VALUE-ADDED PRODUCTS DERIVED FROM INTERIOR DOUGLAS-FIR

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ABSTRACT

"Value-added" may be defined as increased value as a result of the production process. Consequently, more value added means more jobs in the production process and increased revenue from product sales in local or regional economies. Value-added concepts for wood products include: (1) improved access to the forest resource and efficiency in timber harvest, (2) primary manufacturing, (3) remanufacturing and secondary manufacturing, and (4) marketing strategies.

Remanufacturing and secondary manufacturing processes are currently employed to produce a variety of value-added products from interior Douglas-fir. Structural products include machine-stress-rated (MSR) lumber, finger-jointed studs, roof and floor trusses, log home components, and glued-laminated beams. Other products include architectural millwork, pallets, furniture, cabinets, doors and windows.

INTRODUCTION

"Value-added" is defined as increased value as a result of the production process. From a company's perspective, this would mean an increase in net income or the return on investment percentage. From a community or regional perspective, value-added also refers to an increase in net income, usually through an increased tax base. Typically, this is achieved by creating additional manufacturing and jobs in a region.

The portion of old-growth timber that has supplied the region's wood products industry cannot be counted on to continue supporting the region's economy. The transition of the timber resource from old-growth to second-growth conifers requires that new wood products be emphasized. Adding value through the five concepts outlined above, will become the key to economic stability in the forest products industry.

Adding value to forest products is achieved through each of the following operations:

- Harvesting efficiency
- Primary manufacturing
- Secondary manufacturing
- Marketing strategies

Efficient harvesting should not be construed as merely keeping the cost of logging operations to a minimum. Specific in-woods activities can add value to logs as marketed in their raw form. For example, log sorting prior to delivery separates logs which can command premium prices for specific end-use markets. In addition, bucking to optimum lengths as needed by the purchaser insures that waste is minimized.

Primary manufacturing refers to the conversion of logs to boards, dimension lumber, and veneers and/or particles for structural panels. The value of these primary products is directly related to conversion efficiency, which can be increased by the optimization of any of the many manufacturing steps. Key areas where substantial gains in conversion efficiency can often be improved is by improving log breakdown systems and kiln drying practices, and maintaining quality control programs.

Secondary manufacturing of primary wood products into higher value, or "value-added" products, includes the following product groups: furniture and cabinets; moulding and millwork; flooring; pallets, boxes and containers; panels; structural components; and specialty products (Forest Industries 1989). Presently, a large percentage of western lumber is shipped out of the region for remanufacture, which suggests that opportunities exist to increase employment and economic stability in timber-dependent communities and regions by increasing diversification in their manufacturing bases.

Marketing forest products for specific consumer groups requires an in-depth knowledge of their needs and preferences as well an understanding of future trends. For example, from 1980 to 1988, U.S. softwood lumber consumption for repair and remodeling (R&R) increased from 8.25 billion board feet to 15.13 billion board feet, or nearly double (WWPA 1989). Marketing strategies that were developed to accommodate this trend include specialized packaging of preferred lengths and grades for home centers, as well as bar-code labeling to facilitate exchange of price and product information at the check-out counter.

This paper focuses on secondary products manufactured from interior Douglas-fir (*Pseudotsuga menziesii*). The products are grouped into two major categories. The first category, structural components and systems, relies on the structural properties of the species. The category of non-structural products includes those products which are not used in structural applications, but utilize interior Douglas-fir primarily for its appearance or availability.

STRUCTURAL PRODUCTS

Mechanical Properties

The mechanical properties of interior Douglas-fir make it particularly useful in structural applications. Both its strength and stiffness characteristics exceed almost all other western conifer species (Table 1). Western larch (*Larix occidentalis*), has similar strength characteristics; consequently, Douglas-fir and larch are often grouped together for grading purposes.

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Table 1.—Allowable design values for structural joists and planks, for selected, visually graded western species. Design values in pounds per square inch (NFPA 1986).

Species or Group	Grade	F_b single	F_b repetitive	E
Douglas-Fir Larch	Select Structural	1800	2050	1,800,000
	No. 1/Appearance	1500	1750	1,800,000
	No. 2	1250	1450	1,700,000
Hem-Fir	Select Structural	400	1650	1,500,000
	No. 1/Appearance	1200	1400	1,500,000
	No. 2	1000	1150	1,400,000
Englemen Spruce Lodgepole Pine	Select Structural	1200	1350	1,300,000
	No. 1/Appearance	1000	1150	1,300,000
	No. 2	825	950	1,100,000
Western Cedars	Select Structural	1300	1500	1,100,000
	No. 1/Appearance	1100	1300	1,100,000
	No. 2	925	1050	1,000,000

Lumber Grading

Pieces of lumber are visually assessed and assigned to grade by certified lumber graders. The allowable stresses for each species and grade depend on the ratio of the strength of the piece to the strength of clear, straight grain wood of the same size, as prescribed by standardized procedures (ASTM 1989). Due to the variability of wood as a biological material, the allowable design values are conservative estimates of the actual performance of each individual piece of lumber.

A mechanical grading system was established in the 1960s which assists the lumber grader by non-destructively measuring the stiffness of each piece (Figure 1). Based on a fundamental relationship between bending stiffness and bending strength, the machine stress-rating system can identify high strength lumber which the visual system is not able to screen out (Hoyle 1982). This grading procedure is called "Machine Stress Rating," or MSR. The MSR grading system still includes edge knot and other visual grading procedures, but the allowable stresses determined in this manner are closer estimates than those determined by visual inspection alone. When you can better predict the strength of each individual piece, you can better predict the performance of engineered systems. This increases reliability of the design and allows a more efficient use of the resource.

Figure 2 illustrates typical grade stamps as found on dimension lumber. The grade stamp on top is the traditional visual grade, in this case a number 1; the one on the bottom is an MSR grade—maximum bending strength for single member use is 1650 psi, stiffness is 1.5 million psi.

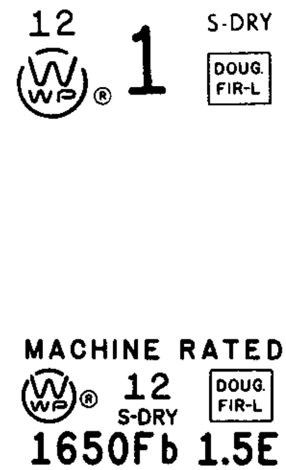

Figure 2.—Typical grade stamps as found on visually graded lumber (above) and machine-stress-rated (MSR) lumber.

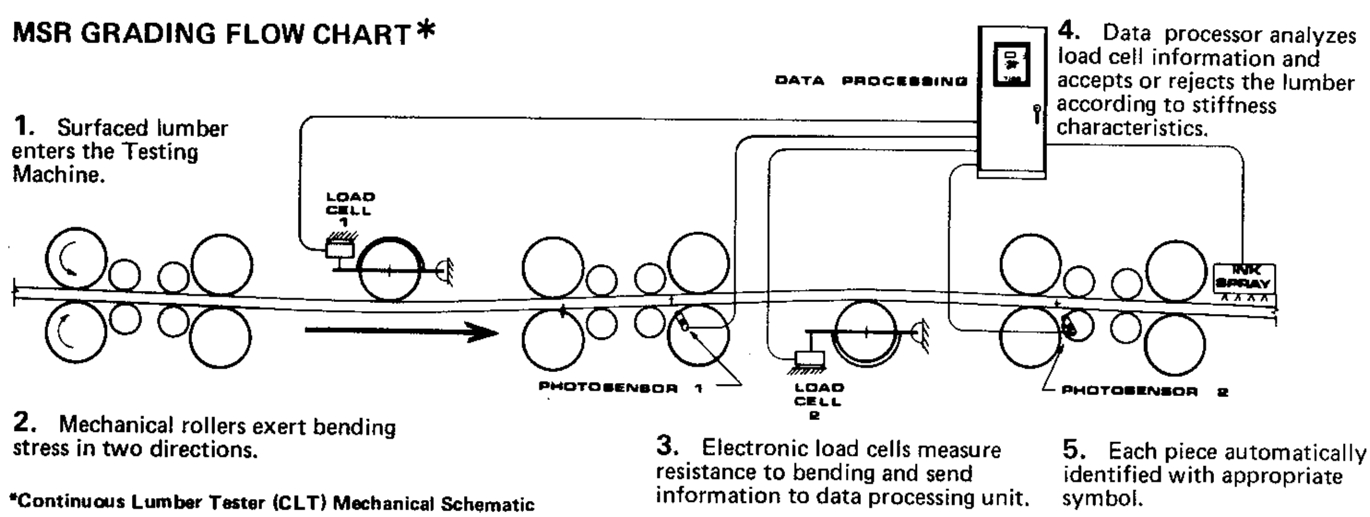

Figure 1.—Mechanical schematic of a continuous lumber tester (CLT) for machine stress rated (MSR) grading of lumber (WWPA 1987).

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Engineered Structural Components

Glue-laminated beams, made by laminating layers of dimension lumber, allow the fabrication of large members. Structures have been built with glued-laminated beams over 100 feet in length. The laminating process allows more efficient use of the timber resource, because smaller trees can be fabricated into large structural members. Scarf or finger joints (Figure 3) allow shorter members to be joined together to make beams of desired lengths. The resource is further extended by using lower-grade material for the inner lamination layers. The outer laminations receive the greatest stresses (Figure 4), so this is where the higher grades of lumber are placed.

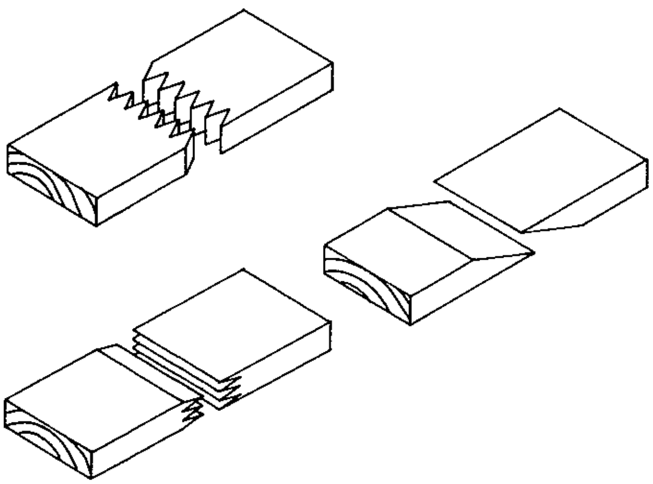

Figure 3.—Common end joint types used in structural glued laminated timbers. Clockwise from the top: vertical finger joint, plane scarf joint, and horizontal finger joint (Wibbens 1982).

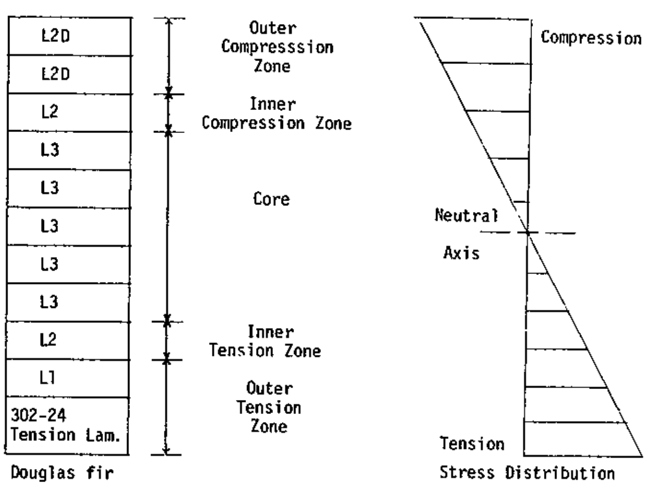

Figure 4.—Distribution of lumber grades in glued laminated timber beams to correspond to the distribution of bending stresses (Wibbens 1982).

Roof and floor trusses also extend the resource through efficient engineering (Figure 5). Both MSR and visually graded lumber is used for the manufacture of these value-added products.

I-beams (Figure 6) represent one of the most efficient uses of wood for structural members. As with all bending members, the top and bottom portions receive the highest axial stresses, which means that the inner portion can be fabricated of material which is best suited to handle only the shear stresses. The top and bottom flanges are usually made of lumber, plywood, or parallel-laminated-veneer-lumber (LVL), while the inner web is usually made of plywood or waferboard. Only coastal Douglas-fir is presently being used for I-beams made with LVL, since the manufacturing facilities are all located west of the Cascades; however, the structural properties of interior Douglas-fir make it suitable as well.

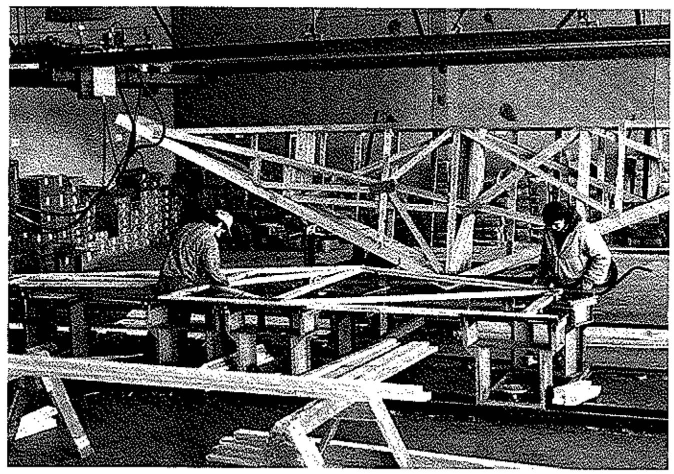

Figure 5.—Prefabrication of engineered roof trusses.

Log Homes

Another structural application that allows interior Douglas-fir to be used for high-value structural products is the log home.

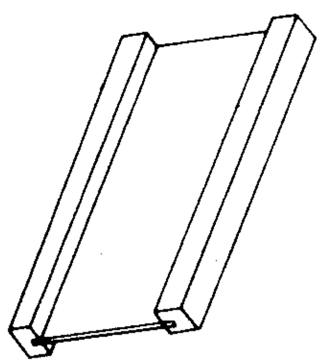

Figure 6.—The typical configuration of wood I-beams. The top and bottom flanges are designed to accommodate axial stresses due to bending; the central web portion resists shear stresses.

While lodgepole pine is presently the preferred species, due to its straightness with little taper, Douglas-fir is being increasingly used due to its availability. A case could probably be made to selectively use Douglas-fir where its structural characteristics are most useful—specifically for joists or rafters.

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NON-STRUCTURAL PRODUCTS

Current directories listing wood product manufacturers (Gorman 1989; MDSL 1990; SAEDC 1989) indicate that over 200 manufacturers in the Inland Northwest produce secondary wood products for other than structural applications. These products include: cutstock (window and door parts), millwork and mouldings; doors and windows; furniture and cabinets; pallets, boxes and containers; flooring; preservative treated lumber and wood products; and other specialty items.

While ponderosa pine is the predominant species for products such as windows, doors, millwork and mouldings, Douglas-fir may also be used when its appearance or strength characteristics are desirable or more appropriate. For example, paneled doors made of Douglas-fir are enhanced by its distinct growth rings and relative straightness of grain. Dowels for closet rods are often made from Douglas-fir due to its stiffness.

Finger-jointing of small, clear pieces allows greater utilization of the resource. Figure 7 shows how waste wood, in this case trim ends from mills, can be salvaged and made into useable products such as door and window parts or tongue-and-groove paneling.

Finally, pallet production keeps over 100 people employed in Montana and Idaho alone—most of these pallets are made from low grade interior Douglas-fir.

SILVICULTURAL INFLUENCES ON WOOD PROPERTIES

The value of interior Douglas-fir for producing many wood products lies primarily in its physical properties. The suitability of interior Douglas-fir for use in structural applications is significantly influenced by density, presence of juvenile wood, and presence of reaction wood. Silvicultural prescriptions can be directed towards enhancing those factors which result in the highest quality timber for specific end-use products.

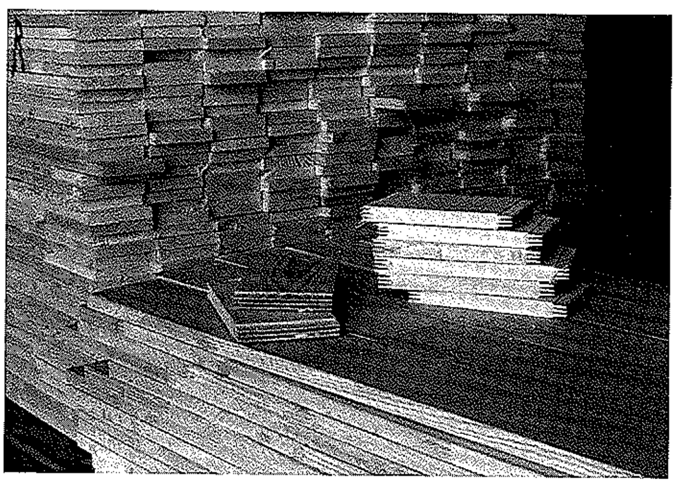

Figure 7.—By finger-jointing the clear portion of trim ends from sawmills, solid wood products such as door and window components and wall paneling are made from waste that otherwise would be converted to chips.

Wood density is the single most important indicator of strength in wood (Hoadley 1980). In general, density of Douglas-fir increases with age, improved site class, and increased average growing season temperature, and decreases with increased growing season precipitation and higher altitudes (USFS 1965).

The growth of juvenile wood trachieds is influenced by their proximity to the pith. Juvenile wood cells are shorter and of lower density that those of mature adult wood. A study of Douglas-fir (Senft *et al.* 1986) found wood formed during the first 15 years to have a specific gravity difference of 32% compared to the wood formed later. In addition, the adult wood strength was about 40-60% higher than that of the juvenile wood. For wood products used in structural applications, this strength difference tends to make the juvenile wood portion of the tree less desirable.

For most purposes, longitudinal shrinking and swelling is not considered in wood assemblies. However, shrinking and swelling characteristics in the longitudinal direction are much more pronounced in juvenile wood. The influence of longitudinal shrinking on the seasonal movement of roof trusses was suspected by researchers (Percival and Suddarth 1983) and demonstrated by Gorman (1985), who showed that seasonal moisture content differences in the top and bottom chords of trusses could cause the lower chord to bow upward (Figure 8), even under load. Often attributed to trusses made with lumber from the large juvenile core of plantation-grown Southern pine, this problem has also been identified in regions where trusses are routinely made with interior Douglas-fir.

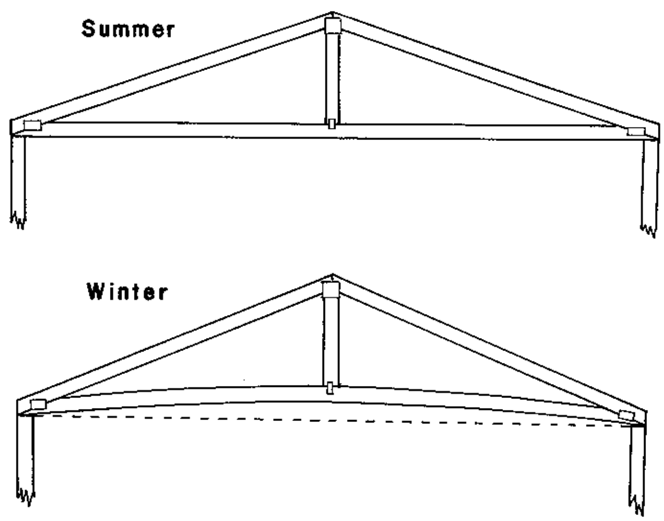

Figure 8.—The large longitudinal shrinking and swelling of juvenile wood makes it undesirable for many structural applications. Seasonal roof truss arching can occur as a result of a moisture content difference between upper and lower chords which contain juvenile wood.

Rapid early growth results in a significant volume of juvenile wood. In addition, shorter rotations will result in a larger percentage of juvenile wood in the tree's volume, increasing the likelihood that an individual board will contain some juvenile wood.

We need to consider wood properties as we look to maximize volume through various silvicultural practices. There will be

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continued opportunity for utilization of interior Douglas-fir for high-value, structural products. However, we must consider the effect of management on the wood's physical properties. Management for maximum volume in shortest period may not give us a timber resource with the same highly-valued physical characteristics that it presently enjoys. A better understanding of the needs of the end-user will help to make the best management decisions.

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LITERATURE CITED

ASTM. 1989. Standard methods for establishing structural grades and related allowable properties for visually graded lumber, D245-81. 1989 Annual Book of ASTM Standards, Sec. 4, Vol. 04.09. American Society for Testing and Materials, Philadelphia, PA.

Forest Industries. 1989. Secondary Wood Products Manufacturers Directory. Miller Freeman Publications, San Francisco, CA. 612 pp.

Gorman, T. M. 1985. Juvenile wood as a cause of seasonal arching in trusses. Forest Prod. J. 35(11/12):35-40. Gorman,

T. M. 1989. Directory of Idaho Secondary Wood Products Manufacturers. Idaho Forest, Wildlife and Range Expt. Sta. Misc. Pub. No. 14, Univ. of Idaho, Moscow. 33 pp.

Hoadley, R.B. 1980. Understanding Wood. The Taunton Press, Newtown, CT. 256 pp.

Hoyle, R. J. 1982. Lumber: grades, sizes, species. *In:* Wood as a Structural Material, Vol. II, Clark C. Heritage Memorial Series on Wood, The Pennsylvania State Univ., University Park, PA. 282 pp.

MDSL. 1990. Directory of Montana's Forest Products Industry. Montana Dept. of State Lands, Forestry Division, Missoula. 85 pp.

Percival, D. H. and S. K. Suddarth. 1983. Longitudinal moisture response in lumbera potential cause of ceiling-partition or floor-partition separation. Forest Prod. J. 33(11/12):19-28.

SAEDC. 1989. Inland Northwest Manufacturers Guide. Spokane Area Economic Development Council, Spokane, WA. 138 pp.

Senft, J. F., M. J. Quanci, and B. A. Bendtsen. 1986. Property profile of 60-year-old Douglas-fir. *In:* Juvenile Wood—What Does it Mean to Forest Management and Forest Products? For. Prod. Res. Soc. Proc. 47309.

NFPA. 1986. Design values for wood construction. Supplement to the National Design Specification for Wood Construction, National Forest Products Association, Washington, DC.

USFS. 1965. Western wood density survey: report number 1. USDA Forest Service Res. Pap. FPL-27. USDA Forest Products Laboratory, Madison, WI.

Wibbens, R. P. 1982. Structural and round timbers. *In:* Wood as a Structural Material, Vol. II, Clark C. Heritage Memorial Series on Wood, The Pennsylvania State Univ., University Park, PA. 282 pp.

WWPA. 1987. Machine stress rated lumber. Western Wood Products Association Technical Guide TG-4, WWPA, Portland, OR.

WWPA. 1989. 1988 Statistical Yearbook of the Western Lumber Industry. Western Wood Products Association, Portland OR. 34 pp.

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