C I N T R A F O R

Working Paper 93

Material Substitution Trends in Residential Construction 1995, 1998 and 2001

John Garth
Ivan Eastin
Jane Edelson

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Center for International Trade in Forest Products
University of Washington
College of Forest Resources
Box 352100
Seattle, Washington 98195-2100

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Jane Edelson

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EXECUTIVE SUMMARY

Understanding the ways in which residential builders perceive and use softwood lumber and substitute structural materials is essential to the success of any forest products manufacturer. CINTRAFOR completed its first study of material substitution in 1995 (CINTRAFOR Working Paper No. 57), providing a benchmark for softwood lumber use in structural applications in residential construction. In 1998, a second study by CINTRAFOR (CINTRAFOR Working Paper No. 73) found that softwood lumber was slowly losing market share to engineered wood products and non-wood substitutes. The 1998 CINTRAFOR study also provided a benchmark for wood and non-wood material usage in residential decking applications (CINTRAFOR Working Paper No. 78). This research represents the third in this longitudinal study and will describe the trends in material substitution in the residential construction industry in 2001. This study looks at material substitution in structural framing applications and provides a benchmark for structural panel usage in exterior wall sheathing, sub-flooring and sub-roofing applications.

The survey results suggest that firm size (based on annual revenues) within all segments of the industry has increased since 1998, most likely due to a combination of consolidation within the industry and growth of individual firms in response to the strong housing market. On a regional basis, small firms represented a higher proportion of the industry in the southeast (72%) while they displayed their lowest level in the northeast (49%).

Overall, single family construction represents approximately 53% of total firm revenues, although this was substantially higher in the southwest (63%) and somewhat lower in the northwest (46%). Small builders revenues were evenly split between single family construction and repair and remodel projects whereas the Top 100 builders focused almost exclusively on single family construction (providing over 90% of total revenue). In general, large builders had a strong focus on single family construction (70% of total revenue) but they also derived substantial revenues from multi-family construction (9% of total revenues), repair and remodel projects (8% of total revenue) and non-residential construction (12% of total revenue). The most dramatic change was observed in the Top 100 builders where the percentage of revenue derived from single family construction jumped from 58% in 1998 to 93% in 2001.

Almost 40% of respondents reported that their use of softwood lumber had not changed substantially over the past two years. More importantly, fewer respondents reported that their use of softwood lumber had decreased substantially in 2001 (4.5%) than was reported in the 1998 survey(11.8%). The percentage of respondents who reported that they had used a substitute material in place of softwood lumber in structural framing applications increased slightly from 98.9% in 1998 to 99.5% in 2001. The most commonly used substitute materials were wood I-joists, glue laminated beams, laminated veneer lumber and reinforced concrete. All of these materials exhibited an increase in reported use since 1998 with the exception of reinforced concrete which saw a slight decline in use. The largest increase in use was observed for finger-jointed lumber, despite the fact that less than 40% of respondents reported using it. Small decreases in use were reported for structural insulated panels, wood-steel open web floor joists and reinforced concrete. The largest decline in use was reported for Timberstrand™ lumber, where almost 20% of respondents indicated that their use of this product had declined in the past two years.

Softwood lumber use in wall and roof framing applications actually increased slightly in 2001 although it decreased substantially in floor framing applications. Softwood lumbers share in wall framing and roof framing increased slightly to 83.4% and 40.9%, respectively, while it dropped to 38.6% in floor framing. In header applications (a new category in the 2001 survey), softwood lumber had a 71.9% share while laminated veneer lumber had a 20.4% share. The survey data also suggests that the share of steel in structural framing applications declined across all end-uses: to 6.6% in wall framing, to 1.7% in floor framing, and to 1.7% in roof framing. This data strongly suggests that the steel framing system was used in less than two percent of US housing starts in 2001.

Substitute materials were again perceived by survey respondents as being more environmentally friendly than softwood lumber, continuing a trend established in the 1995 and 1998 surveys. This continuing misperception on the part of residential builders is troubling.

Builders were asked to rate the importance that a broad range of structural softwood lumber attributes had on their material purchase decision. The average attribute importance ratings were virtually identical to those obtained in the previous CINTRAFOR, suggesting that the attitudes of builders toward the importance of specific lumber attributes have remained relatively constant since 1995. Builders were also asked to rate their satisfaction with each product attribute. Although the average satisfaction scores in 2001 were generally higher than in 1998. Straightness and lack of defects, the two of the most important lumber attributes, received the lowest satisfaction ratings. These low satisfaction ratings suggest that builders remain critical of the quality of softwood lumber. In contrast, the satisfaction ratings for price and price stability continue to increase as softwood lumber prices and price volatility continue to moderate.

A new section on structural panel use in wall, sub-floor and sub-roof sheathing applications was included in the 2001 survey. While plywood had just over a 50% market share in sub-floor applications, OSB dominated in wall and sub-roof applications. On a regional basis, plywood use was highest in the northwest and lowest in the southwest. With respect to firm size, the Top 100 builders reported the highest use of OSB while small builders reported the highest use of plywood. Interestingly, there was a substantial difference observed between the Top 100 builders and the large builders, with large builders using substantially more plywood than the 100 largest builders. Survey respondents reported that their use of plywood had decreased between 30-50% across the three end-use applications while their use of OSB increased between 40-47% across the three end-uses.

In considering a total of nineteen structural panel attributes, respondents indicated that plywood was generally perceived as having superior performance relative to OSB. In contrast, OSB was perceived as being superior to plywood in just four structural panel attributes: price, price stability, presence of panel voids, and resistance to delamination. Builders rated resistance to delamination, resistance to edge swelling and resistance to thickness swell as being the most important panel attributes.

The results of this research suggest that the pace of material substitution in the residential construction industry has moderated since 1998. To a large degree this might be attributed to lower lumber prices, less volatility in lumber prices, and the fact that builders have become more accepting of the decreased softwood lumber quality that has been attributed to the younger, faster grown plantation resource. The exception to this trend is in floor framing applications where wood I-joists continue to expand their market share at the expense of softwood lumber. The most troubling result is the continuing misperception among residential builders that softwood lumber is the least environmentally friendly material. This result could have serious implications for the forest products industry in the future as green building programs become more prevalent and home buyers become more assertive in demanding that environmentally friendly materials be used in building their homes. This misperception clearly shows that further research is required to determine the basis for this misperception and to identify strategies to ensure that information regarding the positive environmental benefits of using wood relative to non-wood substitutes is effectively communicated to home builders and home buyers.

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1.0 INTRODUCTION

Historically, residential housing has been the single largest market for softwood lumber in the United States. Currently about 40 percent of lumber consumption can be attributed to residential construction (WWPA 2002). The repair and remodeling sector accounts for another 30 percent of lumber consumption. Residential builders are important players in these two markets and are the subject of this study.

Understanding the ways in which residential builders purchase and use softwood lumber and lumber substitutes is essential to the success of any forest products manufacturer. The Center for International Trade in Forest Products (CINTRAFOR) completed its first study on material substitution in 1995 (CINTRAFOR Working Paper No. 57), providing a benchmark for softwood lumber use in structural applications in residential construction (Eastin, Simon & Shook 1996). In 1998, a second study by CINTRAFOR (CINTRAFOR Working Paper No. 73) found that softwood lumber was slowly losing market share to engineered wood products and non-wood substitutes (Fleishman, Eastin, & Shook 2000). The 1998 CINTRAFOR study also provided a benchmark for wood and non-wood material usage in residential decking applications (CINTRAFOR Working Paper No. 78). This report represents the third in this longitudinal study and will describe the trends in material substitution in the residential construction industry in 2001. The 2001 CINTRAFOR study also provided an analysis of the changes in material usage in residential decking applications, allowing a comparison with the 1998 data. Finally, the 2001 study provided a benchmark for structural panel usage in exterior wall sheathing, sub-flooring and sub-roofing applications.

Following this introduction is a review of the literature on the residential construction industry and current substitution trends. Next the methodology and research objectives are defined and explained. The results section follows the format of the 1998 study closely with the exception that structural panels have been added as a separate section in this report. While individual results are interpreted as they are introduced in the results section, the conclusion section will provide a summary of industry trends.

The residential construction industry has historically used softwood lumber as a primary building material. Gopal Ahluwalia, director of research at the National Association of Home Builders, estimated that ninety percent of all homes in the United States use wood framing (Deane 2001). "Wood Framing" normally connotes solid wood products such as dimension lumber. In recent years, however, the increasing trend of substitution of softwood lumber by a host of other products, including non wood products has been continuing (Eastin 2000). This trend has important implications regarding how forest products are utilized and ultimately how our nation's forests are managed. We hope that the following report will provide industry managers with a better understanding of material use trends within the residential construction industry and provide them with insights into how to better position wooden building materials relative to non-wood substitute materials.

2.0 LITERATURE REVIEW

2.1 RESIDENTIAL CONSTRUCTION INDUSTRY: STATE OF US HOUSING MARKET

In a monthly update, David Seiders (chief economist for National Association of Home Builders) acknowledged that the US was in a recession. The outlook however, was optimistic and Mr. Seiders, citing retail sales, the rising stock market, and improvements in consumer expectations predicted the recession would extend no longer than one year (Seiders 2001). This optimism was shared by the Joint Center for Housing Studies (JCHS) with the statement that housing production was expected to equal or exceed that of the 1990's in the coming decade (Joint Center for Housing Studies 2001). Indeed, even with starts down by 4 percent, the home ownership rate set another record at more than 67 percent (JCHS 2001). Housing starts have been steadily rising since 1991 (Figure 2.1.1) and the year 2000 was the first downturn in the market since 1994. With the strong optimism of the NAHB and the JCHS, the demand for wood building products should continue to rise.

One of the major drivers of the current robust housing market is low mortgage interest rates. At the time of the writing of this report the 30 year mortgage rates were as low as they had been in 30 years (Figure 2.1.1). Low mortgage interest rates have been cited by numerous market reports as a major reason for the steady spending levels observed in an otherwise challenging marketplace. The relationship between housing starts and the 30 year fixed mortgage rate can be seen explicitly when comparing these two measures over time. Figure 2.1.1 demonstrates the inverse relationship between these two measures.

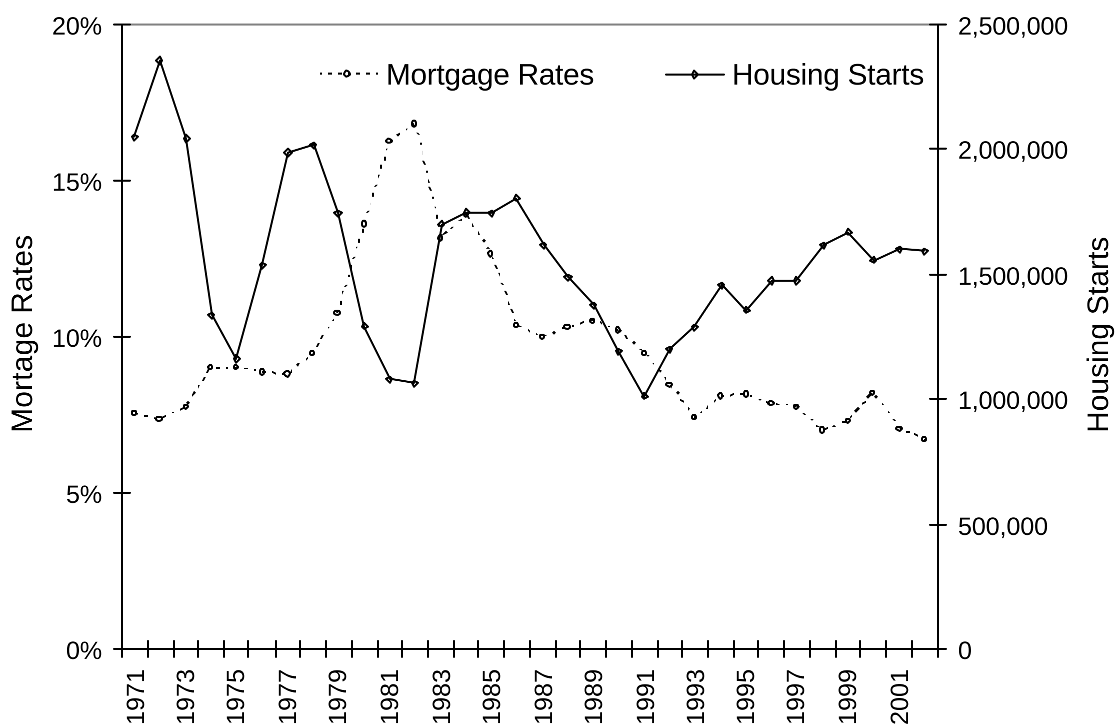

Figure 2.1.1 Average Annual Mortgage Rates and Annual Housing Starts, 1971-2002

2.2 REPAIR AND REMODELING

During the period 1982 to 1987, the repair and remodeling market increased its share of lumber consumption from 20 to almost 30 percent, which corresponds to an increase from roughly 8 billion to 15 billion board feet of lumber consumed (Figure 2.2.1). The American Plywood Association (APA) estimates that approximately $166 billion was spent on repair and remodeling in 2001, up from $153 billion in 2000. This trend is expected to continue with an estimated $180 billion being spent on R&R by 2005 (APA 2002).

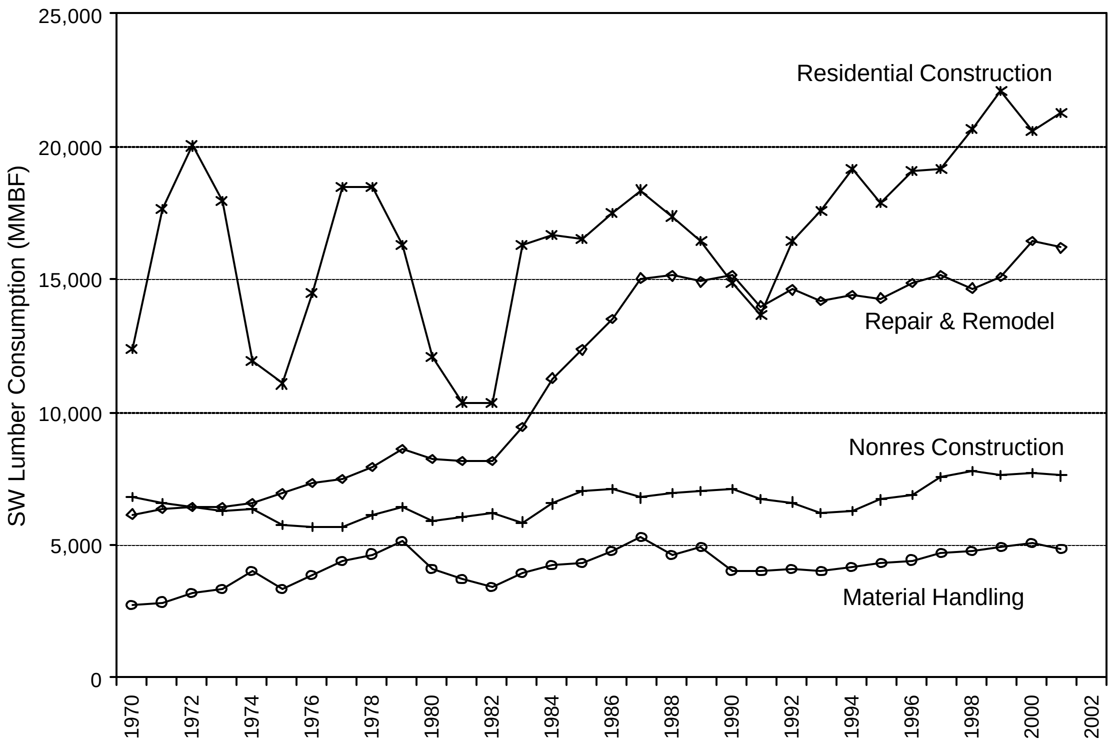

Figure 2.2.1 Softwood Lumber Consumption by End Use
Source: WWPA, 2002

2.3 PRICE AND PRICE STABILITY

Builders in the previous CINTRAFOR material substitution surveys indicated that they were most dissatisfied with the price and quality of softwood lumber. Regarding price, both the overall price and price volatility were identified as points of dissatisfaction (Fleishman et. al. 2000). Figure 2.3.1 shows that since the 1970's there has been a substantial increase in the volatility of lumber prices. The current price of softwood lumber does not seem to be as high as in the 1990's but has reached as high as $490 per thousand board feet (mbf) in recent years (Figure 2.3.1). A lower overall price will favor the use of softwood lumber because substitute products tend to be more expensive than lumber.

To illustrate this last point, Figure 2.3.2 is a graph of the western Spruce-Pine-Fir (SPF) lumber prices as they compare to finger-jointed lumber, an engineered wood product. The SPF measured here is kiln dried so as to compare with the value added element of finger-jointed lumber. Finger jointed lumber is normally sold at a higher price than the softwood lumber (Random Lengths, various years).

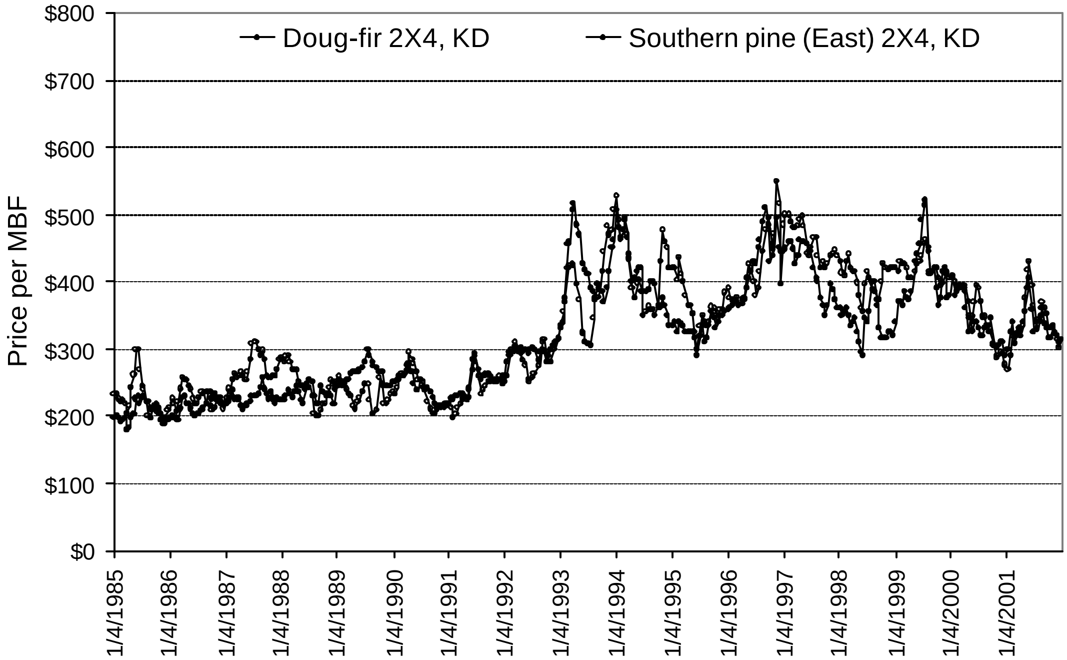

Figure 2.3.1 Nominal Prices of Douglas-fir and Southern Pine 2X4 Std & Btr KD
Source: Random Lengths, Various

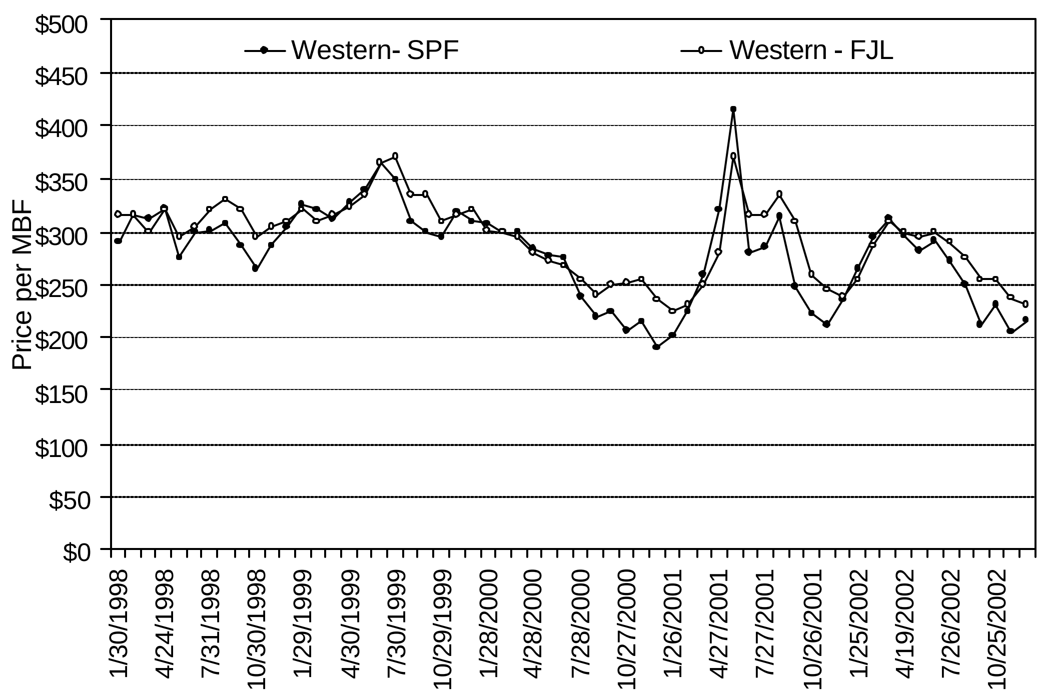

Figure 2.3.2 Price Comparison of Western Spf (Kd) 2x4 Lumber and Western Finger-Jointed Lumber
Source: Random Lengths, Various

2.4 TIMBER QUALITY

Many sources mention that timber products are coming from smaller and smaller trees. Within the current regulatory environment, less timber is being harvested from mature natural forests. What is being harvested is younger, faster growing timber from second and third growth plantations. Youngquist (1999) predicted that "plantations will clearly play a role, and perhaps a dominant role, in providing future wood supplies." Darr (1997) pointed out that increasing pressures on the supply of timber have prompted timber companies to invest in more efficient recovery technologies while striving to achieve similar outputs using smaller sized timber inputs. Eastin (2000) provided an illustration of the timber industry's attempt to address its supply problem by adopting more efficient processing technologies.

Younger and faster growing trees generally produce lower quality lumber than the lumber produced from old growth timber. Builders reported that they perceived a decrease in lumber quality in the previous CINTRAFOR material use surveys (Eastin 2000), and with an increasing volume of softwood lumber coming from the plantation resource, this trend is likely to continue.

2.5 STRUCTURAL PANELS

Structural panels have been used in residential construction since the early 1900's (Shook, et al. 1996). Today, this market consists of plywood, oriented strand board (OSB), and structural insulated panels (SIPs). The growth and maturity of the markets for plywood and OSB were reviewed in CINTRAFOR Working Paper No. 65 (Shook, et. al 1998). In their review, it becomes clear that plywood and OSB are in different stages of the product life cycle. A synopsis of their discussion follows.

Western plywood was the first plywood to come on the market in the early 1900's. It was used primarily for drawer bottoms, door stock and trunks and was not initially used in residential construction. By the 1920's structural plywood was starting to be utilized in structural end uses in residential construction. Progress was slow however as high price, low availability, lack of product standardization and inconsistent product quality contributed to slow acceptance of plywood. It was the aftermath of World War II (and the flood of returning GI's and the resultant increase in residential housing construction) that provided the impetus for the dramatic and sustained growth of western plywood consumption in residential construction. Production of western plywood rose to a peak of roughly 7.9 billion square feet (1/2" thickness) in 1965 (Figure 2.5.1). This dramatic market growth led to the introduction of plywood manufactured from smaller diameter, lower cost southern yellow pine.

Southern plywood actually was introduced in the 1940's but the structural properties where not considered adequate for use in structural applications. By the 1960's however, the large diameter Douglas-fir peeler logs in the Pacific Northwest were becoming scarce and the industry was confronted with a supply problem. Fueling that problem was the increasing export of many of the remaining high quality, large diameter Douglas-fir logs to Japan, the same logs that were used to manufacture structural plywood in the northwest.

Simultaneously with the supply constraints in the PNW, the southern plywood industry took advantage of a series of technological advances in plywood production technology and achieved the required economies of scale to produce structural plywood at a competitive price. The market acceptance of southern plywood was immediate. The last half of the 1960's saw a rapid increase in the volume of southern pine plywood being produced and a corresponding decrease in western plywood production (Figure 2.5.1). It might have appeared that southern plywood production would increase indefinitely at the expense of western plywood but in the late 1970's another structural panel, oriented strand board (OSB), was introduced into the market.

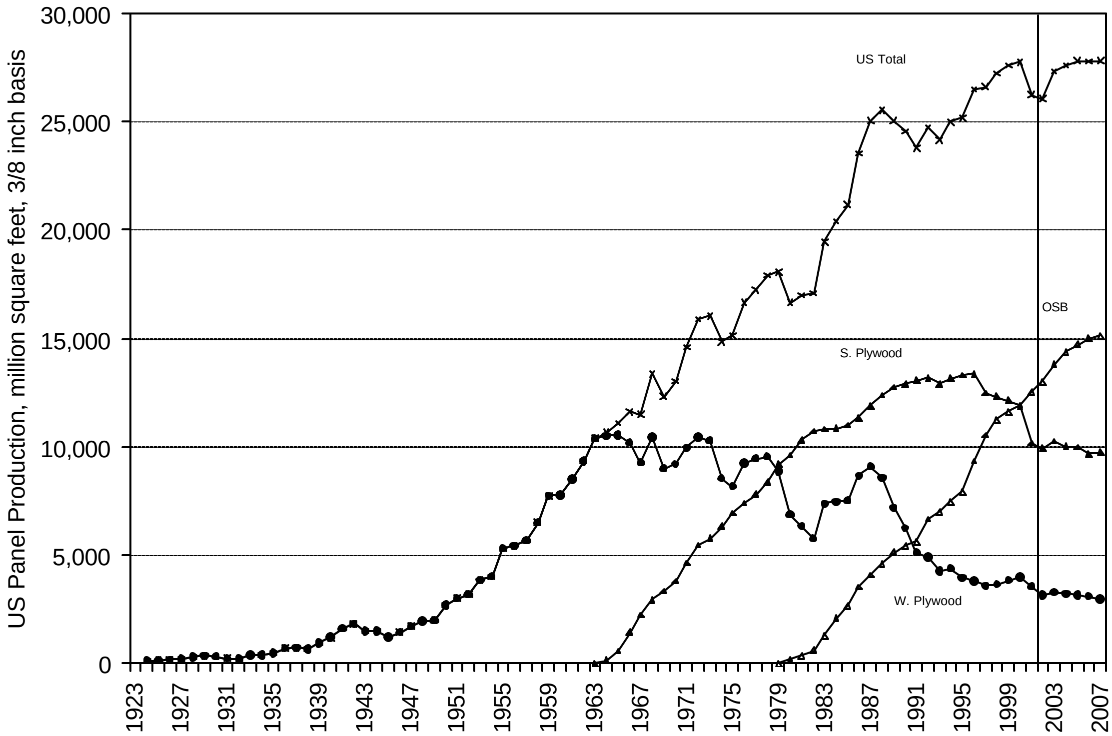

Figure 2.5.1 US Structural Panel Production

Source: APA, 2003

OSB had a couple of manufacturing advantages over plywood from the beginning. First, it was produced from the low cost, fast growing poplar species that was previously considered to be inferior to the Douglas-fir and southern pine resources of the west and southeast. Second, there is a more complete utilization of the timber resource when manufacturing OSB than obtained during the plywood production process.

Southern pine plywood is almost identical both in appearance and structural properties to Douglas-fir plywood in the Pacific Northwest and this further contributed to the rapid acceptance of southern pine as a direct substitute for western plywood. In contrast, OSB was not identical in appearance to plywood. Though most structural properties are rated as equivalent, many builders still perceived OSB to be inferior to plywood, particularly in end-use applications that are subject to edge swelling (Anonymous, 1992). Despite these challenges, OSB has gained rapid market acceptance and by 2002 had penetrated every structural market segment (APA 2002) (Figure 2.5.1). Table 2.5.1 shows the percent of plywood and OSB used in each end use market in 2001 as reported by the American Plywood Association

To help put Table 2.5.1 into context, Table 2.5.2 shows the percentages in each end use class for US/Canada plywood and OSB production. It becomes apparent from this table that industrial and remodeling applications are more prevalent for plywood than OSB. It follows then that those firms more heavily involved in industrial or repair and remodeling construction would tend to use more plywood. Conversely, those firms that participate exclusively in the residential construction market will generally use more OSB.

Table 2.5.1 Structural Sheathing 2001 (Residential Construction)

	Floor	Wall	Roof
Plywood	49%	14%	34%
OSB	50%	51%	65%
Other	1%	35%	1%
	100%	100%	100%

Source: APA 2002

Table 2.5.2 Structural Panel End-use Summary by Construction Activity

End use category	Plywood	OSB
Residential	52%	64%
Repair and Remodeling	21%	17%
Industrial	17%	11%
Non-Residential	10%	7%
Export	0%	1%

2.6 GREEN BUILDING PROGRAMS

Respondents in both the 1995 and 1998 CINTRAFOR surveys evaluated softwood lumber below non-wood substitute materials with respect to its environmental performance (Eastin et.al. 1996; Fleishman et. al. 1998). This perception is also held by many environmental non governmental organizations (ENGO) and government programs created to promote the construction of environmentally friendly buildings. These green building programs influence the perceptions of builders and should be understood in order to identify the reasons wood is not seen as an environmentally sound building material.

Green or Sustainable Buildings incorporate the environment, the economy, and human aspects into the design and construction of a building. Green buildings are created from an integrated process where the site, the design, the construction, the materials, the operation, the maintenance, and the deconstruction of a building are all seen as having an effect on one another. As a result of this integrated process, it is thought that buildings can be made more environmentally friendly, more cost-effective, more resource efficient, while providing a healthier work environment. Green Building Programs are slowly but surely emerging across the US. These programs have been adopted to varying degrees across all levels of government, from the local level up through the federal level. Industry, trade and environmental organizations are also looking at promoting green building initiatives at a variety of levels. Most green building programs are designed or organized by guidelines, usually accompanied by a checklist or a point system. Typically, the guidelines are divided into sections such as energy use, water efficiency, materials, indoor air quality, and construction waste.

2.6.1 CINTRAFOR Survey of Green Building Programs

There has been an accelerated implementation of green building policies, programs, standards and design practices in the United States to promote sustainable buildings and design through partnerships between leading national organizations, product manufacturers, environmental groups, federal agencies, state and local governments, and professional societies. The extent of these policies and regulations along with the potential impact on wood products and building practices are not yet quantified.

To better understand the potential impacts of green building programs on wood use in construction, a survey consisting of 22 questions pertaining to all facets of green building programs was conducted. A majority of the surveys took place over the phone although some were conducted via email. This survey was designed to be a purposive survey of green building programs. The top 100 cities were the primary focus on this survey. Additionally, certain known programs were specifically interviewed. In total, 138 interviews were attempted. As seen in Table 2.6.1, a majority of the interviews were conducted at the city level.

Table 2.6.1 Summary of Programs Contacted for Interviews

Programs in Place	Yes	No	Not Yet	Never heard back	Total Attempted
City	14	36	11	17	78
County	6	8	3	1	18
State	14		1	2	17
Federal	7				7
Other	17	1			18
Total	58	45	15	20	138

Agencies and organizations generally apply their green building guidelines to non-residential buildings. One reason why there are more non-residential programs than residential programs can be attributed to the US Green Building Council which has created a national standard for green buildings called LEED, Leadership in Energy and Environmental Design. Currently, LEED's guidelines have only been adopted for commercial buildings. LEED has been extremely influential in the growth and adoption of green building programs and is widely promoted as the benchmark for green buildings. Out of all of the programs for which information was obtained in this project, 89% referenced LEED. The Green Building Council is currently circulating a draft guideline for residential homes that it hopes to have ratified and approved by 2005.

In general, there are two types of green building programs, voluntary and mandatory. Overall, a majority of the green building programs are implemented on a voluntary basis. At the local level, cities are starting to adopt these programs and make them mandatory for municipal buildings. Government agencies are adopting these programs and requiring this type of building for two reasons; either as a role model to encourage green building within the private sector, or, simply because they believe this type of building is more efficient from both an environmental perspective and an economic perspective. As a result, municipalities perceive that public resources will go a lot further with green buildings.

Since green building programs are frequently implemented on a voluntary basis, incentive programs are often offered to promote participation. These incentives are usually financial in nature and include tax credits or tax advantages related to the use of energy efficient systems or appliances. Other types of incentive programs include one on one consulting, training courses and lectures, opportunities to win awards, and assistance/preference in obtaining building permits.

Green building programs have been successful without having to change existing building codes because they are capable of selling their benefits with a campaign of effective communications. A number of programs assume that the long term cost savings from green buildings is a sufficient incentive to create a demand for them.

Materials

When specifying materials, green building programs are typically designed loosely, allowing architects and builders considerable flexibility in specifying the most appropriate materials. The guidelines for green building programs often identify the range of material options available. Interviewees were all in agreement that their programs are designed to guide, not dictate, the specification of construction materials and techniques. However, certain building materials and applications are implicitly identified as being more favorable based on the number of points awarded for their use.

Wood

Nearly all of the programs are concerned about harvesting old growth forests and sustainable forest management. As a result, the use of softwood lumber is typically not an option that gains many points within a green building program. However, sustainably harvested wood is widely recommended and always preferred when lumber is used. All but three of the green building programs interviewed gave preference to the use of certified lumber, and a majority specifically referenced lumber certified under the Forest Stewardship Council program (FSC).

In addition to certified wood, engineered wood products (EWP's) are referenced as well, Table 2.6.2. The interview respondents often indicated that engineered wood products are viewed as a positive alternative to softwood lumber for several reasons. With respect to environmental concerns, EWP's require less timber to be harvested and result in less wood waste. Additionally, EWP's are generally regarded as being straighter, stronger and better quality than softwood lumber. There are concerns however, regarding the use of engineered wood products. An important aspect of green building programs is indoor air quality. As a result, EWP's made suing adhesives, glues, and finishes that contain formaldehyde are not acceptable. Many programs specifically list plywood, particleboard and other composite wood products as materials to avoid based on the formaldehyde content of the glues used in them.

Many alternative materials to traditional softwood lumber are referenced in green building programs, including insulated concrete forms, autoclaved aerated concrete, structural insulated panels, straw bale, rammed earth, steel and concrete. Programs differ in terms of the number of points allocated to specific materials. An important factor that influences which materials are recommended is based on local availability. Other reasons stated for green building programs emphasizing the use of alternative materials are the perception that they use less material overall, they provide better insulation and are therefore more energy efficient, they are more durable, and total construction costs are lower. Overall life cycle assessments, and the resultant environmental impact, do not seem to be a significant consideration in many programs, or are methodologically skewed to favor non-wood materials.

Table 2.6.2 Programs that Give Preference to Engineered Wood and Recycled Materials

	Preference	No Preference	Depends	Don't Know	Total
Engineered Wood	19	9	7	2	37
Recycled Content	28		9	5	42

Perception of Wood

The manner in which green building programs treat wooden building materials seems to be inconsistent. Nearly all of the programs are concerned about the harvesting of old growth and making sure forests are managed sustainably. Therefore, the use of certified lumber is either highly recommended and preferred, or in some cases required. Engineered wood products are almost always referenced, and often preferred, over the use of softwood lumber. In addition, many alternative materials are suggested by green building programs. Also, other factors which influence how each green building program perceives wood are based on regional availability and suitability to the local climate. However, interviewees were quick to point out wood is a renewable resource, is strong and is recyclable. A few also pointed out that it has low embodied energy. Overall, the programs interviewed are not completely supportive of using wood, although they are not actively opposed to it either. It appears these programs feel most comfortable specifying wood that is certified or where the amount of wood is reduced through the use of an engineered wood product.

2.6.2 Summary Observations on Green Building Programs

Green building programs are becoming more common, a trend that is likely to continue. Several factors have been important in supporting the growth of green building programs. First, non-profit organizations and national non-governmental organizations have been actively creating green building programs. Second, there are enough positive selling points, especially with the use of incentives, to successfully promote this type of building program to residential builders.

Another push for the growth of these programs is coming from the government agencies at city, county, state and federal levels. The public programs, particularly at the city level, differ from the private programs in the sense that they are increasingly becoming mandatory. At present, most mandatory programs are only applicable to publicly funded buildings and construction projects (i.e., parks and walkways). However, green building programs are relatively new and in many cases they are still in the trial period. If these trial programs are successful in the public sector, the program managers interviewed believe they will then be applied more widely to private commercial and residential buildings, most likely on a voluntary basis at first and becoming mandatory later, assuming the continued success of the programs.

Challenges and Opportunities for the Forest Products Industry

Perhaps the most important challenge confronting the wood products industry is the perception of wood, both by program managers and as presented within the green building programs. There is still much confusion and hesitation towards promoting wood as a green building material on the part of many program managers. In order to promote wood as an environmentally sound building material within these programs, the forest products industry must adopt and implement a proactive strategy emphasizing that wood is renewable, recyclable and has low embodied energy. This message must be targeted to program managers and those people responsible for developing and implementing green building programs.

One important factor that was constantly mentioned by program managers during the interviews was the importance of protecting old growth forests and the responsible and sustainable management of public and private forests. Many program managers indicated that the specification of certified wood was one strategy that effectively addressed these concerns. However, a substantial number of green building programs specify the use of only FSC certified wood. The forest products industry and its industry associations should work to promote alternative certification programs as being equivalent to FSC to ensure that a range of certification programs will be specified in green building programs.

The use of engineered wood was often favored within green building programs. However, because of the concern voiced by interviewees about products with toxic chemicals, it appears that engineered wood will be more likely to receive program approval if programs' fears about toxic materials can be alleviated. For example, many program managers expressed concern about low level off-gassing of formaldehyde from the resins used in most engineered wood products.

The results of life-cycle analyses (e.g., the CORRIM and ATHENA projects) have firmly established wood as an environmentally sound construction material. However, many program managers were unfamiliar with these life-cycle projects or their results. In fact, several program managers suggested that they thought they would have to conduct their own analyses on building materials before they could include life cycle analysis (LCA) or life cycle inventory (LCI) in their green building programs. These results suggest that the forest products industry should proactively provide managers of green building programs with the results of LCA/LCI studies and analyses that have been completed.

Many green building programs consider the energy efficiency of building materials to a large extent. This emphasis is either because the green building program started as an energy conservation program or because the benefits of a green building program can be more readily measured and demonstrated through the energy savings derived from using specific materials or technologies. Given this emphasis on energy efficiency by many green building programs, the forest products industry should work to communicate the superior thermal characteristics of wood relative to alternative building materials (e.g., steel and concrete) to green building program managers.

Finally, the forest products industry should also consider how to promote the benefits of recycling, reusing, and recovering wood building materials within the context of green building programs. Program managers mentioned that having a strategy to keep wood out of landfills would allow carbon sequestration to continue and would be considered an important point in positioning wood as a green building material. For example, they noted that recycling wood building materials would result in less harvesting, would require the use of less energy, and would support local economies.

2.7 SOLID LUMBER ENVIRONMENTAL PERFORMANCE

The Consortium for Research on Renewable Industrial materials (CORRIM) is a research group comprised of 15 research institutions that was assembled with the express objective of measuring the environmental performance of wood and non-wood building materials (CORRIM 2002). The primary objective of the CORRIM study was to perform a life cycle inventory and subsequent analysis of wood and non-wood light frame construction materials. The inventory covered all aspects of the production and use (from cradle to grave) for each product included in the study. The analysis included an assessment of the resource management, harvesting, processing, construction, use, maintenance, and disposal.

The resulting database was used to compare houses built using wood framing with houses utilizing both steel and concrete systems. For the steel versus wood comparison, two identical houses were built in Minneapolis, MN and the results were analyzed. One house was built using wood framing while the other house used steel framing. For the concrete versus wood house comparison, two identical houses were built in Atlanta, GA and the results were analyzed. One house was built using wood framing while the other house was built using concrete. The results of both comparisons conclusively demonstrated that wood was more environmentally friendly building material. Tables 2.7.1 and 2.7.2 summarize the results of these tests.

Table 2.7.1 Environmental Performance Indices for Wood and Steel Buildings in Minneapolis

Measure	Wood			Steel			% Change for Steel
	Floor	Walls	Total	Floors	Walls	Total	
Embodied Energy (GJ)	97	12	186	148	83	308	+66%
Global Warming Potential*	20,790	1,970	39,810	28,930	13,332	59,290	+49%
Air (kg)	1,497	242	2,778	2,246	1,414	4,711	+70%
Water (kg)	31	10	185	492	544	1,179	+537%
Solid Waste (kg)	7,600	1,130	12,110	6,320	1,323	11,020	-9%

* CO_2 equivalence Effects (CO2, CO, NOx, Ch4)

Table 2.7.2   Environmental Performance Indices for Wood and Concrete Buildings in Atlanta

Measure	Wood		Concrete		% Change for Concrete
	Walls	Total	Walls	Total	
Embodied Energy (GJ)	22	115	69	162	+41%
Global Warming Potential*	1,400	20,020	14,510	33,130	+65%
Air (kg)	116	1,035	954	1,862	+80%
Water (kg)	10	86	23	99	+15%
Solid Waste (kg)	562	4,270	4,260	7,970	+86%

* CO2 equivalence Effects (CO2, CO, NOx, Ch4)

In order to simplify the comparison of the data, a variety of environmental outputs associated with each building material were aggregated into five environmental indices. These indices, derived by the ATHENA Institute, were used to compare the relative environmental impact of each type of building material. As an example, embodied energy represents the total amount of energy required to produce a particular product. In a life cycle inventory this value would represent all of the energy used in the extraction, manufacture, use and subsequent disposal of the building product.

To create a comparable index of greenhouse gasses emitted during processing or extraction of each material, a global warming potential was calculated. This index takes all gasses and calculated their respective carbon dioxide (CO_2) equivalent global warming potential (or heat trapping capacity).

The air and water pollution indices generally measure the volume of air or water that would be required to dilute contaminants to acceptable levels. As with many other portions of the CORRIM research, the ATHENA model was used to estimate the actual amount of emissions and the subsequent air and/or water pollution index value.

Relative to steel, wood was shown to be superior in its environmental performance in every category except solid waste (Table 2.7.1). The comparison with concrete favored wood in every category (Table 2.7.2). It is important to note that all of the house structures analyzed use a fair amount of similar materials. For example, both homes built in Atlanta utilized a concrete foundation. Both houses in Minneapolis employed plywood sheathing. Because of these inherent similarities, the total differences between the houses were reduced somewhat. If the non-wood substitutes were directly compared to their wooden counterparts the results would weigh more heavily in favor of wood.

The take away message from the CORRIM research is that wood outperforms both concrete and steel as an environmentally friendly construction material. However, many consumers and builders perceive the opposite to be true. This trend was first seen in the 1995 and 1998 CINTRAFOR surveys and was more pronounced in the 2001 survey.

2.8 MATERIAL SUBSTITUTION

The National Association of Home Builders, at a recent conference, noted that softwood lumber was twice as expensive as it was only 10 years ago (Sichelman 2000). It is not surprising then, that many builders are more open to the idea of substitution. Substitutes are truly gaining acceptance and market share in the residential building industry (Eastin 2000) and that includes steel, concrete, and plastic composites (Sichelman 2000). The APA tracks the number of houses built using one of eight different construction systems, Table 2.8.1. Though stick built wood is the dominant building method, the 72% figure is a decline from the estimated 80% used in housing construction in 1997.

Table 2.8.1 Estimated US Housing Starts by Building Method - 2001

	Single Family	Multi-Family	Total	Percent
Stick-Built Wood	912	245	1157	72%
Panelized Wood	190	33	223	14%
Concrete	110	40	150	9%
Steel Frame	22	8	30	2%
Modular	20	2	22	1%
SIP	10	1	11	1%
Logs	5		5	<1%
Post & Beam	3		3	<1%
Other	1	0	1	<1%
Total	1,273	329	1,602	100%

Source: APA, The Engineered Wood Assn., 2002

When considering the process of material substitution, the idea of adoption must be introduced. Before a buyer uses a given product there is a process that is followed to minimize risk and maximize the utility of a given product. The products or innovations that are the most expensive or risky tend to take longer to adopt (Baker 1975). Also, there is a demographic profile of the companies or individuals most likely to adopt. The early adopters in the construction industry tend to be the largest companies and those with the most resources (Eastin 2000, Fell 1999). To understand why a given company or individual has chosen to adopt a substitute, it helps to look at some of the many models of adoption behavior. Baker uses the acronym AIDA that stands for Attention, Interest, Desire, and Action. That model was later expounded on by Rogers (Baker 1975) and defined as Awareness, Interest, Evaluation, Trial, and Adoption.

Eastin (1996) comments that "the key to achieving a positive outcome during the adoption process is the effective design and implementation of a marketing strategy that makes potential customers aware of the new product and persuades them to try the product." Understanding the attitudes of builders in the residential construction industry is key to achieving success in new product adoption. The successful substitution products are those that have correctly identified a need gap and filled it without compromising performance.

2.8.1 Steel

For almost as long as steel has been around it has competed with wood on some level. As early as 1890, it was viewed as an alternative to wood in railroad ties (Tratman 1890). In the early 1990's, the American Iron and Steel Institute projected that steel would claim 25 percent of the residential framing market by 1998 (Price-Robinson 2001). That ambitious goal has yet to be met. However, steel has seen some substantial gains in recent years. From the NAHB Research Center website, the number of houses using steel framing has increased by 10% for single family homes and around 50% for multi family buildings to 38 and 21 thousand homes respectively. These are substantial gains with most of the gains coming in steel floor I-joist (~100% increase from last year). One of the selling points of the North American Steel Framing Alliance is that steel is better for the environment than wood. This claim is disingenuous at best and has been rebutted by several respected organizations, but it appears to have gained some credence with consumers (Price-Robinson 2001).

2.8.2 Other non-wood substitutes

In 1999, over 120,000 houses were built using concrete, of which about 20,000 used the insulated concrete form system (Sichelman 2000). This system combines concrete and insulation by using polystyrene forms, stacking them in the desired shape and then filling them with concrete. While 20,000 homes represent just over 1 percent of total housing starts, compared to 0 just five years ago, there has been definite growth in this technology.

Plastic can be made into several different kinds of substitutes. The most common form of non-structural substitute is plastic lumber (Eastin 2000). This type of lumber can be made from virgin or recycled plastic and is mostly used in exterior non-structural applications (Eastin 2000). Another form of plastic is vinyl fencing which now accounts for about 15 percent of the fencing market (Rogers 2001). Though the fencing market ($2.3 billion) pales in comparison to the housing market ($244.6 billion – JCHS 2001) it is still a significant gain and should be noted.

All of the non-wood substitutes have shown increases in use since 1998. Wood frame construction still represents the majority of the housing market but products like steel, concrete and plastic represent a growing threat as time passes (Price-Robinson 2001).

2.8.3 Engineered Wood Products

Virtually all of the engineered wood products on the market experienced a rise in production and sales over the past 3 years with the exception of laminated veneer lumber (LVL). Acceptance and use of engineered wood products is on the rise due to the strong marketing efforts of the APA-The Engineered Wood Association. The Composite Panel Association (CPA) and Composite Wood Council (CWC) have also played a role in gaining this acceptance with a joint marketing effort (Anonymous 2001). With appearances on television shows and magazines, the CPA & CWC are promoting the environmentally friendly aspects of engineered wood products (Anonymous 2001).

2.8.4 Structural Insulated Panels

Structural insulated panels are a type of building system that replaces the traditional 2x4 construction and require substantially fewer studs. Simply put, SIPs are some type of foam core sandwiched between two wooded structural panels. The panels are usually OSB but can be plywood, wafer-board or gypsum board (Cathcart, 1998). The foam core is normally made of expanded polystyrene (EPS) but can be one of several other foam composites (Cathcart, 1998). The finished panels are installed as the wall of the house and replace many of the studs that would otherwise be used.

Structural insulated panel (SIP) usage in housing construction has been traced back to the 1950’s when a student of Frank Lloyd Wright’s built a house using structural insulated panels in Midland, Michigan (Cathcart 1998). As early as 1940, SIPs were used for limited applications such as curtain walls and short span roofs over timber frame construction (Tracy 2000). However, early growth was hampered by high costs and a fragmented industry that produced products of inconsistent quality.

In the last decade producers are reporting steady growth and predicting such growth to continue in the years to come (Tracy 2000; Cathcart 2000; Andrews 1989). The main driver for the increased acceptance of SIPs is the reduced labor cost. Labor is cited by many sources as the major cost associated with building a home. SIPs allow much of the manufacturing to occur at the production facility and results in a shortened installation time for a wall, floor or roof system on the building site. As an example, a SIP wall system would only require workers to raise each section of the pre-manufactured wall, anchor it and move to the next piece.

Another advantage of SIPs are the lower energy costs associated with owning a home built using SIPs (Bevier 2000; Cathcart 1998). Although the strict R-value tests have not shown the drastic improvement over stick framing that many had hoped, the overall building envelope is generally conceded to be more energy efficient than an equivalent wood frame house (Tracy 2000).

The main disadvantage of SIPs is the higher cost. Recent research suggests that SIPs cost more than traditional framing. This high cost can be more than compensated for through labor cost savings and time savings. For example, the McDonalds restaurant chain decided that the use of SIPs in their new store construction program would shorten construction time by more than enough to offset any material cost premiums (Tracy 2000).

SIPs are generally thought to be primarily used in residential construction, with custom home building being the most prevalent user of SIPs. However, by one account 27% of SIPs produced in north America were shipped to non-residential construction sites in 1998 (Tracy 2000). The potential to create long continuous wall forms can be appealing to the architect or builder in the non-residential construction segment.

The structural insulated panel association (SIPA) conducted a survey of 61 companies in 2002 for an estimate of the production and usage of SIPs. They estimate that approximately 70 percent of SIPs produced were used in residential construction and the remainder was used in non-residential construction. In addition, the current estimate is that some 12,000 homes were built using SIPs in 2002. This compares with about 8,000 built in 1997 or a 50 percent increase over 5 years.

3.0 METHODOLOGY

3.1 SURVEY DESIGN

The sample population for this survey consisted of 2,400 single family home builders as well as the top 100 home builders in the United States. The random sample of 2,400 home builders was obtained from a national database of US homebuilders while a census of the top 100 homebuilders was obtained from Builder Magazine (May 2001 edition).

The residential builders database was specifically designed to include an equal number of builders in each of the four regions used in previous surveys, Figure 3.2.3. As the total random sample was determined to be 2,400 builders, this equated to 600 firms per region (Table 3.1.1). In addition to regional specifications, the database also provided a sub-sample within each region that equally represented small, medium and large companies. Therefore in every region the total sample of 600 firms was segmented into 200 small, 200 medium, and 200 large firms.

A cover letter was mailed to each survey recipient stating the goals and purpose of the survey (Appendix I). In addition, each home builder received an eight page survey and a self addressed stamped envelope in which to return the completed survey. The results of this survey were offered free to any builder that participated in the survey. As an additional incentive, the names of all survey respondents were entered into a drawing for five Porter Cable 10 Amp Quick Change Reciprocating Saws.

Two follow up letters (Appendix I) were sent to those recipients that had not returned a survey. The two follow up letters and the reciprocating saw drawing increased the response rate from 7 to 9 percent.

3.2 REGIONAL BREAKDOWN

Regions are defined differently depending on the source of information. The US Census bureau segments the United States into four regions: Northeast, Midwest, South and West (Figure 3.2.1). A summary of the ratio of housing starts in each of these regions is provided in Figure 3.2.2. According to the Census Bureau, the south is the leader in housing starts while the northeast represents the smallest segment of the market. The CINTRAFOR material substitution surveys (2001, 1998, 1995) segment the US into four different regions: Northeast, Southeast, Northwest, and Southwest. A summary of the housing starts ratios for each of these regions is substantially different than that found in the US Census (Figure 3.2.3 and Figure 3.2.4). The major differences between the two methodologies are that Texas (the second largest state in terms of housing starts) is included in the southwest region in the CINTRAFOR report but is included in the southern region by the US Census. Also, the CINTRAFOR research does not have a Midwest region and instead splits the states in this region somewhat equally between the northwest and northeast regions (Figure 3.2.3). The net effect is to equalize the southwest, southeast and northeastern region leaving the northwest as the smallest region.

According to Figure 3.2.4, the northwest is substantially smaller in terms of housing starts while the rest of the regions are relatively similar. As in the census report however, the percentages represented by each region have remained fairly stable. However, while the Census bureau's regional definitions suggest that the percentage of housing starts in the northeast have declined slightly and those in the west have increased slightly, the CINTRAFOR regional definitions suggest the opposite. Thus it is important to note the definitional differences between studies. As mentioned in past surveys, virtually every market research institution has slightly different regional definitions. These different methodologies will cause some variances between the reports and makes direct comparisons difficult.

Table 3.1.1 Regional Sample Frame Summary

	Number Sampled		Number Sampled
Northeast Region		Northwest Region	
Connecticut	22	Alaska	14
Delaware	5	California(north)	139
District of Columbia	1	Idaho	31
Illinois	67	Iowa	61
Indiana	34	Minnesota	86
Kentucky	15	Montana	23
Maine	5	Nebraska	33
Maryland	31	North Dakota	8
Massachusetts	30	Oregon	71
Michigan	63	South Dakota	14
New Hampshire	8	Washington	110
New Jersey	44	Wyoming	11
New York	67	*Regional subtotals*	*601*
Ohio	57		
Pennsylvania	66		
Rhode Island	5	Southwest Region	
Vermont	4	Arizona	41
Virginia	38	California(south)	214
West Virginia	5	Colorado	58
Wisconsin	31	Hawaii	9
Regional subtotals	*598*	Kansas	23
		Missouri	45
Southeast		Nevada	18
Alabama	37	New Mexico	16
Arkansas	22	Oklahoma	22
Florida	207	Texas	134
Georgia	86	Utah	22
Louisiana	28	*Regional subtotals*	*602*
Mississippi	15		
North Carolina	108		
South Carolina	44	Top 100 Builders	100
Tennessee	52		
Regional subtotals	*599*	Grand Total	2500

Figure 3.2.1 Census Bureau Regional Breakdown of the US

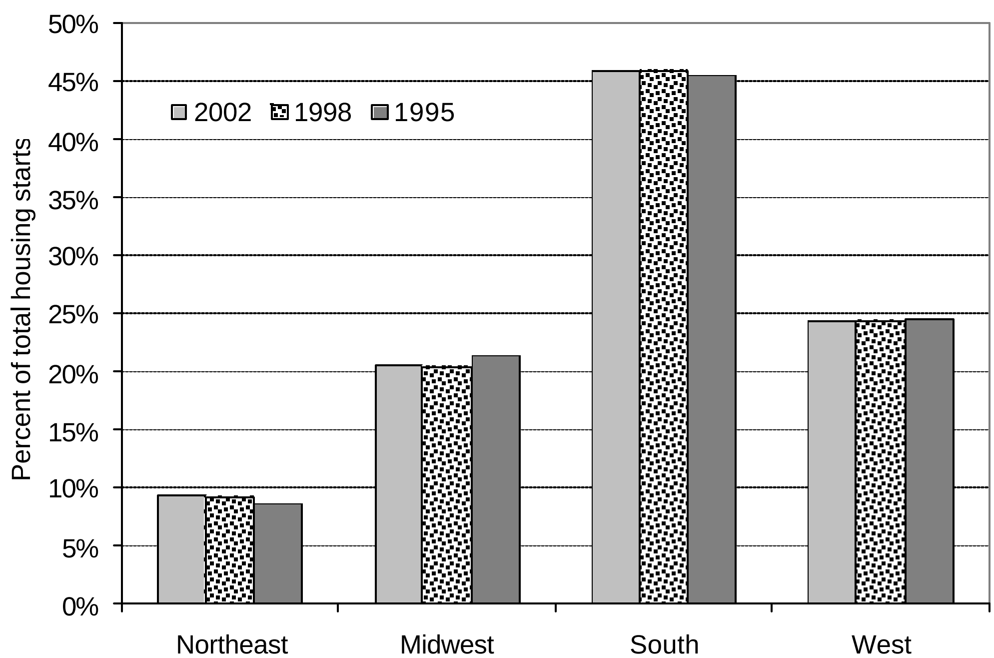

Figure 3.2.2 Housing Market Share by Region
Source: US Census Bureau, 2003

Figure 3.2.3 CINTRAFOR Regional Breakdown of the US

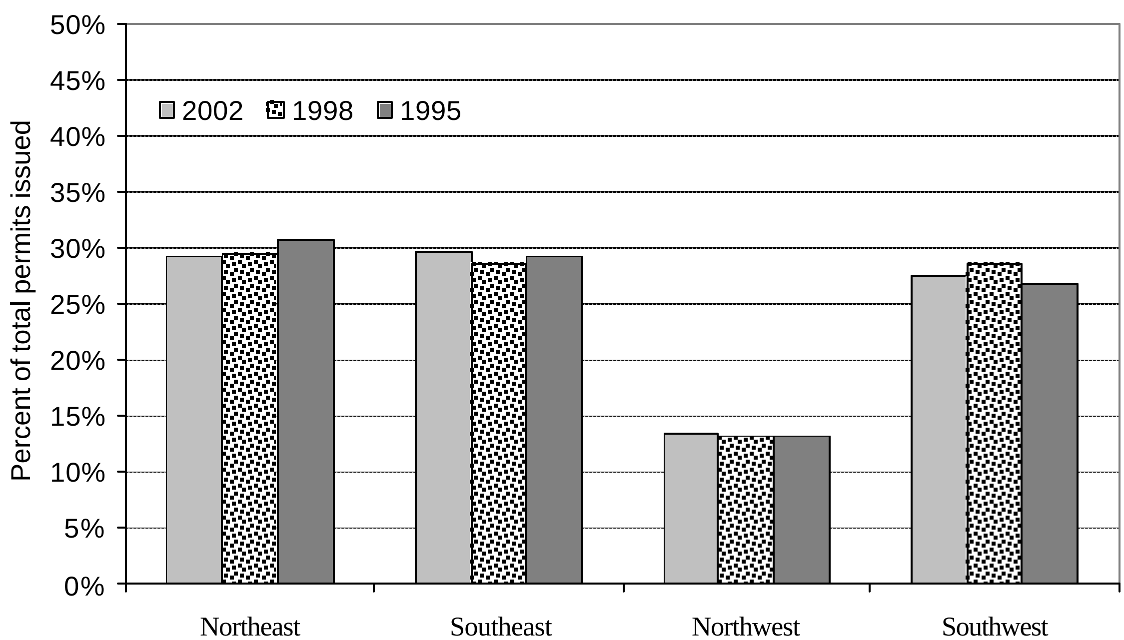

Figure 3.2.4 Housing Market Share by Region using CINTRAFOR Regional Definitions

3.3 NON-RESPONSE BIAS

As in every survey non-response bias is a valid concern. Many articles address this issue to some degree or another. In some cases a test of the late responders can serve as a proxy for the scores of the non-responders (Ifju, 1993). In these cases a simple comparison test of late responders to early responders can assess the extent of non-response bias. This is based on the notion outlined by Armstrong and Overton (1977) that subjects who respond less readily are more like non-respondents. "Less readily" is further defined to mean later and therefore late respondents serve as a proxy for the non-responding population. However, others have shown that the direct correlation between non-respondents and late responders may not be tenable (Van Goor & Stuiver, 1998).

This survey has more than 200 variables that are measured for each respondent. To test the difference in late responders and early responders with a traditional independent samples t-test inflates the probability of type I error to an unacceptable level. To correct for such a procedure would require that the alpha be set so small that the test is again rendered invalid. In short there is not a truly valid statistical method in existence that will accurately measure the differences among early and late responders for such a large number of variables. In lieu of such a method, the early and late responder demographic data was analyzed to look for any noteworthy differences. As none were found, non-response bias was considered to have a negligible effect on this survey.

4.0 STRUCTURAL LUMBER RESULTS

The format of the 1998 survey results is followed wherever possible to facilitate comparisons between the two surveys. To this end, the 2001 survey was broken down into identifiable segments similar to those used in the 1998 survey.

The first section will describe all respondents as a total sample. Criteria used to categorize each respondent regionally and by firm size will be discussed. Following sections of the survey will be discussed with respect to the described classification and compared to the 1998 survey where applicable.

4.1 RESPONSE RATE

A total of 189 usable surveys provided an overall response rate of 9% (Table 4.1). This compares to an overall response rate of 13.1 percent in the 1998 survey. Some of the non-response could be attributed to a tumultuous market place. A proxy of such turmoil might be the number of undeliverable addresses contained in the sample frame.

Table 4.1 Sample Size and Response Rate

	Sample frame	Responses	Response Rate
General firms	2001	174	8.70%
Top 100 firms	98	15	15.31%
Total	2099	189	9.00%

Note: Sample frame represents 401 builders eliminated as a result of bad addresses.

Table 4.2 shows the number of undeliverable addresses is about 8 times that of the 1998 study. So many bad addresses could be an indicator of a bad sample, or a tumultuous market place. In either case, the response rate would be negatively impacted. However, for the purposes of most industrial surveys, a 9% overall response rate is generally considered to be adequate.

Table 4.2 Percent of Undeliverable Addresses

	2001	1998
Sample Frame	2500	2500
Undeliverable	401	56
% of sample	16.0%	2.2%

4.2 REGIONAL DISTRIBUTION

Each state was coded into one of four mutually exclusive regions: Northeast, Northwest, Southeast, and Southwest. The percentage of all respondents represented in each of these regions is summarized in Figure 4.1. Regional distributions for this survey closely parallel the distribution of the 1998 survey.

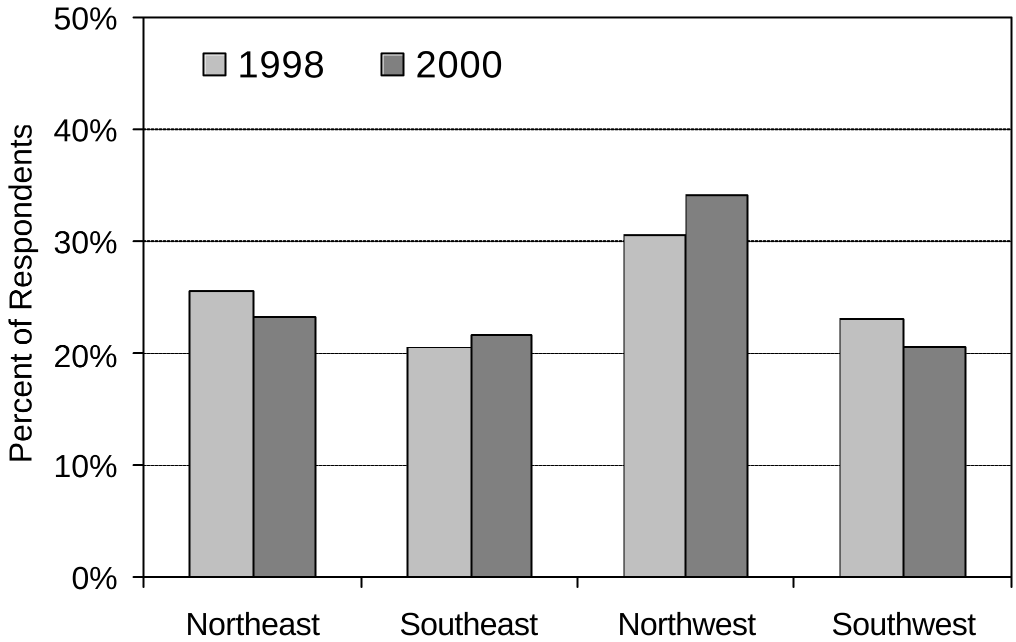

Figure 4.1 Distribution of Respondents by Region

The regional distribution of response rates from the general sample frame is presented in Table 4.3 and a comparison of these numbers to those of the 1998 survey can be seen graphically in Figure 4.2. The distribution is relatively even and there were no significant differences detected in response rates across regions.

Table 4.3 Total Sample Response Rate by Region

Region	Sample Size	Responses	1998 Response Rate	2001 Response Rate
Northeast	534	43	12.4%	8.0%
Southeast	515	40	9.9%	6.8%
Northwest	500	62	14.9%	11.5%
Southwest	550	39	11.3%	6.3%

Note: Sample sizes have been reduced by 401 general builders that were eliminated as a result of undeliverable addresses.

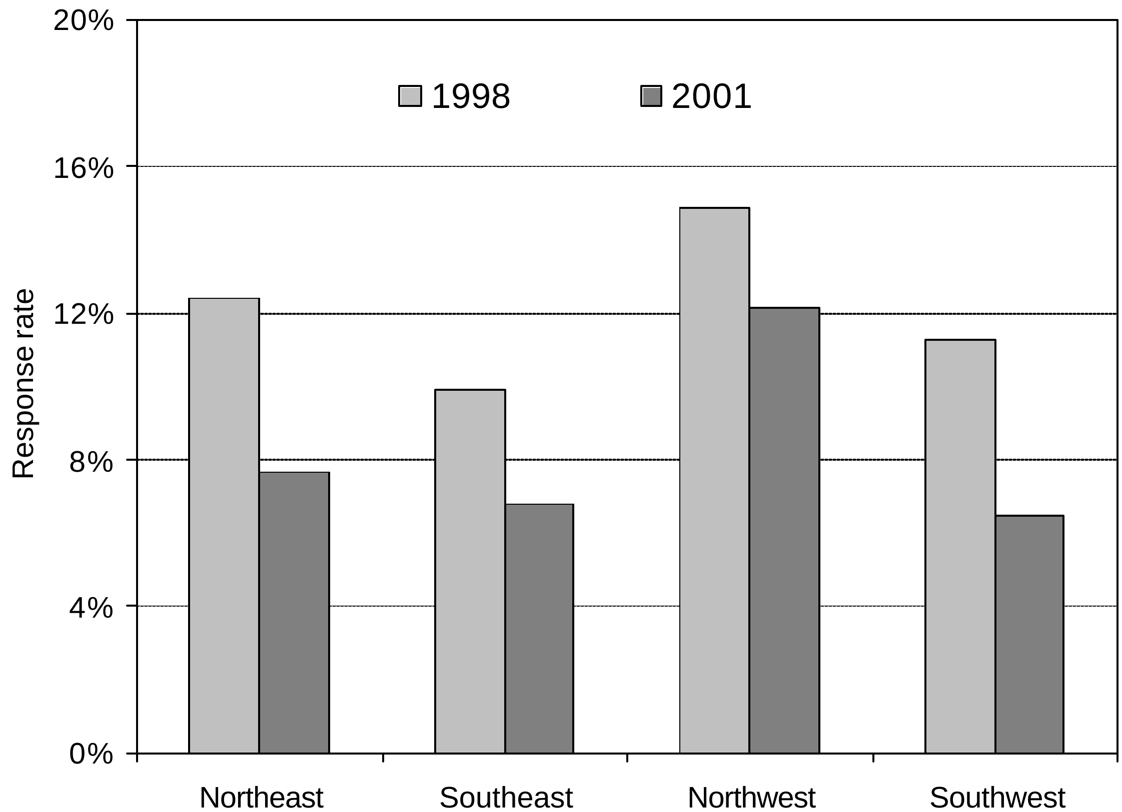

Figure 4.2 Regional Response Rate

4.3 FIRM SIZE

Firm size was defined exactly as it was in the 1998 survey. Firms were asked to indicate total 2001 sales revenue using six mutually exclusive categories. Figure 4.3 shows the percent of firms that fall into each revenue category for 2001 and 1998. In 2001 there was a higher percentage of small firms (0-$1 million) reporting more than $500,000 in sales than in 1998. Also the number of firms in the $2.5-$5 million category has risen. This trend toward larger firms is most likely driven by consolidation. The housing market is growing with housing starts at record levels. However this growth cannot account for all of the growth in individual firms. To illustrate, the top 100 firms will be discussed with respect to growth rates in the top 100 firm section.

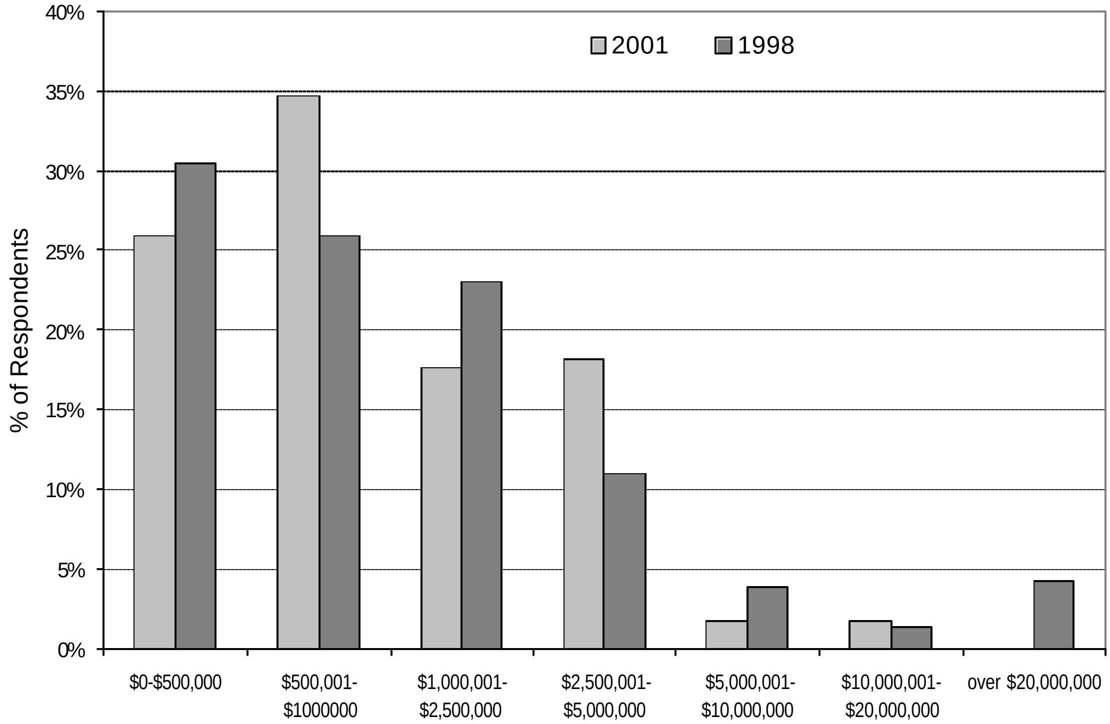

Figure 4.3 Construction Revenue 1998 vs. 2001

To facilitate the analysis of the survey data, respondent firms were classified based on firm size into three categories based on their reported 2001 sales revenue. Small firms reported sales revenue of less than $1 million, medium firms earned revenue of $1 million to $2.5 million and large firms were classified as earning more than $2.5 million ion sales revenue (Table 4.4).

Next firms were classified into small firms (less than $1 million) and large firms (more than $2.5 million). The large firm group included the top 100 firms. Like the 1998 analysis, this classification ignored the medium size firms ($1 million to $2.5 million). Thirty firms fell into the medium size firm category (Table 4.4). By eliminating the 30 firms classified as medium, differences related to firm size are accented and easier to interpret. In addition the differences in the 2001 sample and the 1998 survey are minimized making time line comparisons more viable. A breakdown of this classification can be seen in table 4.5.

Table 4.4 Classification of Respondent Firm Size into Three Groups

	1995	% of total	1998	% of total	2001	% of Total
Small	58	33.5%	159	56.4%	103	60.6%
Medium	69	39.9%	107	37.9%	30	17.6%
Large	46	26.6%	16	5.7%	37	21.8%
Total	173	100.0%	282	100.0%	170	100.0%

Note: Small = Less than $1 million; Medium = $1 million to $2.5 million; Large = More than $2.5 million

Table 4.5 Classification of Respondents into Two Groups

	1998	% of Total	2001	% of Total
Small	159	63.10%	103	66.45%
Large	93	36.90%	52	33.55%
Total	252	100.00%	**155**	100.00%

4.4 TOP 100 FIRMS

A total of 15 top 100 firms responded to the survey, providing a response rate of 15.34%. Throughout this report, the top 100 firms will tend to accent differences between large and small firms. This will be observed when the top 100 firms are compared to the large firms in the general sample.

To compare the top 100 firms of 1998 to those of 2001, all 100 firms reported in Builder magazine for both years were used. The average revenue of the top 100 in 2001 was $705,430,000, a 63 percent increase from the 1998 average revenue of $432,190,000.

The top 100 firms are clearly getting larger as time passes. Wall Street analysts attributed most of that growth to industry consolidation. Daniel Guido (2001) reports that the top 10 firms comprise over 50 percent of the top 100 volumes. This compares with 36 percent in 1997. Most of this change actually occurred in the top 5 firms, who in 2000 accounted for more than a third of all homes built by the top 100 firms. NAHB confirmed this trend by stating that the big firms would most likely continue their growth through mergers and acquisitions (Guido 2001). In 2000, 16 firms reported over $1billion in revenues compared to only 10 firms three years earlier and the top 100 firms accounted for 26 percent of all single family home construction compared with 18 percent in 1997 (Maynard and Depietrapaolo 1998)

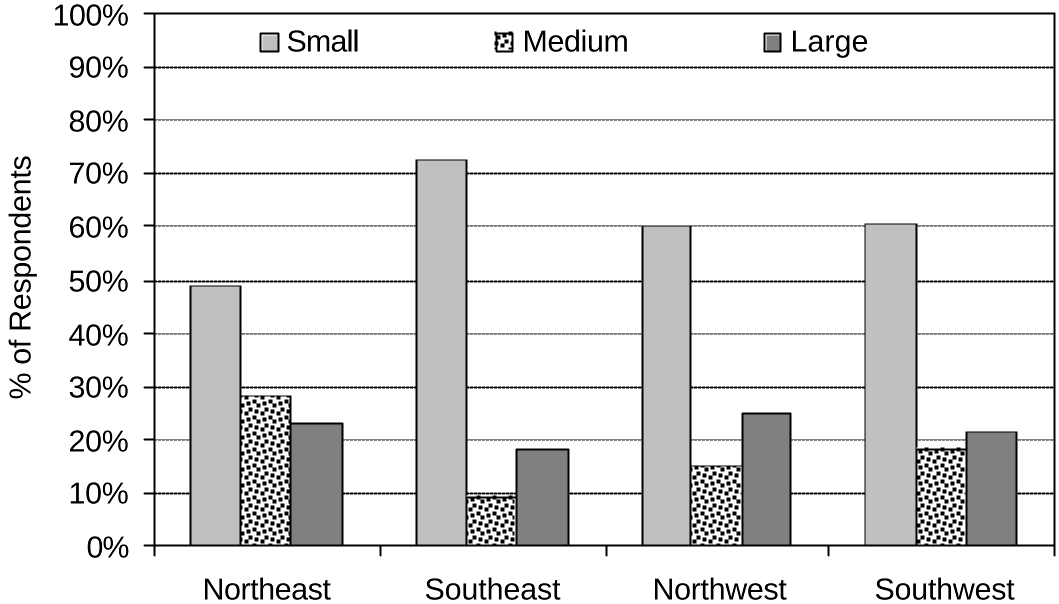

Figure 4.4 Regional Distribution of Respondents by Firm Size

Figure 4.4 shows a regional distribution of firms by firm size. As in the 1998 study, there were no significant differences between the proportion of respondents in each region. However, over 70 percent of the respondents in the southeast were classified as small firms, while less than half of the respondents in the northeast were small firms. In addition, the percentage of medium firms in the northeast was much higher than in the southeast.

Table 4.7 shows the regional distribution of the top 100 firms. Compared with the 1998 survey, the number of firms located in the south (including southeast and southwest regions) has increased from 64 to 69 with a corresponding decrease in firms based in the northern regions.

The differences in sample size do not represent a source of bias as this sample frame is a census. However there was a high response rate for those firms based in the southeast, and a correspondingly low response rate for firms based in the northeast. This may over represent opinions of firms based in the southeast and under represent opinions of firms based in the northeast. Therefore, the reader is cautioned to consider the responses of the Top 100 firms in aggregate, rather than looking for any regional differences.

Table 4.7 Distribution of Top 100 Firm Respondents by Region

	Sample Size	Response rate
Northeast	23	6.7%
Southeast	27	46.7%
Northwest	6	6.7%
Southwest	42	40.0%

4.5 TYPE OF CONSTRUCTION ACTIVITY

Builders were asked to estimate the percentage of their company's sales revenue that was generated from each of the business categories presented in Table 4.8. When looking at the total sample, single family construction accounts for over half of construction firms' revenue. From the 1995 survey and the 1998 surveys, a fairly large decrease in single family and multi-family residential construction was observed with a corresponding increase in repair and remodeling activities and nonresidential construction (although this activity declined somewhat from 1998 to 2001).

Table 4.8 Average Percent of 2001 Revenue Generated in Each Activity (Excluding the Top 100)

	1995	1998	2001
Single family	72.7%	52.3%	53.9%
Multi-family	9.4%	5.7%	3.9%
Repair/Remodeling	12.9%	26.6%	30.0%
Patio/Decks	1.2%	2.4%	2.4%
Nonresidential	3.2%	11.1%	8.3%

Regional distribution

Few of the regional differences summarized in Table 4.9 are statistically significant. However, the fact that the northwest region represents the lowest percentage of single family home construction is consistent with earlier observations (see literature review). Multi-family home construction was significantly different across regions with the northwest reporting a substantially higher percentage than any other region. In summary, the construction portfolios of residential builders in the northwest are much more diversified than in the other regions of the US.

Table 4.9 Type of Construction Activity by Region

	Northeast	Southeast	Northwest	Southwest
Single family	56.2%	59.3%	46.4%	63.2%
Multi-family *	1.4%	2.5%	8.2%	1.4%
Repair/Remodeling	31.8%	29.7%	27.8%	25.7%
Patio/Decks	2.3%	2.6%	3.6%	4.1%
Nonresidential	8.3%	5.8%	11.4%	6.6%

* Significant at the .05 level

Firm size

Figure 4.5 summarizes the construction activity as a percent of revenue for 2001 by firm size. There appears to be a positive relationship between firm size and percentage of single family housing starts. Similarly, there appears to be a negative relationship between firm size and the amount of revenue generated from repair and remodel activities. Clearly, the Top 100 builders are focused almost exclusively on residential construction projects whereas small builders are diversified between residential construction and R&R projects.

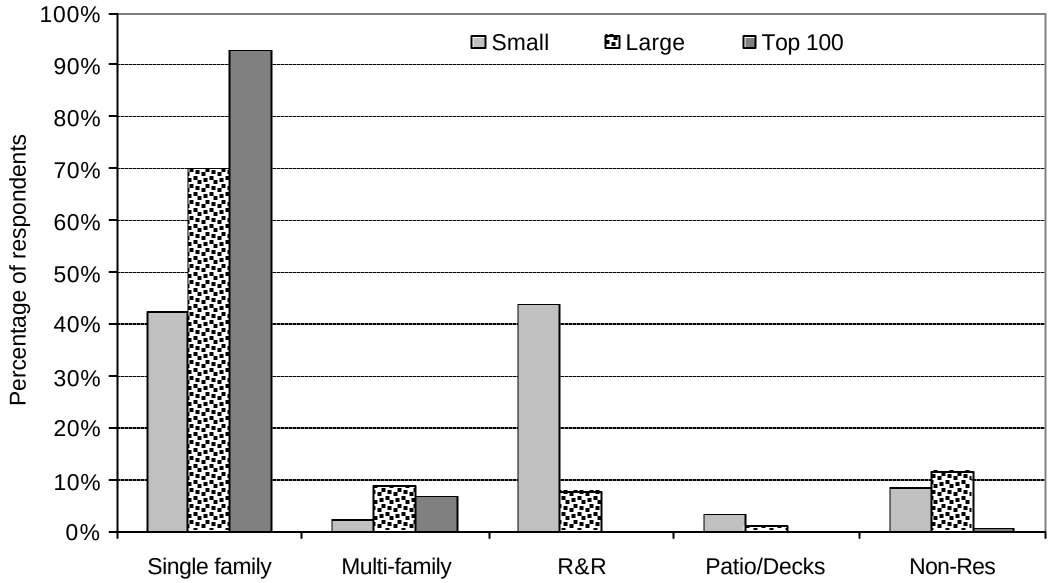

Figure 4.5 2001 Construction Activity

According to the 1998 data, the Top 100 firms generated most of their revenue from single family home construction but still had almost 40 percent coming from multi-family construction (Table 4.10). However, the Top 100 home builders appear to be focusing almost exclusively on single family home construction with more than 90 percent of their revenue coming from this activity.

Another interesting trend relates to the growing repair and remodeling sector. Similar to the 1998 results, small firms dominate this sector. In fact, this survey marks the first time that repair and remodeling accounted for more revenue than single family construction for small firms.

Table 4.10 Type of Construction Activity by Firm Size, 2001 vs. 1998

	Small Firms		Large Firms		Top 100	
	1998	2001	1998	2001	1998	2001
Single family	44.9%	42.3%	62.3%	70.0%	57.4%	92.7%
Multi-family	1.0%	2.2%	25.0%	8.7%	39.4%	6.7%
Repair/Remodeling	38.2%	43.8%	4.7%	7.6%	0.6%	0.0%
Patio/Decks	4.0%	3.2%	0.2%	1.1%	0.0%	0.1%
Nonresidential	9.3%	8.5%	6.4%	11.5%	0.6%	0.5%

Another point relates to multi-family housing. Both large and top 100 firms reported substantial decreases in multi-family home construction activity. These declines account for much of the increase in single family construction activity reported by both Top 100 and large firms.

4.6 USE OF STRUCTURAL MATERIALS

One of the objectives of this study was to evaluate the ongoing process of substitution between structural softwood lumber and alternative materials. To assess respondents' use of substitute materials, they were asked whether their usage of thirteen substitute materials had increased, decreased or remained the same over the past two years. Less than one percent of respondents indicated that they had never used any of the substitute products (Table 4.11). This compares to 1.1% of the 1998 survey respondents and 8.5% in 1995. A list of the substitute products included in the survey is presented in Table 4.12.

Table 4.11 Number of Respondents Using at Least One Substitute for Softwood Lumber

	1995	1998	2001
Total Respondents	176	284	189
# reporting usage of substitutes	161	281	188
% who have used a substitute	91.5%	98.9%	99.5%
% who have not used a substitute	8.5%	1.1%	0.5%

Table 4.12 and Figure 4.6 summarize the percentage of firms indicating that they have used each of the substitute products included in the survey. To test the statistical significance of these changes, a t-test was performed testing the difference between the 2001 and 1998 data. The largest percentage changes were in finger jointed studs, wood/plastic composite lumber and wood/steel joists. All of these were significant increases except for wood/steel joists which declined significantly.

Table 4.12 Percentage of Firms Reporting Usage of Each Substitute Product, 2001 vs. 1998 vs. 1995

		Percent usage			1998-2001
Abbreviation	**Structural Product**	**1995**	**1998**	**2001**	***% Change***
FJ	Finger-jointed Lumber**	19.3%	24.6%	36.2%	47.2%
Steel	Steel Framing	26.7%	43.8%	47.8%	9.2%
WPC	Wood Plastic Composite**	8.5%	29.6%	53.6%	80.9%
RC	Reinforced Concrete	29.5%	78.4%	75.0%	-4.3%
SIP	Structural Insulated Panels	14.8%	22.8%	20.5%	-9.9%
PWS	Panelized Wall Systems	N/a	n/a	25.0%	n/a
I-Joists	Wood I-Joists*	55.1%	85.8%	90.4%	5.4%
W/S Truss	Wood/Steel joists**	37.5%	64.3%	45.1%	-29.9%
LVL	Laminated Veneer Lumber (LVL)*	46.6%	82.3%	87.6%	6.5%
TimberStrand	TimberStrand™ Lumber	N/a	62.1%	60.8%	-2.1%
Parallam	Parallam™ Beams and Headers	42.6%	70.0%	70.1%	0.2%
Glulam	Glue Laminated Beams (Glulam)	72.7%	86.6%	88.6%	2.4%

** Significant at the .001 level

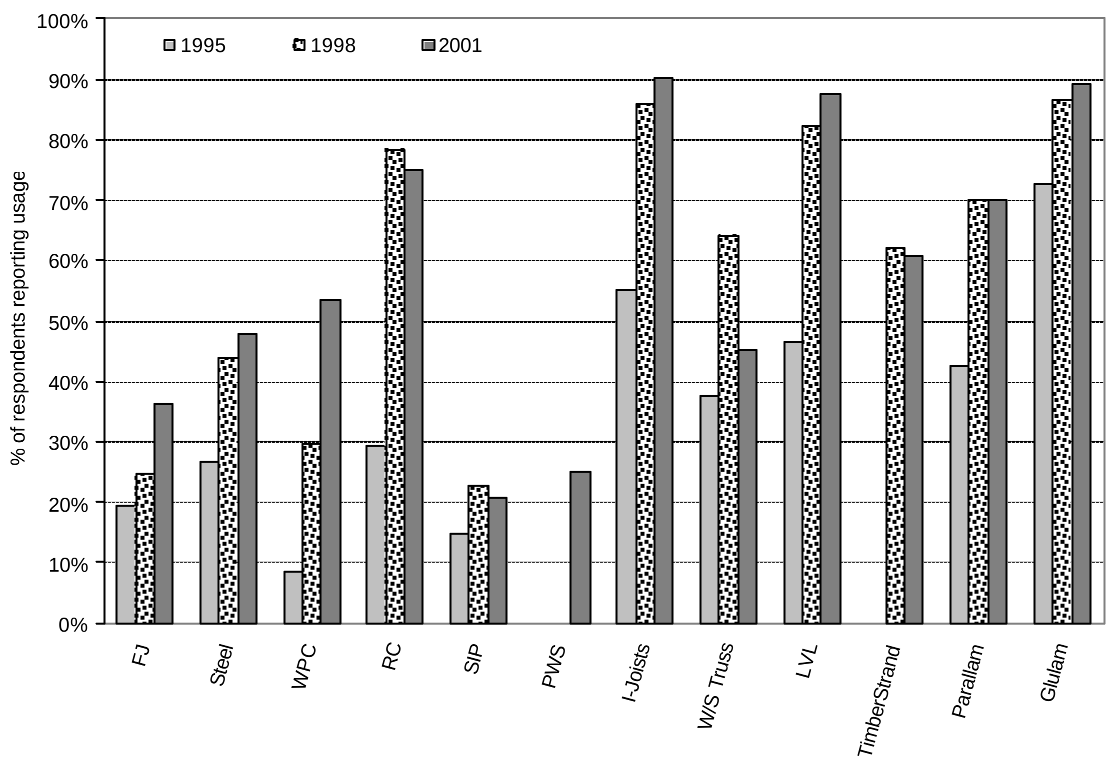

Figure 4.6 Percentage of Firms Indicating Usage of Each Substitute Product

Regional distribution

In the 1998 study, firms in the southwest were the dominant users of substitute products. In 2001 however, usage was more evenly spread across the regions (Table 4.13). Concrete was used by a substantially higher percentage of builders in the northwest and southeast than in the other regions. Also TimberStrand™ lumber was used most by the builders in the southwest and least by builders in the southeast. Other trends include higher usage of SIPs in the northeast and higher usage of finger jointed lumber in the south.

Table 4.13 Percent of Firms Reporting Usage of Each Substitute Product by Region

Structural Product	Northeast		Southeast		Northwest		Southwest	
	1998	2001	1998	2001	1998	2001	1998	2001
Finger-jointed Lumber	13.9%	27.9%	17.9%	40.0%	29.9%	32.3%	35.4%	43.6%
Steel Framing	45.1%	41.9%	38.2%	52.5%	35.7%	50.0%	58.1%	41.0%
Wood/Plastic Composite	29.6%	48.8%	22.4%	47.5%	33.3%	58.1%	31.3%	48.7%
Reinforced Concrete	71.8%	55.8%	80.0%	82.5%	77.4%	82.3%	85.7%	64.1%
Structural Insulated Panels	26.5%	27.9%	15.8%	15.0%	21.7%	19.4%	26.6%	17.9%
Panelized Wall Systems	n/a	23.3%	n/a	25.0%	n/a	27.4%	n/a	20.5%
Wood I-Joists	83.3%	86.0%	74.1%	85.0%	89.4%	95.2%	93.9%	92.3%
Wood/Steel Joists	67.6%	25.6%	63.0%	50.0%	54.2%	48.4%	75.0%	46.2%
Laminated Veneer Lumber	90.1%	90.7%	45.4%	85.0%	83.5%	85.5%	78.1%	87.2%
TimberStrand™	53.8%	53.5%	47.2%	45.0%	74.4%	64.5%	67.2%	71.8%
Parallam™	69.4%	69.8%	54.5%	65.0%	73.8%	66.1%	78.8%	74.4%
Glue Laminated Beams	81.4%	79.1%	78.6%	87.5%	91.7%	90.3%	92.4%	87.2%

Firm size

Consistent with previous studies, the large firms reported higher usage of substitute products than smaller firms for most of the products listed (Table 4.14). However, small firms reported significantly higher usage of several products; including finger-jointed lumber, structural insulated panels (SIPs), and wood/plastic composite lumber. For SIPs the interesting trend is not so much smaller firms reporting a slight increase but large firms (and top 100 firms) reporting a significant decrease. Both large and top 100 firms reported more than a 20% decrease in usage of SIPs. This decrease could be the result of poor product performance or other substitutes filling the same niche that SIPs attempt to fill. Wood/plastic composites are used mainly in decks and the dominance of small firms in the deck market is most likely the reason for their higher usage of this product.

Table 4.14 Percent of Firms Reporting Usage of Each Substitute Product by Firm Size

Structural Product	Small		Large		Top 100	
	1998	2001	1998	2001	1998	2001
Finger-jointed Lumber	18.5%	33.0%	47.3%	51.6%	65.7%	47.6%
Steel Framing	41.2%	49.5%	42.4%	51.6%	35.5%	38.1%
Wood/Plastic Lumber Composite	33.5%	59.2%	34.8%	41.9%	41.7%	47.6%
Reinforced Concrete	77.0%	77.7%	83.0%	74.2%	78.8%	61.9%
Structural Insulated Panels	17.6%	20.4%	40.2%	19.4%	48.5%	14.3%
Panelized Wall Systems	NA	18.4%	NA	35.5%	NA	38.1%
Wood I-Joists	82.2%	89.3%	82.4%	96.8%	83.3%	81.0%
Wood/Steel Joists	55.6%	41.7%	62.9%	51.6%	73.5%	47.6%
Laminated Veneer Lumber	78.6%	82.5%	88.2%	93.5%	86.1%	90.5%
TimberStrand™	59.1%	53.4%	70.9%	61.3%	79.4%	71.4%
Parallam™	62.2%	62.1%	79.3%	71.0%	77.8%	81.0%
Glue Laminated Beams	81.3%	85.4%	87.9%	90.3%	80.0%	85.7%

Whereas small firms substantially increased their use of finger-jointed lumber, Top 100 firms reported a sharp drop in their use of finger-jointed lumber. In fact, the Top 100 firms reported that they had reduced their use of six substitute products. This may indicate that lower softwood lumber prices have encouraged these firms to increase their use of softwood lumber.

4.7 NUMBER OF SUBSTITUTE PRODUCTS USED

The total number of substitute products used is very similar to the 1998 survey. A cumulative percentage graph comparing the three survey results of 1995, 1998, and 2001 is presented in Figure 4.7. Almost half of the respondents have used 7 or more substitute products compared to similar results in 1998. In addition, almost a quarter of the respondents have used 9 or more of the substitute products. In 1998, only 15% of builders had tried 9 or more substitutes. The further outward shift of the usage curve to the right indicates that builders continue to use more substitute products over time.

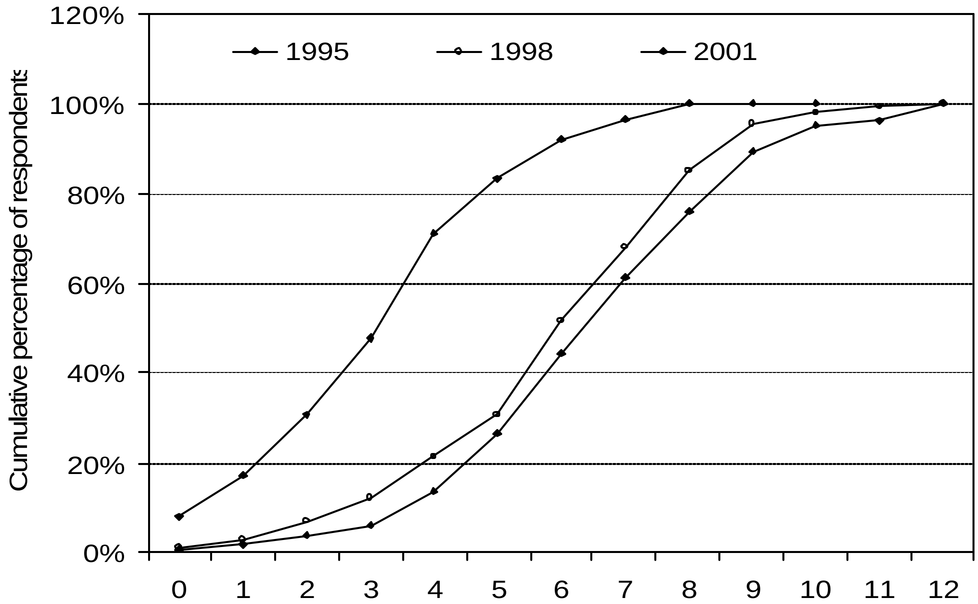

Figure 4.7 Number of Substitute Products Used

As was mentioned in previous survey results, the trend of higher substitute usage can be partially explained by builders' dissatisfaction with softwood lumber, particularly with respect to overall price, price stability and lumber quality. As a traditionally conservative group with respect to substitute materials, the shift of builders toward using more of these products could represent their continued dissatisfaction with softwood lumber. It could also indicate that builders have become more willing to try new products as a result of their past experiences using substitute materials. This would help to explain the fact that the aggregate use of substitute materials continues to grow even as the prices of softwood lumber have moderated in recent years.

4.8 RATE OF CHANGE IN SOFTWOOD LUMBER USE

Respondents were asked to assess how their usage of softwood lumber had changed over the past two years. Softwood lumber change was measured using a scale where a rating of one indicated that the respondents' use of softwood lumber had not changed at all, while a rating of 4 indicated that the use of lumber had changed moderately and a rating of seven meant that their use of softwood lumber had changed substantially (Table 4.15).

Table 4.15 Change in Softwood Lumber Usage, 2001 vs. 1998

1998 (7-point scale)			2001 (7-point scale)			
Rating	**% of respondents**	**Group %**	**Rating**	**% of respondents**	**Group %**	**Degree of change**
1	16.8%	**30.9%**	1	19.0%	**37.4%**	*Little or none*
2	14.1%		2	18.4%		
3	15.5%		3	14.5%		
4	30.3%	**57.0%**	4	34.1%	**57.5%**	*Moderate*
5	11.2%		5	8.9%		
6	7.9%	**11.8%**	6	3.4%	**4.7%**	*Substantial*
7	3.9%		7	1.4%		

Fewer builders in 2001 reported a substantial change in lumber usage relative to the 1998 survey. A corresponding increase in the number of builders reporting little or no change can be seen. This trend may be partly due to the fact that softwood lumber prices were generally declining over the period 1999-2001. In addition, price volatility was also lower over this period than during earlier periods. Taken together, these factors may have helped contribute to an overall increase in builder satisfaction with softwood lumber. The scale rating scores were analyzed by region and firm size and no statistical differences were found. However, the southwest did have the highest rate of change in softwood lumber and the larger firms tended to report more drastic changes in their softwood lumber usage.

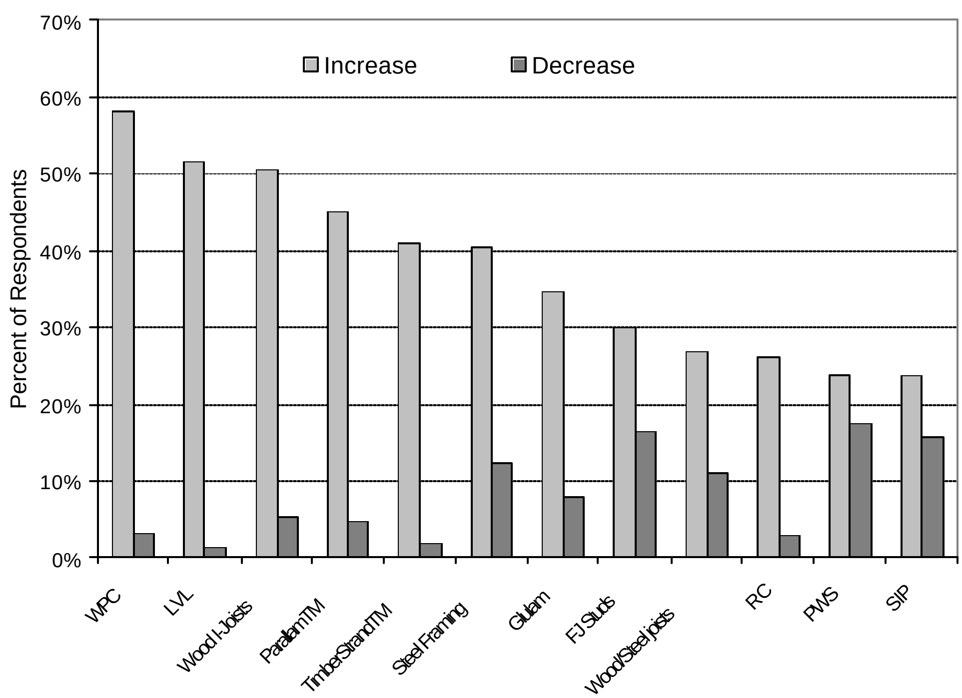

Figure 4.8 Substitute Product Usage Change

Builders were then asked to indicate whether their usage of each substitute product had increased, decreased, or remained the same. Each respondent also had the option to indicate that they had never used a particular product. The summary in Figure 4.8 represents the percentage of respondents who indicated that their usage of each material had increased or decreased. This summary does not include those builders indicating no change in usage or having never used a product. It is useful to note that the highest levels of dissatisfaction were noted for those products with the lowest trial rates (Table 4.16).

Wood/plastic composite lumber is non-structural lumber that is normally used in deck or fencing applications. When analyzed by firm size it was found that small firms are increasing their usage of this product more than other firms. This follows earlier observations of the smaller firms' dominance in the repair and remodeling market.

Over 40% of the survey respondents reported that their use of WPC, LVL, wood I-joists, Parallam and Timberstrand lumber had increased while the rate of decreased usage for these same products was generally less than 5%, suggesting a high level of builder satisfaction with these products. In contrast, while 40% of respondents increased their use of steel framing, almost 15% reported that their use of steel framing had declined. Similar trends were noted for finger-jointed lumber, panelized wall systems and SIPs, although the percentage of respondents indicating that their use of these products had increased was generally less than 25% while the percentage of builders reporting declining use of these products was between 15% and 20%.

Table 4.16 Percent of Builders Reporting Usage of Substitute Products

	Percent Usage
Wood I-Joists	90.4%
Glulam	88.7%
LVL	87.6%
Concrete	75.0%
Parallam™	70.1%
TimberStrand™	60.8%
Wood/Plastic Composite Lumber	53.6%
Steel Framing	47.8%
Wood/Steel Joists	45.1%
Finger-jointed Lumber	36.2%
Panelized Wall Systems	25.0%
SIP	20.5%

4.9 MATERIAL USE IN SPECIFIC END USE APPLICATIONS

Survey participants were asked to estimate the percentage (on a volume basis) of material usage during the past year in specific end-use applications (Tables 4.17 and 4.18). These applications included floor framing, roof framing, headers and wall framing (including both load bearing and non-load bearing walls). The non-load bearing and load bearing wall categories were a new addition to the 2001 survey. To facilitate the comparison with the 1998 survey results, both of these categories were averaged resulting in the "Wall Framing 2001 Average" category seen in Table 4.17. Headers were also a new category in the 2001 survey.

Table 4.17 Product Usage in Specific Framing Applications, 2001 vs. 1998 vs. 1995

Product

Wall Framing	**1995**	**1998**	**2001**
Softwood lumber	93.0%	83.1%	83.4%
Finger-jointed stud	4.0%	5.3%	5.5%
Steel framing*	0.0%	8.8%	6.6%
LVL*	0.0%	0.8%	1.6%
Wood truss	0.0%	1.1%	1.1%
Wood I-joist	0.0%	0.4%	0.4%

Floor Framing	**1995**	**1998**	**2001**
Wood I-joist	23.0%	38.8%	43.2%
Softwood lumber	59.0%	41.8%	38.6%
Wood truss	16.0%	10.4%	12.7%
LVL	0.0%	3.0%	2.3%
Steel framing	2.0%	2.2%	1.7%
Finger-jointed stud	0.0%	0.3%	0.3%

Roof Framing	**1995**	**1998**	**2001**
Wood truss	46.0%	47.7%	49.7%
Softwood lumber	51.0%	40.0%	40.9%
Wood I-joist	2.0%	3.4%	3.0%
LVL	0.0%	2.7%	2.7%
Steel framing	1.0%	2.9%	1.7%
Finger-jointed stud	0.0%	1.3%	0.1%

Headers	**2001**
Softwood lumber	71.9%
LVL	20.4%
Steel framing	3.8%
Wood truss	1.6%
Wood I-joist	1.2%
Finger-jointed stud	0.2%

The softwood lumber usage changes since 1998 are minimal. In wall framing softwood lumber gained ground slightly and wood I-joists saw a corresponding increase in floor usage. Wall and roof change was less than 1 percentage point. This is a different story than that of 1998 when softwood lost considerable ground to virtually every other product listed in the survey. Low timber prices appear to be a major factor in explaining the stabilization of softwood lumbers market share between 1998 and 2001.

Steel has seen a moderate decline across all structural end-use applications. Table 4.18 provides a clearer picture of steel use in wall framing. The underlying message is that steel, though used by some builders in some applications has not been successful in offering a total system. Builders remain reluctant to use steel to frame the entire house and as a result, its overall market share has declined. Again, low lumber prices are seen as a significant factor in the declining use of steel framing.

The share of softwood lumber used in header applications is less than that observed in wall framing, although it still exceeds 70% (Table 4.17). Builders reported using LVL for about 20 percent of header construction. As seen in Figure 4.8, builders reported large increases in their use of LVL and while some LVL is used in wall, floor and roof framing applications, the largest volume was used in header applications which often require the higher stiffness of LVL to bridge large window, door and garage door openings.

Table 4.18 segments the wall framing data into load bearing and non-load bearing wall applications. Steel framing is used significantly more in non-load bearing walls than in load bearing walls. LVL shows the opposite trend and is used significantly more in load bearing walls than in non-load bearing walls. Interestingly, the use of softwood lumber is relatively consistent between both types of wall applications.

Table 4.18 Load Bearing vs. Non-load Bearing Wall Summary

Product	Wall Framing 2001	
	Load bearing	**Non-load bearing**
Softwood lumber	83.4%	83.9%
Finger-jointed stud	5.5%	5.5%
Steel framing*	6.6%	8.5%
LVL*	2.7%	0.4%
Wood truss	1.1%	0.8%
Wood I-joist	0.4%	0.4%

4.9.1 Wall framing by region

The use of softwood lumber in wall framing applications has declined in the eastern regions while builders in the western regions have increased their usage (Table 4.19). Finger jointed lumber usage has increased substantially in the northeast and in the southwest. However builders have decreased their use of finger jointed lumber in the northwest and southeastern regions. Builders in the southeast and northwest reported decreasing usage of LVL whereas builders in the northeast and southwest reported increases in LVL usage. Finally steel framing usage has declined in every region, with the exception of the southeast where it increased to over 12 percent.

Table 4.19 Product Usage in Wall Framing Across Region

Average	Northeast		Southeast		Northwest		Southwest	
Wall framing	**1998**	**2001**	**1998**	**2001**	**1998**	**2001**	**1998**	**2001**
Softwood lumber	86.1%	78.9%	83.4%	77.0%	82.1%	89.7%	80.6%	84.1%
Wood truss	2.3%	4.2%	0.3%	0.1%	0.9%	0.1%	0.8%	0.8%
Finger-jointed stud	2.0%	7.1%	4.8%	3.0%	7.8%	4.1%	6.2%	8.5%
Wood I-joist	0.3%	0.2%	0.0%	0.5%	0.2%	0.1%	1.4%	0.8%
LVL	0.5%	2.0%	0.0%	3.9%	1.6%	1.1%	0.4%	0.0%
Steel framing	9.2%	5.2%	10.6%	12.2%	7.4%	3.9%	8.5%	5.9%

Table 4.20 Product Usage in Floor Framing Across Regions

	Northeast		Southeast		Northwest		Southwest	
Floor framing	**1998**	**2001**	**1998**	**2001**	**1998**	**2001**	**1998**	**2001**
Softwood lumber	58.7%	39.6%	45.9%	44.2%	29.4%	35.9%	35.5%	30.8%
Wood truss	10.1%	10.0%	14.0%	28.7%	8.3%	7.9%	10.5%	8.4%
Finger-jointed stud	0.5%	0.8%	0.0%	0.0%	0.6%	0.2%	0.0%	0.5%
Wood I-joist	26.1%	43.3%	22.2%	20.9%	55.9%	51.0%	44.7%	56.7%
LVL	1.9%	4.0%	1.1%	2.2%	3.1%	2.4%	5.7%	0.5%
Steel framing	0.8%	1.6%	7.1%	1.9%	1.3%	1.0%	0.5%	3.0%

4.9.2 Floor framing by region

The southeast reported using the highest amount of softwood lumber in flooring. Wood trusses were also used the most by southern builders. Wood I-joists were used more by those firms located in the western regions and represent the products used the most in every region except the southeast. Finally, steel framing declined substantially in the southeast and is used to frame 3% or less of floor systems across the US.

4.9.3 Roof framing by region

Table 4.21 summarizes the product usage in roof framing across the regions. Softwood lumber usage increased substantially in the western regions and decreased substantially in the eastern regions. Wood truss usage increased in all regions except for the northwest, where it declined modestly. Wood I-joist usage declined in every region except the northeast. Steel usage decreased substantially in the southeast and decreased by smaller margins in all of the other regions except the northeast where usage increased. Similar to the floor framing data, steel usage in roof trusses declined to 3% or less in every region of the country. The survey data shows that steel use in structural wall framing declined to 6.6%, in floor framing declined to 1.7%, and in roof framing declined to 1.7%. This data strongly suggests that the steel framing system was used in less than two percent of US housing starts in 2001.

4.9.4 Headers by region

The LVL and softwood lumber usage is relatively even across region and no significant differences were detected. Combined, these two products represent over 90% of the material use in header applications across all four regions of the US. The southeast does show a higher percentage of steel framing being used and this is consistent with the wall framing percentages reported earlier (Table 4.22).

Table 4.21 Product Usage in Roof Framing Across Regions

	Northeast		Southeast		Northwest		Southwest	
Roof framing	**1998**	**2001**	**1998**	**2001**	**1998**	**2001**	**1998**	**2001**
Softwood lumber	48.0%	38.2%	46.0%	38.4%	29.1%	39.2%	40.4%	47.9%
Wood truss	44.4%	48.3%	42.0%	54.3%	57.4%	54.1%	43.1%	44.5%
Finger-jointed stud	0.0%	0.2%	1.7%	0.0%	1.3%	0.2%	2.5%	0.1%
Wood I-joist	1.1%	3.3%	2.4%	1.4%	5.1%	3.5%	4.7%	3.7%
LVL	1.6%	3.1%	0.9%	0.7%	2.7%	1.8%	5.6%	0.6%
Steel framing	0.7%	1.7%	5.4%	2.2%	2.8%	0.5%	3.3%	3.1%

Table 4.22 Header Usage Summary by Region

Headers	Northeast	Southeast	Northwest	Southwest
Softwood lumber	68.1%	70.9%	72.8%	74.7%
Wood truss	3.2%	0.0%	1.0%	1.8%
Finger-jointed stud	0.2%	0.5%	0.1%	0.0%
Wood I-joist	2.0%	0.0%	1.2%	0.9%
LVL	22.7%	19.6%	22.5%	17.2%
Steel framing	2.6%	9.0%	1.5%	3.8%

4.10 PERCEIVED ENVIRONMENTAL PERFORMANCE

Another objective of this research was to assess builders perceptions of the environmental impacts associated with the use of each substitute material relative to softwood lumber. Each builder was asked to compare the substitute products to softwood lumber with respect to their impact on the environment using a Likert-like scale where a rating of 1 indicated that the substitute material had a less favorable impact on the environment than softwood lumber, a rating of 4 indicated that it had the same impact and a rating of 7 indicated that the substitute material had a more favorable impact on the environment. The average scores for this and previous surveys are summarized in Table 4.23 and Figure 4.9. All of the products listed in this survey saw an increase in average ratings with the exception of wood I-joists. The biggest increase has been seen in steel, followed by concrete blocks, SIPs and wood/steel trusses.

Clearly builders still see softwood lumber as having a poor environmental image. Much of the marketing effort for steel has been to position steel as an environmentally friendly product relative to softwood lumber and this message seems to have taken hold. However, environmental performance currently ranks low in importance during the purchase decision. While there have been several efforts to improve the environmental perception of wood recently, it appears that these have been too limited in scale and scope to have had any substantial impact on builders' perceptions of wood.

Table 4.23 Perception of the Environmental Impact of Substitute Materials Relative to Softwood Lumber, 1995-2001

Product	1995	1998	2001
LVL	5.0	5.4	5.6
Wood I-Joists	4.9	5.4	5.4
TimberStrand™	4.9	5.3	5.4
Parallam™	4.9	5.2	5.4
Glulam	4.9	5.1	5.3
Wood/Steel Trusses	4.8	4.9	5.2
Finger-Jointed Studs	4.6	4.8	4.9
WPC Lumber	4.5	4.7	4.9
Reinforced Concrete	4.5	4.6	4.7
SIP	4.3	4.4	4.7
Concrete Blocks	4.1	4.2	4.6
Steel Framing	3.8	3.8	4.4

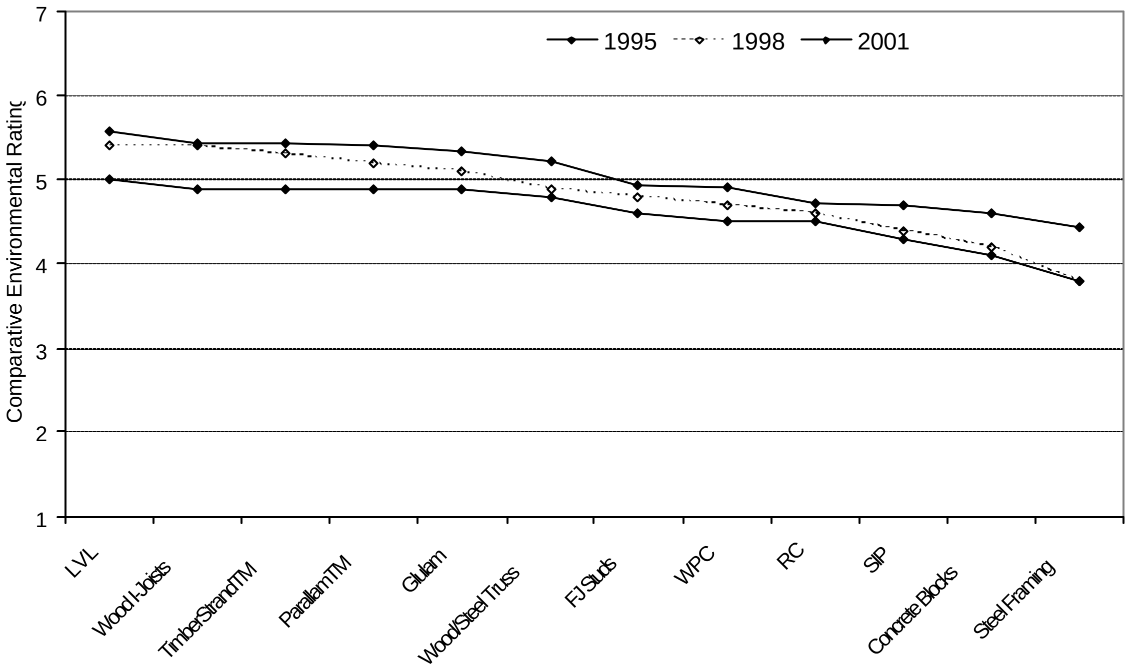

Figure 4.9 Perceptions of Environmental Performance of Substitute Products Relative to Softwood Lumber

4.11 IMPORTANCE/SATISFACTION RATINGS FOR SOFTWOOD LUMBER ATTRIBUTES

Builders were asked to rate the importance of a broad range of structural softwood lumber attributes in their material purchase decision. The average importance ratings summarized in Table 4.24 are virtually identical to those obtained in previous CINTRAFOR surveys and there are two important inferences to be made regarding this observation. First, attitudes of builders toward the importance of specific lumber attributes have remained relatively constant since 1995. Second, the builders surveyed in 2001 are similar to those surveyed in the 1995 and 1998 studies. These results are of note because, given the fact that residential construction framing technology has remained fairly constant over time, we would not expect the relative importance of specific purchase criteria to change much over time.

Table 4.24 Average Softwood Lumber Importance Ratings

	1995	1998	2001
Straightness	6.4	6.6	6.5
Strength	6.4	6.5	6.5
Availability	6.2	6.2	6.2
Lack of defects	6.1	6.1	6.1
Overall Price	6.2	6.0	6.0
Price Stability	6.1	6.0	5.9
Ease of use	5.7	5.9	5.9
Little product waste	n/a	5.8	5.8
Longer length	5.7	5.8	5.9
Availability of Tech./Eng. support	5.6	5.6	5.6
Appearance	5.0	5.3	5.3
Energy Efficiency	4.9	5.1	5.2
Red. Environmental Impact	4.5	4.5	4.7

The satisfaction ratings for the softwood lumber attributes are summarized in Table 4.25. It is important to note that although the satisfaction scores have generally increased, straightness and lack of defects still represent the attributes with the lowest satisfaction ratings. Straightness and lack of defects are reported to be the two of the most important lumber attributes and yet they are the two attributes with the lowest satisfaction ratings. Considering the low ratings provided for the straightness and lack of defects attributes of softwood lumber, it appears clear that builders continue to be critical of the quality of softwood lumber, a trend that has remained fairly consistent over the 1995-2001 period. In contrast, the satisfaction ratings for price and price stability continue to increase as softwood lumber prices and price volatility continue to moderate.

Both importance ratings and satisfaction ratings were analyzed by firm size and by region. Tables A.1 and A.2 summarize these analyses (Appendix III). While the magnitude of importance and satisfaction scores did differ by region, the relative ranking of the attributes remained very similar. Regarding firm size, the larger firms regarded price as more important than the smaller firms and also reported higher satisfaction scores for these attributes. In general however, the relative ranking of both the importance and satisfaction scores were fairly similar across geographic regions and firm size.

Table 4.25 Average Softwood Lumber Satisfaction Ratings

	1995	1998	2001
Availability	5.0	5.5	5.5
Ease of use	n/a	5.4	5.5
Strength	5.0	5.1	5.0
Overall Price	3.3	4.5	4.8
Tech./Eng. support	n/a	4.5	4.7
Energy Efficiency	4.1	4.5	4.7
Longer length	4.1	4.5	4.7
Little product waste	n/a	4.2	4.6
Price Stability	2.7	4.2	4.5
Red. Envt'l Impact	4.1	4.1	4.4
Appearance	n/a	4.2	4.2
Straightness	3.7	3.6	3.8
Lack of defects	3.5	3.5	3.7

A gap analysis highlights the observation that builders appear to be more satisfied with softwood lumber. Table 4.26 quantifies the difference between the importance and satisfaction ratings for each of the 13 softwood lumber attributes. These gaps were calculated by subtracting the satisfaction rating from the importance rating for each product attribute. Strength was the sole attribute for which an increase in the importance-satisfaction gap was reported. For the remaining twelve attributes, either a decrease in the gap or no change was reported. This is certainly good news for softwood lumber manufacturers. However, substantial gaps were observed for the straightness and lack of defects attributes, although the magnitude of these gaps was slightly lower than observed in the previous survey. Similar to the 1998 survey, builders were asked to list the three most important lumber attributes that they consider when purchasing softwood lumber. The softwood lumber attributes of strength, price, and straightness remained the top three attributes.

Table 4.26 Average Gap between Satisfaction and Importance

	1995	1998	2001	Change 1998-2001
Straightness	2.7	3.0	2.7	
Lack of defects	2.6	2.6	2.4	
Strength	1.4	1.4	1.5	
Price Stability	3.4	1.8	1.4	
Longer length	1.6	1.3	1.3	
Little product waste	n/a	1.6	1.2	
Overall Price	2.9	1.5	1.2	
Appearance	n/a	1.1	1.1	
Tech./Eng. support	n/a	1.1	0.9	
Availability	1.2	0.7	0.7	
Energy Efficiency	0.8	0.6	0.5	
Ease of use	n/a	0.5	0.4	
Red. Env. Impact	0.4	0.4	0.3	

4.12 FACTOR ANALYSIS OF THE SOFTWOOD LUMBER IMPORTANCE ATTRIBUTES

The goal of factor analysis is to identify underlying patterns and interrelationships among variables (Lilien & Rangaswamy 2003). The scales used to identify the relative importance and satisfaction of thirteen lumber attributes will be correlated to a certain extent by the nature of the measures. For example, appearance and lack of defects are correlated by the fact that a board with several defects will not receive a high appearance score. In this case appearance and lack of defects are said to be co-linear variables. A factor analysis can reduce the number of variables by combining those variables that are correlated into independent subsets of variables, or factors. The variables grouped within each factor tend to be highly correlated while there is much less correlation between variables grouped into different factors.

Each factor identified by the factor analysis is named in a subjective manner by the analyst. In this case the attributes included in a given factor determined its name. In the analysis of the importance ratings, three factors were identified (Table 4.27). These three factors were named Technical, Economic and Quality, respectively, based on the softwood lumber attributes included within each factor.

To better assess the reliability of the factors for future analysis, a scale reliability test statistic called Cronbach's Alpha was used. The results of this test are summarized in Table 4.28 for each factor analyzed. Cronbach's alpha is a correlation variable and its value ranges from 0 to 1. A value above .7 is typically considered high and can be interpreted as a reliable scale (Lattin, Carroll, & Green 2003; p.184). A high loading for this statistic validates the scale used in a particular factor. The three factors resulting from the analysis explained a little more than 60% of the total variance among the attributes included in the analysis. While a factor analysis was also conducted for the satisfaction attribute data, the results are not discussed here. The summary results are presented in a tabular form in Appendix III (Tables A2-A4).

Table 4.27 Rotated Component Matrix for Importance Ratings

Factor 1 Attributes	**Technical Characteristics**		
Appearance	**.77521**	-.10461	.09853
Tech./Eng. Support	**.75010**	.21304	.03574
Lack of Defects	**.72004**	.13163	.31046
Product Waste	**.69135**	.23310	.28220
Energy Efficiency	**.55949**	.25078	.37963
Longer Lengths	**.49599**	.28984	.09685
Red. Env. Impact	**.40900**	.26349	.37949
Ease of Use	**.55424**	.55795	.02843
Factor 2 Attributes		**Economic**	
Price Stability	.24642	**.83553**	.15818
Overall Price	-.00318	**.83196**	.04902
Availability	.19580	**.67029**	.19050
Factor 3 Attributes			**Quality**
Strength	0.0582	.09037	**.89024**
Straightness	.32649	.13000	**.77852**

Table 4.28 Total Variance Explained by Factors (Importance Ratings)

	Eigen Value	% Variation Explained	Cumulative Percent	Cronbach's Alpha
Factor 1	5.20	40.00	40.00	.8377
Factor 2	1.52	11.66	51.66	.7580
Factor 3	1.15	8.88	60.54	.7333

There were only subtle differences in the factors derived from the 2001 survey and those found in the 1998 survey. In 1998, the "Ease of Use" variable was included exclusively in the technical performance factor whereas in 2001 it could have been included in either the technical performance or the economic factor. Also the "Lack of Defects" and "Longer Lengths" factors were part of the quality factor previously but they were included in the technical performance factor in 2001. These differences can be regarded as minor as most of these variables had relatively low loading values.

Similar to the 1998 survey, the importance attributes were aggregated into their respective factors and the average importance rating was calculated. Table 4.29 shows the results of this analysis. Not surprisingly, the quality of the product is most important to builders, followed by the economic attributes and the technical attributes.

Table 4.29 Importance Factor Score Summary

Attribute	Importance Rating	Avg. Factor Imp. Rating	Factor Name
Straightness	6.50	6.48	Quality
Strength	6.46		
Availability	6.13	6.02	Economic
Price Stability	6.02		
Overall Price	5.90		
Lack of Defects	6.05	5.53	Technical Performance
Longer Lengths	5.90		
Ease of Use	5.85		
Product Waste	5.79		
Tech./Eng. Support	5.57		
Appearance	5.28		
Energy Efficiency	5.15		
Red. Env. Impact	4.67		

5.0 STRUCTURAL PANEL RESULTS

The structural panel component of the 2001 survey expanded the scope of the original research to measure the usage patterns of builders related to structural panels. Builders were asked to estimate their usage of oriented strand board (OSB), plywood, and structural insulated panels (SIPs). Survey respondents were also asked to provide an evaluation of the importance they attach to a range of structural panel attributes when purchasing these products. Finally, survey respondents were asked to provide a comparison of plywood and OSB with respect to a variety of structural panel attributes.

5.1 STRUCTURAL PANEL END USE APPLICATIONS

There are three main end-use applications for structural panels in residential construction: exterior wall sheathing, sub-flooring, and roof sheathing. These three end use applications will be examined in aggregate as well as by region and firm size. Table 5.1 provides a summary of structural panel use for the three end-use applications.

OSB is the primary material used in exterior wall sheathing and roof sheathing while plywood maintains a slight edge over OSB in sub-floor applications, Table 5.1. Plywood also has a substantial share of the exterior wall and roof sheathing market segments. The strong demand for plywood in sub-floor is generally attributed to builders concerns about excessive thickness swell in OSB caused by standing water on sub-floors during the construction process. Further analysis of the survey data noted some differences in usage across region and firm size.

Table 5.1 2001 Product Usage in Specific Sheathing Applications

Structural Panel Application	Plywood	Oriented Strand Board	Structural Insulated Panel
Sub-Floor	51.4%	45.3%	0.8%
Exterior Wall Sheathing	24.4%	70.5%	2.2%
Roof Sheathing	37.8%	61.6%	0.2%

Regional Distribution

A regional breakdown of material use by end-use application is summarized in Table 5.2. This data suggests that SIP usage appears to be concentrated in the northeast. This is most likely due to the long history of usage in this region. Plywood usage is concentrated in the northwest and, to a lesser extent, the southeast. This trend can be largely attributed to the fact that the vast majority of plywood producers are located in these regions (APA 2001). Therefore it is not surprising that these two regions reported the lowest ratio of OSB usage. In contrast, the southwest region reported the highest use of OSB despite the lack of any significant production capacity in the region. This suggests that builders in this region may be more price sensitive than in other regions or that the dry climate in the southwest helps promote the use of OSB. Finally, plywood market shares were found to be highest in sub-floor applications in every region.

Table 5.2 2001 Structural Panel Usage by Region

Structural Panel	Northeast			Southeast		
Application	Plywood	OSB	SIP	Plywood	OSB	SIP
Sub-floor	45.2%	54.1%	4.8%	56.2%	39.2%	2.6%
Exterior Wall Sheathing	16.5%	76.7%	4.2%	17.8%	73.5%	2.6%
Roof Sheathing	33.0%	67.0%	0.0%	36.4%	60.8%	0.8%

Structural Panel	Northwest			Southwest		
Application	Plywood	OSB	SIP	Plywood	OSB	SIP
Sub-floor	57.9%	38.0%	2.0%	40.3%	55.8%	0.0%
Exterior Wall Sheathing	35.3%	61.5%	2.0%	18.1%	78.6%	0.3%
Roof Sheathing	48.5%	51.4%	0.2%	23.9%	76.2%	0.0%

Table 5.3 2001 Structural Panel Usage by Firm Size

Structural Panel	Small			Large			Top 100			
Application	Plywood	OSB	SIP	Plywood	OSB	SIP	Plywood	OSB	SIP	Other
Sub-floor	59.5%	39.6%	0.2%	46.0%	40.3%	3.3%	33.7%	66.3%	0.0%	0.0%
Exterior Wall Sheathing	29.2%	68.5%	1.5%	24.0%	69.9%	1.9%	6.3%	79.0%	0.7%	14.0%
Roof Sheathing	42.5%	57.4%	0.1%	42.1%	55.1%	0.6%	10.0%	90.0%	0.0%	0.0%

Firm Size

Reviewing structural panel usage across firm size suggests that smaller firms use more plywood in every end use application, particularly sub-flooring (Table 5.3). Since small firms make up close to 60 percent of the respondents in this survey, it is reasonable that they could be considered to be an important driver of the higher plywood usage in floor sheathing. In addition, small builders are the dominant builders in the repair and remodeling sector and this market tends to use more plywood. Top 100 builders, who tend to be more price sensitive, use a substantially higher proportion of OSB than either large builders or small builders.

Table 5.4 Structural Panel Usage Change in 2001

End Use Application	Structural Panel Material	Increased	Remained the Same	Decreased	We Have Never Used This Type of Panel
Sub-floor	Plywood	4.8%	60.5%	34.7%	7.2%
	Oriented Strand Board	44.6%	48.6%	6.8%	18.7%
	Structural Insulated Panel	29.6%	59.3%	11.1%	83.9%
Exterior Wall Sheathing	Plywood	3.8%	49.0%	47.1%	10.3%
	Oriented Strand Board	45.6%	50.9%	3.6%	7.6%
	Structural Insulated Panel	28.2%	56.4%	15.4%	77.5%
Roof Sheathing	Plywood	8.9%	53.8%	37.3%	11.7%
	Oriented Strand Board	40.7%	52.7%	6.7%	16.2%
	Structural Insulated Panel	21.4%	67.9%	10.7%	83.4%

Notes: Percentages for usage change exclude never used category

5.2 BUILDERS CHANGING USE OF STRUCTURAL PANELS

Table 5.4 summarizes builders changing use of structural panels over the past two years. Almost 84 percent of respondents indicated never using SIPs for sub-floors or roof sheathing while over three-quarters have not used SIPs for exterior walls. Considering only those respondents who indicated that they had used each material, percentages for the “increased”, “decreased”, and “remained the same” categories were calculated, Table 5.4.

Tables 5.4 and Figure 5.1 clearly show that builders have been decreasing their usage of plywood in favor of OSB in all three end-use applications. SIPs are seeing more increase than decrease but these numbers are put into context by the high proportion of builders who have not yet tried SIPs. Also, among those builders who have tried SIPs, approximately 10-15% reported a decrease in usage. This decrease was found to be among mostly larger builders with the increases reported most by smaller firms. Whereas less than ten percent of builders reported that their OSB use is declining, between 35-50% of builders reported that their use of plywood has declined. In contrast, 40-45% of builders reported that their use of OSB is increasing, less than ten percent report increasing their use of plywood (less than five percent in sub-floor and wall sheathing applications).

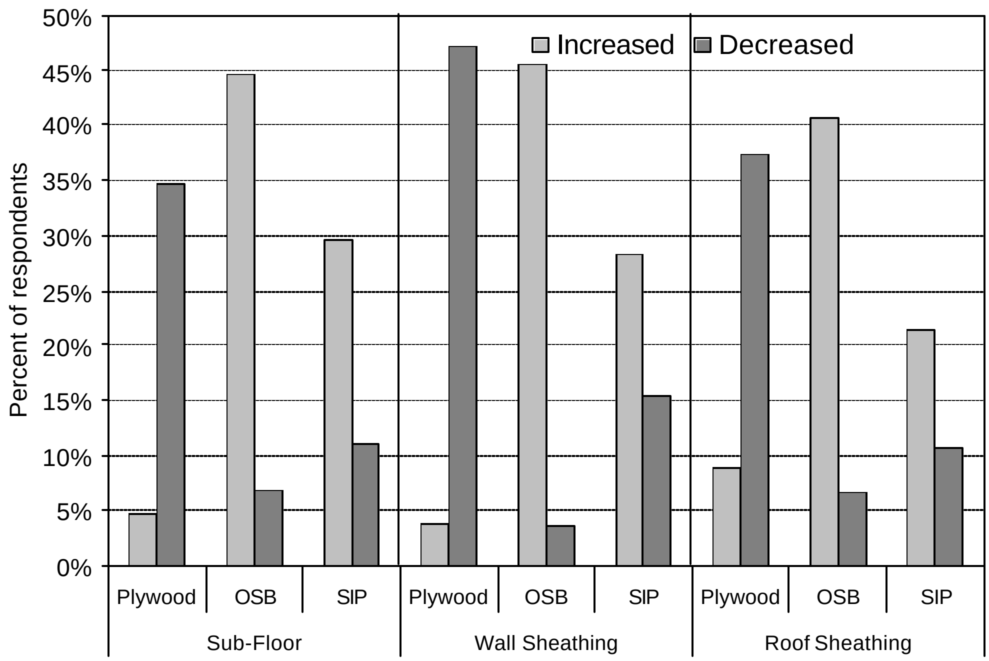

Figure 5.1 Structural Panel Usage Change over the Past Two Years

Both regional and firms size analyses with respect to increase and decreased usage were performed. Only a few noteworthy observations were found and for simplicity sake the respective charts are presented in Tables 5.5 and 5.6. The survey results illustrate only the increase and decrease of each structural product to highlight any trends. Generally the regional and firm size distinctions were not significantly different.

For plywood the increases and decreases by region support what was already seen in the usage trend analysis. The northeastern firms reported the largest decreases and the southeast reported correspondingly large increases. However, both of these regions had much higher decreases than increases. This was generally true for all applications while the highest increases for plywood were in roof sheathing.

Across all end-uses, regions and firm sizes, opposite trends were observed for plywood and OSB. For plywood, only about 5-10% of respondents indicated that they had increased their use of plywood whereas 30-50% indicated that their use of plywood had decreased. In contrast, the usage patterns for OSB were opposite those observed for plywood with 35-50% of respondents indicating that their use of OSB had increased and just 5-10% reporting decreased use. However, it is important to note that approximately 40-60% of respondents indicated that their use of plywood had not changed during the past two years.

Table 5.5 Structural Panel Change by Region

		Northeast		Southeast		Northwest		Southwest	
		Increased	Decreased	Increased	Decreased	Increased	Decreased	Increased	Decreased
Sub-floor	Plywood	3.0%	51.5%	10.3%	35.9%	1.8%	22.8%	6.1%	36.4%
	OSB	48.5%	5.4%	56.7%	0.0%	46.5%	9.3%	34.4%	9.4%
Exterior Wall Sheathing	Plywood	9.1%	56.3%	3.1%	46.9%	0.0%	46.6%	6.7%	40.0%
	OSB	57.6%	4.9%	38.9%	0.0%	50.9%	5.7%	41.7%	2.8%
Roof Sheathing	Plywood	15.2%	48.5%	13.9%	30.6%	3.6%	30.9%	6.9%	41.4%
	OSB	42.4%	3.0%	34.4%	6.3%	46.8%	12.8%	31.4%	2.9%

Table 5.6 Structural Panel Change by Firm Size

		Small		Large		Top 100	
		Increased	Decreased	Increased	Decreased	Increased	Decreased
Sub-floor	Plywood	4.2%	31.6%	6.3%	34.4%	8.3%	33.3%
	Oriented Strand Board	47.4%	7.7%	37.5%	12.5%	35.7%	0.0%
Exterior Wall Sheathing	Plywood	4.5%	46.1%	3.2%	38.7%	0.0%	37.5%
	Oriented Strand Board	44.7%	4.3%	39.4%	3.0%	35.7%	0.0%
Roof Sheathing	Plywood	9.7%	34.4%	10.0%	33.3%	0.0%	33.3%
	Oriented Strand Board	38.0%	7.6%	44.8%	6.9%	26.7%	0.0%

5.3 ATTRIBUTE IMPORTANCE SCORES FOR STRUCTURAL PANELS

Table 5.7 summarizes the results of the panel attribute importance ratings where survey respondents were asked to evaluate the importance of a range of structural panel attributes on their purchase decision. Survey participants were asked to rate the importance of nineteen product attributes using a Likert-like scale where a rating of 1 meant that the attribute was not important, a rating of 4 meant that the attribute was somewhat important and a rating of 7 indicated that the attribute was extremely important. The same attributes were considered for all three of the end-use applications (sub-floor, exterior wall sheathing and roof sheathing).

Resistance to delamination received the highest importance score in floor, wall and roof sheathing. Resistance to edge swelling and thickness swelling received high importance scores in floor sheathing although both received somewhat lower importance ratings in wall and roof applications. Non-slip surface, energy efficiency and resistance to fire ranked low across all end-use applications.

The attribute ratings were analyzed by firm size to determine if there were significant differences within this group. This analysis was done for floor, wall and roof applications and the pertinent tables can be found in Appendix III (Tables A.8-A.10). In general, the larger firms rated the quality attribute lower then the small firms. In addition, large firms (especially top 100 firms) rated price much higher than their smaller counterparts. Finally, product warranty seems to be less important for the Top 100 firms.

Table 5.7 Average Attribute Importance Ratings for Structural Panels

	Floor	Wall	Roof	Average
Resistance to Delamination	6.3	5.9	6.0	6.0
Resistance to Edge Swelling	6.2	5.7	5.9	5.9
Resistance to Thickness swelling	6.1	5.7	5.8	5.9
Quality	6.0	5.9	6.0	6.0
Deflection Performance (stiffness)	6.0	5.5	6.0	5.8
Resistance to Linear Expansion	5.9	5.7	5.8	5.8
Durability	5.7	5.6	5.7	5.7
Overall Price	5.7	5.8	5.8	5.8
Price Stability	5.6	5.7	5.6	5.6
Decay Resistance	5.5	5.4	5.4	5.4
Shear Strength	5.5	5.8	5.9	5.7
No voids in panel	5.5	4.7	5.4	5.2
Ease of nailing	5.2	5.1	5.3	5.2
Weight of panel	4.7	4.9	5.2	4.9
Ability to Withstand Natural Disasters	4.6	4.9	4.9	4.8
Resistance to Fire	4.5	4.6	4.7	4.6
Energy Efficiency	4.5	4.8	4.4	4.6
Non-slip Surface	4.4	3.5	5.2	4.4
Product Warranty	4.4	5.3	5.4	5.1

A regional analysis of the panel attribute importance ratings was also performed and the results can be found in Appendix III (Tables A5-A7). Some of the regional differences were expected and are somewhat intuitive. The southeastern firms, for example, generally rated decay resistance and resistance to disasters higher than other regions. In all regions, the three attributes with the highest importance rating were the same as presented in Table 5.7.

5.4 RESPONDENTS' PERCEPTION OF OSB VS. PLYWOOD PERFORMANCE

Survey respondents were then asked to compare the relative performance of OSB and plywood for each of the 19 panel attributes. Relative performance was evaluated using a Likert-like scale where a rating of 1 indicated that OSB was much better than plywood, a rating of 4 indicated that the performance of both panels was the same and a rating of 7 meant that plywood was much better than OSB.

Virtually all of the attributes studied resulted in values that were statistically different than 4 (the rating value where OSB and plywood were perceived to have similar performance). Table 5.8 shows that plywood is perceived as being superior to OSB for 4 of the 5 most important attributes as identified in Table 5.7. OSB, on the other hand is rated as being better than plywood with respect to its resistance to delamination and its price attributes. However, the data in Table 5.4 shows that OSB usage is increasing dramatically across every end-use application. These findings suggest that although builders rate performance and quality attributes as having the greatest impact on their purchase decision, price would still appear to be the primary factor influencing builders purchase decisions. Another factor in the purchase decision may be that while the performance of plywood is generally perceived to be superior to that of OSB, OSB performance is still considered to be adequate for residential construction applications.

Table 5.8 Average Comparison Rating between OSB and Plywood

Panel Attribute	Comparative Ratings	
Weight of panel*	4.8	
Shear Strength*	4.8	
Resistance to Thickness swelling*	4.7	
Resistance to Edge Swelling*	4.7	
Deflection Performance (stiffness)*	4.6	
Ease of nailing*	4.5	Plywood is perceived to be better than OSB
Durability*	4.5	
Ability to Withstand Natural Disasters*	4.4	
Resistance to Linear Expansion*	4.3	
Decay Resistance*	4.2	
Quality	4.2	
Product Warranty*	4.2	
Resistance to Fire*	4.1	
Energy Efficiency	4.0	
Non-slip Surface*	3.9	OSB is perceived to be better than plywood
Resistance to Delamination*	3.4	
Price Stability*	3.3	
Overall Price*	2.9	
No voids in panel	2.8	

* Significantly different than 4 p<.05

Comparison ratings based on a Likert-like scale where a rating of 1-indicated that OSB is perceived to be much better than Plywood while a rating of 7 - indicated that plywood is perceived to be much better than OSB.

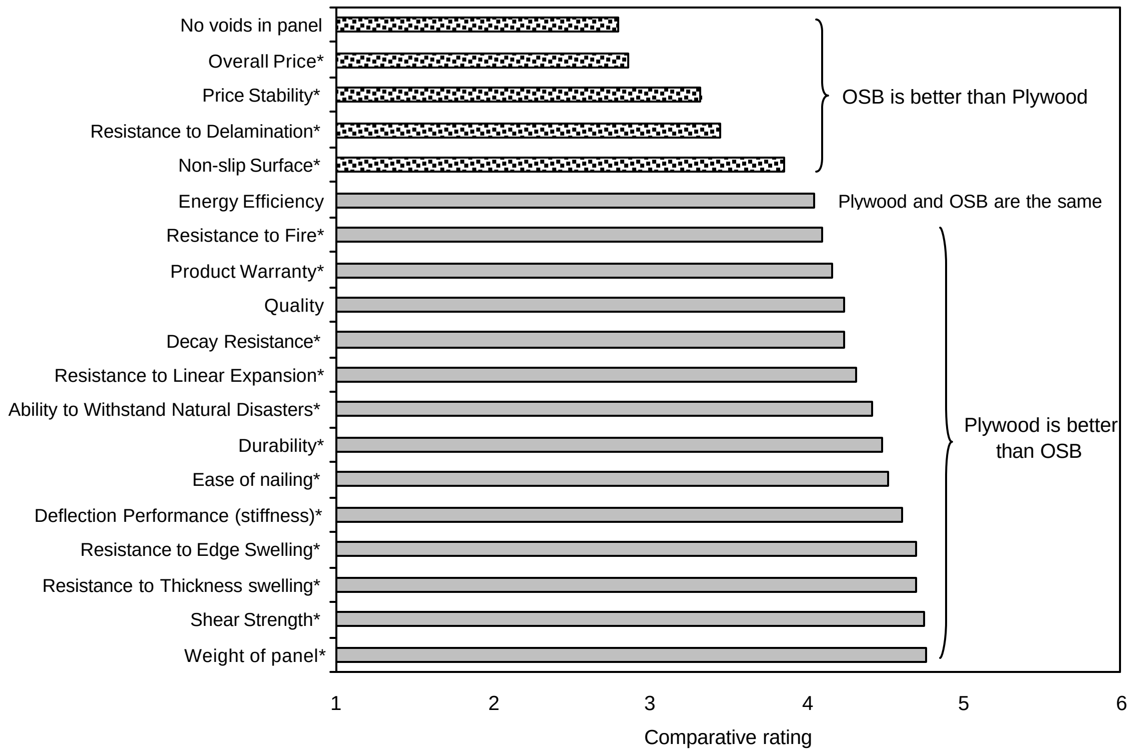

Figure 5.2 Mean Comparison Ratings for Plywood and OSB

(Comparison ratings based on a Likert-like scale where a rating of 1 indicated that OSB is perceived to be much better than plywood while a rating of 4 indicated that the two panels are considered to have similar performance and a rating of 7 indicated that plywood is perceived to be much better than OSB.)

5.5 STRUCTURAL PANEL FACTOR ANALYSIS

Similar to the softwood lumber data, the importance scores obtained in the panel section of the survey were aggregated using a factor analysis. The attribute ratings entered into the factor analysis were the average attribute importance scores across each end-use application.

Tables 5.9 and 5.10 summarize the results of the structural panel attribute factor analysis. Factor 1 was named "value" as it contained the price and quality attributes rated highest by builders as shown in Table 5.7. As previously discussed however, the price facet of this factor may play a larger role than the quality attributes in the buying decision.

Factor two was named "convenience" because it contains those attributes that were ranked lowest in importance by builders. These might be thought of as the end user satisfaction attributes that do not play a major role in the purchase decision of builders. It should also be noted that in the comparison of OSB to plywood (Figure 5.2), OSB is perceived as better than plywood on those attributes that loaded high on the value factor, with the singular exception of non-slip surface.

Table 5.9 Rotated Component Matrix for Structural Panel Attributes

Factor 1 Attributes	Value	
Res. Delamination	**.89340**	.27803
Res. Edge Swell	**.87324**	.34617
Res. Linear Exp	**.86131**	.34677
Res. Thickness Swell	**.86017**	.35676
Quality	**.80118**	.34978
Durability	**.77079**	.39859
Deflection	**.69031**	.43732
No Voids in panel	**.63248**	.48660
Price Stability	**.61482**	.47296
Strength	**.55266**	.35693
Overall Price	**.55627**	.40443
Factor 2 Attributes		**Convenience**
Res. Fire	.28413	**.84001**
Energy Efficiency	.28394	**.83819**
Natural Disaster	.31803	**.77815**
Weight of panel	.41425	**.73348**
Non-slip Surface	.43555	**.61582**

Table 5.10 Table Total Variance Explained by Factors (Structural Panel Ratings)

	Eigen Value	% Variation Explained	Cumulative Percent	Cronbach's Alpha
Factor 1(Value)	5.50	64.81	64.81	.9599
Factor 2(Convenience)	1.02	6.48	71.29	.9271

6.0 Conclusions

This survey represents the third of its kind and has compared substitution trends in 2001 to those of 1998 and 1995. The methodology in 2001 was identical to that of 1998 as was the survey design itself with the exception of the addition of the structural panels section. In general the trend of increasing material substitution in the residential construction market appears to be moderating.

Softwood lumber is the dominant material used in two of the four structural end uses analyzed: wall framing and headers. Floor framing continues to be dominated by wood I-joists while wood roof trusses continue to dominate the roof framing market. In 2001, builders indicated using softwood lumber in 72 percent of the header applications compared with 20 percent for LVL. However, over one-third of builders reported that their use of LVL, wood I-joists, Parallam™, Timberstrand™, Steel, and glulam and finger-jointed studs, had increased between 1998 and 2001. In addition, softwood lumber is expected to see an increasing threat from structural panel systems such as SIPs and ICFs. While neither of these systems represents a significant portion of the market presently, builders continue to increase usage of these systems, citing labor cost savings as a major factor for their use.

The attribute importance ratings and satisfaction ratings were measured for both structural framing and for structural panels (for sheathing applications). The product attributes rated most important for framing applications are virtually identical to those identified in 1998. The structural framing attribute satisfaction scores were also ranked in an almost identical order to that observed in the 1998 study. However, the survey data suggests that in 2001 builders were more satisfied with softwood lumber quality and performance as signified by the smaller gap between the importance and satisfaction for many of the lumber attributes included in the analysis. However, it is important to note that the largest gaps between satisfaction and importance scores occurred for those attributes rated as being the most important by respondents. The most important lumber attributes remained strength, straightness, availability and lack of defects.

Environmental performance remained the least important attribute during the purchase decision process. However, builders now perceive steel and concrete to be better for the environment relative to solid lumber, a significant change from the 1998 survey. The trend of green building programs and the increasing use of environmental performance in the marketing mix are expected to increase the importance of this attribute in the future. If this occurs, solid wood producers will be at a distinct disadvantage relative to virtually every other building product on the market.

The structural panel section in this survey followed the format of the framing section closely. Three main products, plywood, OSB, and SIPs, were analyzed for floor, wall and roof sheathing applications. OSB dominates in all end use applications except floor sheathing where plywood still enjoys a slight edge in market share. Overall however, many builders reported increasing their OSB use and a correspondingly high percentage of builders indicated decreasing their use of plywood. More respondents indicated increasing their SIP usage than decreasing. However, this product was not found to be increasing at a dramatic rate, as sometimes reported.

The most recent results in this series of surveys on material substitution in the residential construction industry suggest that the drivers of the substitution process appear to be price, price volatility, and value (defined as the ratio of quality per unit price). Of these factors, price and price volatility appear to be the most important drivers of the substitution process. Thus it should come as no surprise that as softwood lumber prices and price volatility have moderated, the market share of softwood lumber in residential construction has stabilized. However, substitute materials were again perceived by survey respondents as being more environmentally friendly than softwood lumber, continuing a trend established in the 1998 survey. This continuing misperception on the part of residential builders is troubling and, to the extent that the use of green building codes become more established in the future, it is imperative that the forest products industry develop a strategy to communicate the environmental benefits of using wood relative to non-wood substitute materials.

7.0 Limitations and Future Research

As mentioned in the beginning of this report, the number of bad addresses may have been abnormally high in the general builder sample frame of 2400 domestic builders. If this is indeed representative of a tumultuous market then those builders who changed their addresses or names were underrepresented.

In future surveys, a satisfaction rating scale in the structural panel section would be beneficial. This way the same gap analysis performed for the structural lumber section could be done for structural panels. In addition, this and previous surveys asked builders to indicate their rate of change in softwood lumber use. However, the 2001 version did not ask builders to indicate an increase, or decrease in their usage. This information would make possible a direct comparison of softwood lumber change in Figure 4.8.

With the addition of the structural panel section, this year's survey length may have become a burden. In the future, a shorter length could be obtained by separating the structural panel section and the softwood lumber section into two separate surveys. This will result in a better more usable data set for each section.

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APPENDIX I: SURVEY COVER LETTERS

1 November, 2001

Dear Residential Builder:

The residential construction sector is an important component of the US economy and consumes more than half of the softwood lumber and structural panels produced annually. However, new construction technologies and materials continue to work to increase their market share in residential construction and new construction materials are being introduced seemingly on a daily basis. CINTRAFOR has established its ***Material Substitution in Residential Construction*** survey to track changes in material use in structural applications, as well as builders' perceptions of different structural materials, over time. Previous ***Material Substitution*** surveys were conducted in 1996 and 1999. The results of this research are presented to the various US wood products associations to provide them with some insight into what is happening in the marketplace and how builders perceive their products relative to substitute products. While this research is not funded by the forest products industry, it is useful in helping them understand how better to meet the needs of their most important customers…residential contractors.

Your company is one of a small number of residential construction companies being asked to provide their opinions regarding a variety of wood and non-wood residential construction materials used in structural end-use applications. Your company was selected through a random sampling of residential construction companies located throughout the U.S. In order for the results to truly represent the opinions of the residential construction industry, it is important for each survey to be completed and returned. Therefore, the answers that your company provides will be of significant importance to the success and accuracy of this research project. To give you a better idea of how the information you provide will be used, I have included a summary of the results of the surveys that we conducted in 1996 and 1999.

I hope that you will take about 10 minutes of your valuable time to help with this project by completing the enclosed survey. I ask that the survey be completed by the person in your firm most involved in the purchase and use of structural building materials. If you are interested in receiving a summary of the current project results, please print your name and address on the last page of the survey. As a way of thanking you for participating in the survey, we will be conducting a prize drawing for five Porter Cable 10 Amp Quick Change Reciprocating saws. The 5 winners will be posted on our website (*www.cintrafor.org*) at the beginning of December, and each will hopefully receive their prize before Christmas.

You can be assured of complete confidentiality. All information that you provide will be held in the strictest confidence and will only be reported in combination with the information provided by other residential construction companies. Your participation is very important to the success and reliability of this project. If you have any questions or comments regarding this survey, please feel free to contact me. Thank you again for your assistance.

Sincerely,

Ivan L. Eastin
Associate Director and Associate Professor, CINTRAFOR
College of Forest Resources
University of Washington
Telephone: (206) 543-1918
Email: eastin@u.washington.edu

15 November, 2001

Dear Residential Builder:

We recently sent you a letter requesting your company's participation in a national survey being conducted by the University of Washington regarding your use and specification of structural building materials. If you have already returned your survey, please disregard this letter and thank you for your help! If not, I realize that you are likely to be busy and may not yet have found the time to complete your survey. However, I would like to strongly encourage you to do so.

The residential construction sector is an important component of the US economy and consumes more than half of the softwood lumber and structural panels produced annually. However, new construction technologies and materials continue to work to increase their market share in residential construction and new construction materials are being introduced seemingly on a daily basis. CINTRAFOR has established its ***Material Substitution in Residential Construction*** survey to track changes in material use in structural applications, as well as builders' perceptions of different structural materials, over time. Previous ***Material Substitution*** surveys were conducted in 1996 and 1999. The results of this research are presented to the various US wood products associations to provide them with some insight into what is happening in the marketplace and how builders perceive their products relative to substitute products. While this research is not funded by the forest products industry, it is useful in helping them understand how better to meet the needs of their most important customers…residential contractors.

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Ivan Eastin

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Email: eastin@u.washington.edu

7 January, 2002

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Sincerely,

Ivan L. Eastin
Associate Director and Associate Professor, CINTRAFOR
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University of Washington
Telephone: (206) 543-1918
Email: eastin@u.washington.edu

APPENDIX II: SURVEY INSTRUMENT

CINTRAFOR
U.S. Residential Builders Survey
of Structural Lumber & Deck Materials

This survey inquires about your company's use of wood and non-wood products in structural end-use applications (e.g., wall studs, floor joists, roof joists/trusses and sheathing). It is designed to gather information that will help in understanding material use trends, and the factors that are influencing material substitution, within the residential construction industry.

UNIVERSITY OF WASHINGTON
SEATTLE, WA

Section I. Use of Building Materials in Structural Framing Applications

1) Approximately what percentage of your company's 2001 sales revenue was generated from the following activities?

Single Family Cons truction

_______%

Multi-family Construction

_______%

Home Improvement /Remodeling

_______%

Patio/Deck Construction

_______%

Nonresidential Construction

_______%

Other (please specify below)

_______%

____

Total = 100%

2) Please describe the area that your company conducts most of its business? (*please only check on box*)

- ❑ URBAN/SUBURBAN: A city or group of contiguous communities with a population greater than 50,000.
- ❑ SMALL TOWN: A city or town that is generally isolated from a major urban area with a population less than 50,000.
- ❑ RURAL: Low density population s cattered over a wide area

3) In which state does your company generate its greatest amount of revenue?

____

4) Considering the past two years, please indicate how your company's use of each structural product listed below has changed *relative to your use of softwood lumber*. Also indicate the year that your company first used each of the products (*please provide a response for each product listed*).

	Over The Past Two Years, My Company's Use of This Product Relative to Softwood Lumber Has…..			**My Company**	
Structural Product	**Increased**	**Remained the Same**	**Decreased**	**Has Never Used This Product**	**Year First Used (if applicable)**
Finger-jointed Studs	❑	❑	❑	❑	________
Steel Framing	❑	❑	❑	❑	________
Fiber/Plastic Lumber Composite	❑	❑	❑	❑	________
Reinforced Concrete	❑	❑	❑	❑	________
Structural Insulated Panels	❑	❑	❑	❑	________
Panelized Wall Systems	❑	❑	❑	❑	________
Wood I-joists	❑	❑	❑	❑	________
Wood/Steel joists	❑	❑	❑	❑	________
Laminated Veneer Lumber (LVL)	❑	❑	❑	❑	________
TimberStrand™ Lumber	❑	❑	❑	❑	________
Parallam™ Beams and Headers	❑	❑	❑	❑	________
Glue Laminated Beams (Glulam)	❑	❑	❑	❑	________

5) Please indicate how the volume of softwood lumber used as a structural material in your company changed over the past two years? (*Please circle one number on the scale*)

THE AMOUNT OF SW LUMBER USED BY MY COMPANY HAS NOT CHANGED AT ALL			**THE AMOUNT OF SW LUMBER USED BY MY COMPANY HAS CHANGED MODERATELY**			**THE AMOUNT OF SW LUMBER USED BY MY COMPANY HAS CHANGED SIGNIFICANTLY**
1	2	3	4	5	6	7

6) For each of the end-uses listed below, please estimate the percentage (on a volume basis) of each material used during the past year by your company. (*Write the approximate PERCENTAGE in the appropriate category for each building application*)

	¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾ **Structural Materials** ¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾ ¾							
End-Use Application	**Softwood Lumber**	**Wood Truss**	**Finger-Jointed Stud**	**Wood I-joist**	**Laminated Veneer Lumber**	**Steel Framing**	**Other (specify)** ________	**Total**
Floor Joists								100%
Load Bearing Walls								100%
Non-Load Bearing Walls								100%
Headers								100%
Roofs								100%

7) In your opinion, how do each of the following materials compare to softwood lumber with respect to their impact on the environment? (*Please rate each product on a scale of 1 = LESS FAVORABLE to 7 = MORE FAVORABLE number*).

PRODUCTS	**LESS FAVORABLE**			**THE SAME**			**MORE FAVORABLE**
Steel Framing	1	2	3	4	5	6	7
Wood-Plastic Composite Lumber (Trex)	1	2	3	4	5	6	7
Finger-Jointed Studs	1	2	3	4	5	6	7
Reinforced Concrete	1	2	3	4	5	6	7
Concrete Blocks	1	2	3	4	5	6	7
Structural Insulated Panels	1	2	3	4	5	6	7
Wood I-joists	1	2	3	4	5	6	7
Wood/Steel Trusses	1	2	3	4	5	6	7
Laminated Veneer Lumber (LVL)	1	2	3	4	5	6	7
Parallam™ Beams and Headers	1	2	3	4	5	6	7
TimberStrand™ Lumber	1	2	3	4	5	6	7
Glue Laminated Beams (Glulam)	1	2	3	4	5	6	7

8A) When purchasing structural framing materials (BOTH **WOOD AND NON-WOOD**), how important are the following product attributes? (*Please rate each attribute on a scale of 1 = NOT IMPORTANT to 7 = VERY IMPORTANT*)

PRODUCT ATTRIBUTES	NOT IMPORTANT AT ALL			NEUTRAL			EXTREMELY IMPORTANT
Strength	1	2	3	4	5	6	7
Straightness	1	2	3	4	5	6	7
Reduced Environmental Impact	1	2	3	4	5	6	7
Availability	1	2	3	4	5	6	7
Price Stability	1	2	3	4	5	6	7
Overall Price	1	2	3	4	5	6	7
Availability of Longer Lengths	1	2	3	4	5	6	7
Energy Efficiency	1	2	3	4	5	6	7
Ease of Use	1	2	3	4	5	6	7
Technical/Engineering Support	1	2	3	4	5	6	7
Lack of Defects	1	2	3	4	5	6	7
Appearance	1	2	3	4	5	6	7
Little Product Waste	1	2	3	4	5	6	7
Other (please specify) ______________	1	2	3	4	5	6	7

8B) Using the product attributes listed above (Question 8A), please list the three *most important attributes* that you are concerned with when purchasing structural lumber:

Most Important Product Attribute ___________________________

Second Most Important Product Attribute ___________________________

Third Most Important Product Attribute ___________________________

9) When purchasing **SOLID SOFTWOOD LUMBER**, how satisfied are you with the following attributes. (*Please rate each statement on a scale of 1 = NOT SATISFIED to 7 = VERY SATISFIED*)

SOLID LUMBER PRODUCT ATTRIBUTES	NOT SATISFIED AT ALL			NEITHER SATISFIED NOR UNSATISFIED			EXTREMELY SATISFIED
Strength	1	2	3	4	5	6	7
Straightness	1	2	3	4	5	6	7
Reduced Environmental Impact	1	2	3	4	5	6	7
Availability	1	2	3	4	5	6	7
Price Stability	1	2	3	4	5	6	7
Overall Price	1	2	3	4	5	6	7
Availability of Longer Lengths	1	2	3	4	5	6	7
Energy Efficiency	1	2	3	4	5	6	7
Ease of Use	1	2	3	4	5	6	7
Technical/Engineering Support	1	2	3	4	5	6	7
Lack of Defects	1	2	3	4	5	6	7
Appearance	1	2	3	4	5	6	7
Little Product Waste	1	2	3	4	5	6	7
Other (please specify) _____________	1	2	3	4	5	6	7

Section II. Use of Decking Materials

10) Approximately what percentage of spec and custom family homes that your company builds have decks?

% of spec homes built with deck _______% % of custom homes built with deck _______%

11) What is the *average size* of decks that your company builds?

Average size of spec home decks ________sq. ft. Average size of custom home decks ________ sq. ft.

12) What is the *average cost* of decks that your company builds?

Average cost of spec home decks $__________ Average cost of custom home decks $__________

13) Please indicate how your company's use of each deck material has changed over the past two years. Also indicate the year that your company first used each of the products. If your company has never used the product, then simply check the *Has Never Used* box. Also, please indicate the percentage of decks that were built with each material in the past year.

	Over Past Two Years, My Company's Use of Deck/Porch Material Has…..			**My Company Has Never**	**Percent of Decks**	**Year First Used**
Deck/Porch Structural Material	**Increased**	**Remained the Same**	**Decreased**	**Used This Product**	**Built With Material**	**(if applicable)**
Solid Cedar	❑	❑	❑	❑	____%	_____
Solid Redwood	❑	❑	❑	❑	____%	_____
Pressure Treated Wood	❑	❑	❑	❑	____%	_____
Untreated Wood (excluding cedar/redwood)	❑	❑	❑	❑	____%	_____
Wood-Plastic Composite Lumber (e.g., Trex™)	❑	❑	❑	❑	____%	_____
Plastic Lumber (100% plastic)	❑	❑	❑	❑	____%	_____
Concrete (excluding footing/piers)	❑	❑	❑	❑	____%	_____
Imported Hardwood Lumber	❑	❑	❑	❑	____%	_____

Total=100%

14) How important are the following attributes when building deck surfaces and accessories (stair treads, benches, railings)?

Material Attributes	NOT IMPORTANT AT ALL			NEUTRAL			EXTREMELY IMPORTANT
Long Life	1	2	3	4	5	6	7
Beautiful & Aesthetically Pleasing	1	2	3	4	5	6	7
Low Material Costs	1	2	3	4	5	6	7
Easy to Maintain	1	2	3	4	5	6	7
High Workability	1	2	3	4	5	6	7
Consistent Material Quality	1	2	3	4	5	6	7
Availability	1	2	3	4	5	6	7
Price Stability	1	2	3	4	5	6	7
High Strength Properties	1	2	3	4	5	6	7
Durability	1	2	3	4	5	6	7
Little Product Waste	1	2	3	4	5	6	7

Section III: Use of Structural Panels in Sheathing Applications

15) For each of the building applications listed below, please estimate the percentage of each type of structural panel material used during the past year by your company. (*Write the approximate PERCENTAGE in the appropriate category for each building application)*

Structural Panel Application:	Plywood	Oriented Strand Board	Structural Insulated Panel	Other (Specify)	Total
Floor Sheathing					100%
Exterior Wall Sheathing					100%
Roof Sheathing					100%

16) Please indicate how your use of each structural panel has changed over the past two years.

End-Use Application:	Structural Panel Material	Increased	Remained the Same	Decreased	We Have Never Used This Type of Panel
Floor Sheathing	Plywood	❑	❑	❑	❑
	Oriented Strand Board	❑	❑	❑	❑
	Structural Insulated Panel	❑	❑	❑	❑
Exterior Wall Sheathing	Plywood	❑	❑	❑	❑
	Oriented Strand Board	❑	❑	❑	❑
	Structural Insulated Panel	❑	❑	❑	❑
Roof Sheathing	Plywood	❑	❑	❑	❑
	Oriented Strand Board	❑	❑	❑	❑
	Structural Insulated Panel	❑	❑	❑	❑

17**)** When purchasing structural panels, how important are the following product attributes for sub-flooring applications? (*Please rate each attribute on a scale of 1 = NOT IMPORTANT to 7 = EXTREMELY IMPORTANT by circling the appropriate number and do the same for 17B – sub-roofing applications and 17C - wall sheathing*)

17A.) Floor Sheathing	**NOT IMPORTANT AT ALL**			**SOMEWHAT IMPORTANT**			**EXTREMELY IMPORTANT**
Shear Strength	1	2	3	4	5	6	7
Price Stability	1	2	3	4	5	6	7
Overall Price	1	2	3	4	5	6	7
Deflection Performance (Stiffness)	1	2	3	4	5	6	7
Energy Efficiency	1	2	3	4	5	6	7
Durability	1	2	3	4	5	6	7
Non-slip Surface	1	2	3	4	5	6	7
No voids in panel	1	2	3	4	5	6	7
Ease of nailing	1	2	3	4	5	6	7
Product Warranty	1	2	3	4	5	6	7
Weight of panel	1	2	3	4	5	6	7
Quality	1	2	3	4	5	6	7
Decay Resistance	1	2	3	4	5	6	7
Resistance to Thickness Swelling	1	2	3	4	5	6	7
Resistance to Delamination	1	2	3	4	5	6	7
Resistance to Edge Swelling	1	2	3	4	5	6	7
Resistance to Linear Expansion	1	2	3	4	5	6	7
Resistance to Fire	1	2	3	4	5	6	7
Ability to Withstand Natural Disasters	1	2	3	4	5	6	7

17B) Wall Sheathing	NOT IMPORTANT AT ALL		SOMEWHAT IMPORTANT				EXTREMELY IMPORTANT
Shear Strength	1	2	3	4	5	6	7
Price Stability	1	2	3	4	5	6	7
Overall Price	1	2	3	4	5	6	7
Deflection Performance (Stiffness)	1	2	3	4	5	6	7
Energy Efficiency	1	2	3	4	5	6	7
Durability	1	2	3	4	5	6	7
Non-slip Surface	1	2	3	4	5	6	7
No voids in panel	1	2	3	4	5	6	7
Ease of nailing	1	2	3	4	5	6	7
Product Warranty	1	2	3	4	5	6	7
Weight of panel	1	2	3	4	5	6	7
Quality	1	2	3	4	5	6	7
Decay Resistance	1	2	3	4	5	6	7
Resistance to Thickness Swelling	1	2	3	4	5	6	7
Resistance to Delamination	1	2	3	4	5	6	7
Resistance to Edge Swelling	1	2	3	4	5	6	7
Resistance to Linear Expansion	1	2	3	4	5	6	7
Resistance to Fire	1	2	3	4	5	6	7
Ability to Withstand Natural Disasters	1	2	3	4	5	6	7

17C) Roof Sheathing	NOT IMPORTANT AT ALL			SOMEWHAT IMPORTANT			EXTREMELY IMPORTANT
Shear Strength	1	2	3	4	5	6	7
Price Stability	1	2	3	4	5	6	7
Overall Price	1	2	3	4	5	6	7
Deflection Performance (Stiffness)	1	2	3	4	5	6	7
Energy Efficiency	1	2	3	4	5	6	7
Durability	1	2	3	4	5	6	7
Non-slip Surface	1	2	3	4	5	6	7
No voids in panel	1	2	3	4	5	6	7
Ease of nailing	1	2	3	4	5	6	7
Product Warranty	1	2	3	4	5	6	7
Weight of panel	1	2	3	4	5	6	7
Quality	1	2	3	4	5	6	7
Decay Resistance	1	2	3	4	5	6	7
Resistance to Thickness Swelling	1	2	3	4	5	6	7
Resistance to Delamination	1	2	3	4	5	6	7
Resistance to Edge Swelling	1	2	3	4	5	6	7
Resistance to Linear Expansion	1	2	3	4	5	6	7
Resistance to Fire	1	2	3	4	5	6	7
Ability to Withstand Natural Disasters	1	2	3	4	5	6	7

18) Using the product attributes listed above, please indicate what you consider to be the three *most important attributes* for structural panels being used in each end-use application:

	Sub-flooring	***Sub-roofing***	***Sheathing***
Most Important Product Attribute	____________________	____________________	________________
Second Most Important Product Attribute	__________________	________________	________________
Third Most Important Product Attribute	____________________	___________________	________________

19) Please indicate how you feel plywood and OSB compare to each other for each of the attributes listed below. *(For example, If you believe plywood is much easier to nail than OSB, you might circle a 6 or 7 for Ease of Nailing).*

Material Attribute	OSB is much better than Plywood			OSB and Plywood are the Same			Plywood is much better than OSB
Shear Strength	1	2	3	4	5	6	7
Price Stability	1	2	3	4	5	6	7
Overall Price	1	2	3	4	5	6	7
Deflection Performance (Stiffness)	1	2	3	4	5	6	7
Energy Efficiency	1	2	3	4	5	6	7
Durability	1	2	3	4	5	6	7
Non-slip Surface	1	2	3	4	5	6	7
No voids in panel	1	2	3	4	5	6	7
Ease of nailing	1	2	3	4	5	6	7
Product Warranty	1	2	3	4	5	6	7
Weight of panel	1	2	3	4	5	6	7
Quality	1	2	3	4	5	6	7
Decay Resistance	1	2	3	4	5	6	7
Resistance to Thickness Swelling	1	2	3	4	5	6	7
Resistance to Delamination	1	2	3	4	5	6	7
Resistance to Edge Swelling	1	2	3	4	5	6	7
Ability to Withstand Natural Disasters	1	2	3	4	5	6	7
Resistance to Fire	1	2	3	4	5	6	7
Ability to Withstand Natural Disasters	1	2	3	4	5	6	7
Resistance to Linear Expansion	1	2	3	4	5	6	7

Finally, we would like some information about you and your company for statistical purposes.

★ ***ALL SURVEY INFORMATION IS KEPT STRICTLY CONFIDENTIAL*** ★

All identifying information (personal names, company names, and locations) will be removed from the data

20) What is your position/title?

____

21) How long have you been with the company?

________ years

22) Approximately what were your firm's total sales in 2001. *(please check only one)*

- ❑ 0 - $500,000
- ❑ $500,001 to $1,000,000
- ❑ $1,000,001 to $2,500,000
- ❑ $2,500,001 to $5,000,000
- ❑ $5,000,001 to $10,000,000
- ❑ $10,000,001 to $20,000,000
- ❑ Over $20,000,000

23) Approximately how many of the following types of structures did your company complete in 2001?

________ single family homes

________ multi-family homes

________ nonresidential structures

24) If your company built single family homes in 2001, how many of these homes were of the following type?

________ number of spec home

________ number of custom homes

❑ Did not build any single family homes in 2001

25) On average, what percentage of your company's framing costs is subcontracted to other companies?

_______________ percent

26) Approximately how many years has your company been involved in the residential construction industry?
_______ years

Thank you for your time and cooperation in completing this survey. Please return the survey in the pre-addressed stamped envelope provided. If you would like a summary of the final results, please check the box below.

Name: ____

Address: ____

____

____

Phone: ____

❑ Please send me a copy of the survey results.

APPENDIX III: ADDITIONAL TABLES & FIGURES

Table A.1 Softwood Usage Change (1998-2001) by Region and Firm Size

Region	**Scale Rating**
Northeast	3.4
Southeast	3.4
Northwest	3.4
Southwest	3.6
Firm Size	
Small Firms	3.2
Large Firms	3.6
Top 100	3.5

Table A.2 Rotated Component Matrix for Softwood Lumber Satisfaction Ratings

Factor 1 Attributes	**Quality**			
Lack of Defects	**.88049**	.12646	.20798	.056233
Straightness	**.85612**	.13872	.058358	.22229
Appearance	**.76871**	.21691	.20502	.15555
Strength	**.53702**	.27854	.23240	.12169
Product Waste	**.44122**	.29222	.38648	.30690
Factor 2 Attributes		**Economic**		
Availability	.018744	.79861	.17766	.23497
Price Stability	.34997	.79052	.038210	.044357
Overall Price	.33841	.77535	.13509	.056018
Factor 3 Attributes			**Convenience**	
Tech./Eng. Support	.22394	-.00645703	.83789	-.0241896
Ease of Use	.068910	.42200	.58412	.29202
Longer Lengths	.39323	.28471	.52395	.10419
Factor 4 Attributes				**Environmental Performance**
Energy Efficiency	.19688	.037280	.38123	.73850
Red. Env. Impact	.19190	.22150	-.0984583	.84639

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.

a Rotation converged in 6 iterations.

Table A.3 Total Variance Explained by Factors (Softwood Lumber Satisfaction Ratings)

	Eigen value	% Variation Explained	Cumulative Percent	Cronbach's Alpha
Factor 1	5.50	42.29	42.29	.8553
Factor 2	1.32	10.16	52.45	.8026
Factor 3	1.10	8.49	60.94	.6217
Factor 4	1.02	7.86	68.80	.6340

Table A.4 Satisfaction Factor Score Summary for Softwood Lumber

Attribute	Satisfaction Rating	Avg. Factor Sat. Rating	Factor Name
Price Stability	4.36		
Overall Price	4.70	4.81	Economic
Availability	5.39		
Tech./Eng. Support	4.54		
Ease of Use	5.37	4.81	Convenience
Longer Lengths	4.51		
Energy Efficiency	4.46	4.35	Environmental Performance
Red. Env. Impact	4.24		
Lack of Defects	3.51		
Straightness	3.64		
Appearance	4.01	4.09	Quality
Strength	4.86		
Product Waste	4.43		

Table A.5 Floor Panel Importance Ratings by Region

	Northeast	Southeast	Northwest	Southwest
Resistance to Delamination	6.5	6.5	6.1	6.2
Resistance to Edge Swelling	6.5	6.5	6.0	6.2
Resistance to Thickness swelling	6.5	6.3	5.9	6.0
Quality	6.2	6.3	5.8	6.0
Resistance to Linear Expansion	6.1	6.3	5.7	5.9
Overall Price	6.0	6.0	5.4	5.6
Durability	6.0	5.9	5.5	5.6
Price Stability	6.0	5.8	5.2	5.7
Deflection Performance (stiffness)	5.9	6.3	6.0	5.8
Decay Resistance	5.8	5.9	5.3	5.3
Shear Strength	5.7	5.9	5.5	5.1
Product Warranty	5.7	5.7	5.1	5.4
No voids in panel	5.7	5.5	5.4	5.3
Ease of nailing	5.3	5.5	5.1	5.2
Weight of panel	4.9	4.8	4.6	4.7
Resistance to Fire	4.6	5.1	4.1	4.6
Non-slip Surface	4.6	4.5	4.4	4.3
Energy Efficiency	4.5	4.7	4.3	4.3
Ability to Withstand Natural Disasters	4.4	5.1	4.5	4.5

Table A.6 Wall Panel Importance Ratings by Region

	Northeast	Southeast	Northwest	Southwest
Resistance to Delamination	6.2	6.1	5.6	6.0
Quality	6.1	6.1	5.7	5.9
Overall Price	6.0	6.2	5.5	5.8
Price Stability	6.0	5.9	5.3	5.8
Resistance to Edge Swelling	5.9	6.0	5.5	5.9
Resistance to Thickness swelling	5.9	5.9	5.4	5.8
Resistance to Linear Expansion	5.8	5.9	5.4	5.7
Durability	5.8	5.8	5.3	5.7
Decay Resistance	5.8	5.8	5.0	5.5
Product Warranty	5.6	5.6	5.0	5.3
Shear Strength	5.5	5.9	5.9	5.9
Deflection Performance (stiffness)	5.3	5.9	5.5	5.4
Ease of nailing	5.1	5.5	5.0	5.2
Weight of panel	5.0	5.0	4.9	4.9
Energy Efficiency	5.0	5.2	4.4	4.7
No voids in panel	4.9	4.8	4.5	4.8
Ability to Withstand Natural Disasters	4.8	5.3	4.6	5.0
Resistance to Fire	4.6	4.9	4.2	4.9
Non-slip Surface	3.7	3.5	3.3	3.6

Table A.7 Roof Panel Importance Ratings by Region

	Northeast	Southeast	Northwest	Southwest
Quality	6.4	6.2	5.8	6.0
Resistance to Delamination	6.4	6.1	5.7	6.0
Deflection Performance (stiffness)	6.2	6.2	5.9	5.9
Resistance to Edge Swelling	6.2	6.0	5.6	6.0
Resistance to Thickness swelling	6.2	5.9	5.5	5.9
Shear Strength	6.1	5.9	5.8	5.9
Overall Price	6.1	6.1	5.5	5.8
Resistance to Linear Expansion	6.1	5.9	5.5	5.9
Price Stability	6.1	5.9	5.2	5.8
Durability	6.0	6.0	5.4	5.9
Product Warranty	6.0	5.7	5.0	5.5
Decay Resistance	5.7	5.9	5.0	5.2
Non-slip Surface	5.7	5.1	5.0	5.3
No voids in panel	5.6	5.5	5.2	5.6
Ease of nailing	5.4	5.6	5.0	5.3
Weight of panel	5.4	5.5	5.0	5.2
Ability to Withstand Natural Disasters	5.1	5.4	4.8	5.1
Resistance to Fire	4.7	5.1	4.3	4.9
Energy Efficiency	4.3	5.0	4.1	4.6

Table A.8 Floor Sheathing Attribute Importance Scores by Firm Size

	Small	Large	Top 100
Resistance to Delamination	6.37	6.09	6.13
Resistance to Edge Swelling	6.32	5.97	6.14
Resistance to Thickness swelling	6.23	5.97	6.13
Quality	6.13	5.66	6.20
Deflection Performance (stiffness)	6.04	5.83	6.00
Resistance to Linear Expansion	6.02	5.80	5.80
Durability	5.89	5.46	5.67
Shear Strength	5.63	5.60	5.64
Decay Resistance	5.59	5.37	5.67
Overall Price	5.56	5.54	6.27
Price Stability	5.54	5.43	6.20
No voids in panel	5.45	5.49	5.60
Product Warranty	5.37	5.34	5.80
Ease of nailing	5.18	5.11	5.47
Ability to Withstand Natural Disasters	4.77	4.20	4.87
Weight of panel	4.67	4.54	4.60
Resistance to Fire	4.55	4.43	4.73
Non-slip Surface	4.51	4.29	4.00
Energy Efficiency	4.51	4.54	4.40

Table A.9 Wall Attribute Ratings by Firm Size

	Small	Large	Top 100
Resistance to Delamination	6.00	5.61	5.87
Quality	5.93	5.81	6.07
Resistance to Edge Swelling	5.86	5.31	5.67
Shear Strength	5.80	5.75	5.93
Resistance to Thickness swelling	5.79	5.36	5.60
Overall Price	5.72	5.75	6.33
Resistance to Linear Expansion	5.69	5.31	5.60
Durability	5.66	5.36	5.67
Price Stability	5.62	5.56	6.27
Decay Resistance	5.42	5.44	5.57
Deflection Performance (stiffness)	5.41	5.50	5.80
Product Warranty	5.24	5.22	5.53
Ease of nailing	5.09	4.92	5.40
Ability to Withstand Natural Disasters	4.96	4.43	5.33
Weight of panel	4.89	4.81	4.60
No voids in panel	4.83	4.06	4.80
Energy Efficiency	4.73	4.89	4.93
Resistance to Fire	4.60	4.33	4.79
Non-slip Surface	3.49	3.08	3.27

Table A.10 Roof Attribute Ratings by Firm Size

	Small	Large	Top 100
Resistance to Delamination	6.19	5.50	6.00
Quality	6.10	5.89	6.07
Deflection Performance (stiffness)	6.01	5.92	5.73
Resistance to Edge Swelling	5.99	5.42	5.93
Resistance to Thickness swelling	5.92	5.33	6.00
Durability	5.88	5.47	5.53
Resistance to Linear Expansion	5.88	5.50	5.87
Shear Strength	5.84	6.03	5.87
Overall Price	5.70	5.75	6.20
Price Stability	5.60	5.61	6.20
No voids in panel	5.48	5.11	5.60
Product Warranty	5.41	5.36	5.53
Decay Resistance	5.39	5.28	5.67
Non-slip Surface	5.32	4.78	4.87
Ease of nailing	5.30	5.08	5.47
Weight of panel	5.23	5.19	4.73
Ability to Withstand Natural Disasters	4.97	4.69	5.47
Resistance to Fire	4.64	4.69	5.07
Energy Efficiency	4.55	4.17	4.64

Table A.11 Percent of Firms Reporting Usage of Each Product by Region

		Northeast	Southeast	Northwest	Southwest
Floor Sheathing	Plywood[1]	86.8%	100.0%	95.0%	86.8%
	Oriented Strand Board	92.5%	81.1%	70.5%	82.1%
	Structural Insulated Panel	18.9%	11.8%	10.7%	25.0%
Exterior Wall Sheathing	Plywood	84.2%	86.5%	96.7%	85.7%
	Oriented Strand Board	100.0%	94.7%	88.3%	92.3%
	Structural Insulated Panel	26.3%	20.0%	22.4%	21.6%
Roof Sheathing	Plywood[2]	82.5%	92.3%	94.8%	78.4%
	Oriented Strand Board	84.6%	91.4%	77.0%	89.7%
	Structural Insulated Panel	18.9%	18.2%	15.8%	16.2%

(1) ANOVA p=.064 across regions. Southeast vs. Northeast p=.165

(2) ANOVA p=.055 across regions. Northwest vs. Southwest p=.098

Table A.12 Percent of Firms Reporting Usage of Each Product by Firm Size

		Small	Large	Top 100
Floor Sheathing	Plywood[1]	96.0%	88.9%	92.3%
	Oriented Strand Board	77.2%	88.9%	93.3%
	Structural Insulated Panel	14.0%	27.3%	7.7%
Exterior Wall Sheathing	Plywood[2]	94.7%	88.6%	61.5%
	Oriented Strand Board	93.1%	91.7%	93.3%
	Structural Insulated Panel	20.0%	26.5%	15.4%
Roof Sheathing	Plywood	94.9%	85.7%	64.3%
	Oriented Strand Board	80.6%	85.3%	100.0%
	Structural Insulated Panel	14.1%	21.2%	7.7%

(1) ANOVA p=.039 across firm size. Small vs. Top100 p=.038

(2) ANOVA p=.005 across firm size. Small vs. Top100 p=.009

Table A.13 Average Comparison Rating between OSB and Plywood by Region

	Northeast	Southeast	Northwest	Southwest
Shear Strength	4.51	4.95	5.08	4.21
Price Stability	3.53	3.78	3.52	3.26
Overall Price	2.93	3.15	3.18	2.92
Deflection Performance (stiffness)	4.98	5.10	4.76	4.49
Energy Efficiency	4.07	4.48	4.53	3.92
Durability	4.42	4.93	4.94	4.00
Non-slip Surface	3.93	4.05	4.16	3.97
No voids in panel	2.74	3.20	2.92	3.03
Ease of nailing	4.60	4.52	4.85	4.62
Product Warranty	4.12	4.65	4.61	4.26
Weight of panel	4.88	4.95	5.08	4.69
Quality	4.19	4.65	4.48	4.03
Decay Resistance	4.23	4.48	4.79	4.13
Resistance to Thickness swelling	4.77	4.90	5.21	4.44
Resistance to Delamination	3.02	3.85	4.03	3.44
Resistance to Edge Swelling	4.77	4.75	5.29	4.31
Ability to Withstand Natural Disasters	4.51	4.70	4.81	4.33
Resistance to Fire	4.28	4.53	4.35	4.03
Resistance to Linear Expansion	4.37	4.55	4.68	4.26

Comparison ratings based on a Likert-like scale where a rating of 1-indicated that OSB is perceived to be much better than Plywood while a rating of 7- indicated that plywood is perceived to be much better than OSB.

Table A.14 Average Comparison Rating between OSB and Plywood by Firm Size

	Small	Large	Top 100
Shear Strength	4.91	4.63	4.21
Price Stability	3.27	3.39	3.47
Overall Price	2.77	3.12	2.40
Deflection Performance (stiffness)	4.62	4.44	4.46
Energy Efficiency	4.11	4.09	3.93
Durability	4.73	4.15	4.00
Non-slip Surface	3.88	4.06	3.67
No voids in panel	2.88	2.82	2.47
Ease of nailing	4.67	4.56	3.93
Product Warranty	4.28	4.32	3.54
Weight of panel	4.85	4.68	4.50
Quality	4.44	4.00	3.87
Decay Resistance	4.33	4.18	4.07
Resistance to Thickness swelling	4.76	4.85	4.14
Resistance to Delamination	3.52	3.41	2.93
Resistance to Edge Swelling	4.73	4.94	4.14
Ability to Withstand Natural Disasters	4.54	4.29	3.86
Resistance to Fire	4.07	4.18	4.00
Resistance to Linear Expansion	4.38	4.32	3.57

Comparison ratings based on a Likert-like scale where a rating of 1-indicated that OSB is perceived to be much better than Plywood while a rating of 7- indicated that plywood is perceived to be much better than OSB.