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Evaluation of Mixed Hardwood Studs Manufactured By the Saw-Dry-Rip (SDR) Process

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Abstract

In some areas, harvesting mixed hardwood species may be necessary to provide enough log volume to keep a hardwood stud mill in business. Basswood and red maple should make good studs and should be suitable for combination with yellow-poplar, paper birch, or other species shown to be good performers using the Saw-Dry-Rip (SDR) process. This study evaluates basswood, red maple, and black willow for making studs using SDR.

Results show that basswood and red maple have lower crook when SDR is used with either conventional or high-temperature drying. Black willow crook is lower using SDR but is still much higher than basswood or maple. This poorer performance is believed to be due to wetwood and poor drying. Warp in wetwood studs is due to wet pockets that are exposed when ripped from the flitches, causing delayed shrinkage after ripping.

The percentage of pieces rejected because of warp, based on the STUD grade, is 50-100 percent lower for SDR than for conventionally sawed studs.

Keywords: Saw-Dry-Rip, SDR, hardwoods, studs, manufacturing. red maple, basswood, black willow, wetwood, sawing

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Introduction

The Saw-Dry-Rip (SDR) process for manufacturing structural lumber (studs) from hardwoods has great potential for providing a quality product, reducing shipping costs, and relieving pressure on the softwood resource (Maeglin and Boone 1983). However, a problem may occur in getting enough logs of a given species from the operating area of a mill.

Unlike the more uniform coniferous forests, hardwood forests tend to be of diverse species. This fact often makes harvest of one species economically difficult. The most practical solution to this situation is to find suitable companion species for processing.

The purpose of this study is to evaluate three species frequently found growing in mixture with the four major species already evaluated for production using SDR, i.e. yellow-poplar (Maeglin and Boone 1983), aspen (Maeglin and Boone 1981) cottonwood (Trachsel 1982), and paper birch (Larson and others 1984). The three new species considered are basswood (*Tilia americana* L.), red maple (*Acer rubrum* L.), and black willow (*Salix nigra* Marsh.). The evaluation is to see if SDR will reduce the amount of warp normally expected with conventional processing of these three species.

Basswood, red maple, and black willow are found throughout much of the eastern U.S. (fig. 1) and when combined with the other low- and medium-density hardwoods provide an expanded resource base and an excellent economic opportunity for many mills.

Materials and Methods

This study involves three hardwood species, two processing systems, and two kiln drying methods. The study is designed to evaluate the quality of studs produced by SDR, in relation to conventionally produced studs. Evaluations of quality are based on amount of warp (crook, bow, and twist) and number of studs meeting STUD grading rule requirements (Northern Hardwood and Pine Manufacturers Association 1978).

Nine willow, 18 maple, and 15 basswood logs were selected from trees 8-12 inches diameter at breast height (d.b.h.). Logs were bucked 8 feet long plus trim, bucking to a 5-inch top diameter inside bark (d.i.b.).

All logs were live sawn into 7/4 (1-3/4-in. thick) flitches. Alternate but adjacent flitches were used for control (conventional) and SDR processing. Control flitches were ripped into target-sized stud blanks immediately after sawing from the log, and then dried in stud form. SDR flitches, lightly edged to obtain a compact kiln load, were dried in flitch form and then ripped to stud size after drying.

Two different kiln schedules, conventional and high temperature, were used in this study. Conventional kiln drying was accomplished using FPL schedule T8-D3 (Rasmussen 1961; McMillen and Wengert 1978). High-temperature drying was done on a schedule of 235° F dry bulb and 190° F wet bulb for 28 hours, followed by 40 hours of equalizing at 200° F dry bulb and 188° F wet bulb. The high-temperature schedule is based on previous SDR trials (Boone and Maeglin 1980) and work of Boone (1984). A final moisture content of 12 ± 3 percent was the goal.

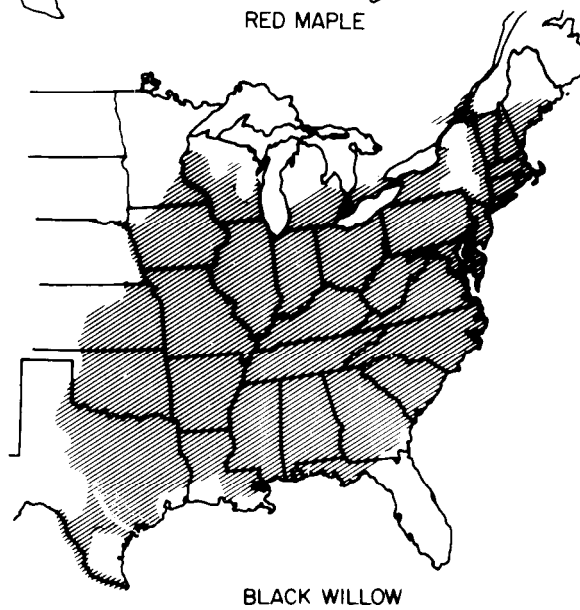
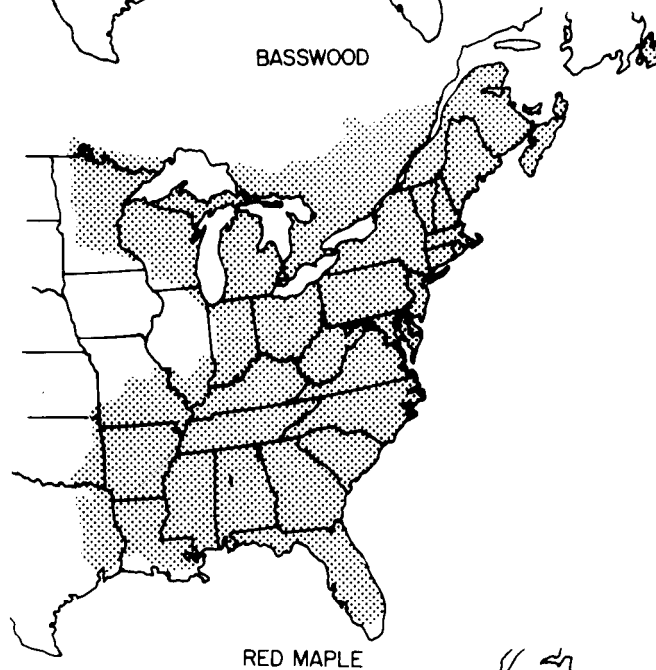
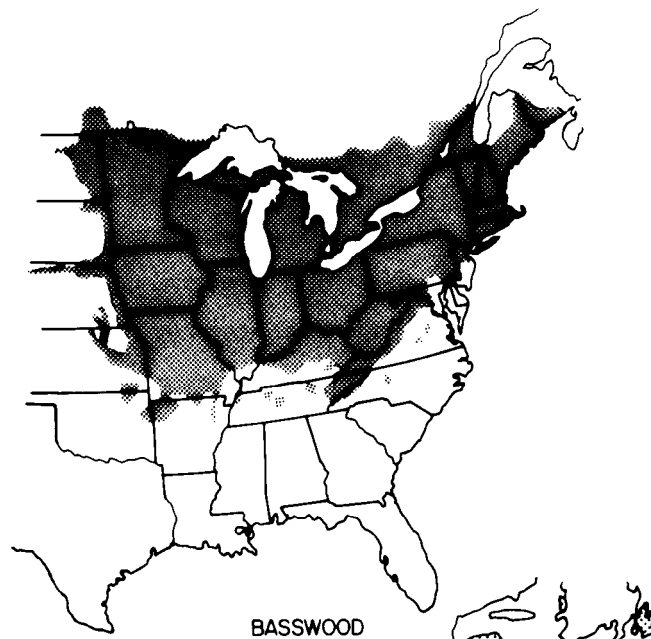


Figure 7.—Geographic distribution of basswood (*Tilia americana* L.), red maple (*Acer rubrum* L.) and black willow (*Salix nigra* Marsh.) (Little 1977). (ML84 5548)

Treatments

The combinations of treatments and their respective codes are:

CC = Conventional processing, conventional drying

CH = Conventional processing, high-temperature drying

SC = SDR processing, conventional drying

SH = SDR processing, high-temperature drying

Measurement of Warp and Moisture Content

After drying and machining to final American Lumber Standard sizes (2 by 4 = 1-1/2 in. by 3-1/2 in.; 2 by 3 = 1-1/2 in. by 2-1/2 in.; and 2 by 2 = 1-1/2 in. by 1-1/2 in.), all studs were measured for warp and moisture content.

Warp measurements were for crook, bow, and twist (fig. 2). Crook is a deviation edgewise from a straight line drawn from end to end of a piece. Bow is a deviation flatwise from a straight line drawn from end to end of a piece. Twist is a deviation flatwise or flatwise and edgewise, in the form of a curl or spiral so that the four corners of any face are not in the same plane. All measurements were to the nearest 1/32 inch.

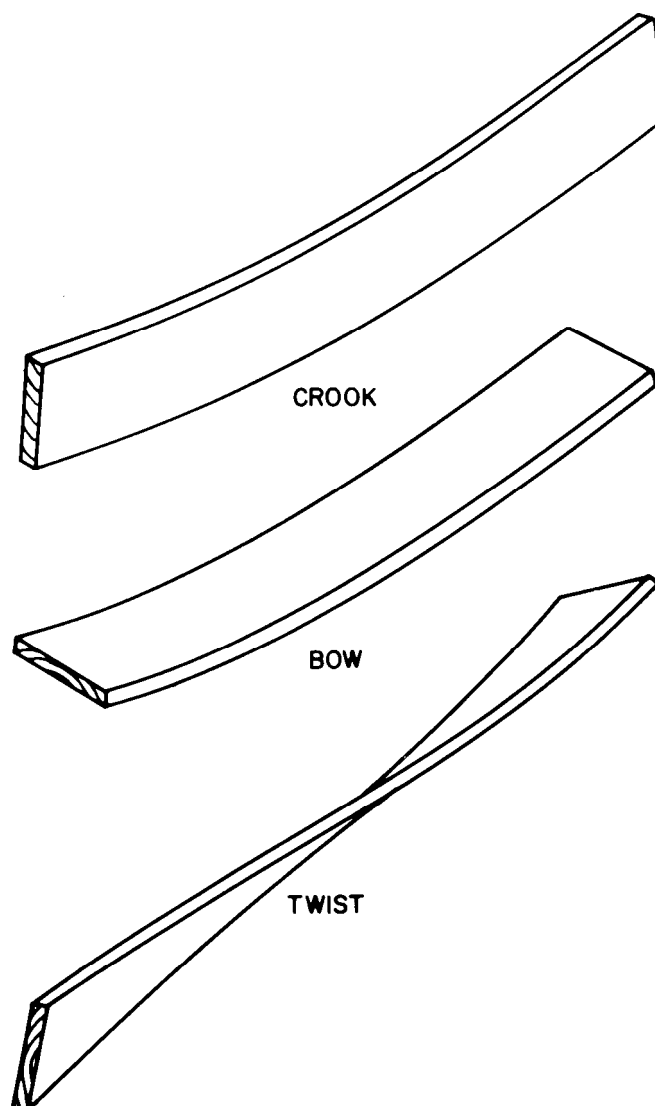


Figure 2.—Different forms of warp. (ML84 5549)

Acceptance of studs was determined using the National Grading Rule for STUD grade (Northern Hardwood and Pine Manufacturers Association 1978). Limits of warp are, for 2 by 4 and 2 by 3, crook 1/4-inch, bow 1/2-inch, and twist 3/8-inch; and for 2 by 2, crook 3/4-inch, bow 3/4-inch, and twist 3/16-inch.

Moisture content was measured at three locations on each stud, about 1 foot from each end and near the middle. The moisture content was obtained using an insulated pin, resistance-type moisture meter. The pins were driven to a depth of three-eighths inch.

Storage and Remeasurement

After final processing and initial measurements were completed, the lumber was stored in an open-sided shed. Here it was exposed to ambient temperature and humidity but protected from precipitation for 30 months. Then it was remeasured for the three types of warp only.

Results and Discussion

The small sample size of this study permits an estimate of the grade quality of these species but may not permit statistical inference as to their actual performance. These results must, however, be weighed in light of results of previous species trials (Maeglin and Boone 1981, Trachsel 1982, Larson and others 1984, and Maeglin and Boone 1983) which showed SDR to produce high-quality studs from hardwoods. The long storage period before remeasure helps to determine if stability is or is not achieved.

Warp

Crook.—The studs produced by conventional processing treatments, CC and CH, had greater average crook than those produced by SDR, i.e. SC and SH (table 1). For basswood 2 by 4's, CC average crook was 6.7 thirty-seconds inch and CH 10.2 thirty-seconds, whereas SC had 0.0 average crook and SH 0.4 thirty-seconds inch. Similar trends were found for 2 by 3's and 2 by 2's.

For red maple 2 by 4's, the CH average for crook was 6.0 thirty-seconds inch compared to 2.5 and 1.0 thirty-seconds respectively for SC and SH. Similar trends were found for 2 by 3's and 2 by 2's.

The sample size for willow was much smaller, but the trends hold for crook reduction using SDR. The average crook for CH was 10.0 thirty-seconds inch compared to 2.5 and 0.8 thirty-seconds for SC and SH respectively.

Bow.—The effect of treatment on bow was not as clear-cut as for crook. In some instances the SDR treatments had lower bow, and in others they had higher bow than the conventional treatments.

A good example of the variability in bow response is basswood. For basswood 2 by 4's, SC had a lower average bow, and SH had a higher average than the CC and CH treatments. For 2 by 3's, SC and SH were both higher in bow than CC and CH. But, for 2 by 2's, CC and CH were higher than SH.

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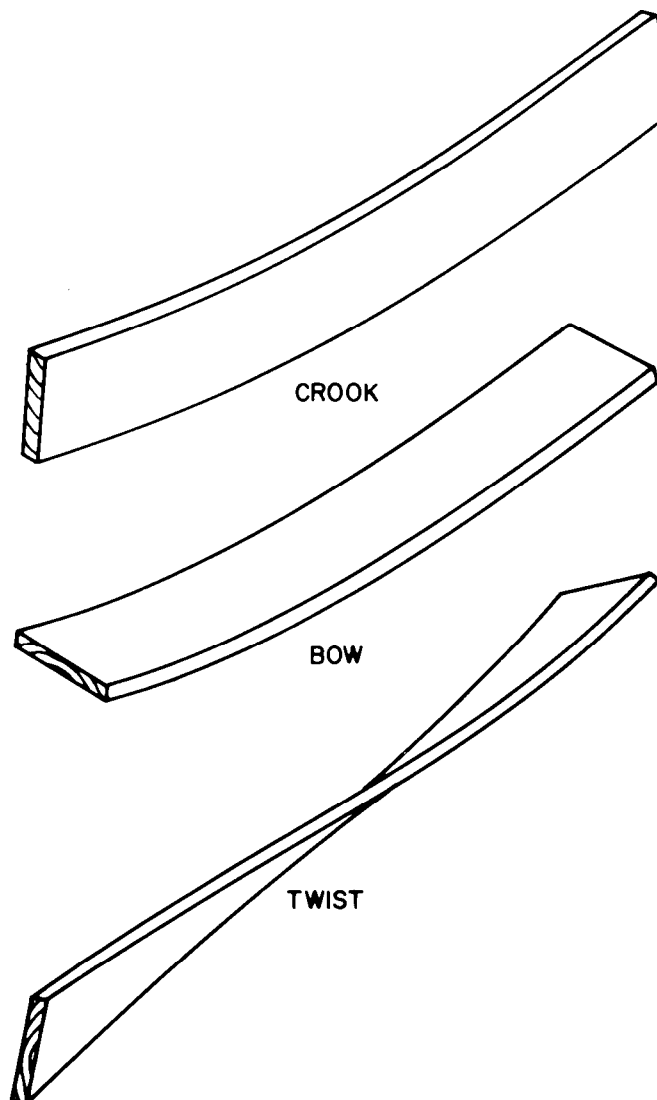


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Table 1.—Average warp for studs by species, treatment, and stud size

Stud size	Sample size	CC ¹ warp			Sample size	CH Warp			Sample size	SC warp			Sample size	SH warp		
		Crook	Bow	Twist		Crook	Bow	Twist		Crook	Bow	Twist		Crook	Bow	Twist
	No.	1/32 in.			No.	1/32 in.			No.	1/32 in.			No.	1/32 in.		
INITIAL MEASURE																
BASSWOOD																
2x4	3	6.7	2.7	2.3	22	10.2	3.9	1.4	3	0	2.0	1.7	20	0.4	5.4	1.2
2x3	1	5.0	5.0	0	5	10.4	5.4	1.8	1	3.0	6.0	2.0	9	0	6.4	1.0
2x2	2	4.5	19.5	0.5	9	3.1	9.3	1.1	—	—	—	—	8	1.8	5.0	0.2
RED MAPLE																
2x4	—	—	—	—	20	6.0	4.3	1.6	2	2.5	0	0.5	22	1.0	3.9	1.4
2x3	1	7.0	4.0	0	3	6.7	2.3	2.0	1	0	12.0	4.0	4	0.8	6.5	1.2
2x2	2	2.0	7.5	0.5	11	3.0	6.9	0.5	—	—	—	—	10	1.5	3.4	0.4
BLACK WILLOW																
2x4	1	2.0	14.0	1.0	6	10.0	5.5	3.7	2	2.5	11.5	2.5	4	0.8	17.2	2.5
2x3	—	—	—	—	4	22.2	8.0	3.5	—	—	—	—	—	—	—	—
2x2	—	—	—	—	2	3.0	19.5	0.5	1	1.0	8.0	3.0	3	13.3	20.3	0.3
REMEASURE																
BASSWOOD																
2x4	3	4.3	3.7	5.7	22	9.7	3.3	1.0	3	3.0	5.0	1.3	20	0.7	4.6	1.0
2x3	1	2.0	6.0	0	5	9.6	2.4	0.4	1	12.0	11.0	1.0	9	1.0	5.6	0.4
2x2 ²	—	—	—	—	9	2.9	8.1	0.7	—	—	—	—	8	1.1	4.4	0.1
RED MAPLE																
2x4	—	—	—	—	20	5.8	3.3	1.4	2	2.5	3.0	2.0	22	1.8	3.2	1.1
2x3	1	7.0	4.0	1.0	3	7.0	0.7	2.3	1	2.0	15.0	5.0	4	3.5	4.2	1.0
2x2 ²	—	—	—	—	11	2.4	6.0	0.4	—	—	—	—	10	1.5	3.2	0.4
BLACK WILLOW																
2x4	1	12.0	15.0	0	6	14.7	5.7	4.2	2	2.0	21.5	12.5	4	4.2	10.8	4.0
2x3	—	—	—	—	4	10.0	3.8	1.5	—	—	—	—	—	—	—	—
2x2	—	—	—	—	2	2.0	19.5	0	1	11.0	12.0	3.0	3	5.7	16.3	1.7

¹CC = Conventional processing, conventional drying; CH = conventional processing, high-temperature drying; SC = SDR processing, conventional drying; SH = SDR processing, high-temperature drying.

²Pieces missing on remeasure of CC treatment.

Table 2.—Percent of rejects based on STUD grade 1 for all stud sizes (2 by 2-2 by 4) by species and treatment

	% Rejects			
	Initial		Remeasure	
	CH	SH	CH	SH
Basswood	44	0	36	0
Red Maple	21	0	18	0
Black Willow	58	29	50	29

¹Northern Hardwood and Pine Manufacturers Association 1978.

For red maple 2 by 4's, CH was higher in bow than SC and SH, while for 2 by 3's CC and CH were lower in bow than SC and SH. And, for 2 by 2's CC and CH were again higher than SH.

For willow, the situation was even more complex. In 2 by 4's, the SC treatment had lower bow than CC but higher than CH, while SH was higher than CC or CH. In 2 by 2's, SC was lower than CH while SH was higher than CH.

Twist.—Twist, for the most part, was very low and not of practical concern. The response to treatments was as mixed for twist as for bow, with SDR treatments being lower in twist in some cases and being higher in others.

Rejects.—As with average crook values, the rejects were greatly reduced using SDR and either drying system (table 2). Because of the small number of specimens in the CC and SC treatments, they are dropped from table 2. The SH treatment for basswood and maple had no rejects. Willow, however, had 29 percent rejects. The sample size of willow was considerably smaller, however, even for the CH and SH treatments (table 2).

Remeasure

Average warp values fluctuated with treatment and species after storage (table 1). The CC and SC treatments showed an average increase in warp after storage while the CH and SH treatments showed an average decrease in warp. The instances where the high temperature-dried treatments increased in warp after storage were of low magnitude, e.g. 2 by 4 basswood crook increased from 0.4 thirty-seconds inch to 0.7 thirty-seconds. The changes for the conventionally dried material were much greater, e.g. 2 by 3 basswood was initially 3 thirty-seconds inch, and on remeasure 12 thirty-seconds inch.

Black willow showed more warp after storage than the other species. This is due to the presence of wetwood in the flitches and the subsequent unbalanced shrinkage on drying.

The number of rejects was affected by the storage period. For the CH treatment all species showed a reduction of rejects (table 2). For SH the percentage of rejects was unchanged, both basswood and maple had no rejects initially or after storage. Willow still had 29 percent rejects after storage.

Drying

Both basswood and red maple can be dried at high temperature with minimal defects (Boone 1984). Average moisture content for high temperature-dried basswood and maple studs in this study was lower than the recommended

12 percent; 7.1 and 7.7 percent respectively because of excessive kiln time. But, the average moisture content of high temperature-dried willow was higher than the desired 12 percent at 18.4 percent because of wetwood content.¹

The range of moisture contents for both conventional and high-temperature drying were 5.2-13.7 percent for basswood; 5.3-23.0 percent for maple; and 6.0-30+ percent for willow. While nearly 85 percent of the basswood and maple pieces were between 5 and 10 percent, 74 percent of the willow pieces were at or above 14 percent moisture content and 57 percent over 18 percent moisture content.

The high-temperature drying schedule used, obviously, was not optimum for our experimental kiln. For production facilities, with scale-up for size, however, the schedule may be about right for basswood and red maple. Further schedule development for black willow is necessary.

The greatest problem to overcome with willow is wetwood. The wet pockets and streaks in willow cause the high moisture content and subsequently the warping. Wetwood is evident through discoloration of the wood. Sorting of logs and lumber can upgrade the product by separating wetwood for special drying treatment.

The success of SDR is dependent on fairly uniform drying of the flitches so that on ripping, wet pockets or streaks are not exposed. Exposure of wetwood on the narrow edge of studs results in after-processing shrinkage and subsequent warping in crook.

Grading

The data on basswood and red maple, and to a lesser extent on black willow, show positive results using SDR, but these species are not yet accepted for grading as structural lumber. Marketing of these species, and any others not now graded, will be curtailed until they are accepted for grading. Species now accepted for grading under the softwood structural lumber rules are aspen, cottonwood, red alder, and yellow-poplar (Northern Hardwood and Pine Manufacturers Association 1978, Western Wood Products Association 1980). Gaining grading acceptance is the responsibility of manufacturers and grading associations.

¹Wetwood is a type of heartwood, formed in living trees, that has been internally infused with water. Wetwood in trees has been attributed to causes such as bacterial infection and injury. Wetwood of many species has low permeability and requires longer drying times than normal wood to reach a desired moisture content. Pockets or streaks of wetwood may exceed the fiber saturation point when adjacent normal wood has dried to the desired moisture content. Further drying of the wetwood can result in warp or collapse (Ward and Pong 1980).

Conclusions

Because of the small sample size, conclusions 1 and 2 are perhaps less well founded than those for previous studies on SDR. But, from experience with other species, we see the same performance trends with basswood and red maple as with yellow-poplar, paper birch, cottonwood, and red alder. The problems of wetwood in black willow have been experienced to a lesser degree with aspen and cottonwood.

1. Basswood and red maple should perform suitably using SDR and probably can be processed with either yellow-poplar or paper birch to make high quality studs.
2. If black willow is used for structural lumber, logs and flitches with wetwood should be sorted for separate drying, not mixed with normal wood.
3. Mill management and grading associations should seek approval to grade basswood, red maple, black willow, and other low- and medium-density hardwoods as structural lumber.

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Early research at the Laboratory helped establish U.S. industries that produce pulp and paper, lumber, structural beams, plywood, particleboard and wood furniture, and other wood products. Studies now in progress provide a basis for more effective management and use of our timber resource by answering critical questions on its basic characteristics and on its conversion for use in a variety of consumer applications.

Unanswered questions remain and new ones will arise because of changes in the timber resource and increased use of wood products. As we approach the 21st Century, scientists at the Forest Products Laboratory will continue to meet the challenge posed by these questions.

