lumber annually. In contrast, almost 60% of the respondents indicated that their manufacturing operation used less than 1 million board feet, while about one-third of the responding firms used less than 100,000 board feet of softwood lumber. This information provides a strong indication that the typical firm using clearwood lumber as a raw material input was a small- to medium-sized firm.

Respondents were also asked to report their annual sales revenue (Figure 3). The analysis of the survey data indicated that the average sales revenue for the responding firms was almost $9.1 million, although the median sales revenue was determined to be a more modest $2.8 million. The average revenue figure was skewed by the responses of a few large firms. Almost half of the respondents reported that their annual sales revenue was less than $2.5 million, while approximately one-third reported having annual sales revenue of less than $1 million. The annual sales revenue data provides further support that survey respondents tended to be small- to medium-sized firms.

The survey also asked respondents to describe their position within the firm. Thirty-six percent of the respondents indicated that they were the president/CEO of the firm, 14% were the owner of the firm, and another 14% were the purchasing manager. The remaining respondents held a variety of other positions within their firms, including vice president (10%), general manager (9%), manufacturing manager (7%), and sales/marketing manager (4%). Given the national structure of the sample frame, the survey data was analyzed to determine the geographical distribution of the respondents. The results of the analysis indicated that the largest segment of the firms was located in the northeastern US (33%), followed by the northwest (26%), the southwest (25%), and the southeast (16%).

Table 4. Percentage of solid softwood lumber purchased by respondents' firms annually.

Volume (mbf)	Number of respondents[a]	Percent of firms responding
10,000 or less	28	18
10,000 <= 100,000	25	16
100,000<= 1,000,000	35	22
1,000,000 <= 10,000,000	42	27
Over 10,000,000	23	15

[a]n=163.

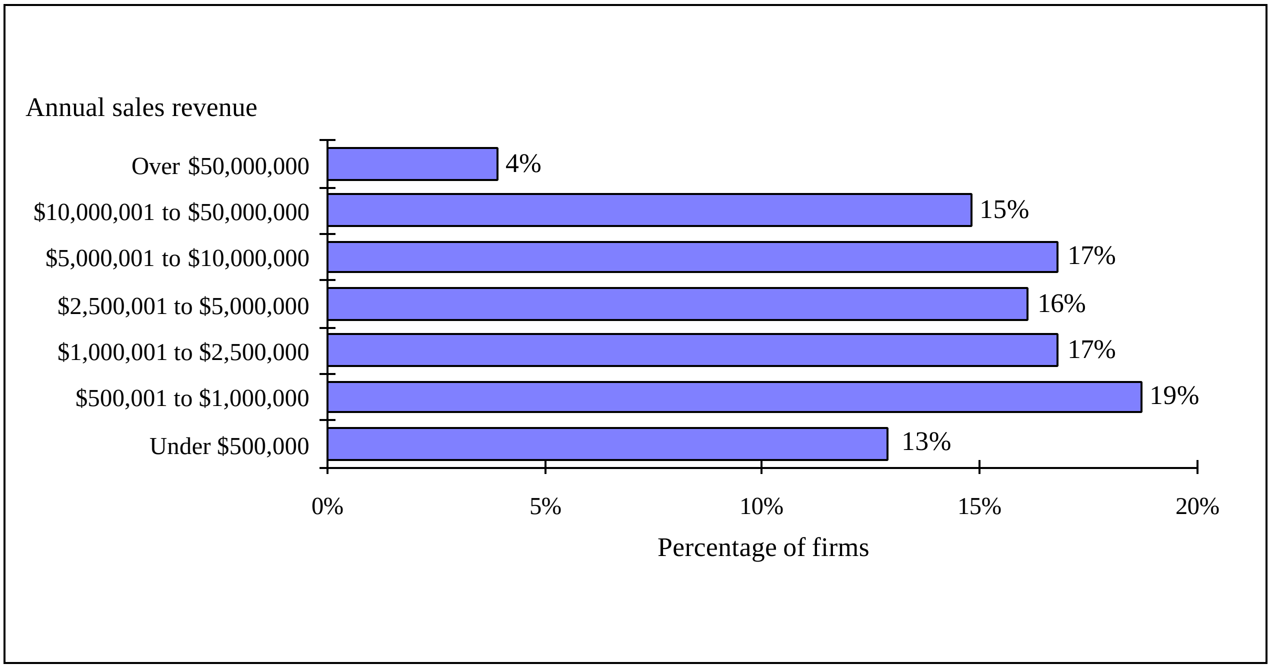

Figure 3. Distribution of firms by annual sales revenues in 1994.

One of the objectives of the survey was to determine where manufacturers were sourcing the raw material used in their operations. This question was of particular interest because of recent speculation that US firms have begun to source their raw materials from offshore suppliers in response to both supply restrictions and the price instability of domestic lumber. When asked where they purchased their softwood lumber, the overwhelming majority of respondents indicated North America, including the US, Canada, and Mexico (Table 5). While New Zealand provided the largest volume of imported softwood timber (2.6% of the total lumber purchased by respondents), less than 5% of the total volume of softwood lumber purchased by respondents was obtained from offshore suppliers.

Profile of Industry Segments

One objective of the study was to identify industry segments that use clearwood lumber and to evaluate how their use of this product was changing. Respondents were asked to estimate the annual volume of lumber dedicated to the manufacture of specific product lines. This information was used to segment firms by their primary manufacturing activity since many firms are involved in the manufacture of more than one product line. Analysis of the survey data indicated that moulding manufacturers comprised the single largest industry segment, with 33% of respondents indicating that they were involved in the manufacture of moulding products (Figure 4). Other

Table 5. Source of timber used by manufacturers, by country of origin.

Source Country	Percent	Cumulative Percent
North America	95.5	95.5
New Zealand	2.6	98.1
Chile	0.9	99.0
Brazil	0.6	99.6
Other countries	0.4	100.0

industry segments included in the survey were millwork manufacturers (14% of respondents), door manufacturers (10%), window manufacturers (8%), pallet and packaging manufacturers (7%), structural products manufacturers (6%), and manufacturers of miscellaneous products (22%). Producers of products such as toys, craft items, musical instruments, stair parts, furniture components, and cabinets were grouped together in the miscellaneous products category to ensure the confidentiality of their responses because of the small number of responding firms engaged in the manufacture of each of these products.

Firm size. The number of employees reported per firm ranged from 1 to 3,000 (Table 6). The average number of employees was 94, with 23% of the respondents employing 10 people or less, and a total of 65% of the firms employing 50 or less. The median number of employees was 30. The survey data indicates that moulding manufacturers, on average, tended to be small firms, purchased the smallest volume of softwood lumber, and had the lowest sales revenue, while window manufacturers, on average, had the highest number of employees, purchased the largest volume of softwood and had the third highest sales revenue.

Timber species used. One of the objectives of the study was to identify the timber species being used by secondary wood processors. In addition, the information from the survey was used to evaluate what timber species were used within specific industry segments and determine if there was a relationship between industry segment and the timber species being used as a raw material input. In order to assess the relationship between industry segment and timber species, respondents were asked to indicate what timber species they were using as a raw material input for each of their product lines.

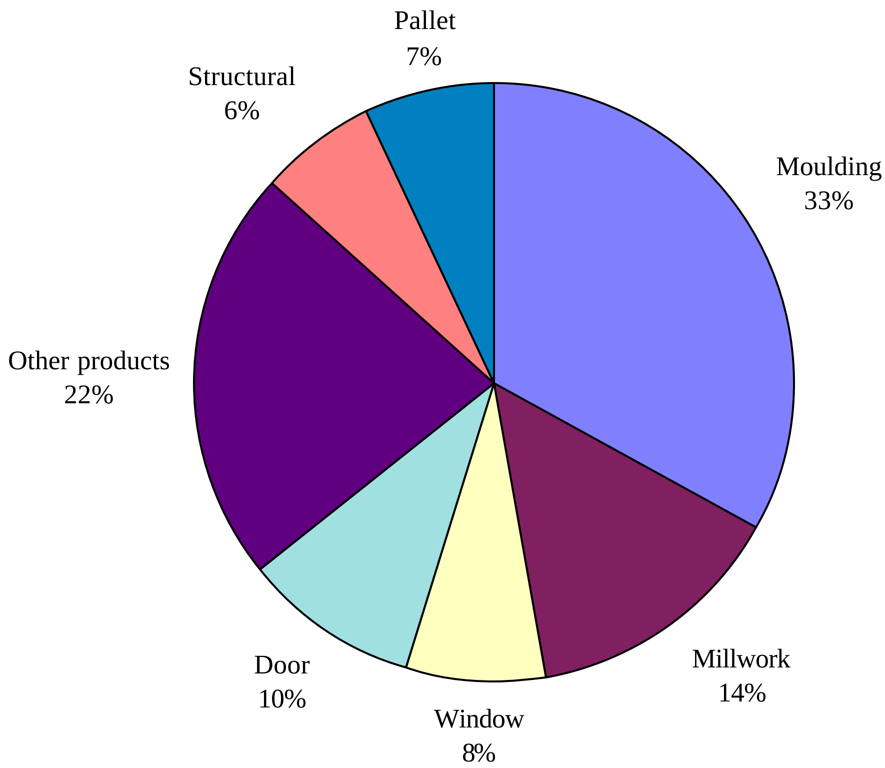

Figure 4. Industry segmentation of the firms responding to survey.

Table 6. Summary of the demographic characteristics of survey respondents, by industry segment.

Industry segment	Number of firms	Average number of employees	Average volume of lumber used, (mbf)	Average annual sales, ($000)
Moulding	48-51	53	2,453	6,318
Millwork	19-22	131	8,730	17,326
Windows	9-12	415	9,815	15,188
Doors	12-15	106	7,023	16,320
Pallets	10-11	56	2,886	9,195
Structural materials	9-10	61	7,187	7,602
Other products	29-34	56	5,401	5,609

The results of the data analysis indicated that ponderosa pine was the most prevalent species being used by the respondent firms, comprising 28% of softwood lumber inputs (Figure 5). Other important timber species being used included hem-fir (19%), southern yellow pine (15%), Douglas-fir (9%), and white pine (9%). Otherdomestic softwood species (*e.g*., western red cedar, redwood, lodgepole pine, and a spruce-pine-fir lumber mix) represented 14% of the raw material being used. Radiata pine was the only imported softwood species used in significant volumes, representing 7% of the raw material input reported by survey respondents.

There was a definite relationship between timber species and industry segment (Table 7). Over half of the raw material utilized by the moulding and millwork industries and almost three-quarters of the raw material input for the window industry was ponderosa pine. Similarly, almost two-thirds of the raw material input for door manufacturers consisted of hem-fir (33%) and Douglas-fir (31%).

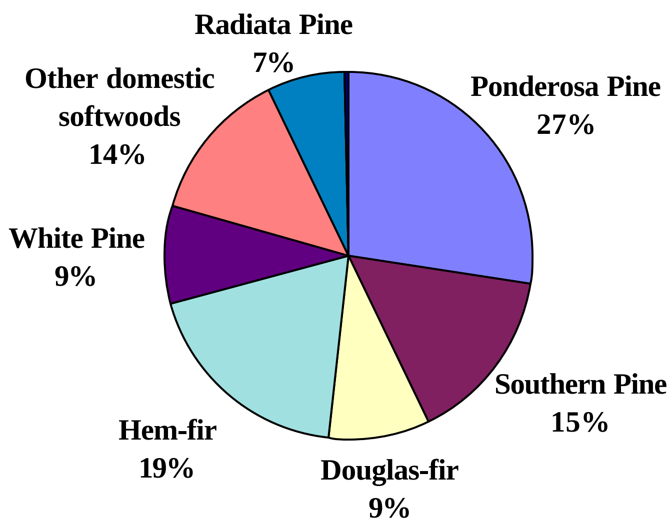

Figure 5. Summary of the timber species being used by respondents in 1994.

Table 7. Analysis of timber species used by responding firms, by industry segment.

Timber Species	Moulding	Millwork	Windows	Doors	Other
Domestic species					
Ponderosa pine	53%	51%	74%	15%	8%
Southern pine	10%	3%	4%	12%	17%
Douglas-fir	2%	4%	4%	31%	12%
Hem-fir	11%	25%	2%	33%	21%
White pine	9%	1%	8%	6%	23%
Other domestic	6%	1%	2%	4%	19%
Imported species					
Radiata	8%	14%	5%	0%	0%
Other imported	1%	0%	0%	0%	0%

Hem-fir was an important raw material input for all of the industry segments with the exception of windows, where it represented just 2% of the raw material. White pine was used to some extent in each of the main industry segments, with the exception of the millwork industry, although its use never exceeded 10% of the raw material input. Southern yellow pine was primarily used in the door and moulding industries, although it represented a small percentage of the raw material used by millwork and window manufacturers. Given the focus of the project on clearwood lumber, the pallet and structural products were integrated into the "other" category for this analysis and there does not appear to be a strong orientation towards a single species by these firms.

Radiata pine represented a substantial component of the raw material mix for manufacturers in the moulding and millwork industries (Table 7). Millwork manufacturers relied on radiata pine to supply 14% of their raw materials and it represented 8% of the raw material input for moulding manufacturers. Of the total volume of radiata pine lumber imported in 1994, 87% was used by the moulding and millwork industry, which used approximately 2.5 million board feet of radiata pine lumber.

Timber grades used. Respondents were also asked to identify the grades of timber that they used in their manufacturing operations, based on a series of broad grade categories. Respondents indicated that the raw material mix used in their manufacturing operations was derived from eight softwood lumber grades (Table 8). While more firms (69) used C & Better lumber than any other grade of softwood lumber, shop grade lumber was by far the most widely used grade of softwood lumber, representing 45.5% of the total volume of lumber used. Although eight grades of softwood lumber were utilized by respondents, just three grades represented nearly three-quarters of the total softwood lumber used: Shop, Common, and Standard & Better.

Figure 6 provides a summary of the grades of softwood lumber segmented by the primary industry groups that traditionally utilize clearwood lumber. The most commonly used softwood lumber grades across all of the industry segments were Shop and Common. The primary softwood lumber grades used by moulding manufacturers were Moulding (both stain and paint grade), while millwork manufacturers favored Shop grade lumber. Both window and door manufacturers reported using a similar mix of softwood lumber grades, although window manufacturers used more Common grade lumber while door manufacturers used more C&Better grade lumber. Finally, manufacturers of structural products used more Common, Standard & Better, and Shop grades of lumber than anything else.

Interestingly, the moulding, millwork, door, and window manufacturers reported using more Shop lumber than any other grade of softwood lumber. Traditionally, the greatest volume of high grade lumber (Moulding and C&Better) has been utilized within the moulding, millwork, and door industries. This is still the case, although the proportion of high grade lumber in their raw material mix appears to be declining. This change in raw material mix can be attributed in part to reduced availability and high price of high grade softwood lumber. In addition, changes in products and product lines have also impacted the type of raw material used in the manufacturing process.

Table 8. Summary of lumber grades used by responding firms.

Lumber Grade	Number of Firms Using	Lumber Volume (mmbf)	Percent of Total
Moulding: stain	46	39.3	4.4
Moulding: paint	26	38.0	4.3
C & Better	69	58.0	6.5
D	36	22.4	2.5
Common	46	138.9	15.6
Standard & Better	40	105.4	11.9
Cutstock	30	73.4	8.3
Shop	52	404.8	45.5
Other	4	8.6	1.0

Clearwood Lumber Attributes

Another objective of the study was to determine the relative importance of different softwood lumber attributes. Respondents were asked to rate the importance of sixteen different softwood lumber attributes with respect to their manufacturing operation. The importance of each softwood lumber attribute was rated using a seven point Likert-like scale where a score of “1” indicated that the attribute was not important, while a score of “7” indicated that the attribute was considered to be very important.

The mean importance rating for each lumber attribute is presented in Figure 7. The importance data was analyzed using a variety of statistical techniques. First, the statistical test known as Hotelling’s T^2 was used to determine if the attribute means were significantly different from the intermediate rating of 4. If they were not found to be statistically different from four, the attribute had less impact on the respondents lumber purchase decision. On the basis of the statistical analysis, it was found that twelve of the attributes had importance ratings that were significantly higher than four and were consequently perceived by respondents to be important.

Reliability of supply, price, and price stability were identified as the three most important attributes, with mean importance ratings of 6.17, 5.99, and 5.89 (Table 9). In contrast, those factors associated with old-growth clearwood lumber (*e.g*., absence of knots, straight grain, uniform color, narrow growth rings, and vertical grain) were rated much less important than the other attributes, generally receiving mean importance ratings below five. Lumber attributes associated with the technical properties of lumber received intermediate importance ratings when compared to the economic and old-growth type attributes.

Unfortunately, the sample sizes of some of the industry segments were too small to perform a statistical analysis of the importance ratings across industry segments. Rather, a comparison of the average importance rating was performed across industry segments (Table 9). While there was some variation in mean importance ratings for the different lumber attributes across the industry segments, they were not significantly different from the overall mean importance ratings presented in Figure 7. However, lumber attributes typically associated with clearwood lumber grades were again rated lower than many of the other attributes on an industry segment basis.

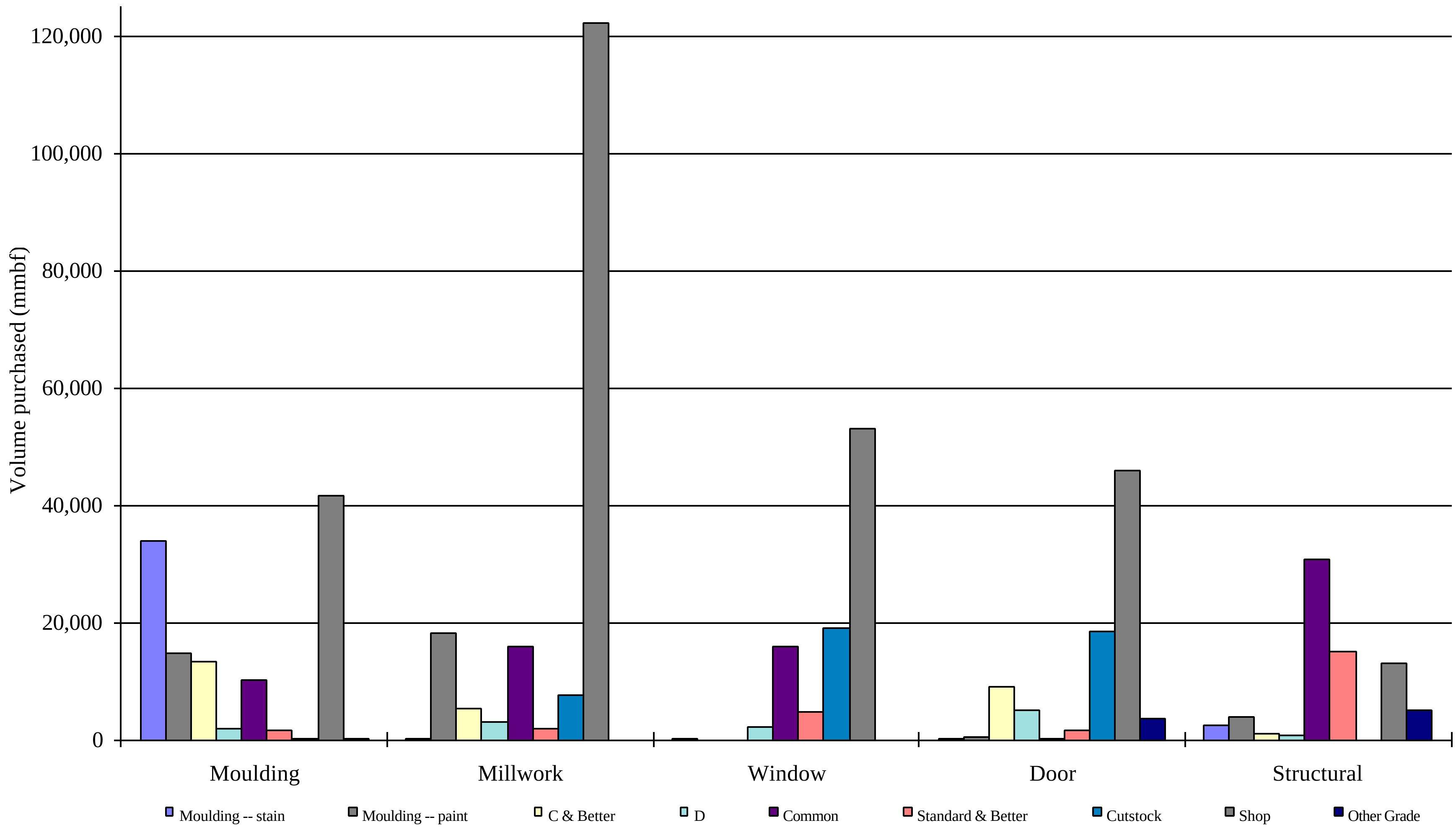

Figure 6. Lumber grades purchased by respondents, by industry segment.

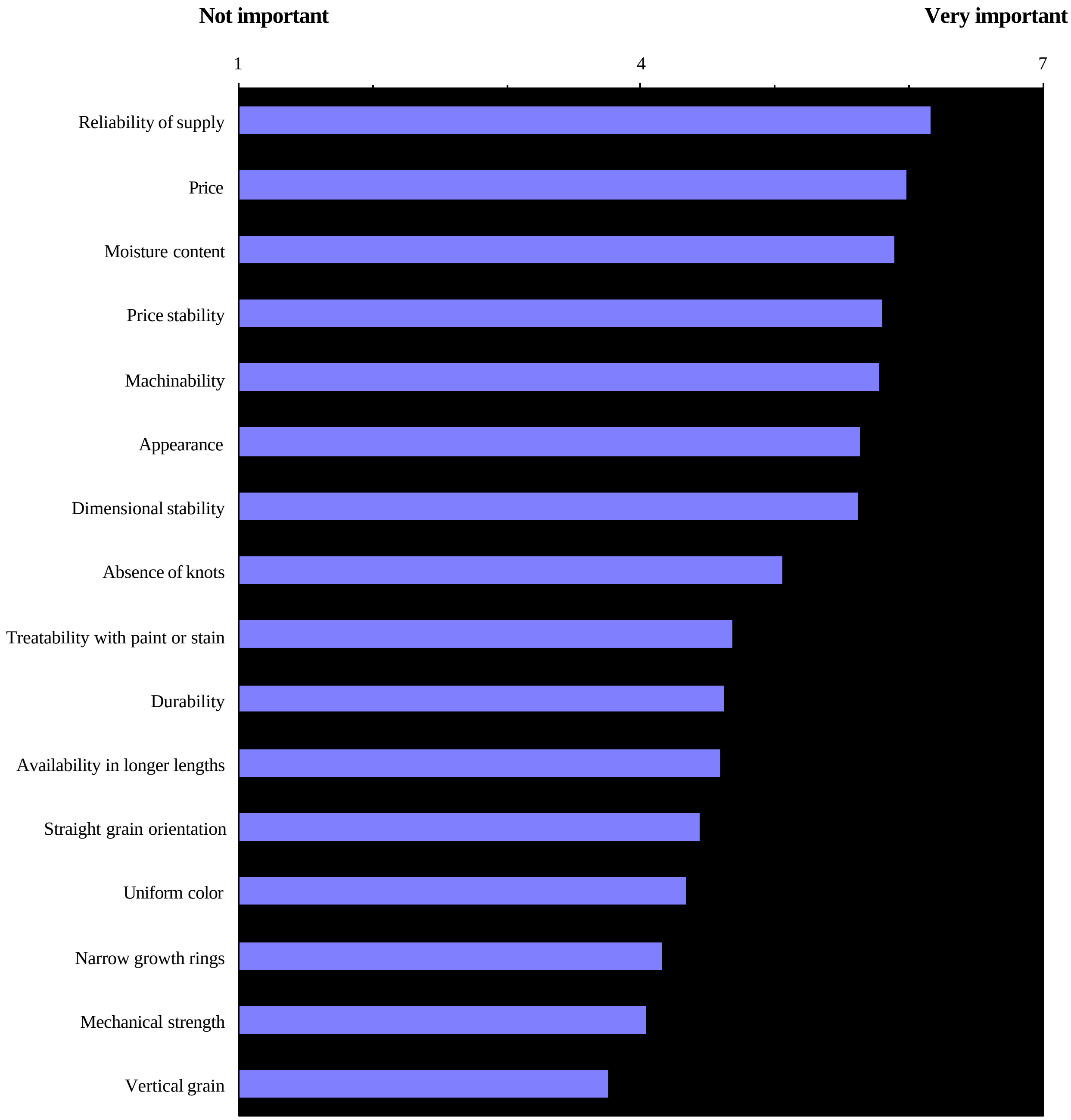

Figure 7. Average importance ratings of clearwood attributes.

Table 9. Mean importance rating for softwood lumber attributes by industry segment.

Softwood Lumber Attribute	Industry Segment					
	All	**Moulding**	**Millwork**	**Window**	**Door**	**Structural**
Reliability of supply	6.17	6.25	5.90	6.55	6.40	6.60
Price	5.99	6.08	5.60	6.09	6.20	5.50
Moisture content	5.89	6.32	5.95	6.45	6.47	5.70
Price stability	5.81	5.90	5.48	6.09	5.73	5.90
Machinability	5.78	6.25	5.62	6.09	6.07	5.40
Appearance	5.64	5.67	5.71	6.00	6.13	6.00
Dimensional stability	5.63	5.59	5.81	6.09	6.27	5.50
Absence of knots	5.06	5.42	5.76	5.27	5.67	4.60
Treatability with paint or stain	4.69	5.18	4.62	5.82	5.27	3.80
Durability	4.63	4.35	5.10	5.09	5.43	5.00
Availability in longer lengths	4.60	5.12	4.52	4.70	4.60	4.70
Straight grain orientation	4.44	4.80	4.71	5.27	5.14	4.30
Uniform color	4.34	4.52	4.57	5.36	4.67	3.80
Narrow growth rings	4.16	4.37	4.24	5.10	5.13	3.90
Mechanical strength	4.04	3.77	4.00	4.27	4.40	4.40
Vertical grain	3.77	3.53	4.19	4.82	4.40	3.20

Factor analysis of softwood lumber attributes. Another objective of this study was to identify a subset of softwood lumber attributes that could be used to represent the concept of clearwood lumber. This was done using a multivariate statistical technique known as principal component factor analysis. The basic premise of a factor analysis is that a subset of underlying, often undetected, and uncorrelated factors can be used to simplify and explain the complex relationships within a larger set of correlated attributes (Hair *et al*. 1995). These factors are based on the original attributes and can be represented by a linear combination of those attributes. In order for the factor analysis to be useful, each factor solution should be composed of a small subset of the original attributes. For example, the factor analysis of the clearwood lumber attributes generated a four factor solution, where factors I and II each contained five softwood lumber attributes, while factors III and IV each included three softwood lumber attributes (Table 10).

Quite often in a factor analysis each attribute will score moderately high on more than a single factor. To simplify the interpretability of the results, a varimax rotation procedure is used to transform the initial factor matrix orthogonally into one where each attribute scores high on a single factor and low on the other factors.

The factor analysis reduced the original 16 softwood lumber attributes to four factors that explained 65% of the total variance in the data. Factor I accounted for 35.5% of the total variance, Factor II 14.2%, Factor III 9.8%, and Factor IV 7.0% of the total explained variance (Table 10). Bartlett's test of sphericity, the Kaiser-Meyer-Olkin measure of sampling adequacy, and the anti-image correlation matrix were all used to evaluate the appropriateness of using a principal components factor analysis on this set of data. The results of each of these tests indicated that a factor analysis was appropriate.

Those softwood lumber attributes that receive high loading scores for a particular factor are grouped together (Table 10). By examining those attributes that score high on each particular factor, we can facilitate the interpretation and labeling of the factors. For example, Factor I contained the following softwood lumber attributes: narrow growth rings, vertical grain, straight grain, absence of knots, and uniform color. Based on the fact that each of the softwood lumber attributes contained in the first factor related to the quality of softwood lumber, the first factor was given the label "timber quality". Following a similar procedure, Factor II was labeled "manufacturing properties," Factor III "mechanical properties" and Factor IV "economic characteristics."

Table 10. Summary of the factor analysis solution and the factor loading scores.

	Rotated Discriminant Function Loading Scores			
Softwood Lumber Attributes	**Factor I: timber quality**	**Factor II: manufacturing properties**	**Factor III: mechanical properties**	**Factor IV: economic characteristics**
Narrow growth rings	***.853***	.153	.086	.090
Vertical grain	***.814***	-.010	.264	.066
Straight grain orientation	***.755***	.354	.264	.066
Absence of knots	***.665***	.377	.156	-.083
Uniform color	***.556***	.541	-.187	.081
Uniform moisture content	.140	***.759***	.133	.109
Treatability with paint or stain	.376	***.671***	.066	.118
Machinability	.124	***.657***	.453	.231
Availability in longer lengths	.469	***.544***	.060	-.129
Appearance	.395	***.525***	-.130	.117
Mechanical strength	.083	-.055	***.825***	.114
Durability	.195	.095	***.795***	.028
Dimensional stability	.004	.506	***.622***	.083
Price stability	.079	.147	.148	***.873***
Price	-.053	-.005	-.027	***.865***
Reliability of supply	.048	.481	.280	***.572***

It is important to note that that the factors are not listed in any particular order with respect to their perceived importance by the survey respondents. Rather, they are simply listed in a declining order based on their ability to account for the variance within the survey data. For example, while the factor analysis listed timber quality as the first factor, the lumber attributes contained in this factor generally received the lowest mean importance ratings by the survey respondents.

The results of the factor analysis indicate that the original sixteen softwood lumber attributes can be reduced to four factors which capture 65% of the variance contained in the original data. This suggests that rather than using sixteen attributes to describe softwood lumber, we can describe softwood lumber based only on its quality characteristics, manufacturing properties, mechanical properties, and economic characteristics. It is interesting to note that all of the softwood lumber attributes associated with old-growth clearwood lumber were grouped together under the "timber quality" factor. This would suggest that these five lumber attributes might form the basis for defining clearwood lumber.

Perceptual map of industry segments. The preferences of survey respondents for particular lumber attributes can be further analyzed by using a perceptual map to locate each industry segment within a two dimensional space. The axes of the perceptual map are defined by the factors generated from the factor analysis, where the scale of the axis indicates the distance of the industry segment (in standard deviations) from the mean score for each factor. For example, the closer that an industry segment is located to the center of the plot, the closer its members were to the average score for that particular factor. Industry segments that rated a factor as being important will be located in a positive direction from the center of the map, while those segments that rated a factor as being less important will be located in a negative direction.

A perceptual map displaying the relationship between the different industry segments along Factors I and II is presented in Figure 8. The vertical axis represents timber quality, while the horizontal axis represents manufacturing properties. Industry segments that rated the attributes in both factors as being important will be

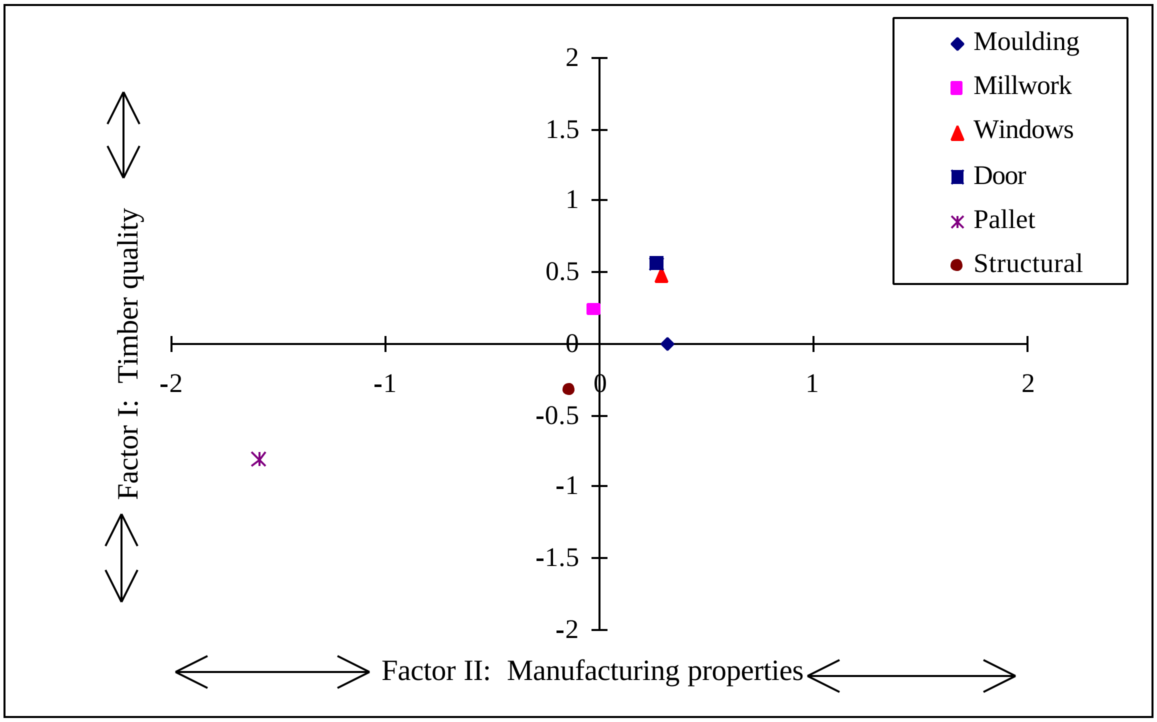

Figure 8. A perceptual map of industry segments along timber quality and manufacturing properties.

located in the upper right quadrant of the map, while an industry segment that rated both factors as being less important will be located in the lower left quadrant of the map.

The results of the perceptual map indicate that both door and window manufacturers attach similar importance rating to the two factors when purchasing softwood lumber for their manufacturing operations. They are also the only industry segments that rated both factors as being important factors in their raw material purchase decision, as indicated by their location in the upper right-hand quadrant of the map. Finally, manufacturers in these industry segments attached a higher importance rating to the quality and manufacturing properties of softwood lumber than did any other group of manufacturers. In contrast, the perceptual map indicates that pallet and structural products manufacturers rated both factors as being less important considerations in their raw material purchase decision, although pallet manufacturers considered both sets of factors to be considerably less important than did the manufacturers of structural products.

Substitutes for Softwood Lumber

Another objective of this study was to identify industry segments that are currently using raw material substitutes for clearwood lumber and identify their reasons for using substitutes. An analysis of the survey data indicated that 98 respondent firms used substitutes for softwood lumber, while 79 firms did not.

The analysis of the survey data indicated that firms using a raw material substitute for softwood lumber on average purchased less softwood lumber, had higher sales revenue, and employed more workers than did firms that did not use substitutes (Table 11). These results indicate that larger firms tend to be the ones that are using substitute products in place of softwood lumber. This result suggests that larger firms may have more slack resources available to invest in new processing technologies that more efficiently utilize softwood lumber substitutes. In contrast, smaller firms may not have the financial or technical resources available that would allow them to capitalize on new materials or processing technologies. It may also be the case that larger firms are better able to

Table 11. Comparison of firms who have and have not used substitutes for softwood lumber.

	Average volume of softwood lumber purchased (bf)	Average sales revenue in 1994	Average number of employees
Have used substitutes	5,469,445	$10,754,875	122
Have not used substitutes	6,147,866	$7,367,600	61

accept the greater level of risk associated with adopting a new manufacturing technology or raw material input. Finally, larger firms generally have greater access to market information and, as a result, may be better able to identify and evaluate substitute products in their manufacturing process in response to dynamic market changes or discontinuous market conditions.

Survey respondents were asked to indicate the percentage of raw material substitutes they used in their manufacturing process as direct substitutes for softwood lumber during 1989 and 1994. The survey data indicates that in 1989, 58% of the respondents used substitute products to replace 31% of the softwood lumber inputs for their production processes. However, the amount of substitution was skewed by a few large manufacturers and the median value of softwood lumber substitution (5%) is likely more accurate. However, by 1994, 85% of the survey respondents reported that they were using substitute products to replace 36% of their softwood lumber requirements. The median value of softwood lumber substitution increased substantially to 24%. The increase in the volume of raw material substitutes used from 1989 to 1994 was significant at the .05 level.

Fifty-five percent of survey respondents indicated that they used at least one raw material substitute for softwood lumber in 1994. Of those using substitute products, 60% reported using hardwood lumber, 43% indicated using finger-jointed lumber, 39% used MDF, and 37% used plywood (Figure 9). The percentage of respondents who reported using non-wood based materials, such as metal and plastic/vinyl, was quite low. This may be an indication that these substitutes are more difficult to incorporate into existing manufacturing processes.

Use of wood-based substitutes, by industry segment. This study sought to determine the frequency of substitution on an aggregate basis as well as within specific industry segments (Table 12). Approximately 60% of the moulding manufacturers indicated that they were using a raw material substitute for softwood lumber. Of those responding, 65% used hardwood lumber in place of softwood lumber, 45% used MDF, and 45% used finger-jointed lumber. Approximately 77% of millwork respondents reported using raw material substitutes, with 80% using hardwood lumber, 47% using MDF, and 40% using finger-jointed lumber. Plywood was used by 40% of these respondents, while edge-glued lumber, veneer wrapped lumber and particleboard were each used by approximately 27% of the respondents.

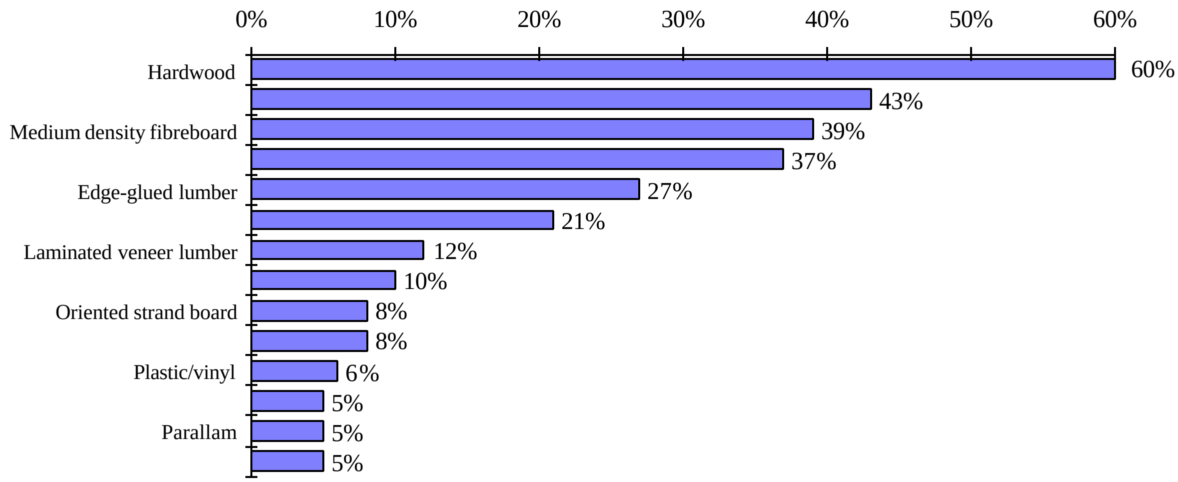

Figure 9. Percentage of respondents who have used raw material substitutes for clearwood lumber.

Over 80% of the window manufacturers responding to the survey indicated that they are using substitute products for softwood lumber. Fifty percent of the window manufacturers reported using edge-glued lumber while one-third reported using hardwood lumber, veneer wrapped lumber, LVL and Timberstrand lumber. While 83% of window manufacturers are using substitutes, only 62% of door manufacturers reported using substitute products. Approximately 85% of the door manufacturers responding to the survey reported using finger-jointed lumber in their manufacturing process. Sixty-two percent of the respondents use MDF, while hardwood lumber, particleboard, OSB and edge-glued lumber were each used 31% of the time. In contrast to window manufacturers, door manufacturers more often reported using panel products as substitutes for softwood lumber.

Table 12. Frequency (percent) of wood-based raw material substitution, by primary industry segment

Substitute Product	**Moulding**	**Millwork**	**Windows**	**Doors**	**Pallets**	**Structural**	**Other**
Hardwood lumber	65	80	33	31	80	25	61
Plywood	25	40	17	15	60	50	61
Particleboard	30	27	0	31	40	50	11
OSB	0	0	0	31	20	50	6
MDF	45	47	0	62	20	50	28
HDF	5	7	0	8	0	0	0
Finger-jointed lumber	45	40	0	85	0	50	22
Wrapped lumber	0	27	33	15	0	0	6
Edge-glued lumber	20	27	50	31	20	0	39
LVL	5	20	33	23	0	25	11
Timberstrand	5	7	33	23	0	0	6
Respondents using substitutes	60	77	83	62	67	100	50

Of the 67% of pallet manufacturers who reported using substitute materials, 80% indicated that they use hardwood lumber, while 60% use plywood and 40% use particleboard. Surprisingly, all of the structural manufacturers reported using at least one raw material substitute for softwood lumber, with most of the substitution occurring in the use of panel products. Fifty percent of the respondents producing structural products reported using plywood, particleboard, OSB or MDF as a raw material substitute. In addition, almost half indicated that they were using finger-jointed lumber to replace solid lumber in their products.

Use of non-wood substitutes, by industry segment. The non wood-based substitutes included in the survey consisted of plastic/vinyl materials and metal. The number of respondents using non wood-based substitutes was found to be relatively small (Table 13). Less than 10% of moulding, millwork, and door manufacturers reported using non wood-based materials. Similarly, 17% of window manufacturers and 20% of pallet manufacturers are using metal products as a substitute for softwood lumber. Twenty five percent of structural manufacturers used plastic/vinyl products as well as another 25% who reported using other non wood-based substitutes.

Factor analysis of substitute product attributes. Another objective of this study was to determine what factors influenced manufacturers to use alternative materials as substitutes for softwood lumber. Respondents were asked to rate the importance of 12 factors in influencing their decision to use alternative materials as substitutes for softwood lumber in their manufacturing process. Responses were reported using a Likert-like scale with a score of 1 being for those attributes that were not considered to be not important and a score of 7 being used for those attributes that were considered to be very important in influencing the substitution decision. The mean importance ratings for each attribute, with the exception of reduced environmental impact, exceeded a score of 4, indicating that most of the attributes were considered by respondents to be at least somewhat important in influencing their decision to utilize substitute products (Figure 10).

A principal component factor analysis was used to determine how important different attributes were perceived to be in influencing a manufacturer's decision to utilize substitute products for softwood lumber. The results of the factor analysis indicated that the twelve original variables could be reduced to two factors. These two factors were able to explain 61% of the total variance in the original data. After analyzing the variables that were included in each factor, the factors were labeled technical characteristics (Factor I) and price and supply (Factor II) (Table 14).

Perceptual map of industry segments. The results of the factor analysis indicate that clearwood manufacturers are likely to be influenced by the technical characteristics of the substitute product as well as by price and supply characteristics. When plotted on a perceptual map, which specifies industry segment positioning between the factors, one can see industry-specific characteristics that influence the decision to use substitutes for solid softwood lumber (Figure 11).

The groupings of different industry segments reveal the relevance of the attribute dimensions in addressing technical performance/consistent product specifications and price and availability. From this matrix, the window and door manufacturers appear to cluster in the positive areas of both dimensions, indicating similar factors influence their decision to utilize a substitute material for softwood lumber.

Table 13. Frequency (percent) of non-wood based raw material substitution, by primary industry segment.

Raw material substitutes	Moulding	Millwork	Windows	Doors	Pallets	Structural	Other
Plastic/vinyl	5	7	0	8	0	25	6
Metal	5	7	17	0	20	0	0
Other	5	7	0	0	0	25	11

Since the number of respondents in each group was too small to perform a principal component analysis for each manufacturing type, a comparison of the mean importance rankings for each attribute was performed by industry segment. The results indicate that the top three attributes were identical for each of the industry segments analyzed. The three most important attributes in influencing the respondents' decision to utilize a substitute material were: the price of the substitute product, availability, and reliability of supply (Table 15). In addition, window, door, and structural manufacturers reported that the price stability of substitute products has an important impact on their decision to utilize that product. The attribute "reduced environmental impact" was found to have the least influence on manufacturers' decision to use a substitute product.

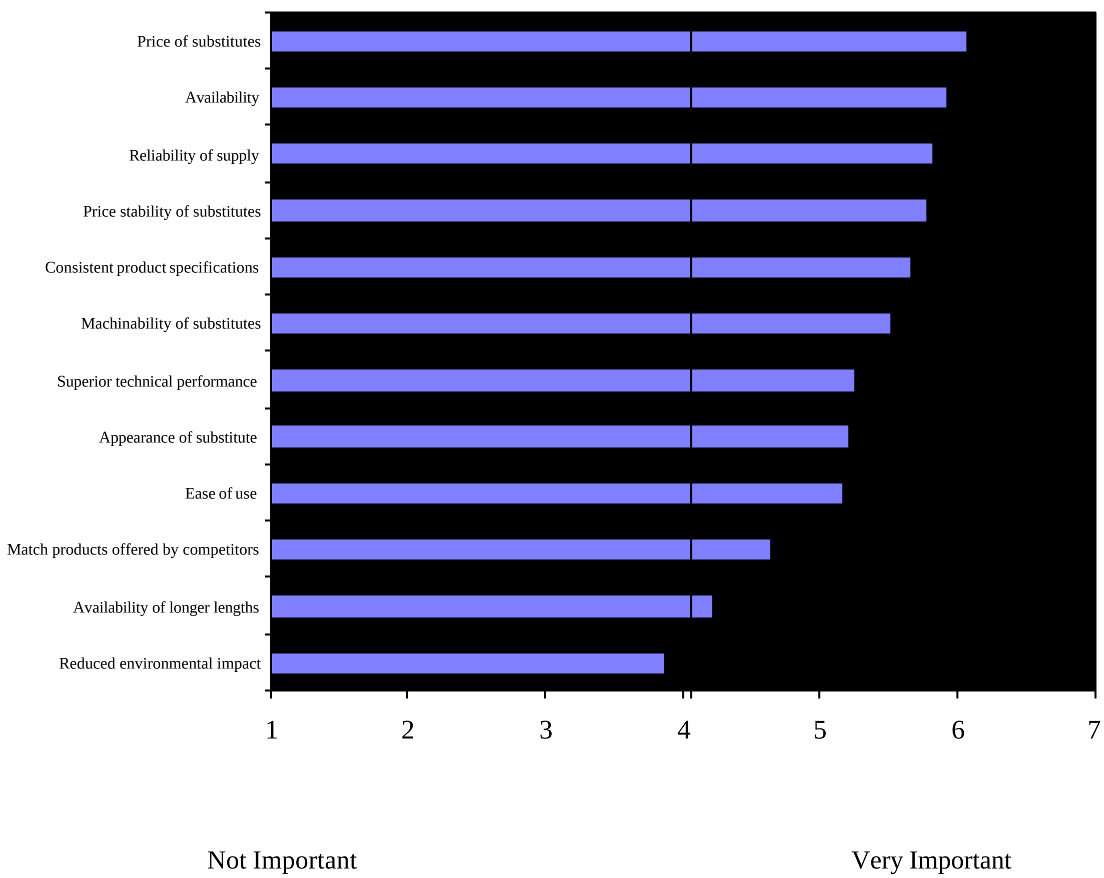

Figure 10. Average importance ratings of attributes that influence substitution.

Table 14. Rotated discriminant factor loadings (correlations) between substitution attributes and factor dimensions.

	Rotated Discriminant Function Loading	
Substitution attributes	**Factor I Technical characteristics**	**Factor II Price and supply**
Ease of use	***.871***	.153
Superior technical performance	***.776***	.217
Consistent product specifications	***.750***	.343
Machinability	***.626***	.475
Appearance	***.622***	.241
Availability in longer lengths	***.618***	.172
Reduced environmental impact	***.585***	.120
To match products offered by competitors	***.559***	.375
Price	-.035	***.872***
Price stability	.199	***.871***
Reliability of supply	.513	***.776***
Availability	.426	***.587***

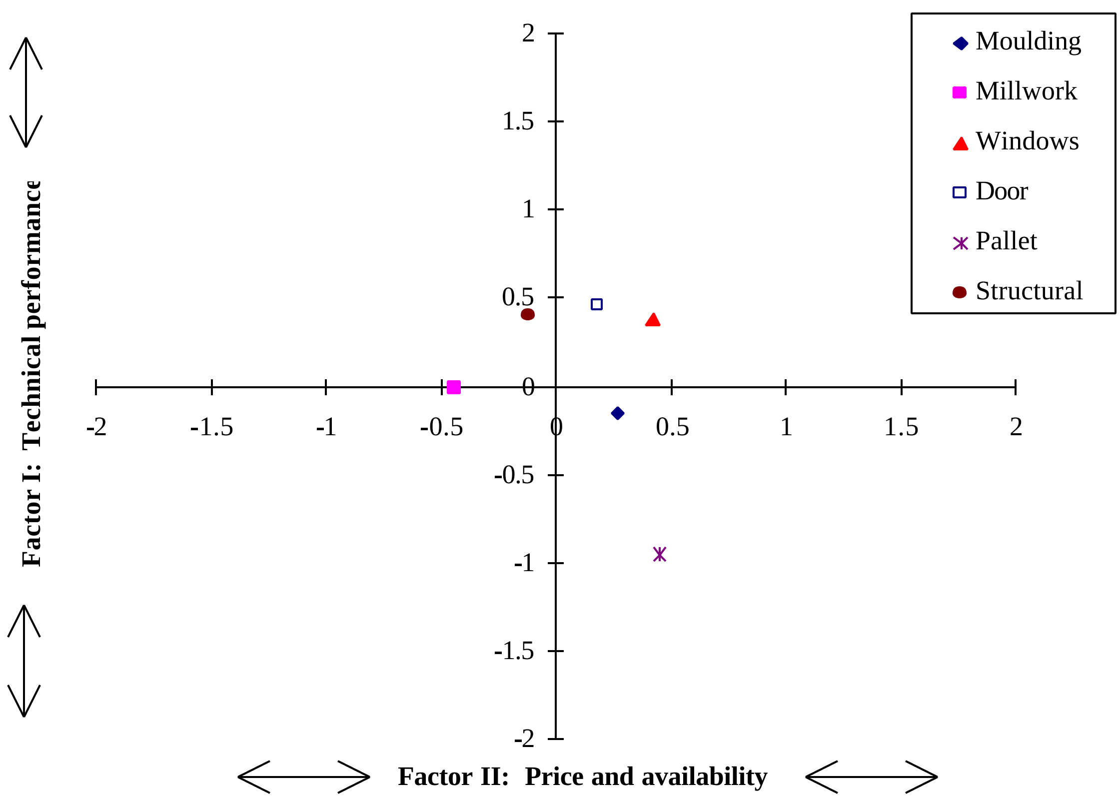

Figure 11. Perceptual map of attributes that influence substitution, by industry segment.

Table 15. Average importance ratings for attributes that influence substitution, by industry segment.

	Industry Segment					
Product Attribute	**All**	**Moulding**	**Millwork**	**Windows**	**Door**	**Structural**
Price of substitutes	6.07	5.75	5.11	6.40	6.88	6.25
Availability	5.93	6.13	5.11	6.40	6.62	6.25
Reliability of supply	5.83	5.63	4.89	6.40	6.50	6.25
Price stability of substitutes	5.78	5.38	4.44	6.40	6.50	6.25
Consistent product specifications	5.66	5.50	4.78	6.20	6.25	5.00
Machinability of substitutes	5.52	5.63	5.44	6.40	6.38	4.25
Superior technical performance	5.25	4.63	4.78	5.60	6.25	5.75
Appearance of substitute	5.22	4.62	4.88	5.80	6.25	5.75
Ease of use	5.17	4.75	5.22	5.60	6.13	4.50
Match competitors offerings	4.65	5.13	3.56	4.80	5.57	4.50
Availability of longer lengths	4.23	4.75	4.44	6.40	4.50	4.00
Reduced environmental impact	3.88	2.75	4.22	4.80	5.50	4.00

PRICES FOR SOFTWOOD LUMBER AND PRICE TRENDS

The consideration of the price trends for softwood lumber products reflects a number of important questions. First, and most directly related to the current study, the role of prices in softwood lumber markets and the potential for substitution of non-clearwood products or lower grade materials with acceptable clearwood attributes is of concern as the supply of traditional clearwood material diminishes over time. Can markets be anticipated to move inexorably towards increasing absolute and relative prices? As revealed by the survey of secondary manufacturers utilizing of clearwood lumber products, manufacturers are indeed concerned by increasing prices and have begun to respond to higher prices through the substitution of alternative products that provide an acceptable mix of attributes previously obtained from clearwood lumber. Other products are seen as being capable of meeting the requirements of these producers and price is one of the key determinants influencing the decision to substitute. Together with price, the predictability of stable and adequate supplies for both clearwood and substitute products determines how markets will respond. Short-term price spikes due to supply restrictions and the longer-term decline in timber quality have raised questions as to how dependable clearwood supplies will be in the future. Further, while higher prices are favorable for timber growers, they potentially encourage greater substitution. While substantial price differentials have persisted in recent years, can these be expected to continue, or are they only reflective of a disruptive market period?

Answers to these and related questions are dependent on reliable information regarding disaggregated prices for specific products. Questions of substitution and the willingness of the lumber market to maintain recent price differentials rest on the relationship of relative prices; that is, how is one product priced relative to other similar and imperfect substitutes, and how is this relationship changing over time? On the other hand, investments in growing timber rest on expected real economic return. This implies that the real price differential is of central importance to forest managers.

Different ways of expressing market dynamics in terms of price require different measurements. This study is primarily based on the dynamics of the softwood lumber market and the differentiated niche markets for clearwood grade lumber relative to potential substitutes. Indicators of relative price behavior are thus reported primarily. However, the price information also provides valuable insight into recent and expected real returns versus changes in wood quality and is thus discussed following the analysis of relative price trends and behavior.

Construction of Softwood Lumber Price Database

A time series of lumber price data was constructed in order to identify both absolute and relative price differentials between various clearwood lumber products and to facilitate a preliminary evaluation of substitution between different competitive materials. A list of product attributes was formulated *a priori* to identify a meaningful definition of clearwood by market segments. While these product attributes can be expected to influence the market price of clearwood lumber, it was also necessary to determine product specifications and grades as proxy measures. Market price information is usually available only for specific product and grade combinations. Thus differences between these product and grade combinations constituted the basis for distinguishing between related attributes embodied as differences in grouped product definitions and grading standards.

Crow's Weekly Report of Lumber and Panel Products Market Report was chosen as the data source given it's relatively complete time series of price data for a variety of products. In addition, products were specified by species, region, product size and grade category. Price data for the period January 1989 through October 1995 was obtained on a bi-weekly basis to reflect the volatility of the price trends and incorporate the adoption of new species and products.

Products included in price analysis

The products included in this analysis were chosen to represent a wide variety of grades and species in traditional product areas (Table 16). Ponderosa pine was selected because it is the traditional species used to manufacture moulding and millwork products. Southern pine and radiata pine, however, are now emerging as a viable, low-cost alternative to western pines in the moulding and millwork market. Although technical challenges still exist regarding drying and stability, many firms in the Pacific Northwest are using these species to produce moulding products (Anon. 1994b).

The objectives of the price series analysis were to:

? identify price differentials between clearwood, clearwood substitutes, and lower product grades,
? establish cross-price elasticities for clearwood products relative to raw material substitutes,
? identify trends in absolute price differentials in real (constant) dollar terms as a measure of market differentiation and potential return on investment in timber quality management.

Measuring Price Trends and Differences

An important objective of this project was to estimate the degree to which clearwood products are effectively differentiated from other products in the marketplace through a price premium and the role that price plays in influencing the choice of lumber grade and species relative to potential substitutes. In almost all cases, price was a strongly relevant variable in user decision-making regarding the use of raw material and the purchase of specific grades or products. Further, prices were shown to be critical to the consideration of possible substitute products, including non-wood alternatives, where clearwood grades have been traditionally chosen.

Prices are a function of dynamic market forces. The focus of this section is to review the behavior of the nominal prices for clearwood products and the structure of prices as a measure of product differentiation in the softwood lumber market. The subsequent discussion of price trends addresses both the relative price trends for different products within a specific species and between species for a specific product. Nominal (spot) price trends provide an initial impression of the apparent price differentials between individual product grade and species over time in order to illustrate the relationship between species, wood quality attributes, and price as reflected in the open lumber market.

Relative price movements demonstrate the tradeoffs between species or products within the overall structure of the softwood lumber market. Changing patterns of relative prices indicate the overall shifts in product differentiation and the degree to which one lumber grade enjoys a premium over other softwood lumber products. Relative prices are expressed as premiums relative to the price of a standard lumber indicator or baseline product as an index (percentage) by which one specific item price varies from the overall market baseline. Relative price spreads are also presented comparing a specific clearwood grade to similar grades of other species and for other grades within the same species.

Table 16. List of products chosen for the price trend analysis, by species and grade.

Ponderosa pine	Douglas-fir	Southern pine	Hem-fir	SPF
Moulding & Better 5/4	Moulding & Better 5/4	Moulding & Better 5/4		
Selects 1x6		Selects 1x6		
Shop 5/4	Shop 5/4	Shop 5/4		
Commons 1x6	Standard & Better 1x6	Commons 1x6		
	Utility 2x4	Utility 2x4	Utility 2x4	Utility 2x4
	Framing RL 2x4	Framing RL 2x4	Framing RL 2x4	Framing RL 2x4

Finally, the trends in real absolute (constant) prices and price premiums are discussed. These real differences are primarily of interest for considerations of possible investments in changing the product quality mix such as through investment in intensive management to yield greater proportions of clearwood. To the extent that this premium can be expected to remain constant over time (or potentially increase) for the higher-valued components of lumber production, such gross returns can be made available to balance the higher costs of intensive management. This present study does not address these investment questions, yet the data presented for the real absolute trends and differences provide a point of departure for subsequent investment analysis. Silvicultural investments are, of course, only one alternative available to increase the value of timber production. Investment in new manufacturing technology, economies in production and distribution resulting in cost savings, and other approaches are also potentially available to the lumber industry. Further, the comparative costs associated with intensive forest management on a global level must also be considered, a topic beyond the scope of the present study.

Nominal price trends

The lumber market does not in reality have a simple, single relationship between quantity and price. Instead, there is a vector of prevailing prices for products that are at least partially differentiated on the basis of perceived product attributes that are important to buyers. In the short-run, this vector of prices is susceptible to random and substantial fluctuations due to unexpected developments in both supply and demand. In the long-run, nominal price trends are useful in establishing the prevailing hierarchy in the relationship between products or species and illustrating how those relationships may change over time due to shortages (actual or anticipated), changes in consumer preferences, and/or other demand shifters, including substitution between products. This section discusses the trends in the absolute nominal (spot) price relationship between the higher-valued clearwood grades of softwood lumber products and a commodity softwood lumber baseline product as a proxy for the aggregate lumber market.

Nominal price trends within species groups: ***Ponderosa pine.*** Ponderosa pine was selected as a primary clearwood species because the higher grades have traditionally been valued as a superior raw material for the production of moulding and millwork products. The higher-valued Moulding and Select lumber grades are particularly appropriate for these industries. *Crow's Weekly Lumber Reports* tracks the price of ponderosa pine lumber manufactured in the Northwest. The ponderosa pine harvested in this region is generally higher-grade, more expensive, and in short supply relative to other supply regions. The ponderosa pine products included in this analysis 5/4 Moulding & Better, 5/4 #3 Shop, 1x6 C & Better, and 1x6 #3 Common. Prices for these products ranged from $200/mbf to almost $2,800/mbf over the time period investigated (Figure 12). Peak prices were observed for ponderosa pine C & Better (1x6) at $2,725 in April 1993, closely linked to the peak price of $2,600 for Moulding & Better (1x6) grades at about the same time.

A clear differential in nominal prices exists between the ponderosa pine products included in the analysis. The partially overlapping prices of 1x6 C & Better Selects and 5/4 Moulding & Better grades indicate some potential for substitution, especially since these products are commonly used by moulding, window, and door manufacturers. The average price for 1x6 C & Better over the six year period was $1801/mbf, $346 more than the average price for the 5/4 Moulding & Better grade ponderosa pine.

Douglas-fir. The average price of Douglas-fir 5/4 Moulding & Better was $1,175/mbf between 1989 and 1995 (Figure 13). In comparison, Douglas-fir 5/4 #3 Shop, from the beginning of July 1992 until October 1995, averaged only $540/mbf, indicating a clear differentiation between the two product grades, with each product serving different markets. The 5/4 Moulding & Better tends to be used for mouldings as a stain grade, while the 5/4 #3 Shop is used primarily as a paint grade product for door jambs and similar products because of the numerous knots allowed in this grade. The Douglas-fir 1x6 Standard & Better, used more for specialty products such as hand rails, ranged in price from $160 to $405/mbf, averaging $259/mbf. Peak prices for Douglas-fir were reached in late spring of 1993 for 5/4 Moulding & Better grade lumber ($1,545/mbf) and 5/4 #3 Shop grade lumber ($810/mbf).

Finally, the Douglas-fir Standard & Better 2x4 prices remained relatively flat in the $200-300/mbf range throughout the period of analysis. Standard and Better 2x4 prices rose in late 1993 and, while the nominal price

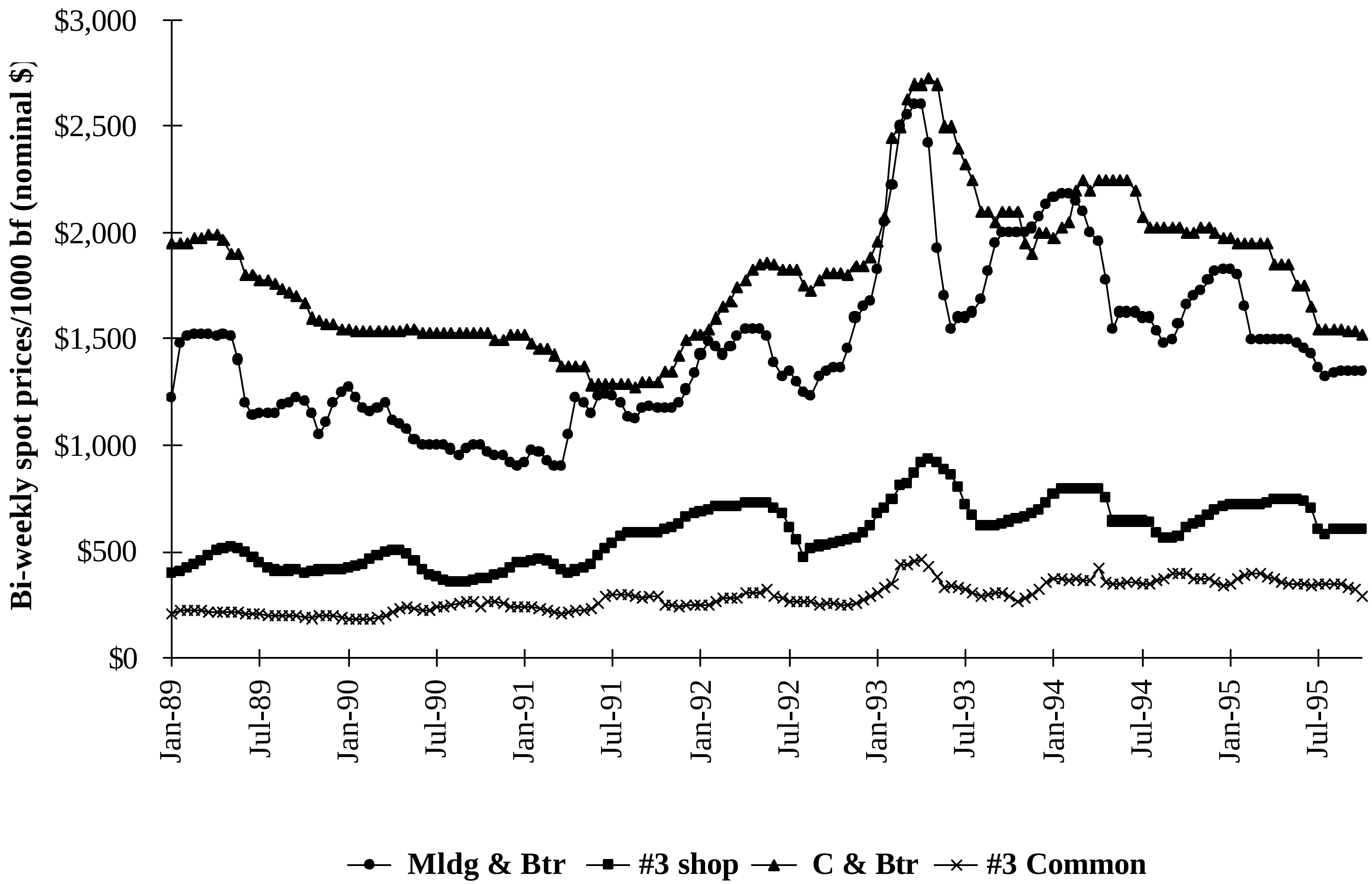

Figure 12. Ponderosa pine nominal price trends.

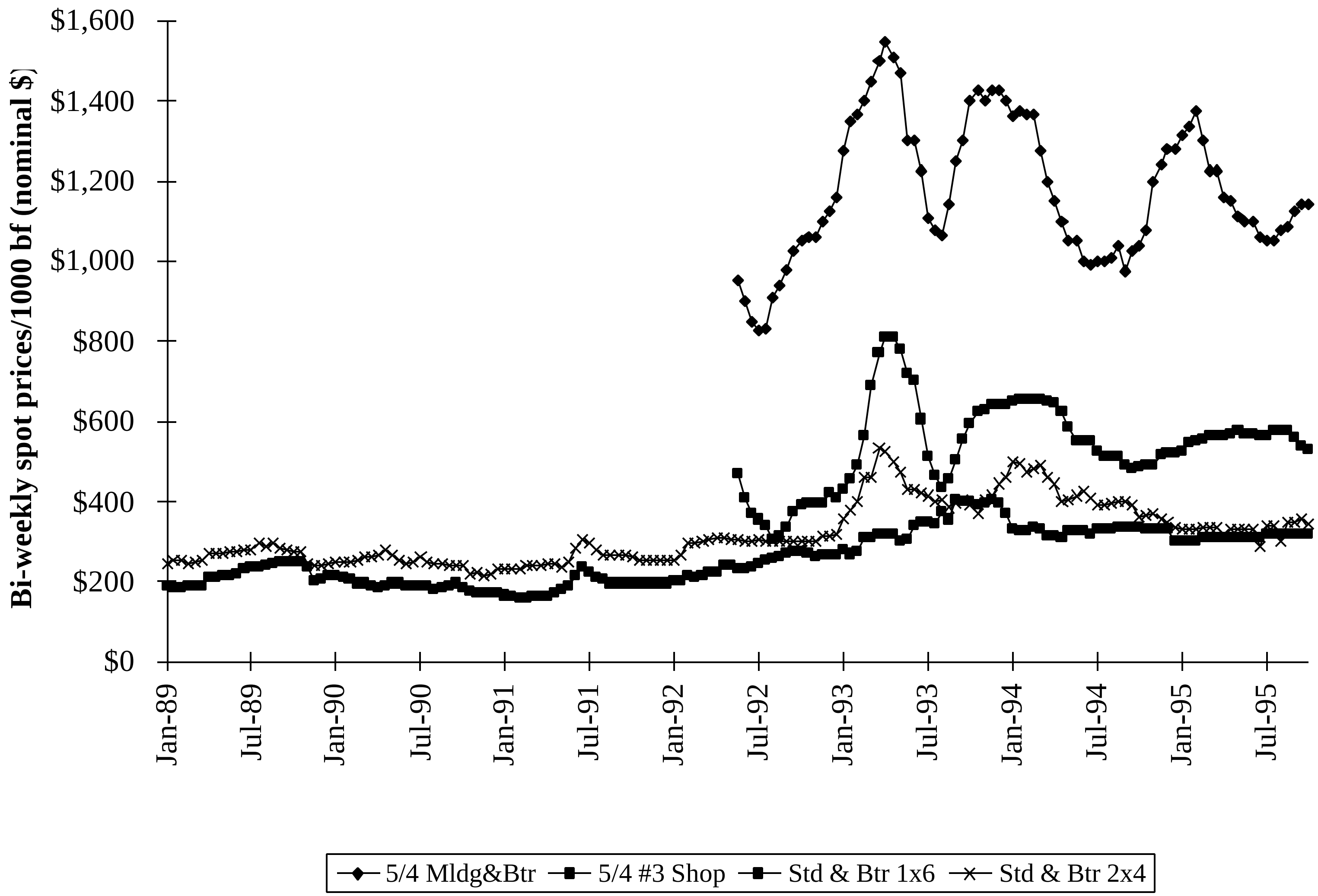

Figure 13. Douglas-fir nominal price trends.

changes were relatively small compared to the higher-valued lumber grades, the percentage increase in price exceeded 100%. The Standard & Better 2x4 lumber grade was selected as an appropriate commodity index for the western softwood lumber market since this product together with other light framing grades constituted over 55% of the Douglas-fir lumber production volume at the end of 1994-1995. It is perhaps this segment of the market (structural framing lumber) that most frequently characterizes softwood lumber in general.

Southern pine. The average price for 1x6 C&Better southern pine was $706/mbf, which was clearly differentiated from the other southern pine products included in the analysis (Figure 14). Only limited price data was available for southern pine Moulding & Better grades which averaged between $1,050-$1,100/mbf during the period of analysis. The 5/4 #3 Shop moulding lumber grade was also differentiated from the lower grade products and was not subject to the same volatility as the Standard & Better 2x4 lumber. Nominal spot prices were relatively stable from 1989 through mid-1992. Since then, prices have fluctuated but have generally trended downward.

Hemlock-fir. The production of hemlock-fir lumber is a smaller volume in the western region, averaging about one-third the volume of Douglas-fir. This species mix does not yield significant proportions of clearwood grades, with C Selects virtually disappearing from the market by 1992. D Select and Shop grades constituted a declining proportion of production, having dropped from about 5% in 1982 to 0.6% in 1994. The trends in nominal prices, therefore, are reflective of lower grade construction and structural products (Figure 15).

Hemlock-fir prices have been volatile since mid 1992, rising to a peak in the spring of 1993 when Standard & Better grades exceeded $500/mbf, while Utility grades passed $300/mbf in late 1993 and early 1994. The two commodity lumber grades tracked each other with an average spread of about $60-100/mbf.

Spruce-Pine-Fir. As with the hemlock-fir species group, the Spruce-Pine-Fir (SPF) species group does not traditionally yield significant volumes of clearwood lumber. Therefore, prices included in this study are for Standard & Better 2x4's and Utility grade 2x4's (Figure 16). Prices were observed to be quite variable following a relatively stable period in 1989-1991, reaching peak levels of $473/mbf in March 1993 for Standard & Better and $315/mbf for Utility grades in March, 1994. As with hemlock-fir lumber, the SPF species group maintained a steady differential in nominal prices between these two lower-valued grades, averaging a spread of approximately $60-75/mbf over much of the observed period.

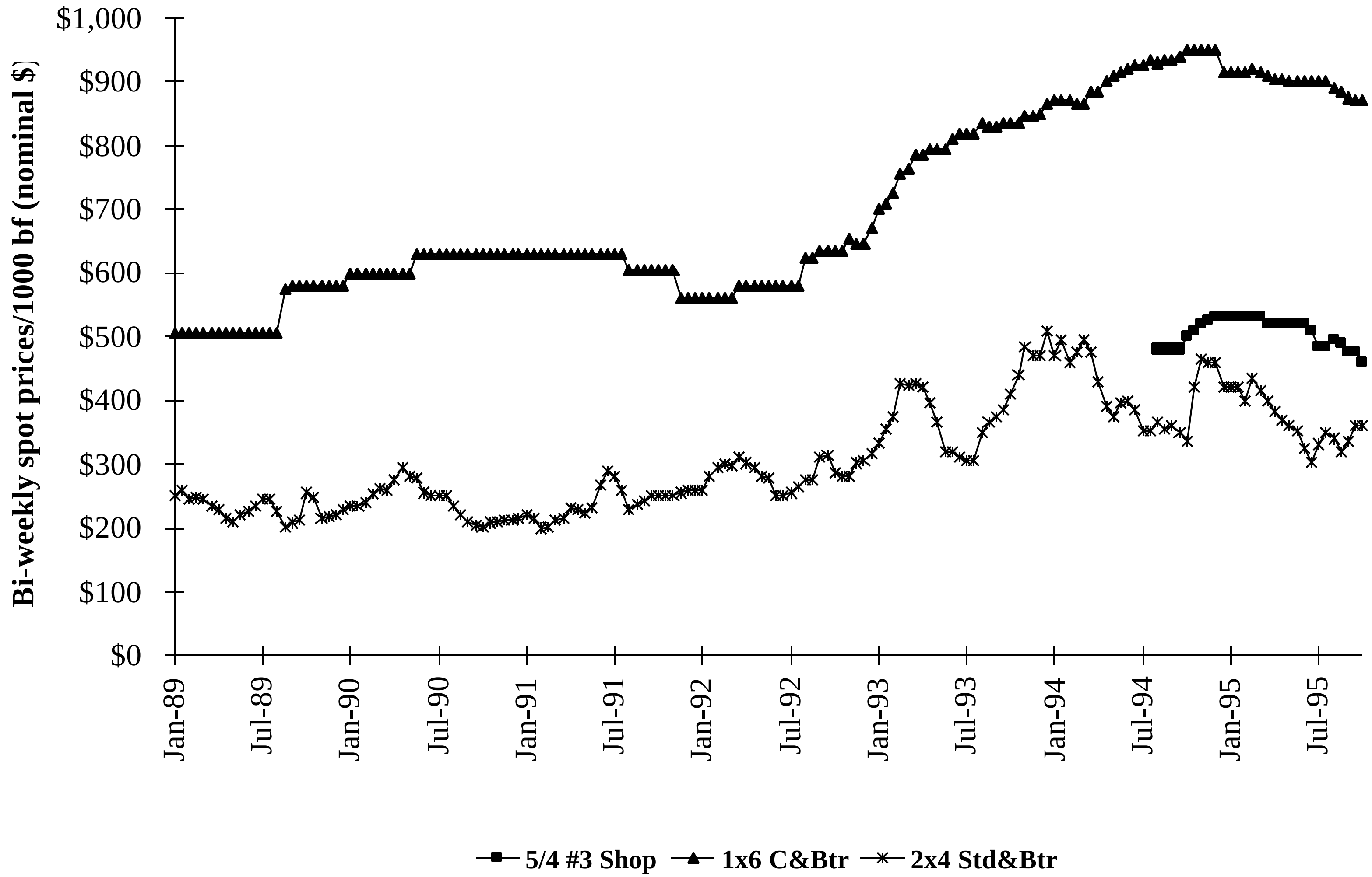

Figure 14. Southern pine nominal price trends.

Figure 15. Hem-fir nominal price trends.

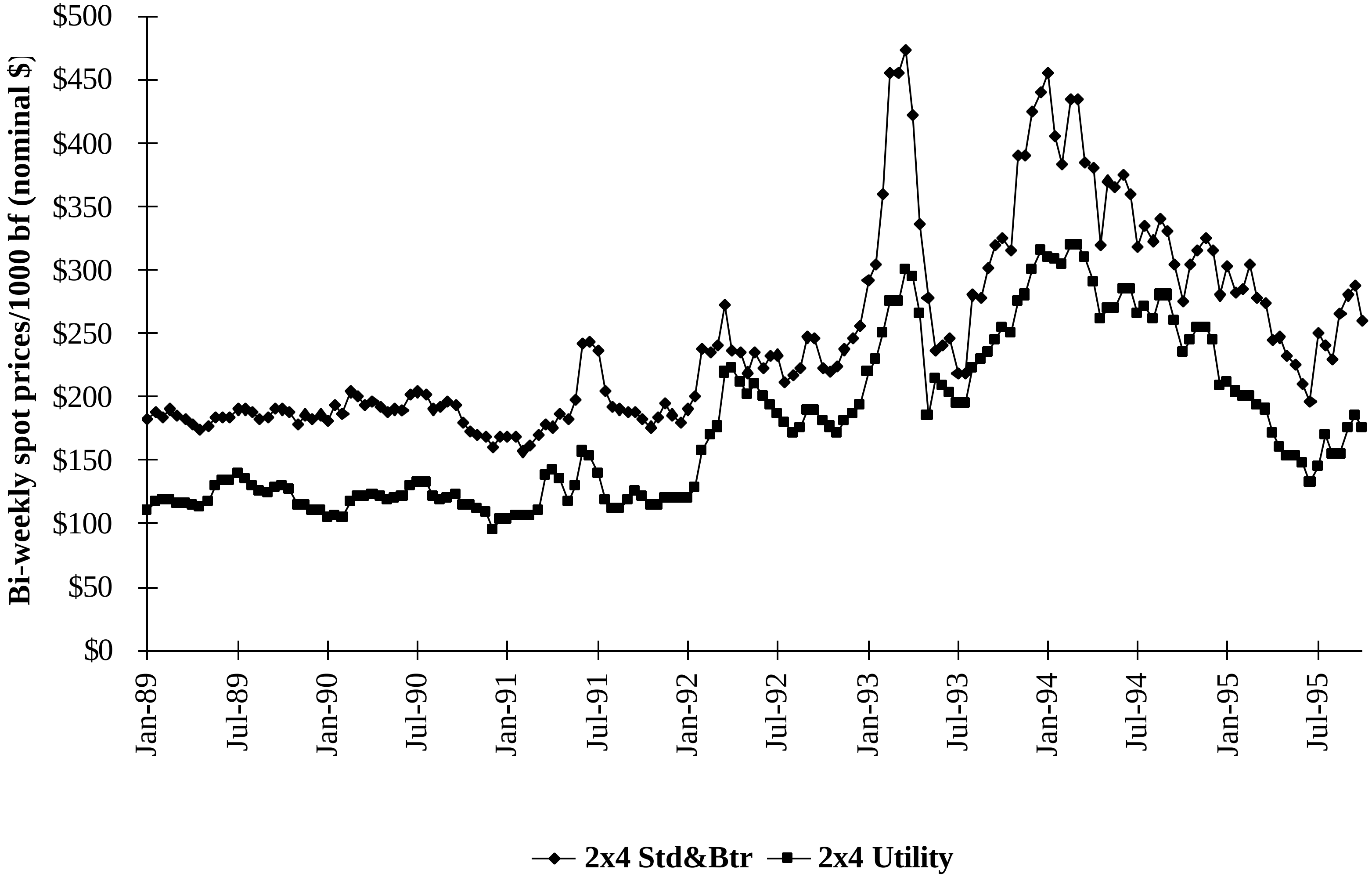

Figure 16. Spruce-Pine-Fir (SPF) nominal price trends.

Nominal price trends by product/grade category: ***Structural grades.*** The composite volume of structural grade softwood lumber most closely approximates the aggregate lumber market. These grades comprise an increasing share of lumber production for the major softwood species across the United States as the volume of smaller-diameter, second-growth timber increases in proportion to large-diameter, old-growth timber which originally served as the raw material base. As previously noted, the quality, and hence the proportion of higher-valued clearwood grades, has declined in relation to total lumber production, resulting in the dominance of the commodity structural lumber grades. Thus the price performance of this segment of the market dominates overall price statistics and price indices based on weighted prices across grades.

An assessment of nominal price trends for structural grades of softwood lumber across major species groups compared the spot prices for Utility and Standard & Better grades. The Utility grades are the lowest valued structural-light framing products, with grades by species showing a definite but variable pattern (Figure 17). The SPF species group is generally priced below the structural grade average for Utility products, with the hemlock-fir species group generally yielding only slightly higher prices. Douglas-fir and southern yellow pine are normally the higher-valued structural grade species, with southern pine nominal prices slightly above Douglas-fir in most periods.

The same general pattern is evident for standard & better grades, where prices are much more closely grouped with smaller and inconsistent price differentials (Figure 18). For the four species groups, the variations in FOB mill prices reflect frequent and significant fluctuations in response to market influences, particularly during the period beginning in 1993. Prices peaked in late spring 1993, then dropped sharply before rising in early 1994. Prices have since declined to levels approximating those observed in late 1992.

Common grades. The price trends were also determined for #3 Commons (ponderosa pine and southern pine) and Standard & Better (Douglas-fir) grades (Figure 19). Both ponderosa pine and southern pine prices are for kiln-dried products, while Douglas-fir is for green material (kiln dried prices were not available). The trends in nominal prices followed the general softwood structural lumber market trends, with relative stability through mid-1992 and substantial price fluctuations thereafter with more variable price differentials between species. Ponderosa pine #3 Common grade was typically the highest-valued of this group, with southern pine registering below Douglas-fir. In general, prices were intermediate to the framing grades (Utility and Standard & Better) with the average prices for #3 Commons maintaining higher levels in the post-July 1993 markets, and ponderosa pine #3 Commons demonstrating a substantial price drop in July 1995.

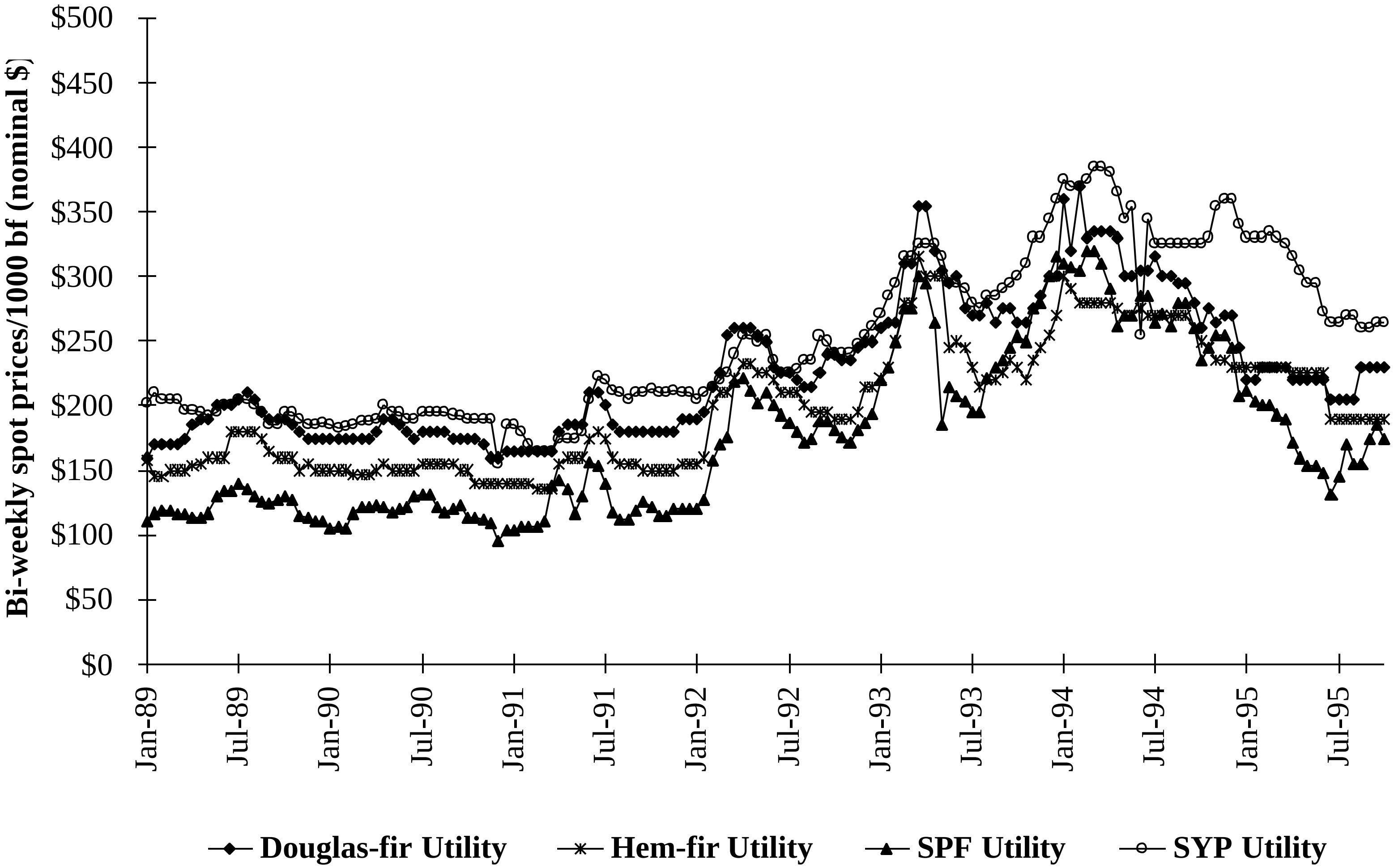

Figure 17. Nominal prices of 2x4 Utility grade lumber, by species.

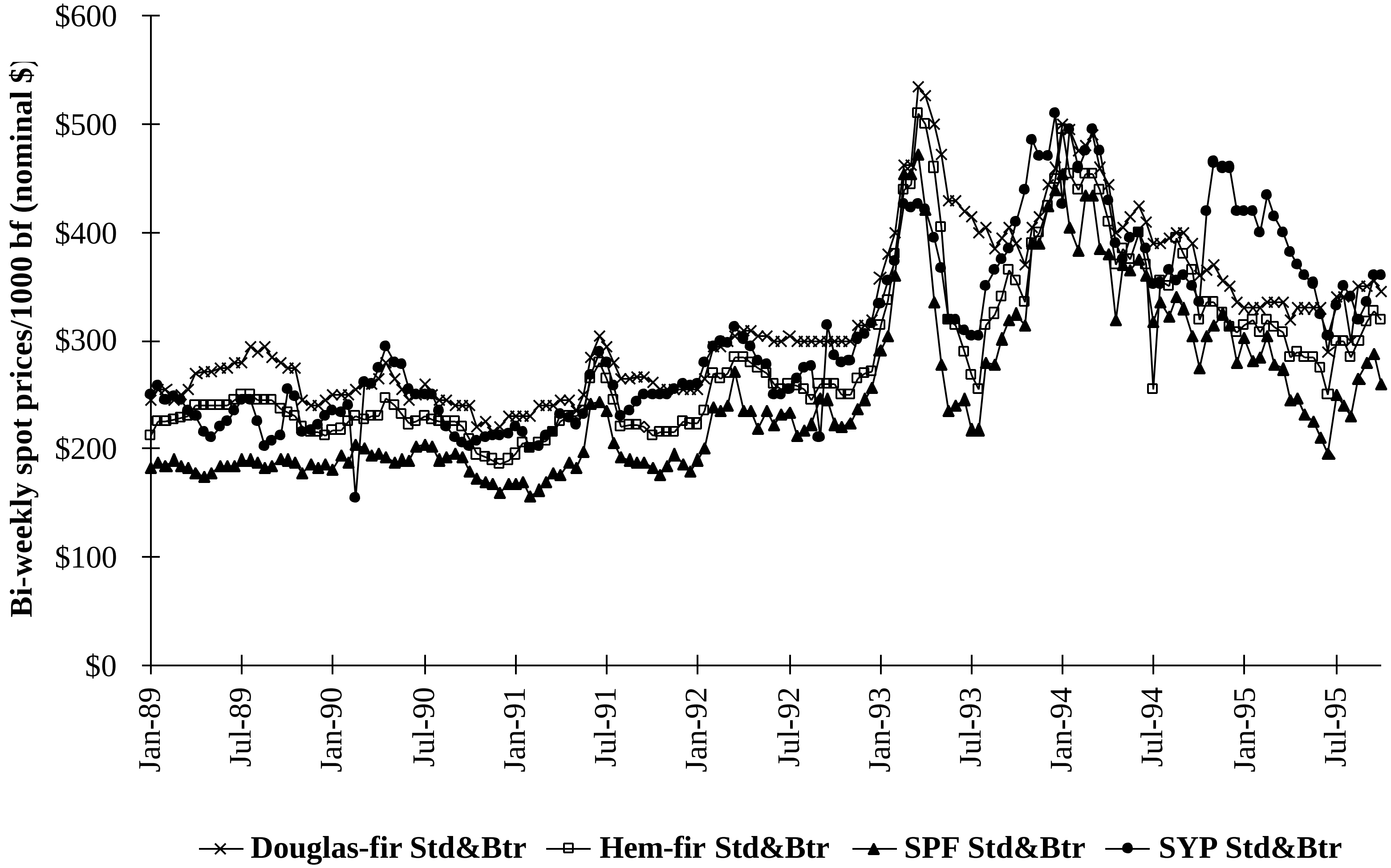

Figure 18. Nominal prices of 2x4 Standard & Better grade lumber, by species.

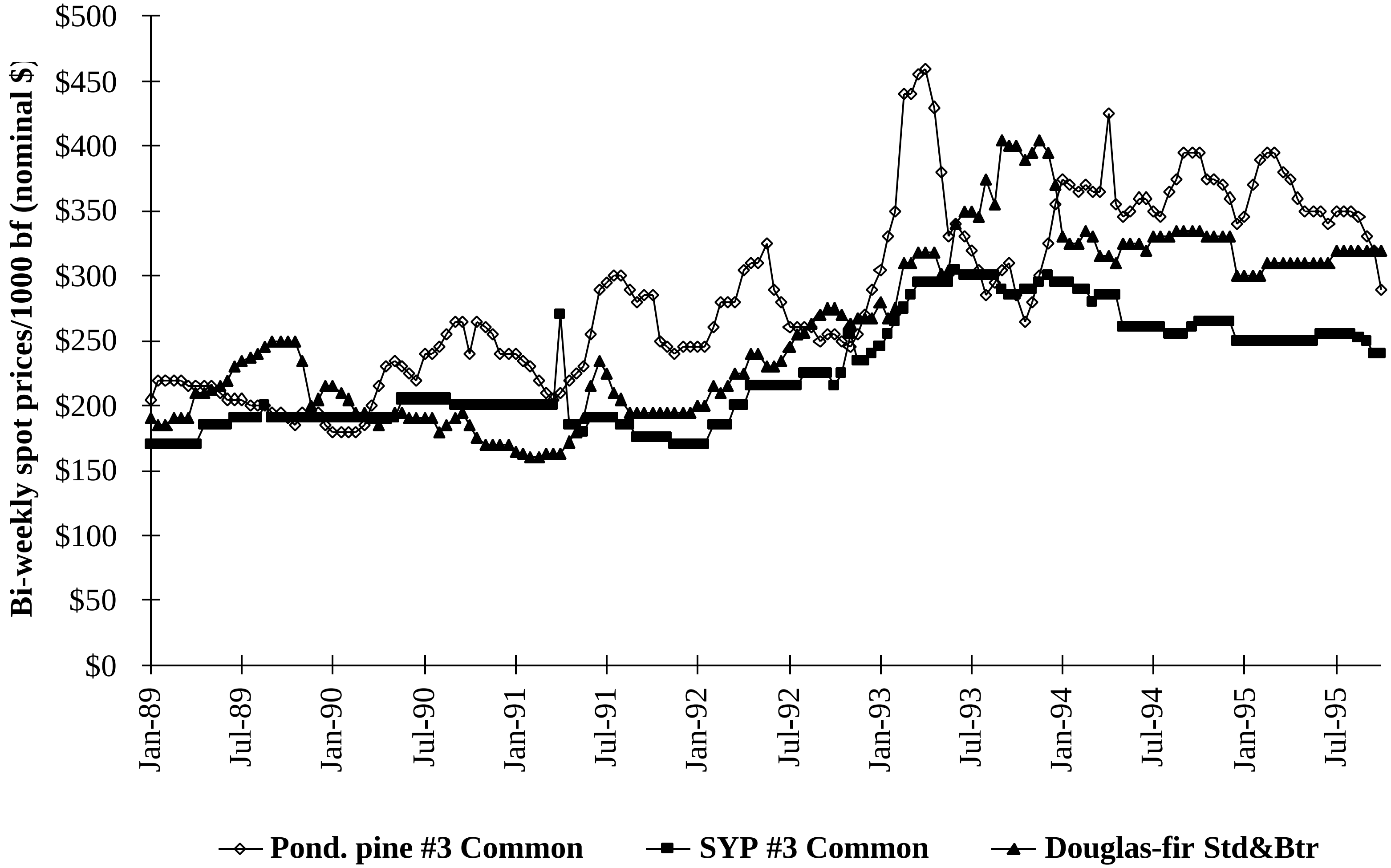

Figure 19. Nominal prices of 1x6 Common and Standard & Better grade lumber, by species.

Shop grades. A comparison of spot FOB prices for #3 Shop grade for ponderosa pine, Douglas-fir, and southern pine was also made (Figure 20). Only ponderosa pine prices were available for the full observation period. Douglas-fir prices became available only in May 1992, while prices for southern pine shop grades were not reported until May 1994. Hence, species comparisons are limited to the more recent market periods. Prices for ponderosa pine #3 Shop grades generally rose over the observed period, starting at $400/mbf in January 1989 and increasing to $730/mbf in April-May 1992. At that time, Douglas-fir #3 Shop was reported at $470/mbf. Both species then experienced a significant drop in nominal price until August 1992 when prices again increased sharply, reaching peaks in April 1993. Prices were thereafter very unstable, clustering near $550-600/mbf by late 1995. Southern yellow pine, first reported at $480/mbf in August 1994 has generally trailed the price of Douglas-fir #3 Shop, having failed to increase in early 1995 in comparison to both Douglas-fir and ponderosa pine #3 Shop grades.

C & Better Select grades. While southern pine C & Better Selects exhibited a relatively steady trend in nominal prices over the 1989-1995 period, the price of ponderosa pine C & Better Select lumber displayed a greater variability (Figure 21). Southern pine prices increased from about $500/mbf in 1989 to $950/mbf in late 1994. In contrast, ponderosa pine prices declined from $2,000/mbf in early 1989 to a low of $1,370/mbf during the period March-May 1991 before again rising to exceed $2,700/mbf in March-May 1993. Prices subsequently dropped, reaching a level of $1,550/mbf by late 1995.

Moulding & Better grades. The effects of market expectations and reactions to anticipated and actual shortages can be severe and sudden, especially for the higher grades of lumber products. For example, the passage of the Forest Resources Conservation and Shortage Relief Amendment Act in January of 1993 drove nominal prices upward for all lumber products as log export buyers became fearful that higher-grade logs would be unavailable for export and domestic buyers feared being unable to obtain timber at any cost. As a result, both domestic and export buyers began aggressively competing against one another for the higher grades of lumber.

This pattern of competition can be seen in the prices of most high-grade lumber products. For example, from January through March 1993, prices for ponderosa pine 5/4 Moulding & Better rose from $1,825/mbf to $2,600/mbf, and from $1,300/mbf to $1,500/mbf for Douglas-fir (Figure 22). Nominal prices had actually declined from about $1,500/mbf for ponderosa pine Moulding & Better grades in early 1989 to lows of about $900/mbf by March, 1991. Prices then increased, at first modestly, then more steeply after August 1992 to the peak of $2,600/mbf in March-April 1993. By late 1995, ponderosa pine Moulding & Better had declined to $1,350/mbf, below the nominal prices of early 1989.

Prices for Douglas-fir Moulding & Better grades were first reported in mid-1992, at just over $900/mbf. The price pattern thereafter mirrors the price trend for ponderosa pine Moulding & Better through late 1995, but at lower levels and with somewhat less extreme fluctuations in both up and down markets. Ponderosa pine is obviously the higher-valued moulding product on a volume basis and that hierarchy is maintained over the period shown.

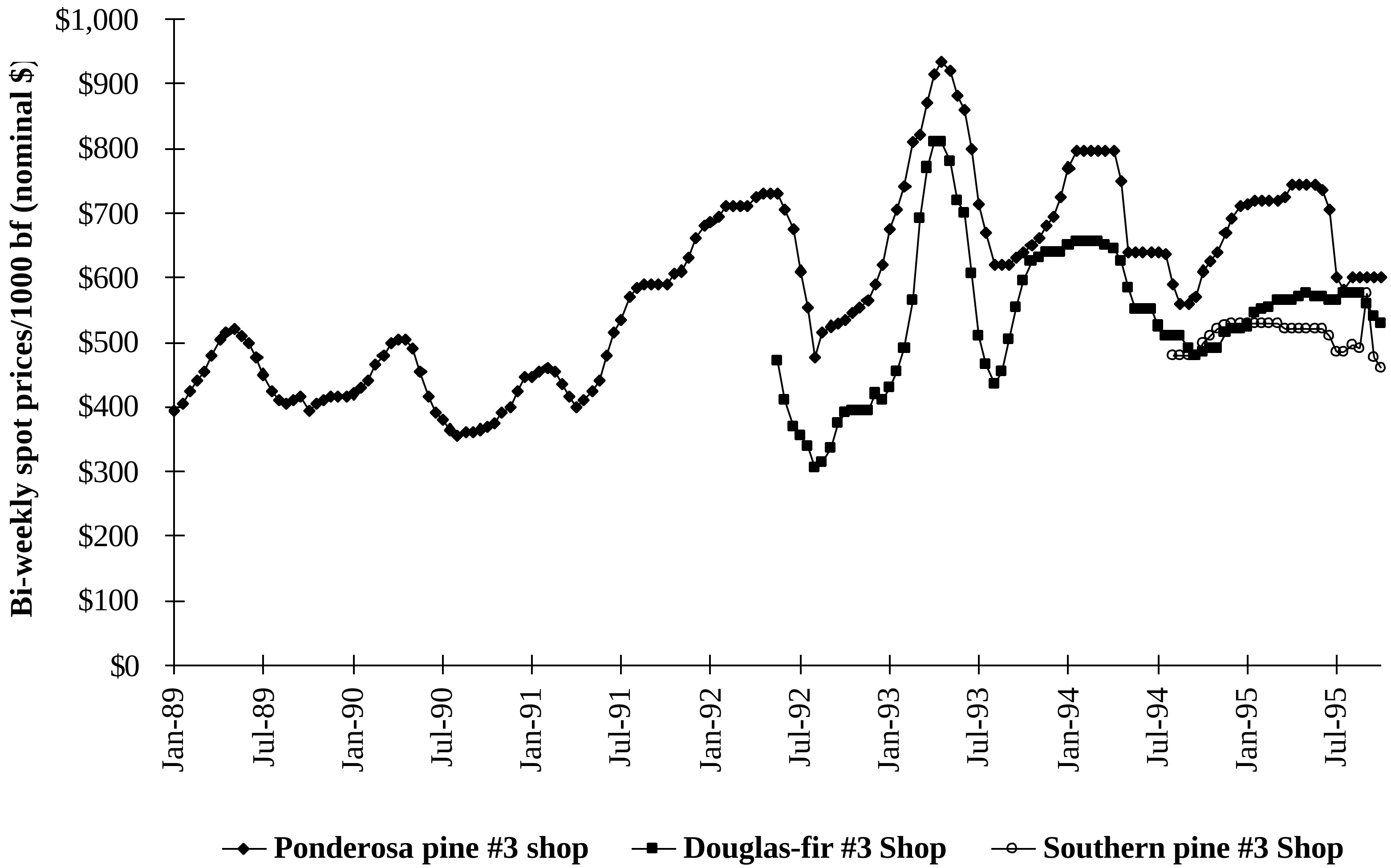

Figure 20. Nominal prices of 5/4 #3 Shop grade lumber, by species.

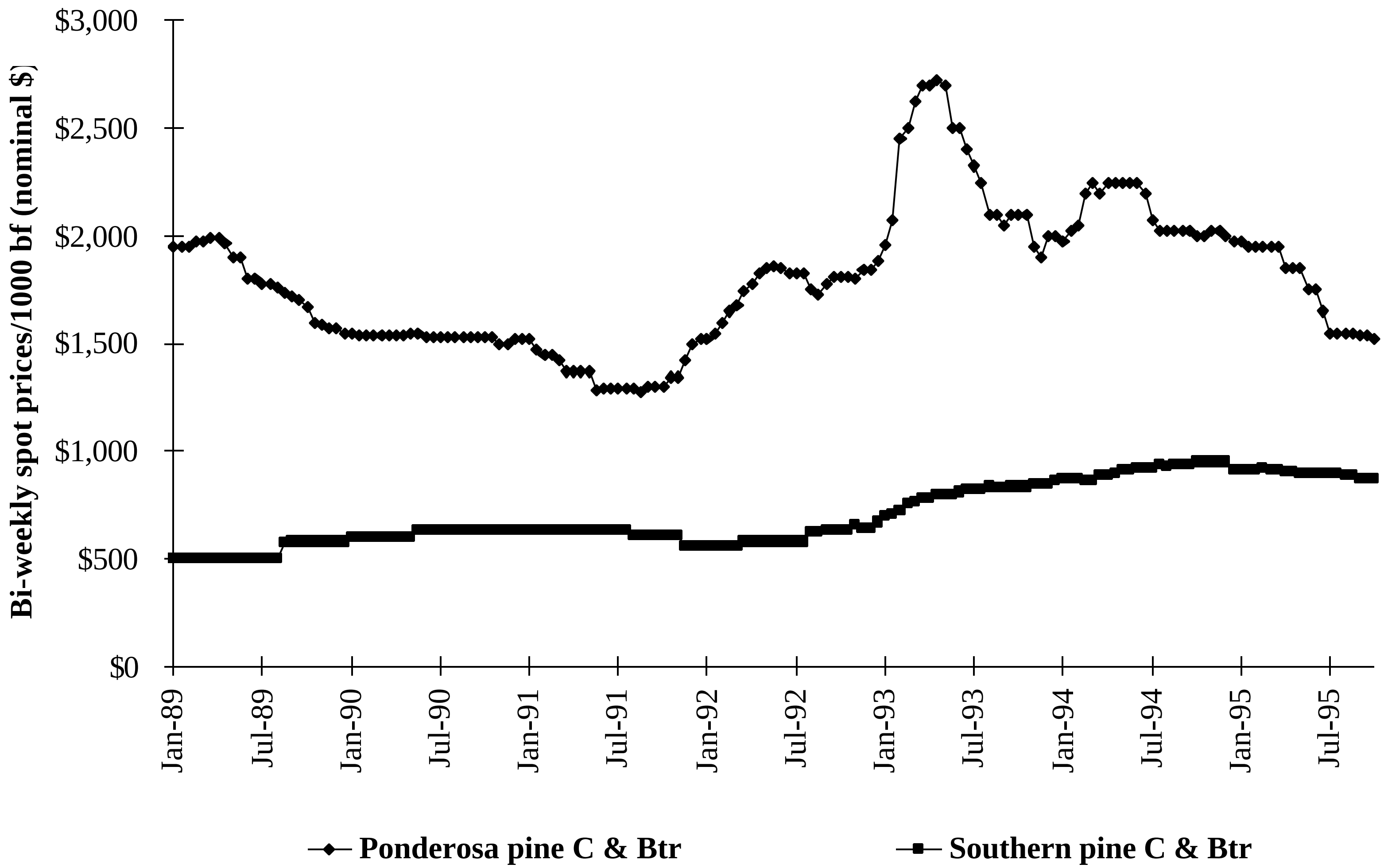

Figure 21. Nominal prices of 1x6 C & Better grade lumber, by species.

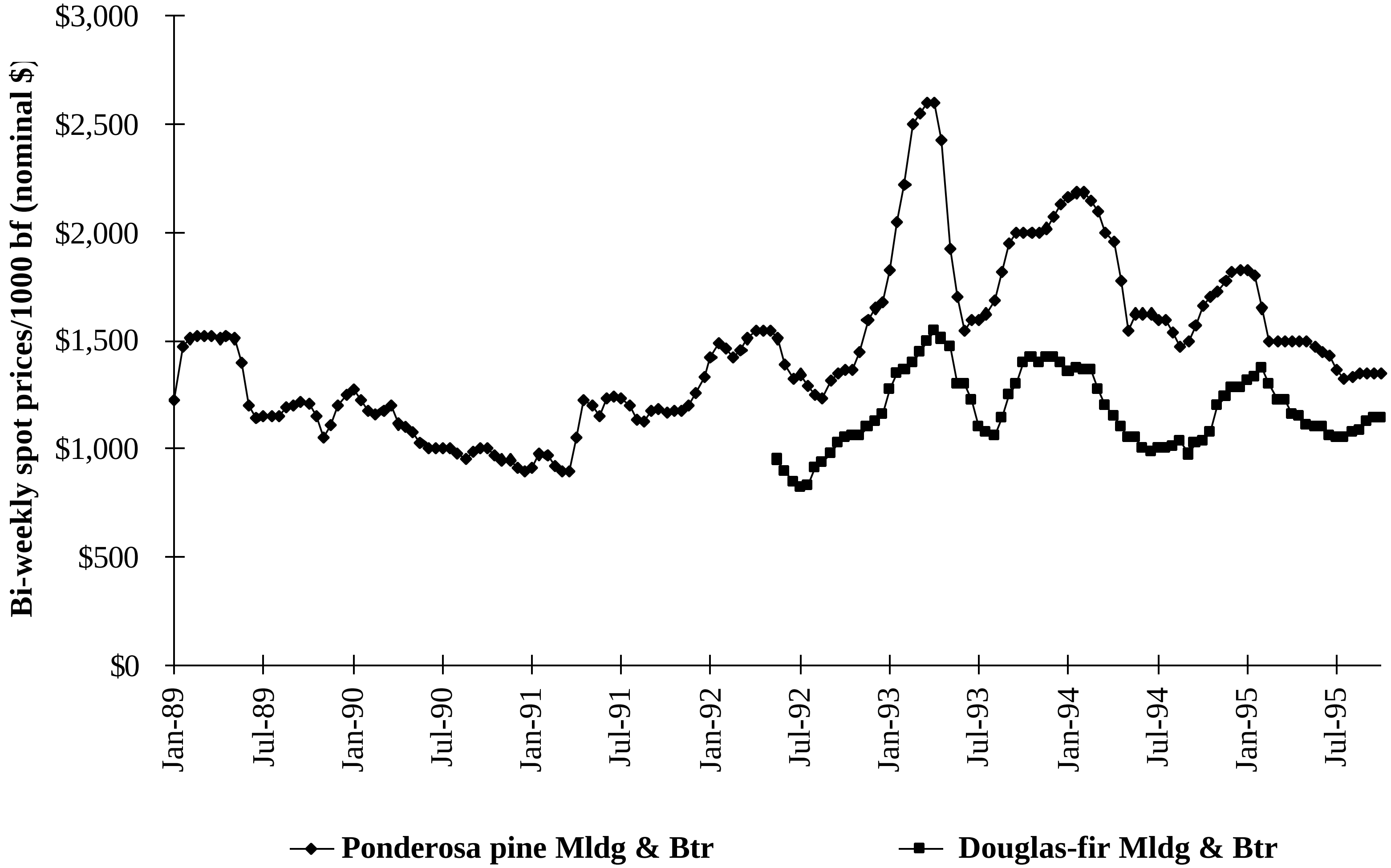

Figure 22. Comparison of nominal price for 5/4 Moulding & Better grade ponderosa pine and Douglas-fir lumber.

Relative price differences

The prevailing structure of nominal prices over time represents both a species and grade differentiation among lumber buyers. For an analysis of lumber market dynamics and clearwood product differentiation, the relative difference between prices is relevant to both short-run and long-run adjustments (elasticities) and product substitution. The lumber market is subject to considerable cyclic fluctuation and softwood lumber prices and quantities are sensitive to changes in the national economy, housing starts, and other macro-level market shifters.

For clearwood lumber users, however, it is also important to understand the dynamics of prices for specific grades of lumber products within the overall structure of softwood lumber prices. How are clearwood prices changing relative to the overall softwood lumber market? How are clearwood prices changing relative to other product grades within the same species group? How are clearwood prices of one species changing relative to similar grades produced from other (and potentially new) species in the marketplace? The survey of manufacturers clearly indicated that clearwood buyers increasing search for more economical sources of clearwood lumber products capable of meeting their specific manufacturing requirements. Manufacturers appear to be less concerned about the species or origin of material so long as the product possesses the required attributes, has a reasonably stable supply, and is price competitive.

Price competition is largely determined by the structure of relative prices. When the overall structure (vector) of softwood lumber prices fluctuates in concert, relative prices may be largely unchanged. That is, as nominal prices fluctuate over time, the relative price advantage or premium of one species or grade over another remains constant. Relative price is conceptually important both to the understanding of product demand (and own-price elasticity) as well as to product substitution (cross-price elasticity). As a product's price changes relative to itself and/or relative to other products, manufacturers are provided with an incentive to either increase or decrease their consumption of the product based on the magnitude and direction of the relative price change and the attributes, price, and availability of alternative products.

The evaluation of relative prices implies a comparison of prices between two different products. The nominal price for a clearwood product may be compared with the overall softwood lumber market (the relative price difference) at any given time. This measure allows for the determination of how a specific product grade or species is priced relative to the aggregate lumber market over time. For this purpose, a baseline, or standard market indicator price is required for the basis of the comparison. To determine the relative price difference, two prices are compared for the same period. As a ratio of prices, therefore, the comparison is unaffected by distortions from inflation over time. The resultant ratio, expressed either as a proportion or as an index, is neutral and the relative price measurement can be compared directly between different observation periods.

The analysis of relative price differences compares the spot prices of a particular softwood lumber product to the overall softwood lumber market. As previously discussed, price and consumption trends for structural framing materials are typically viewed as a valid general indicator for the overall performance of the softwood lumber market. For this reason, this analysis uses the price trends for Douglas-fir structural lumber as the baseline commodity index for softwood lumber. Relative prices for clearwood lumber grades are based on the spot price (nominal price) for a given time compared to the baseline price.

This analysis utilizes a Relative Price Index (RPI) to measure relative price differentials and changes over time for individual species and product grades. The RPI compares a specific product or species spot price to the spot price for the market baseline or commodity index item. The wholesale price for individual products/species is compared to the index product price to determine the product-specific relative price index for that market period. Relative prices can be expressed either as a decimal fraction (ratio) or as a percentage difference from the base price. Both measures are utilized in this analysis. For example, a relative price ratio of 3.5 would indicate that the price of a selected clearwood lumber product was 3.5 times that of the market baseline commodity index. By subtracting 1.00, the difference in the nominal clearwood lumber price is determined to be 2.5 times the baseline commodity index. RPI values are expressed as percentages in the figures presented below to facilitate the discussion and a ratio of 3.5 would be expressed as 350%.

Softwood lumber baseline commodity index. Based on the overall market share for softwood lumber products, Douglas-fir Standard & Better 2x4 framing lumber was selected as an appropriate baseline commodity index. The trends in the nominal spot prices for both the 2x4 Utility and 2x4 Standard & Better grades exhibit a fairly close clustering of species prices as was shown in Figures 17 and 18. SPF Utility was the lowest valued grade within this group, with Douglas-fir and hemlock-fir Utility grades closely priced just below southern pine Utility. The spread in nominal wholesale mill prices was approximately \$100/mbf or less. For Standard & Better 2x4 products, prices followed an almost equivalent trend but with a closer grouping of prices averaging about \$50-\$60/mbf above the Utility grades. Again, SPF was the lowest valued species group while Douglas-fir generally was the highest valued species for standard & better 2x4's.

It can be seen that the nominal prices for the above mentioned structural lumber grades were relatively constant from 1989 through 1991 (Figures 17 and 18). Beginning in 1992, nominal prices began to increase, with peaks in early 1993 and again in early 1994. Since early 1994 nominal prices have generally declined, being approximately \$60/mbf above 1989-92 levels as of October 1995 for both Utility grades and for Standard & Better grades.

The prior discussion of nominal price trends indicates that lumber products (and markets) are not homogeneous, but rather exhibit a definite vector of differentiated prices across both species and product grades. These trends show a consistent hierarchy of price vectors that indicates a changing relationship in prices over time. As with the baseline structural lumber grades, other product grades exhibit price trends with a broad response to market changes over the 1989-95 period, reflecting the tendency for individual lumber products to respond to the overall trends of the general softwood lumber market.

If nominal prices for all products and product grades responded similarly to market forces, the hierarchy (vector) of nominal prices would be maintained relative to each other, and the RPI would remain constant (meaning that the slope of the trend line over time would be zero). This would indicate that each product would have maintained its relative differentiation and a constant percentage nominal price premium within the overall softwood lumber market. That average relative price premium, if maintained, would indicate that buyers are in fact willing to pay more for the specific lumber grade.

It is also possible for the RPI to fluctuate in the short term, for example in response to supply and demand shocks impacting particular product niche markets or cyclic factors uniquely impacting a specific product or grade, yet maintain a constant average relative price ratio over time. Over the longer term, a product grade can maintain a given degree of price differentiation relative to the overall market. A declining trend, however, would indicate a reduction in differentiation relative to the aggregate market over the longer period, whereas an increasing trend would indicate greater differentiation relative to the market. Both the short-term and longer-term price responses are of interest in understanding the dynamics of clearwood markets. Short-run fluctuations in the RPI indicate the relative volatility of the price for a particular product. For example, in mid- to late-1992, mid-1993 and late-1994 Douglas-fir clearwood grades exhibited short-run increases in relative price index values. Buyers of clearwood grades of Douglas-fir products would experience a notable increase in price relative to the overall market. While they would predictably respond in the short-run to such increases in relative price, the longer-run trend is reflective of a broader set of market responses (including product substitution). A rising relative price trend would at least indicate the potential for product substitution as buyers perceive that the relative differential or premium is real. Similarly, a decline in the trend for the RPI over time would signal a potential for increased competitiveness as a product or grade becomes relatively less expensive compared to the overall softwood lumber market.

Douglas-fir. The baseline commodity index (represented by Douglas-fir Standard & Better 2x4's) is represented by the horizontal line located at the 100% position in Figures 23-27. In Figure 23, the lower-valued Douglas-fir commodity products, including Utility 2x4 and Standard & Better 1x6, exhibit a relative price of less than 100%, indicating that the spot price at any observed date was below the baseline commodity index. Further, the plot of the RPI values for these two commodity items shows that the price relationship with the baseline commodity product has been relatively constant. The only significant variation for the Standard & Better 1x6 grade RPI is between July-December 1993 and again after July 1994, when the RPI approaches 100%.

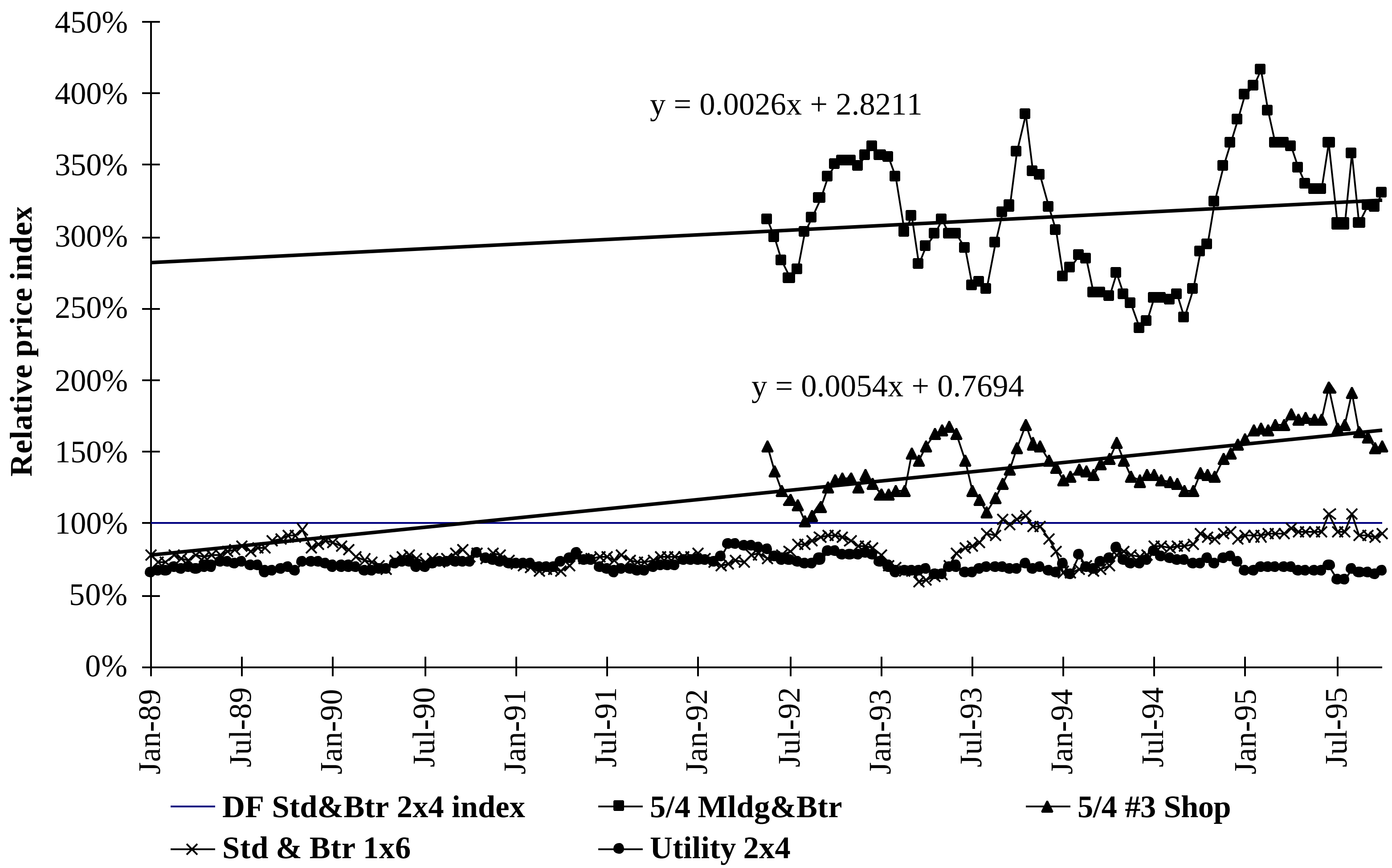

Figure 23. Relative price trends for Douglas-fir lumber products.

In contrast, the plot of the RPI for both Moulding & Better grades and #3 Shop grades shows a persistent and increasing RPI. For the clearwood grades, the RPI is noticeably higher than the baseline commodity index and exhibits considerably higher fluctuation in response to cyclic market factors. The average relative price ratio for Douglas-fir Moulding & Better grade lumber is 315% of the baseline commodity index, while the average relative price ratio for #3 Shop grade lumber is 143%. This simply means that the average price over the 1989 to mid-1995 period (even though spot prices fluctuated in response to short-run market influences) is 3.15 times the baseline commodity index, while the spot prices for Douglas-fir #3 Shop average 1.43 times the baseline commodity index.

The price data illustrates the fact that there have been substantial fluctuations in both RPI values and the price trends since early 1992 for the higher-grade Douglas-fir lumber products. Since mid-1992 the trended RPI for Moulding & Better grades has increased as indicated by the linear trend line plotted in Figure 23. The trend line shows that the RPI increased on average by 0.26% every two weeks or by approximately 0.52% per month relative to the baseline commodity index. Thus Douglas-fir Moulding and Better grade lumber has increased its degree of relative differentiation over this period. In the short-term, the RPI fluctuated substantially in response to cyclic market influences. Although the prices of both Douglas-fir Structural grade lumber products and Moulding grade lumber products fluctuated substantially over this period, relative prices for Moulding grade lumber exhibited more dramatic price fluctuations than the baseline commodity product. As a result of these short-term price fluctuations for the clearwood lumber grades, buyers would have an incentive to reduce their purchases of these grades and/or consider the possibility of product substitution in the longer term.

In the longer term, the higher valued Moulding grades of lumber increased their price differentiation in terms of the baseline commodity index. Similarly, the RPI for Douglas-fir #3 Shop grade lumber increased at approximately 0.54% every two weeks or almost 1.1% per month. Although the average relative price differential was less than for the Douglas-fir Moulding & Better grade lumber, the upward trend in relative price was greater for #3 Shop grade lumber, indicating that this grade was increasingly differentiated from the market average. The steeper price trend for Douglas-fir #3 Shop grade lumber might be attributed to increased demand as manufacturers substituted lower-priced Shop grade lumber for Moulding grade lumber in some applications.

Ponderosa pine. As observed with Douglas-fir, the lower-valued grade of ponderosa pine (#3 Common) maintained relative prices at or near the baseline commodity index (represented by the horizontal line located at the 100% position) (Figure 24). However, the RPI for #3 Shop grades was consistently above the baseline, averaging 185%, with only a very slight upward trend over time at approximately 0.18% per month. The RPI's for the higher-grade ponderosa pine lumber products, however, were considerably higher with C & Better grade lumber displaying an average RPI of 574% over the baseline commodity index.

The trend line indicates that the relative price advantage for C & Better ponderosa pine lumber declined over the observed period. Although this grade enjoyed a relative price of over 500% compared to the baseline commodity index, the RPI declined by over 1.0% every two weeks or by approximately 2.1% per month. The same pattern is

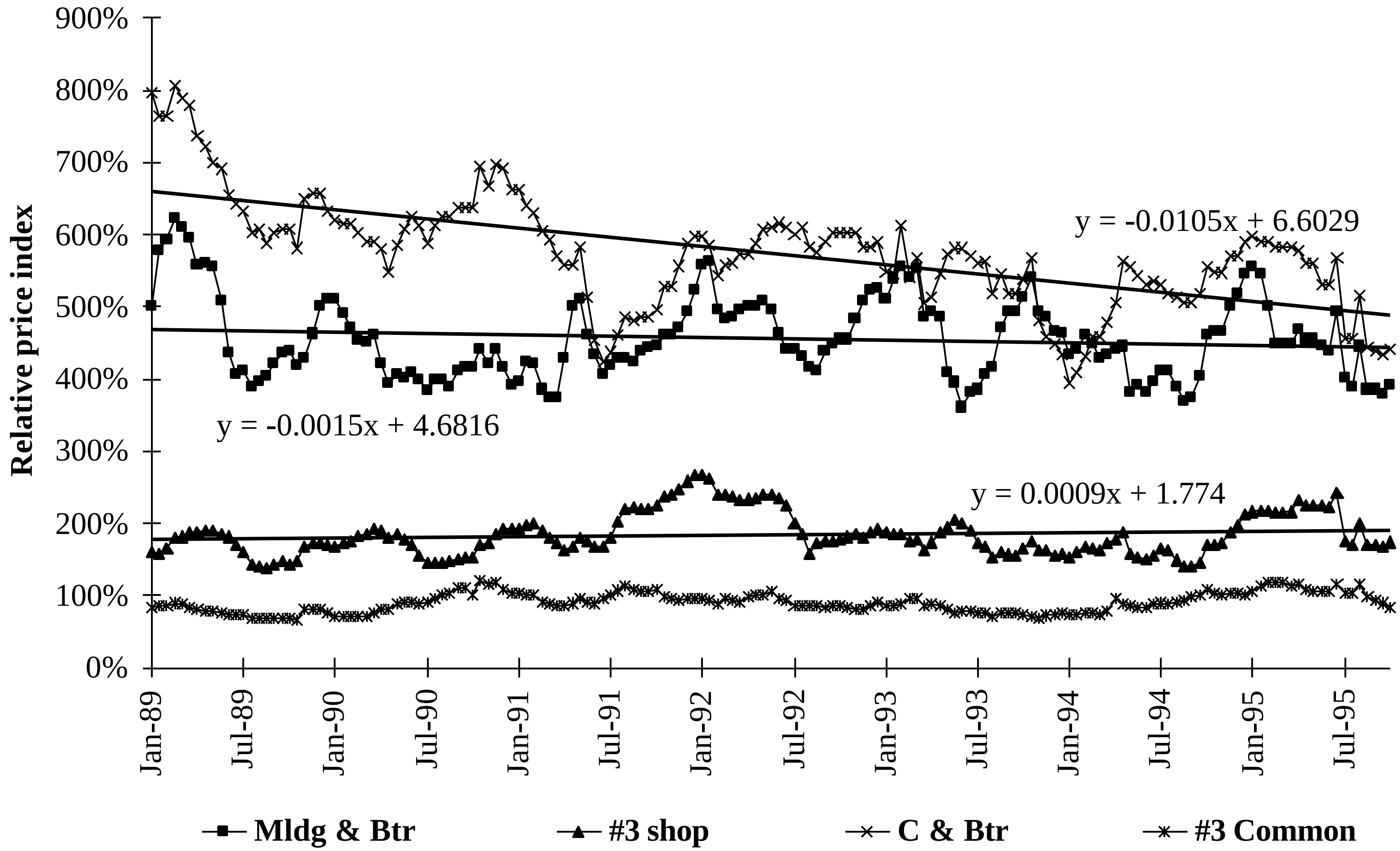

Figure 24. Relative price trends for ponderosa pine lumber products.

demonstrated by the RPI for ponderosa pine Moulding & Better grade lumber. The average RPI was 456%, somewhat below the level for C & Better grade lumber. The RPI for Moulding & Better grade lumber declined over the observed period by approximately 0.15% every two weeks or 0.3% per month. By the end of the observation period, the RPI for these two higher-valued ponderosa pine lumber grades were approaching a common value of approximately 400% the level of the baseline commodity index. The higher-valued grades of ponderosa pine lumber exhibited a relatively strong cyclical pattern for the relative price index. The RPI's declined over much of the mid-1992 to late-1993 period for C & Better lumber and from the mid-1993 to mid-1994 period for Moulding & Better lumber, with strong increases thereafter through early 1995. The RPI for both C & Better grade lumber and Moulding grade lumber declined throughout the 1995 period.

Southern pine. As with both Douglas-fir and ponderosa pine, there is a strong relationship between the baseline commodity index and the prices for the lower grades of southern pine lumber (*i.e.*, 2x4 Standard & Better, Utility 2x4, #3 Common 1x6) (Figure 25). The average RPI for these commodities were 96%, 79%, and 72%, respectively. As these average RPI indicate, the relative prices for the lower grades of southern pine lumber were generally below the baseline commodity index.

Southern pine C & Better 1x6 lumber has consistently shown a strong RPI, averaging 225% compared with the baseline commodity index. Further, the relative price trend has been generally upward, increasing at approximately 0.14% every two weeks or by almost 0.3% per month. The price data indicates a strong cyclic trend for the southern pine C & Better grade lumber. Overall, the RPI declined during much of the 1991 to mid-1993 period, increased from mid-1993 to early-1995, and declined during much of 1995.

Hemlock-fir and spruce-pine-fir. The hemlock-fir and SPF species groups do not traditionally yield high quality grades of softwood lumber. This fact is reflected in the product prices where the average RPI's for SPF products were 0.77% for Standard & Better grade lumber and 0.54% for Utility grade lumber (Figure 26). Similarly, the average RPI's for hem-fir lumber grades were 0.89% for Standard & Better grade lumber and 0.62% for Utility grade lumber (Figure 27).

Although the RPI for hem-fir has fluctuated considerably around the mean, there is little trend towards closing the differential with the baseline commodity index for either hem-fir Standard & Better or Utility grades of lumber. In contrast, although the average relative price index for SPF is also below the baseline commodity index, the trend has been towards a reduction in the differential with the baseline commodity index. There has also been greater a fluctuation in the RPI for the SPF lumber products, particularly since early 1992, indicating more variable markets.

Product Differentiation, Cross-Price Elasticity, and Substitution

Relative price differences between similar lumber products indicate effective differentiation between the products and also the potential for substitution between the two products. The analysis of price trends between species for similar products and between product grades within a species group shows definite patterns of prices, on both a nominal and relative basis. The patterns revealed here indicate that many softwood lumber products are highly differentiated in terms of the perceived market values, reflecting unique attributes that are individually valued by end users. This confirms that there is not a single softwood lumber market, but rather a set of related market segments for specific differentiated lumber products. Nevertheless, the literature for lumber market economics research has shown a strong overall correlation between end uses and lumber demand for residential construction, giving rise to significant overall lumber market fluctuations which are frequently reflected in the prices for individual lumber grades.

The price analysis confirms that softwood lumber product differentiation is significant, particularly for those product grades that possess preferred clearwood lumber attributes. Clearwood lumber products and grades have been able to sustain a level of product differentiation based on relative prices over time, with only moderate changes in the longer term trends of the RPI since 1989.

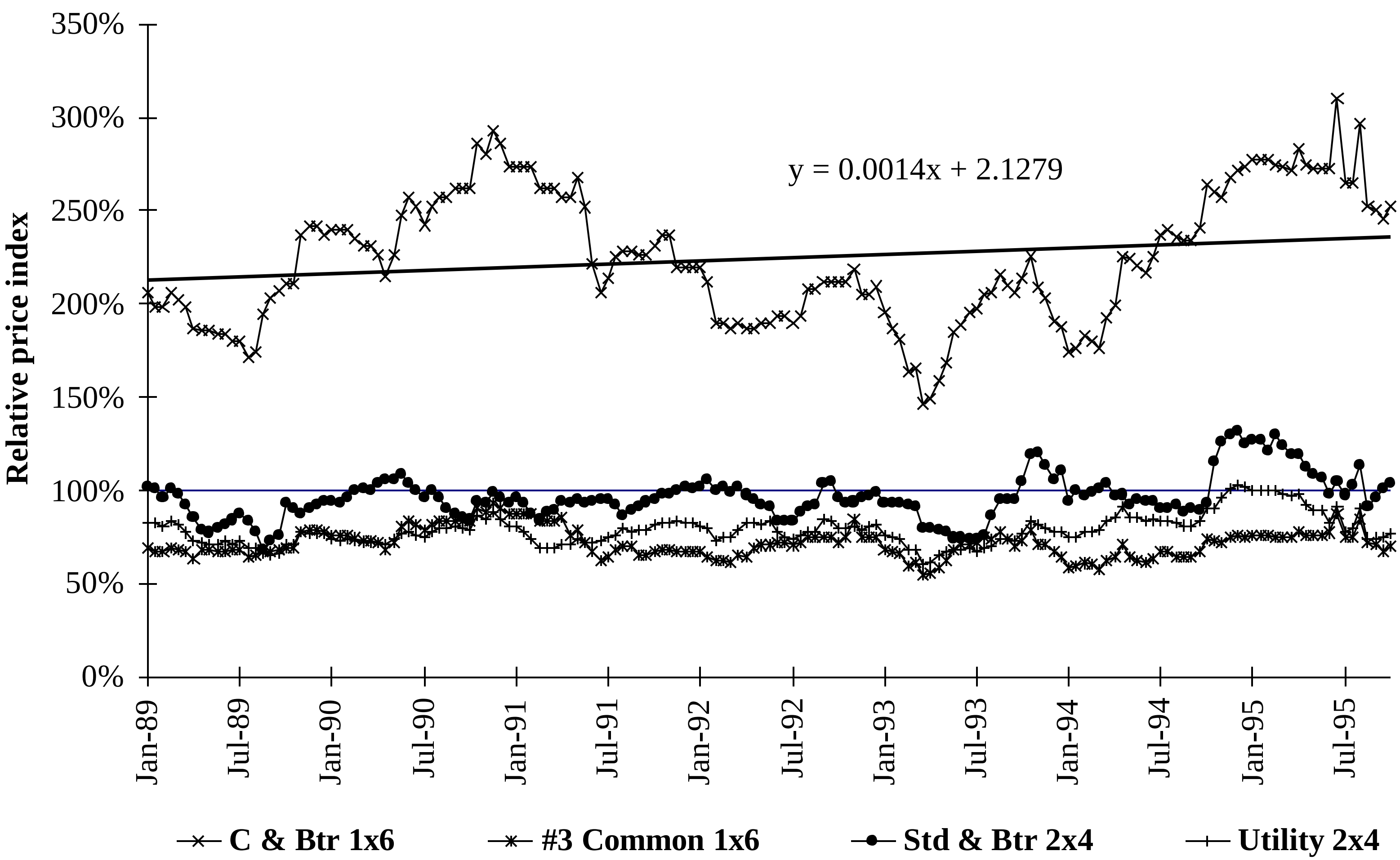

Figure 25. Relative price trends for southern pine lumber products.

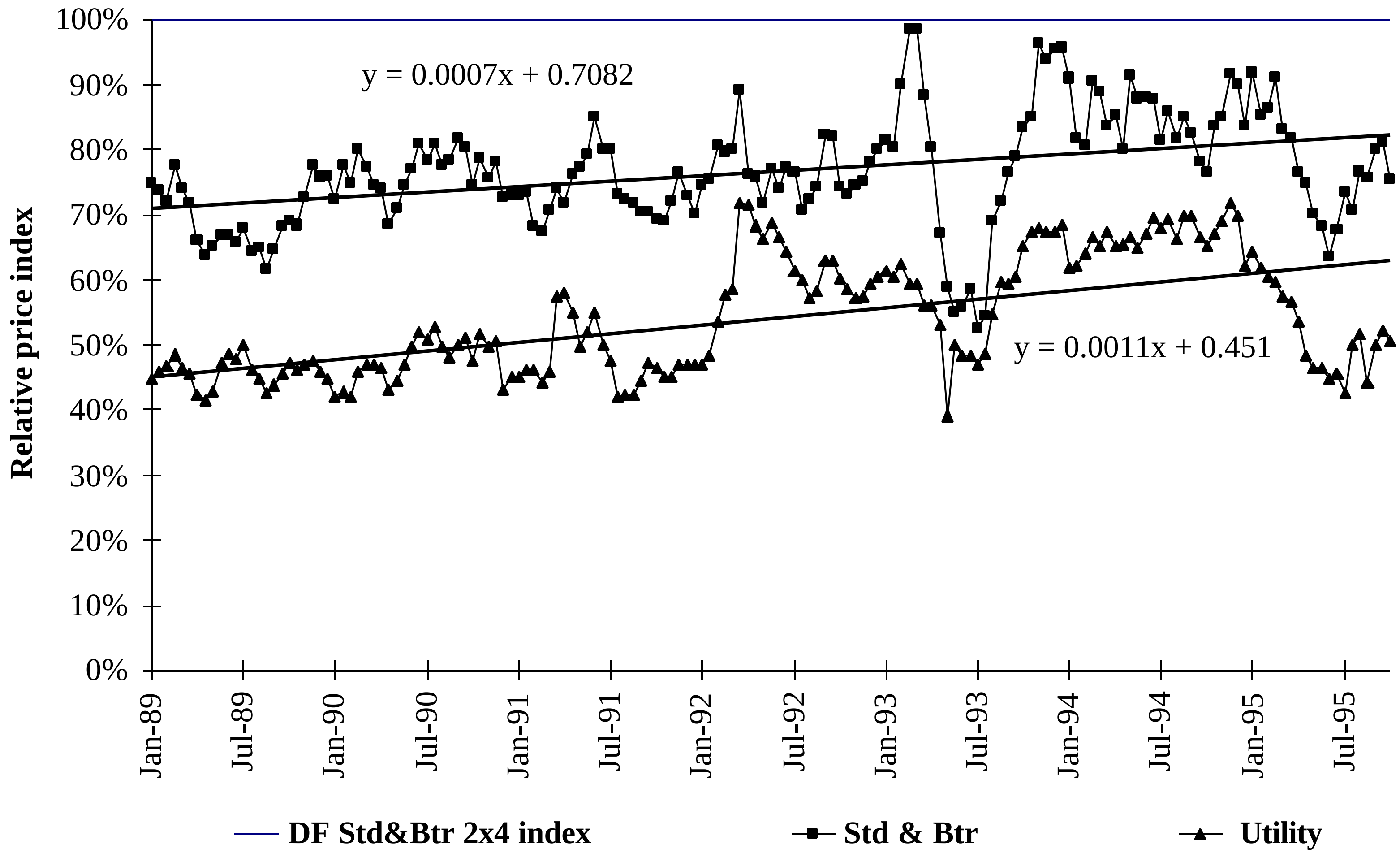

Figure 26. Relative price trends for SPF lumber products.

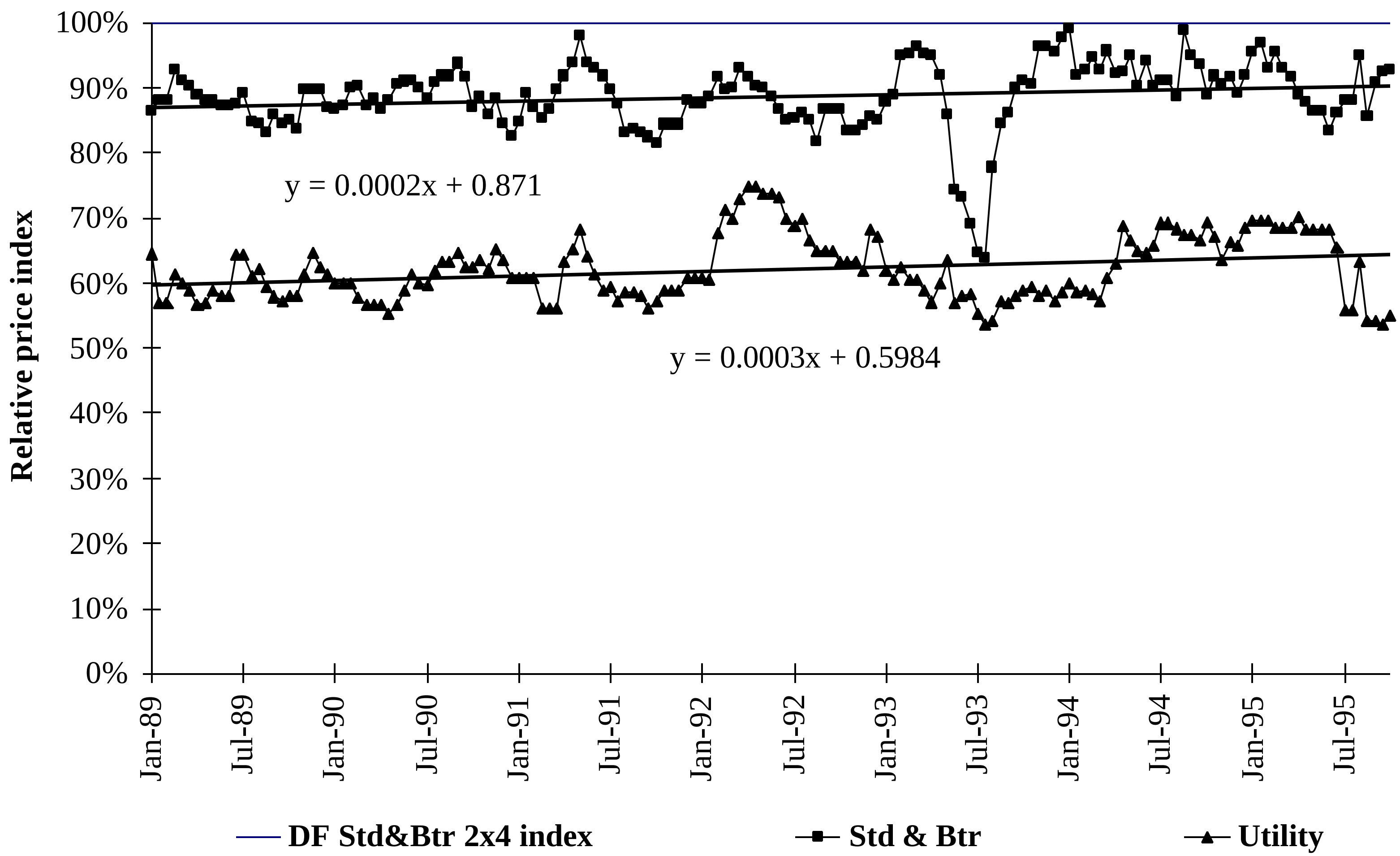

Figure 27. Relative price trends for hem-fir lumber products.

The average RPI values for the different softwood lumber products investigated are summarized in the first column of Table 17. Values for the lower-grade lumber products are below 100%, indicating that the baseline commodity index product commands a modest relative premium over these competing commodity lumber products. Shop grade lumber displays an average relative price premium over the baseline commodity index ranging from 143% for Douglas-fir to 185% for ponderosa pine. C & Better grade lumber exhibits a relative premium over the baseline commodity index of 125% for southern pine to 474% for ponderosa pine. Likewise, Moulding & Better grade lumber commands a relative price premium of 214% for Douglas-fir and 356% for ponderosa pine.

The price premiums indicated by the average RPI values presented in Table 17 changed modestly over time, yet displayed substantial stability. Column 3 of the table summarizes the trend line slope coefficients, indicating the rate of change per two-week data observation period. For the clearwood lumber grades, the coefficients are positive for Douglas-fir Moulding & Better grade and #3 Shop grade lumber, southern pine C & Better grade lumber, and for ponderosa pine #3 Shop grade lumber. The small values of the coefficients indicate changes in the average RPI of 1% or less per month. Increasing RPI trends are an indication of the potential for product substitution as manufacturers experience increased relative prices over time.

In contrast, the RPI values declined over time for ponderosa pine Moulding & Better grade and C & Better grade lumber. The average premiums in relative prices for these grades are high (356% and 474% respectively), with the rate of decline the greatest for C & Better products at just over 2% per month over the observed data period. A declining relative price index would indicate a potential increase in competitiveness, since the product price has become slightly less expensive relative to the overall softwood lumber market.

Table 17. Average relative price index by species, product grade and time trend.

	Average RPI	**Standard Dev. (RPI)**	**Trend line Slope**
Ponderosa pine			
Moulding & Better	4.56	0.56	-0.0015
#3 Shop	1.85	0.30	0.0009
C & Better	5.74	0.77	-0.0105
#3 Common	0.90	0.13	N/A
Southern pine			
C & Better 1x6	2.25	0.35	0.0014
#3 Common 1x6	0.72	0.08	N/A
Standard & Better 2x4	0.96	0.12	N/A
Utility 2x4	0.79	0.08	N/A
Douglas-fir			
Moulding & Better	3.14	0.43	0.0026
#3 Shop	1.43	0.20	0.0054
Standard & Better 1x6	0.81	0.10	N/A
Utility 2x4	0.71	0.05	N/A
SPF			
Standard & Better	0.77	0.09	0.0007
Utility	0.54	0.09	0.0011
Hemlock-Fir			
Standard & Better	0.89	0.05	0.0002
Utility	0.62	0.05	0.0003

Table 17 also provides a summary of the standard deviation of the RPI values around the trend line. This measure is a better index of the short-term dynamics of relative prices and reflects the period to period variation of individual product prices. The variations indicated by the standard deviations for the standard commodity grades of softwood lumber shown in the table are modest, ranging from 0.05 to 0.13. Variations for the clearwood grades, however, are more significant, ranging from 0.30 to 0.77. These variations generally correspond to rapid fluctuations in the relative price index during short-term market cycles. Due to the specialized niche markets for clearwood grades and the relatively less elastic demand, prices for these grades are more volatile in the short-run, indicating a potential for greater short-run substitution. In particular, where short-run fluctuations in relative prices are perceived to be indicators of possible long-run price trends, buyers may be quicker to initiate decisions on the use of substitute products.

The review of the price elasticity literature indicates that own-price elasticities for softwood lumber products are quite low (or inelastic) in the short-run, with absolute values in the range 0.035 to 0.285, most of which clustered between 0.15-0.20. This would indicate a fairly unresponsive inverse relationship between lumber price changes and their impact on the quantity of a lumber product consumed in the short-run. Since the absolute value of the own-price elasticity is less than 1.00, the own-price elasticity is inelastic, indicating that a 1% change in price will result in an approximate 0.2% inverse change in the quantity of lumber consumed in the short-run (holding all other demand factors constant). It should be noted that under the restrictive assumptions of short-term elasticity, not only is it assumed that the price of a commodity changes (own-price) but it is implicit that the relative price with respect to all other goods and services also changes, since all other prices are assumed to remain constant.

The change in the price of one commodity relative to the price of other commodities encourages product substitution. In the short-run, this substitution is effectively prohibited or minimized by economic assumptions. The short-run elasticity simply reflects the basic economic phenomenon implied by a negatively sloped demand, that consumers will use less of a product as its price increases, and conversely, will use more of the product as its price falls.

In contrast, cross-price elasticity seeks to identify the linked response when the own-price elasticity does not change but the price of a potential substitute changes. This situation also implicitly reflects a change in the relative price (or relative price index as defined here). This relationship is clearly a long-term response, allowing buyers to observe and react to price changes of substitute products over time. Estimates of demand long-term elasticity seek to incorporate this effect by capturing both the immediate own-price response (shift along a demand function) as well as the cumulative shift in demand due to changes in other product prices as well as the possibility that other demand shifters also change.

Many econometric techniques seek to use a distributed lag approach to estimate long-term elasticities in order to capture the sequential adjustments (Waggener *et al*. 1978, Moffett 1993). For example, if there is a one-time fixed change in a product's own-price, short-run elasticity estimates the change in quantity consumed during the current (market) period for a static demand function. However, as buyers learn of the price change, they begin to consider using other goods, as well as to modify their product usage in other ways. Clearly a cumulative change process is initiated in response to a specific level of price change. Over time, additional adjustments add to the short-term adjustment in consumption. This lagged change in consumption may be small if the time to adjust purchase behavior is short. However, over successive time periods, additional (lagged) adjustment takes place, ultimately resulting in a cumulative long-term elasticity or final change. A major statistical complication is the inability to observe, in period two, whether the market adjustment is a continuation of the adjustment from the first period own-price change or reflects a new, second period short-term change. In this latter case, the second market period would show the sum of the first (short-run) adjustment to a new own-price change and the cumulative second period adjustment to the previous period change. Deconstructing the second period observed change into these two components is a statistical problem that is beyond the scope of the present discussion.

It has been noted that a relative price change can occur either through a change in the price of a specific lumber product or through the price of a potential substitute product. For example, a change in the RPI for ponderosa pine Moulding & Better grade lumber between any two periods could have resulted from either a change in the absolute price for ponderosa pine Moulding & Better grade lumber or from a change in the price of the baseline commodity index product (Douglas-fir Standard & Better 2x4's). A 1% decline in the price of ponderosa pine Moulding & Better grade lumber would have the equivalent impact on the RPI as a 1% increase in the price of Douglas-fir Standard grade 2x4's. It has been hypothesized in econometric research that buyers should be indifferent to which price changes; rather, they would base their purchase decisions on the change in the relative price (Simon 1979). Simon's innovative analysis (1979), examined the impact of branded products, where brand names established imperfect product differentiation between two similar but differentiated products. Softwood lumber is typically not differentiated by a branding strategy, but rather by product grades. The product attributes established through grading rules allow end users to gauge the degree of differentiation between different lumber grades.

In the discussion of relative price trends for softwood lumber species and grades, the possibility for substitution is most evident in the variations around the average RPI trend lines for the clearwood lumber products. Where the trend line slopes are low, the trend line itself provides a comparison of the variations. The slope coefficients for the trend lines are generally small, indicating a change in relative price index values of less than 1% per month with the exception of ponderosa pine C & Better grade lumber (Table 15). Where the variation (standard deviation) around the trended RPI is fairly significant substitution might be expected to be greater.

Limitations of Harvest and Production Data

A complete statistical analysis of cross-product price elasticity was not feasible in the present study for a variety of technical reasons. While it was possible to derive specific price trends for the selected clearwood products, it was not possible to disaggregate the data for the respective volumes consumed by species or grade because lumber consumption was not available at this level of disaggregation. Very limited data was available for Douglas-fir (coast mills), ponderosa pine (inland mills), hem-fir (inland mills), and hem-fir (coastal mills) (Table 18). The available data disaggregates production into product grade groupings in terms of their proportion of total output. Data for the Douglas-fir clearwood grades of lumber was compiled on an annual basis for the period 1982 to 1994, with quarterly production data being available only for 1993 and 1994.

This breakdown of Douglas-fir clearwood lumber production by grade and species, while useful, does not meet the requirements for a statistical analysis of clearwood trends (both price and consumption) required to derive valid cross-product price elasticities. As noted, bi-weekly prices were selected as being the most representative of market movements for clearwood products. Annual or quarterly production and price data tends to mask much of the dynamic price movement that is important in a statistical analysis of market changes and demand shifts. Further, while the western softwood lumber region is important, this region alone no longer determines the clearwood market dynamics.

The correspondence between own-price change in the short-run (holding other factors constant) and the price change of a substitute product generates a change in the relative price between the two products and allows for some interpretation of the elasticity estimates (Simon 1979). In the studies summarized by Phelps (1993) the short-run own-price elasticity for softwood lumber ranged from 0.15-0.20 for the lumber products included in the reviewed research studies (primarily construction grade lumber). Assuming that these values represent a measure of the change in relative price of lumber products with respect to substitute products in the short-run, this would imply that if lumber prices remained constant while substitute product prices changed (resulting in a similar relative price change) the cross-product price elasticity would be within the same general range (Simon 1979).

The long-term price elasticities summarized by Phelps (1993) also offer an insight into the process of substitution. By relaxing the restrictive static assumptions implicit in short-run own-price elasticities, market dynamics can impact consumption over time. There are, of course, many potential variables which can cause these demand shifts over time, although a change in relative prices for substitute products is foremost in terms of price responses. Simon (1979) introduced a variable for representing all of the non-price terms in the estimated demand equations. For the lumber elasticity studies summarized by Phelps, it is unfortunately not possible to disaggregate the long-term factors leading to the estimated differences between short-term and long-term elasticities.

Table 18. FOB price and estimated yields of Douglas-fir clearwood lumber production in terms of total Douglas-fir lumber production.

YEAR	C Selects PERCENT recovered	C Selects PRICE $/mbf	C Selects VOLUME mbf	D Selects & Shop PERCENT recovered	D Selects & Shop PRICE $/mbf	D Selects & Shop VOLUME mbf	Total VOLUME mbf
1982	4.50	648	69,814	4.30	375	66,711	1,551,419
1983	3.30	685	90,818	3.50	426	96,322	2,752,061
1984	2.60	688	82,381	3.40	407	107,729	3,168,494
1985	2.40	671	70,258	3.20	410	93,677	2,927,403
1986	2.10	726	75,269	2.30	405	82,438	3,584,260
1987	2.00	837	79,518	2.80	411	111,325	3,975,895
1988	1.80	927	66,443	2.10	474	77,517	3,691,263
1989	1.00	1,078	36,598	1.60	503	58,556	3,659,762
1990	1.00	1,236	30,386	1.50	521	45,579	3,038,613
1991	0.60	1,200	16,049	1.20	535	32,098	2,674,855
1992	0.30	1,350	7,524	1.00	576	25,079	2,507,869
1993	0.10	1,197	2,386	0.70	809	16,702	2,386,007
Q1	0.10	1,182	577	0.80	723	4,619	577,373
Q2	0.10	1,178	570	0.70	892	3,988	569,718
Q3	0.10	1,128	609	0.60	807	3,653	608,916
Q4	0.10	1,314	630	0.70	825	4,410	630,000
1994	0.10	1,413	2,701	0.80	752	21,607	2,700,841
Q1	0.10	1,516	606	0.90	795	5,451	605,676
Q2	0.10	1,545	672	0.90	769	6,052	672,422
Q3	0.10	1,328	728	0.60	718	4,368	727,945
Q4	0.10	1,221	694	0.80	722	5,550	693,798
1995							
Q1	0.10	1,164	653	0.60	724	3,918	653,005

Source: Warren (1995).

As a simplification, it is reasonable to assume that the cross-product price responses are no more, and most likely less, than the long-term total change in elasticity. Hence, the long-term elasticities would provide an upper boundary on possible substitution. Assuming a once-and-for-all change in softwood lumber relative prices, the long-term elasticities fell in the general range of 0.88-0.91 at the high end, and overall at about 0.45-0.60. By substitution of the average estimate of short-run elasticity, the additional or incremental dynamic adjustments over time would appear to approximate an increase in the absolute measure of elasticity from 0.25 to 0.65. That is, after recognizing the short-term impact of own-price adjustment, it appears that subsequent market dynamics (including both price and non-price factors) would induce an additional increase in elasticity within the above range. This would provide an initial approximation of the cross-product price elasticity of substitution for softwood lumber substitutes when prices of clearwood product grades increase by small amounts.

Real Price Differences and Economic Returns to Wood Quality

In this analysis, nominal lumber prices were initially differentiated by two separate measures in order to facilitate comparison of the spot prices over time:

? The **real price difference** is computed as the difference between a specific product grade/species and the baseline commodity index (*i.e.*, Douglas-fir Standard & Better 2x4's). The baseline commodity index was used as an indicator of the overall softwood lumber market and nominal price differences were adjusted to a constant (1995$) basis.

? A **real price spread** was computed as the price difference between a species-specific grade and a commodity grade baseline product chosen from the same species. This measure indicates the comparable spread in the nominal prices for a select clearwood grade product and the commodity grade product from the same species. The nominal price spreads were adjusted to a constant (1995$) basis.

The nominal values, as defined above, were first discounted to convert values to constant 1982 dollars in order to minimize the effect of inflation. The price differences and price spreads were discounted using US Department of Labor price index data for all intermediate materials with a base of 1982=100. Next, these constant (deflated) values were adjusted from 1982 to 1995 values (as of January 1, 1995) for ease of interpretation, Appendix E.

Real price differences

Price differences are useful in assessing how an end user's perception of value differs between a specific softwood lumber product and the baseline commodity product where the baseline commodity product serves as a broad market indicator for the aggregate softwood lumber market. However, in order to interpret the behavior of price differences over time, the trends in absolute prices must be converted to real, or constant, dollars to avoid distortions caused by general inflationary trends.

As would be expected, there is considerable variation in the real (constant 1995 dollar) price differences which correspond to fluctuations observed in the nominal price trends themselves. This variation can be attributed to dynamic market shifts over time in response to broad cyclical influences that impact all grades and species of softwood lumber. If, however, these influences were completely independent of species or grade, the relative comparison of prices in real terms would be constant. Fluctuations in the real price differences therefore indicate a changing relationship between the different product-specific species/grade products relative to the overall softwood lumber market as reflected in the commodity baseline product. A value of zero would reflect no difference between the selected product and the baseline product as measured in constant or real dollar terms. Positive differences represent a real price premium received by the selected product in real terms compared to the overall market; a negative difference indicates a comparative price disadvantage relative to the Douglas-fir baseline.

In the figures that follow, a trend line is used to illustrate the trend in real price differences based on spot prices for each of the products being considered. The slope coefficient for the trend line indicates the overall trended change in the real price difference over the data series relative to a two-week interval. Thus, the approximate monthly change in the real price difference would be twice the slope coefficient.

Ponderosa pine. Over the observed period, the three selected grades of ponderosa pine displayed positive absolute real price differentials as reflected by the positive value of the slope of the regression equation (Figure 28). C & Better lumber enjoyed the greatest real price difference, averaging $1,563/mbf above the baseline commodity index. Real prices for Moulding and Better grade ponderosa pine enjoyed an average premium in real terms of $1,195/mbf, while #3 Shop grade had an average real price premium of $280/mbf.

A distinct cyclical trend is evident for the real price differentials for both ponderosa pine C & Better and Moulding and Better grade lumber. Real differences peaked in late spring 1993, reaching levels above $2,300, although the real price differences have subsequently fallen to the more modest levels observed before the price run-ups in early 1993. The period trends indicate increasing real price differences for the three grades shown. Real price differences, on average, showed monthly increases of approximately $1.90/mbf for #3 Shop, $2.02/mbf for C & Better, and almost $5.65/mbf for Moulding and Better grades.

Southern pine. The only grade of southern pine lumber with a substantial series of price data was the C and Better 1x6 southern pine (Figure 29). This product displayed a positive real price differential over the period observed and had an average real price difference of $405/mbf over the period 1989 to 1995. The real price difference increased at approximately $3.15/mbf per month.

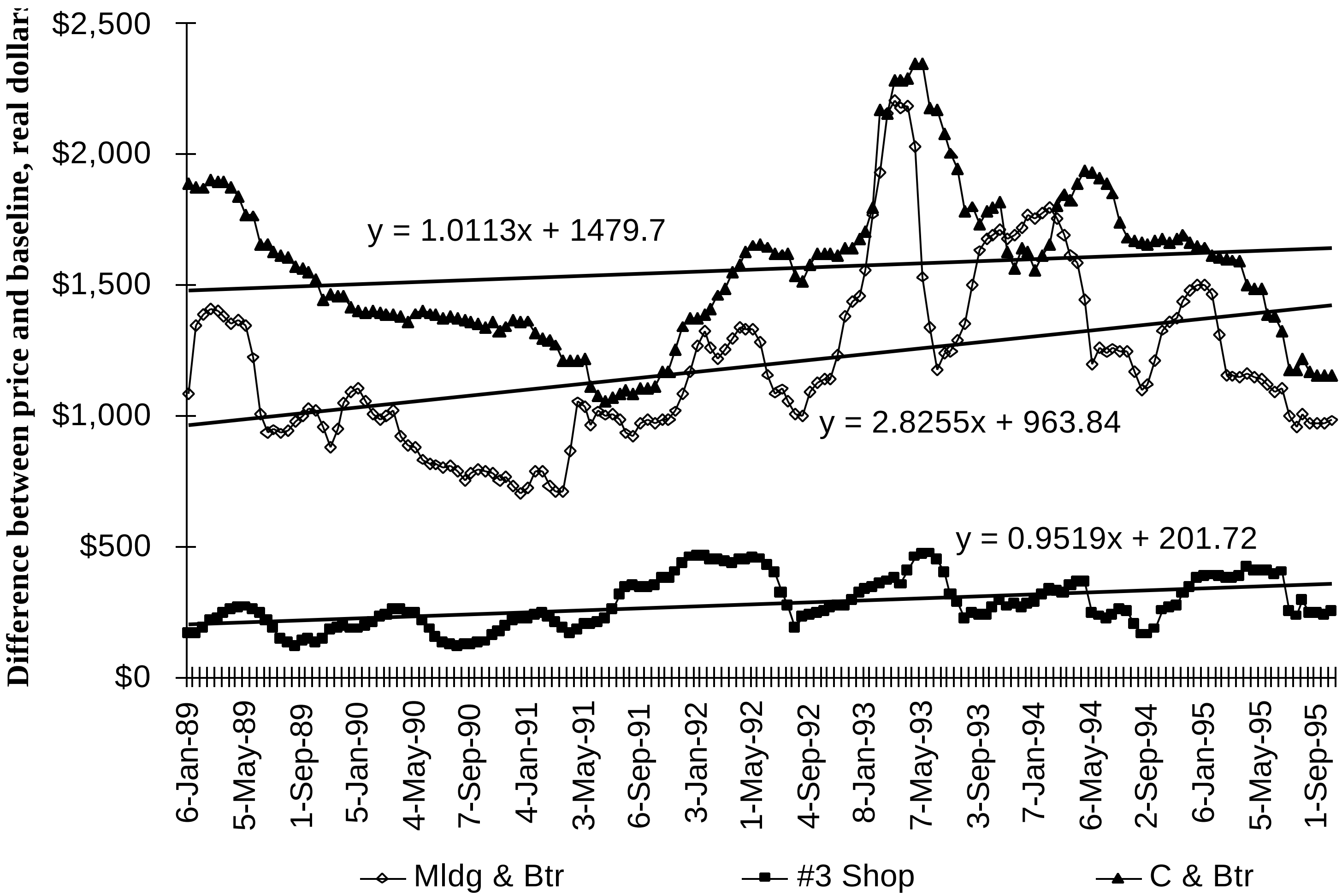

Figure 28. Real price differential between different grades of ponderosa pine and the baseline commodity index (Douglas-fir Standard & Better 2x4's) in 1995 dollars.

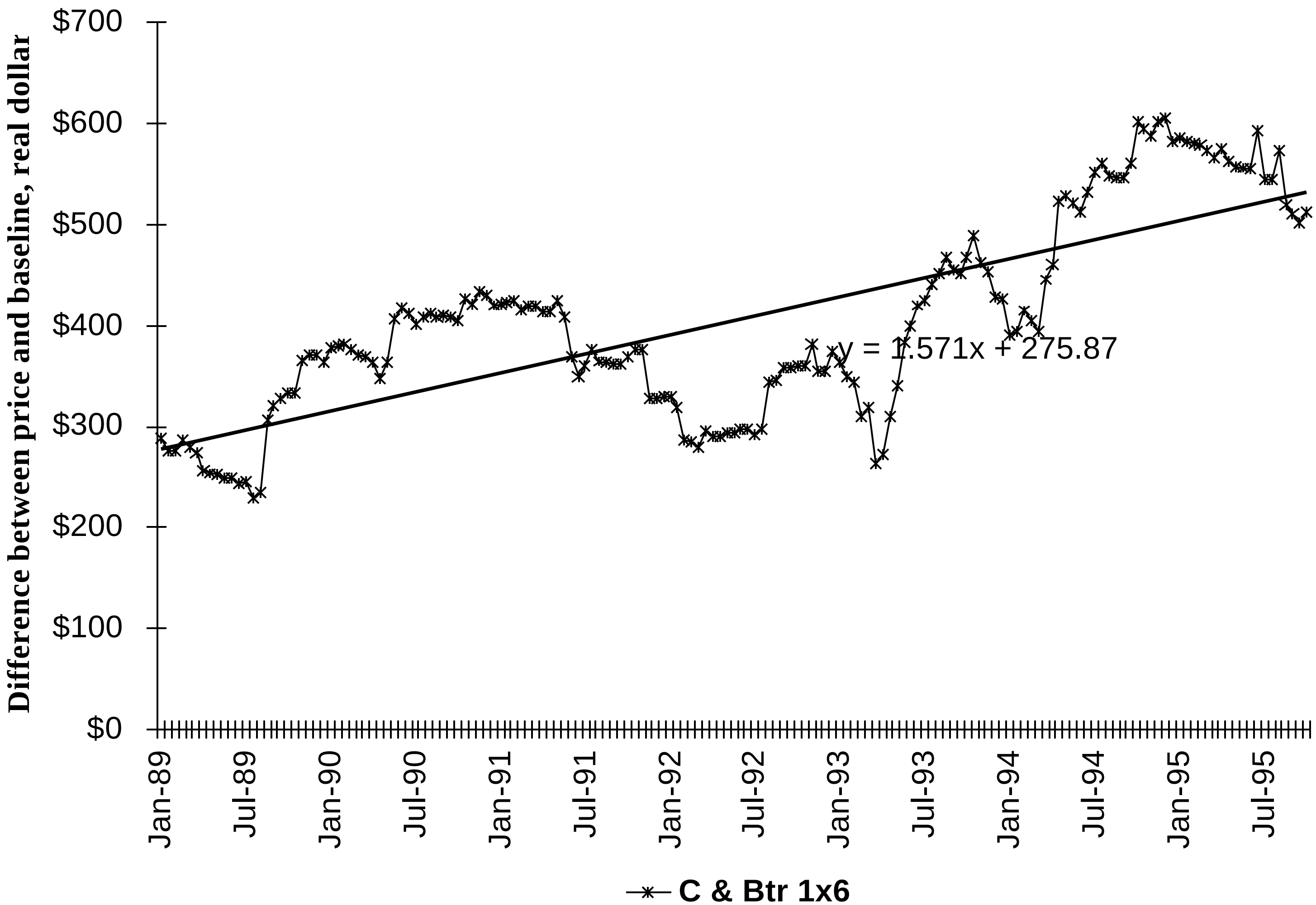

Figure 29. Real price differential between southern pine 1x6 C & Better lumber and the baseline commodity index (Douglas-fir Standard % Better 2x4's) in 1995 dollars.

Douglas-fir. Since Douglas-fir Standard & Better 2x4 was chosen as the overall softwood lumber baseline commodity index for this analysis, the derivation of price differences and price spreads is identical. In both cases Douglas-fir clearwood grades are compared to the same baseline commodity index. For this reason, the discussion of Douglas-fir price differences is deferred to the following sub-section and is presented as the real price spread rather than the real price difference.

Real price spreads

In many cases, the behavior of real prices over time is of primary interest in terms of the financial implications of changing product grade yields within a species. This is the case where investment options are being considered in forest management which might be expected to result in changes in both the total timber volume as well as the relative yields of different product grades. By improving the proportion of clearwood grade yields, a higher gross lumber return may be available, potentially offsetting costs associated with intensive management practices. If the real price spread increases over time, the comparative cost-benefit relationship may also change favorably, assuming that real costs are constant (or, increasing by a smaller amount). In contrast, a decline in the real price spread over time would reduce the economic attractiveness of intensive forest management investments when evaluated on the basis of current real premiums. In this case, it is the real price spread within the species that determines the economic viability of the investment, since lower-quality wood is being replaced by higher-grade wood which can be converted into higher-value lumber products.

Real price spreads for the three major species groups yielding clearwood grades are shown below. Trends for SPF and hem-fir lumber products are not included in this discussion since these species groups do not yield significant volumes of clearwood grades; therefore the relevance of their real price spread for silvicultural investment purposes is less significant.

Douglas-fir. As noted, the trends in real price spreads and real price differences for Douglas-fir clearwood grades are identical due to the choice of Douglas-fir Standard & Better 2x4's as the baseline commodity index for both calculations. The real price spreads for the Douglas-fir clearwood grades show contrasting trends, although the data for both of these grades were limited to the past three years (Figure 30). Douglas-fir Moulding & Better displayed a real price spread of $824/mbf on average over the data period while exhibiting considerable cyclic variation. Based on the trend observed, the real price spread declined by approximately $1.07/mbf per month to approximately $777/mbf (in real dollars) by October 1995. In contrast, the average real price spread for #3 Shop was $166/mbf. With similar cyclic fluctuation, the real price spread trended upward by approximately $2.88/mbf per month since mid-1992 over the period of observation.

These results pose a possible dilemma for potential investors in silvicultural methods to improve grade yields through intensive management. If silvicultural management practices provide an increase in #3 shop lumber versus lower-grade lumber, it appears that real price spreads would contribute to improved economic returns. However, if the gain in quality is reflected in Moulding and Better grade lumber, the moderately declining real price spread might actually indicate lower returns over time. Future gross gains to quality improvement would likely lead to positive returns to higher grade-lumber, but at a slowly diminishing rate. It should, however, be noted that data was only available for the period June 1992-July 1995 for the Douglas-fir clearwood grades, thus limiting the length of time for determining the long-term price trend. This trend is based on some 156 data observations, assuring reasonable statistical validity for the period covered. Nevertheless, it is possible that relatively lower real prices in the 1989-1992 period would alter the long-term trend line.

Ponderosa pine. The average real price spread for #3 Shop was $315/mbf relative to the baseline index, ponderosa pine #3 common (Figure 31). Cyclic variation was modest in this real price spread, with an overall increasing trend at approximately $1.59/mbf per month. The real price spreads were considerably greater (and more variable) for both the Moulding & Better and C & Better clearwood lumber grades. The average real price spread for Moulding & Better was $1,231/mbf, while for C & Better it was $1,598/mbf. The trend line for Moulding & Better prices was increasing at approximately $5.33/mbf per month, although the cyclic trend has been downward since early 1993. The trend for real price spreads was also positive for C & Better, increasing at approximately

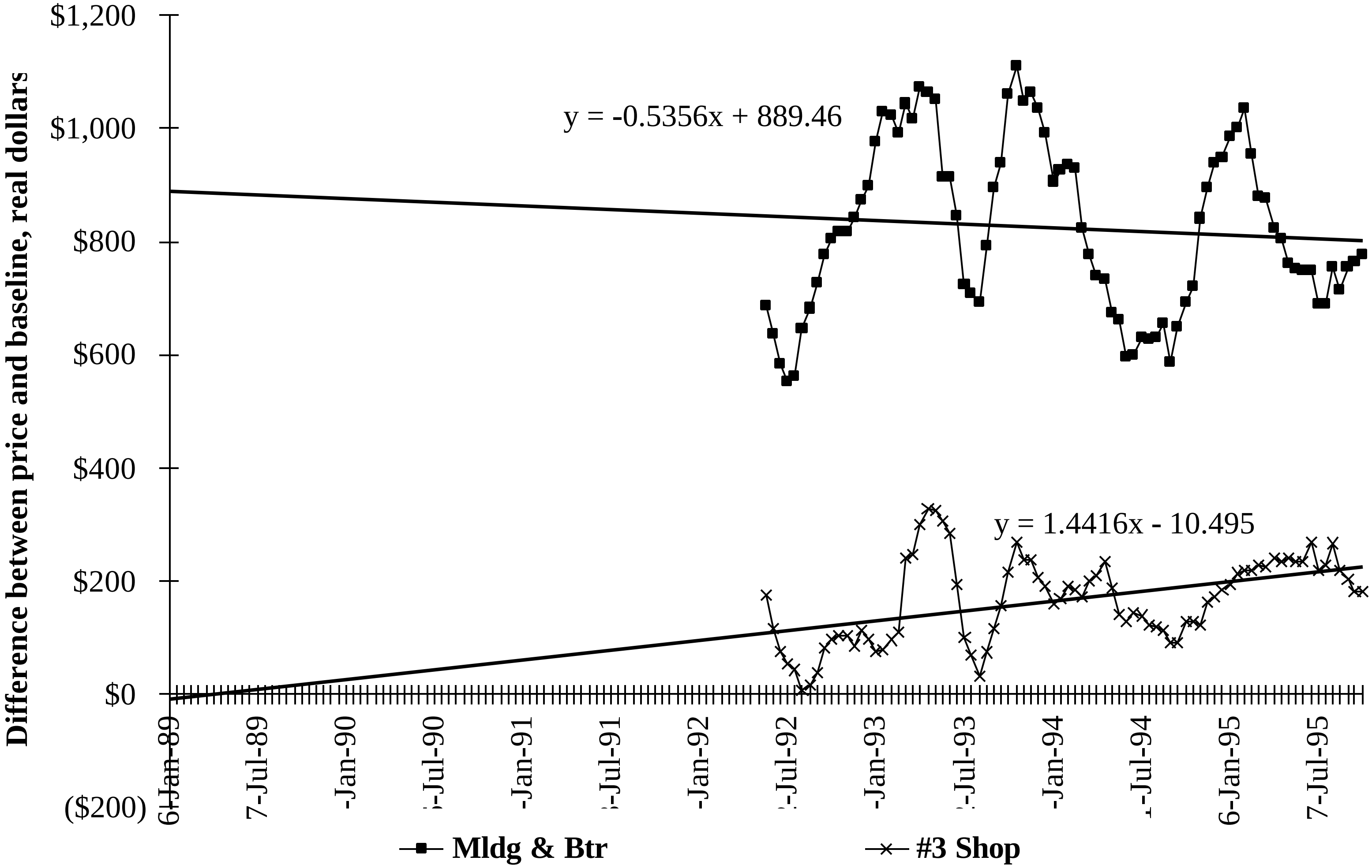

Figure 30. Real price differential between different grades of Douglas-fir lumber and the baseline commodity index (Doulas-fir Standard and Better 2x4's) in 1995 dollars.

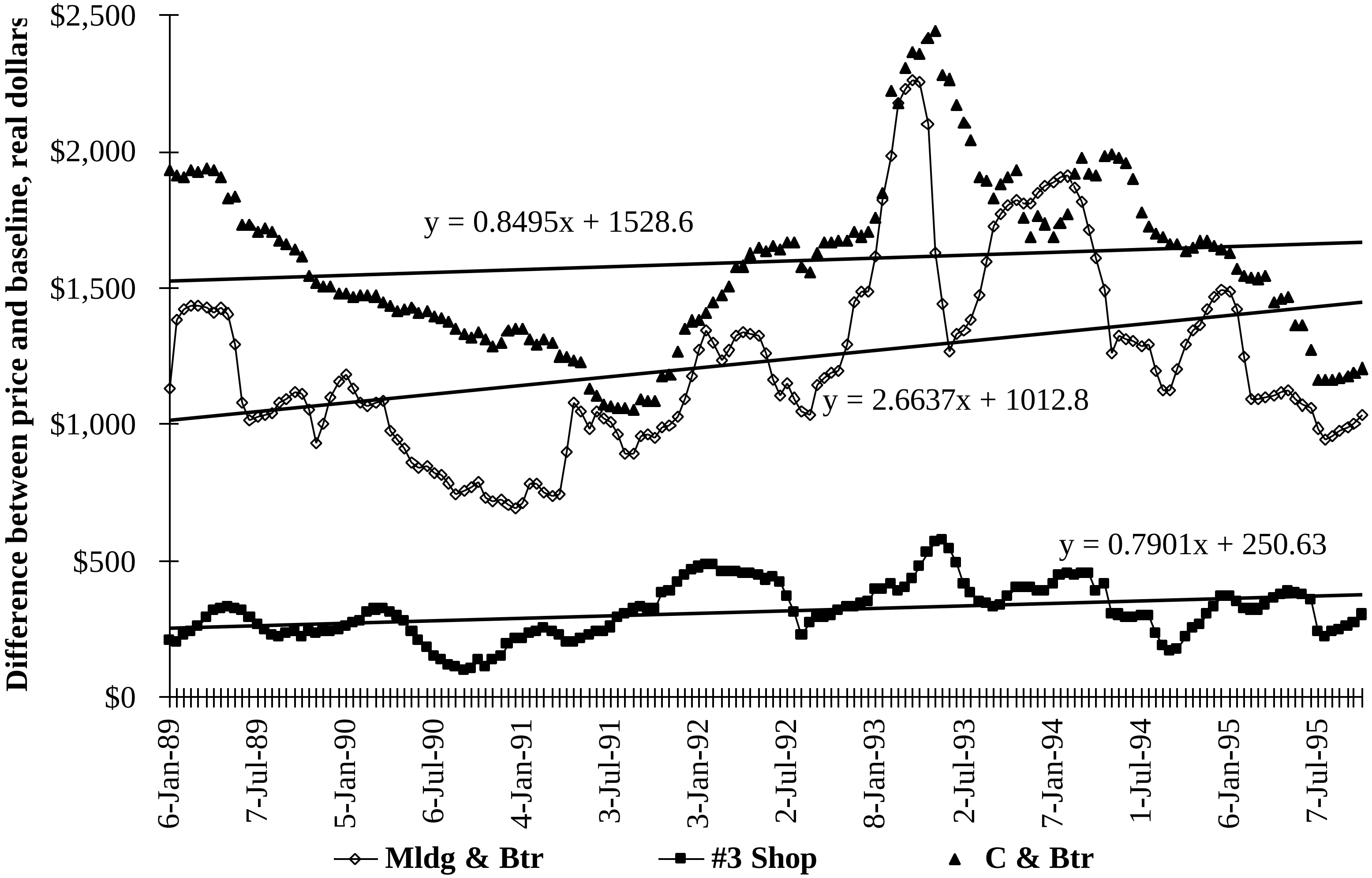

Figure 31. Real price differential between different grades of ponderosa pine lumber and a standard ponderosa pine baseline in 1995 dollars.

$1.70/mbf per month. For each of the three grades of ponderosa pine investigated, the positive real price spread trends observed were slightly lower than the comparable trends for the differences relative to the broad Douglas-fir market indicator baseline. Still, potential investments in intensive silvicultural practices to improve the proportional yields of the higher valued clearwood grades of ponderosa pine would enhance overall gross economic returns to the extent that a portion of the lower valued grade lumber were displaced by increased yields of high grade lumber. Improved yields of #3 Shop, would on the other hand, contribute more modestly to improved gross economic returns.

Southern pine. The southern pine C & Better 1x6 real price spread is compared to southern pine Standard & Better 2x4's (Figure 32). The average real price spread for C & Better 1x6 was $418/mbf over the data period, while the real price spread trended upward at approximately $2.54/mbf per month.

The average real price spreads for southern pine were less than the real price differences observed relative to Douglas-fir Standard & Better 2x4's. Similarly, the trend in the real price spread for southern pine C & Better 1x6 increased at a slightly lower rate than the corresponding change in the trend in real price difference as compared to the broader Douglas-fir market indicator.

Results and Discussion

Table 19 summarizes the findings for the real price differences and price spreads for the major species and grades of clearwood lumber included in the price analysis. Again, the real price differences express the actual dollar premium commanded by a specific product over the period of available price data compared to the baseline commodity index (represented by Douglas-fir Standard & Better 2x4's) and expressed in inflation-adjusted 1995 dollars. Similarly, the real price spread represents the actual dollar premium commanded by a specific product relative to the baseline commodity lumber product of the same species.

Table 19. Summary of average real price differences and real price spreads for clearwood products and rate of change, in 1995 dollars.

	Average Real Price Difference ($/mbf)	Rate of Change ($/mbf/month)	Average Real Price Spread ($/mbf)	Rate of Change ($/mbf/month)
Ponderosa pine				
C & Better	1,563	+ 2.02	1,598	+1.70
Moulding & Better	1,196	+5.65	1,231	+5.33
#3 Shop	280	+1.90	315	+1.59
#3 Common	-36			
Southern yellow pine				
C & Better 1x6	405	+3.15	418	+2.54
Moulding & Better	692		717	
#3 Shop 5/4	159		127	
Douglas-fir				
Moulding & Better	824	-1.07	824	-1.07
#3 Shop	166	+2.88	166	+2.88

Note: Where no rate of change is indicated, price data series was not sufficient to establish a valid long-term trend.

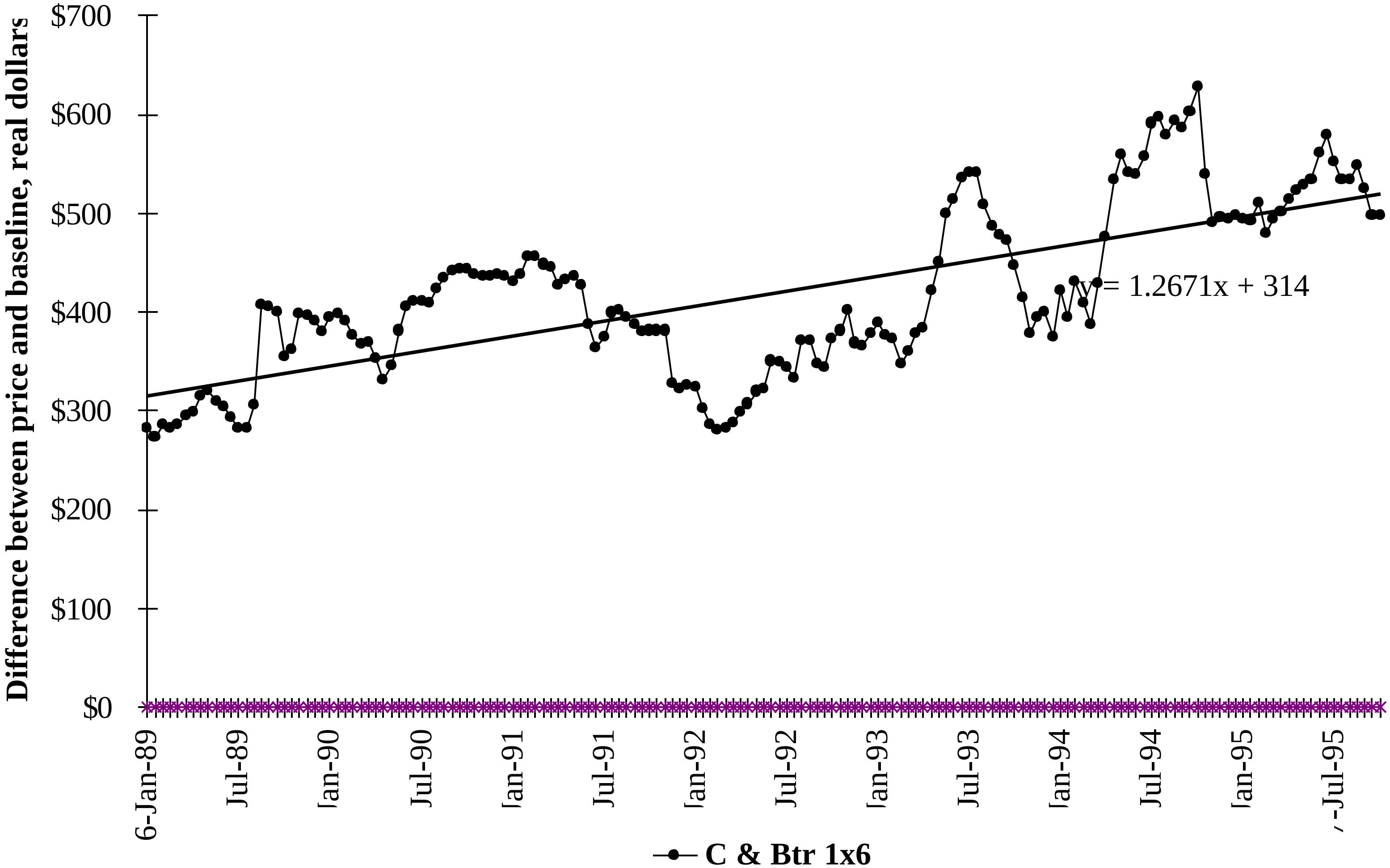

Figure 32. Real price differential between southern pine 1x6 C & Better lumber and a standard southern pine baseline in 1995 dollars.

The real price differences for clearwood lumber grades were substantial over the 1989-95 period (Table 19). The lowest prevailing difference was for Shop grades, which ranged from $159/mbf (southern yellow pine) to $280/mbf (ponderosa pine). C & Better grades showed the greatest real price difference, averaging $1,563/mbf for ponderosa pine and $405/mbf for southern pine respectively. Moulding grade real price differences ranged from $692/mbf for southern pine to $1,196/mbf for ponderosa pine. Based on trend analysis, these real price premiums appear stable over the observed data period, with upward trends for all clearwood grades with the exception of Douglas-fir Moulding and Better. This exception may be influenced by the shorter data time series available and may not fully reflect the longer trend shown for other species and grades.

Real price differences appear to increase in constant dollar terms, from $1.90/mbf per month for ponderosa pine #3 Shop to $4.65/mbf per month for ponderosa pine Moulding & Better These premiums do not appear to be transitory or the result of abnormal short-term market dynamics. Since 1989, the softwood lumber market has experienced a full business cycle in which clearwood products generally maintained and increased their real price premiums.

The real price spreads are likewise significant and tend to increase over the observed market period. This indicates that the higher-quality lumber grades within a species are increasingly differentiated by price from the commodity lumber grades of the same species. As noted above, the single exception to increased real price spreads is for Douglas-fir moulding grade, which may be influenced by the shorter data series. The slope coefficients for the trended behavior of both the real price spreads and real price differences for the lumber products investigated are summarized in Table 20.

Table 20. Summary of rate of change (slope) of trended real price difference and real price spread of selected clearwood products, by species and grades.

Species/Grade	**Real Price Spread -Trend Slope Coefficient**	**Real Price Difference-Trend Slope Coefficient**
Douglas-Fir		
Moulding & Better	-0.5356	-0.5356
#3 Shop	1.4416	1.4416
Southern pine		
C&Better 1x6	1.2671	1.571
Ponderosa pine		
Moulding & Better	2.6637	2.8255
C&Better	0.8495	1.0113
#3 Shop	0.7901	0.9519

(Real dollars - Jan 1, 1995)

Note: Slope coefficient represents average trended change per observation period (2 weeks). Average monthly change in real price difference is approximately twice the coefficient value.

CONCLUSIONS

This study found that clearwood lumber is a differentiated product for which end users are willing to pay a substantial premium. Respondents who utilize clearwood lumber as a raw material input in their manufacturing process indicated that they value reliability of supply, price, and price stability over timber quality. The price data indicates that most higher grades of lumber (e.g., C&Better) displayed a substantial increase in the price premium received with respect to a baseline, lower quality, product. In addition, the price analysis indicated that clearwood lumber prices are subject to substantial fluctuations over the short-term. The survey results indicate that many manufacturers are switching to substitute products to meet their raw material needs and provide price stability for their manufacturing operation.

Although actual elasticity figures for product substitution were not determined in this study, it appears that substitution increases as the supply of high-quality material declines and prices increase. These raw material substitutes include low-grade lumber products, non-traditional species, wood-based products and non-wood products. For example, over 40% of the raw material input reported by respondents was shop grade lumber, while higher-grade lumber products represented just 18% of the total raw material mix. Non-traditional species were also reported to compete successfully with softwood lumber in several of the industry segments investigated. In addition, the median use of wood-based substitutes, such as hardwood lumber, finger-jointed material, MDF, and plywood, rose from 5% in 1989 to 24% in 1994. The study found that wood-based substitutes were much more frequently used than non-wood products. The characteristics that influence raw material substitution were found to be price, product availability, reliability of supply, and the technical properties of the substitute product.

Obviously demand for high grade clearwood lumber will continue to exist. However, many manufacturers appear to be re-evaluating their use of clearwood products as well as the intrinsic value of these products. Substitution of lower-grade material for clearwood is extensive and there is little reason to believe that it will not continue in the future. Product quality is also very important to value-added manufacturers. Clearwood lumber grades represent a true differentiation of lumber based on the perceived attributes important to buyers. A complex price structure exists between different species and product grades, and between grades of the same species. While only limited price data is available for emerging new substitutes (*e.g*., radiata pine), it appears certain that niche markets exist for the differentiated products. While all softwood lumber responds to changes in the underlying fundamentals of market supply and demand, clearwood products can be characterized by significantly higher relative and absolute real prices, with these differences fairly stable even as the overall market experiences substantial fluctuations of a cyclical nature and even large shocks. Overall, long-term trends in relative prices indicate increasing prices for clearwood products, suggesting the potential for increased substitution. On the other hand, the real dollar premiums commanded by clearwood grades have also been steady and increasing over the longer term, providing greater returns to timber producers where clearwood grades can be enhanced through quality management. Over time, this may provide a stimulus to increase the volume of clearwood grade lumber produced through intensive forest management, subject to favorable management cost trends as well.

In the shorter term, widely fluctuating relative prices reflecting less elastic demand and smaller volumes in the specialized clearwood niche markets will expose producers and manufacturers to greater than normal uncertainty. Buyers are wary of widely-fluctuating prices and an uncertain supply outlook. Thus, the short-term perspective may be more unstable with respect to clearwood markets and favor increased product substitution.

This study identified a set of attributes that manufacturers found highly influential during the raw material purchase decision. Based on this information, forest managers can better assess whether to adopt intensive forest management practices to increase the production of clearwood lumber for high-value niche markets, or whether they might be better off managing their forests for the production of commodity grade products. Given the significantly different cost structure associated with each of these forest management regimes, this study can help forest managers determine which regime will be most cost effective based on the characteristics of the market segments served.

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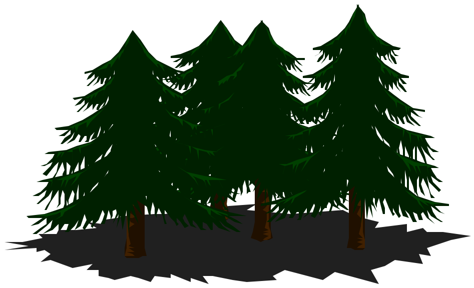
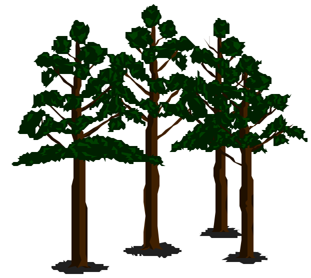
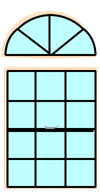
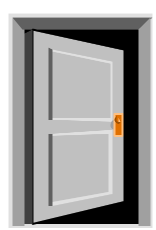
APPENDIX A
SURVEY MATERIALS

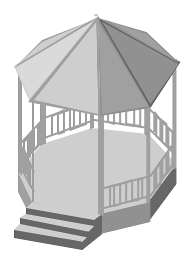


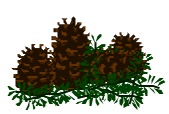


CLEARWOOD LUMBER SURVEY









CENTER FOR INTERNATIONAL TRADE IN FOREST PRODUCTS

CLEARWOOD LUMBER SURVEY

The purpose of this survey is to identify trends related to the use of the higher grades of softwood lumber, often referred to as clearwood lumber. In particular we are interested in identifying which industry segments utilize clearwood lumber, why these industries use clearwood, and what substitute products are being used. ALL RESPONSES WILL BE KEPT CONFIDENTIAL.

1. Approximately how much solid softwood lumber does your manufacturing facility purchase annually?

_____________________________ ***BOARD FEET OF SOFTWOOD LUMBER.***

2. What percentage of your softwood lumber came from the following countries in 1994? *Total should equal 100%.*

Country/Region	Percentage of total purchases
NORTH AMERICA	____%
NEW ZEALAND	____%
CHILE	____%
BRAZIL	____%
ARGENTINA	____%
OTHER (*please specify:*)	
_______________________	____%
_________________________	____%
TOTAL	**100%**

3. What is the approximate grade breakdown of your softwood lumber purchases? *Total should equal 100%.*

Lumber grade	Percentage of total purchases
MOULDING--STAIN GRADE	____%
MOULDING--PAINT GRADE	____%
C & BETTER	____%
D	____%
COMMONS	____%
STANDARD & BETTER	____%
CUTSTOCK	____%
SHOP	____%
OTHER (*please specify:*)	
_______________________	____%
TOTAL	**100%**

4. How important do you consider each of the following factors to be when purchasing softwood lumber?
Please circle the appropriate rating for each factor listed.

	Not Important			*Very Important*			
DIMENSIONAL STABILITY	1	2	3	4	5	6	7
MACHINABILITY	1	2	3	4	5	6	7
MECHANICAL STRENGTH	1	2	3	4	5	6	7
DURABILITY	1	2	3	4	5	6	7
VERTICAL GRAIN	1	2	3	4	5	6	7
NARROW GROWTH RINGS	1	2	3	4	5	6	7
ABSENCE OF KNOTS	1	2	3	4	5	6	7
PRICE	1	2	3	4	5	6	7
PRICE STABILITY	1	2	3	4	5	6	7
RELIABILITY OF SUPPLY	1	2	3	4	5	6	7
UNIFORM MOISTURE CONTENT	1	2	3	4	5	6	7
STRAIGHT GRAIN ORIENTATION	1	2	3	4	5	6	7
UNIFORM COLOR	1	2	3	4	5	6	7
TREATABILITY WITH PAINT OR STAIN	1	2	3	4	5	6	7
AVAILABILITY IN LONGER LENGTHS	1	2	3	4	5	6	7
APPEARANCE	1	2	3	4	5	6	7

5. What factors do you consider to be most important when purchasing softwood lumber?

1)_______________________________2)_______________________________ 3)_____________________________

6. **Please estimate the percentage of softwood lumber that you purchase for each of the following product lines in 1994.**
Percentages across columns should total 100%.

Products:	*Moulding*	*Millwork*	*Windows*	*Doors*	*Stair Parts*	*Cabinets*	*Furniture*	*Veneer*	*Other: ____________*
Total = 100%	%	%	%	%	%	%	%	%	%

7. **Please indicate the percentage of softwood lumber purchased by species for each of the products produced at your manufacturing facility.**
The percentages (by column) of the products your facility manufactures should total 100%.

Products:	*Moulding*	*Millwork*	*Windows*	*Doors*	*Stair Parts*	*Cabinets*	*Furniture*	*Veneer*	*Other: ______________*
Domestic species:									
PONDEROSA PINE									
SOUTHERN PINE									
DOUGLAS -FIR									
HEM-FIR									
WHITE PINE									
OTHER SOFTWOODS: ____________________									
Imported species:									
RADIATA PINE									
SOUTHERN PINE									
OTHER SOFTWOODS: ____________________									
TOTAL	100%	100%	100%	100%	100%	100%	100%	100%	100%

If you do not use any substitute products, please go to question #12.

8. **Which of the following products do you currently use as a substitute for solid sawn softwood lumber?**
Please check all that apply.

________	HARDWOOD LUMBER	________	EDGE-GLUED LUMBER
________	PLYWOOD	________	LAMINATED VENEER LUMBER (LVL)
________	PARTICLEBOARD	________	TIMBER STRAND LUMBER (TSL)
________	ORIENTED-STRAND BOARD (OSB)	________	PARALLEL STRAND LUMBER (PARALLAM)
________	MEDIUM DENSITY FIBERBOARD (MDF)	________	PLASTIC/VINYL
________	HIGH DENSITY FIBERBOARD	________	METAL
________	FINGER JOINTED LUMBER	________	OTHER (*please specify:*) ______________________________
________	WRAPPED LUMBER (VENEER, VINYL, OR EMBOSSED)	_________	____

9. Approximately ________% of the raw materials used in our manufacturing process in *1994* were substitutes for solid sawn lumber.

10. Approximately ________% of the raw materials used in our manufacturing process in *1989* were substitutes for solid sawn lumber.

11. How important are each of the following factors in influencing your decision to use alternative materials as substitutes for solid sawn lumber in your manufacturing process?
Please circle the appropriate rating for each factor listed.

	Not Important						*Very Important*
MACHINABILITY	1	2	3	4	5	6	7
PRICE	1	2	3	4	5	6	7
PRICE STABILITY	1	2	3	4	5	6	7
RELIABILITY OF SUPPLY	1	2	3	4	5	6	7
SUPERIOR TECHNICAL PERFORMANCE	1	2	3	4	5	6	7
EASE OF USE	1	2	3	4	5	6	7
CONSISTENT PRODUCT SPECIFICATIONS	1	2	3	4	5	6	7
AVAILABILITY	1	2	3	4	5	6	7
REDUCED ENVIRONMENTAL IMPACT	1	2	3	4	5	6	7
AVAILABILITY OF LONGER LENGTHS	1	2	3	4	5	6	7
TO MATCH PRODUCTS OFFERED BY COMPETITORS	1	2	3	4	5	6	7
APPEARANCE	1	2	3	4	5	6	7
OTHER (*please specify*:)________________	1	2	3	4	5	6	7
________________________________	1	2	3	4	5	6	7

Demographic Information

The information you provide in this section will assist us in analyzing the research data. Please remember that all information will be kept STRICTLY CONFIDENTIAL.

12. What is your position/title within your firm? ________________________

13. How many people does your manufacturing facility employ? ________________________

14. In what state is your manufacturing facility located? ________________________

15. Please estimate to the nearest $100,000 your manufacturing facility's sales in 1994?
$________________________

✍ ✍

✍ ***We welcome any additional comments that you would like to make regarding the use of clearwood lumber in your facility or in general. Thank you again for your assistance.***

____
____
____
____
____

May 23, 1995

«Formal_Name»
«Company_Name»
«Street_Address»
«City», «State» «Zip»

Dear «Salutation»:

The Center for International Trade in Forest Products (CINTRAFOR) is conducting a study to assess the use of higher-grade softwood lumber, often referred to as clearwood. Changes in the North American timber supply have significantly impacted the traditional resource base and contributed to the use of alternative wood and non-wood products as substitutes. The objectives of this study are to identify current end use markets for clearwood lumber, identify substitute products, and assess the impact of foreign suppliers on the clearwood market.

«Company_Name» is one of a small number of firms that have been selected to participate in this study. The results from this study will be used to assist manufacturers who utilize clearwood products to better understand trends affecting the availability of clearwood. Additionally, the results will provide insights into the utilization of available wood and non-wood substitutes so that manufacturers may better serve their customers.

In order for this study to be truly representative, this survey should be completed and returned promptly. It is important that the individual in your firm who is responsible for purchasing your lumber materials act as the respondent. Please forward this survey to the appropriate individual and urge them to complete and return it. ***I would like to assure you that all information you provide will be held in the strictest confidence.***

I understand your time is valuable and appreciate the time you will be taking to assist us with this survey. If you are interested in receiving a summary of the research results, please fill in the enclosed post card and return it to me with your completed survey in the envelope provided.

Thank you in advance for your participation in this study.

Sincerely,

Dr. Ivan Eastin
Professor, Forest Products Marketing
University of Washington

June 27, 1995

About a month ago, a survey was sent to you seeking information about the use of clearwood lumber at your facility. We have yet to receive your completed survey.

This is the first nationwide survey of manufacturers using clearwood lumber. The results will help manufacturers and suppliers to better serve their customers by

- ***providing an assessment of current end use markets for clearwood lumber,***
- ***identifying alternative wood and non-wood products,***
- ***assessing the impact of foreign suppliers on the clearwood market.***

Your insights and opinions are a vital part of this survey.

If you have not had the opportunity to complete the Clearwood Lumber Survey, we encourage you to so today. You can obtain a copy of the survey by calling
(206) 543-1918.

Your contribution to the success of this study is greatly appreciated.

Sincerely,

Dr. Ivan Eastin
Professor, Forest Products Marketing
University of Washington