HIGH QUALITY STUDS FROM SMALL HARDWOODS BY THE S-D-R PROCESS

By

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Do you realize that 75 percent of the U.S. population and 80 percent of the new housing and light construction is east of the Rockies? But, only 28 percent of the softwood saw-log resource is east of the Rockies.

All of these figures mean one thing--a lot of structural lumber for the building needs of the United States must be moved across the country from west to east. That is, unless the vast hardwood resource in the east can be used for the structural lumber market.

Nearly all of the hardwood resource is east of the Rockies (there are goodly volumes of aspen and red alder in the West, but these are still small by comparison and often scattered). Current forest inventory data show 17 billion cubic feet of aspen, cottonwood, and yellow-poplar growing stock in 5- to 13-inch-diameter class in the east. The annual growth for this resource is over 1 billion cubic feet, of which 55 percent is surplus over removals. This surplus translates to a potential of nearly 2 billion board feet of lumber in these three species.

In 1978, according to Random Lengths,[2/] there were 3.9 billion board feet of studs manufactured in the United States. If half of that amount could be manufactured from hardwoods in the eastern United States, we could see a fourfold impact, (1) some of the surplus hardwood resource could be used, (2) relief for the overburdened softwood resource would be felt, (3) energy savings could be effected by lower transportation needs, and (4) quality products would be available to consumers.

But, conventionally sawing hardwood studs has not been economical to date. Losses due to warp and/or lack of moisture content (MC) control have been too great. Mills in Canada, Minnesota, and Wisconsin sawing

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1/ Research Forest Products Technologists, Forest Products Laboratory, USDA, Forest Service, Madison, Wis.

2/ Random lengths. May 18 1979. Random Lengths Publications Box 867. Eugene, Oreg. 97440.

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aspen studs have gone under or have switched to softwoods. Koch and Rousis[3/] of West Virginia University reported a 60 percent loss due to warp in conventionally manufactured yellow-poplar studs.

How, then, can hardwoods be used for quality studs and other structural dimension lumber? By using the S-D-R concept--that's how!

S-D-R stands for Saw, Dry, and Rip, an FPL development to solve the problem of warping in studs.

Hardwoods generally have higher internal stress levels in trees and logs than do softwoods. Studs can generally be sawn directly from softwoods with minimal warpage. But, hardwoods often cannot be cut directly into studs because internal (growth) stresses are released as warp upon sawing, often degrading the stud below National Grading Rule (NGR) warp limits for STUD grade.

The S-D-R concept calls for live sawing flitches. The flitches are rough edged, for a compact kiln load, dried, and then ripped into studs. The studs are finally dressed to American Lumber Standards (ALS) dimensions, (fig. 1).

Drying stresses are believed to partially offset growth stresses. Additionally, high-temperature drying may be used to further reduce warp. It is hypothesized that, at temperatures above 212° F, lignin is plasticized, and the stressed fibers slip to a neutral or unstressed position. On further drying the fibers are believed to be rebonded in a nearly stress-free state.

Materials and Methods

Let's look at the studies we have made of S-D-R for several hardwood species.

Our major effort to date has been with yellow-poplar, with some work done on aspen, sycamore, cottonwood, sweetgum, and blackgum. All of these species have low or medium densities necessary for utilization as studs.

Yellow-Poplar

The study of yellow-poplar was a comparative study between flitch sawing and conventional sawing, and high-temperature drying (above 212° F) and conventional drying (below 200° F). Logs from North Carolina, Tennessee, Virginia, and West Virginia were used in the reserach.

3/ Koch, C. B., and Rousis, W. T. 1977. Yield of yellow-poplar structural dimensions from low grade logs. For. Prod. J. 27(4):44-48.

Study Log Selection

The logs used were woods run from small trees between 8 and 12 inches diameter at breast height (dbh), and were taken down to a 5-inch diameter inside bark (dib) top. At FPL the logs for each area were sorted by diameters into eight groups of ten logs each (two replicates each for four treatment combinations: S-D-R sawn high-temperature dried, S-D-R sawn conventionally dried, conventionally sawn high-temperature dried, and conventionally sawn-conventionally dried).

Sawing Methods

The S-D-R sawn studs were cut by live sawing (through and through on one plane), cutting 7/4 (1-3/4 in.) flitches starting with at least a 4-inch opening face.

The conventionally sawn studs were cut using the centered cant method (the 4-inch cant is located in the geometric center of the log). The cants were produced using split taper sawing (one-half of the taper removed from each side of the log) (fig. 2).

Drying Methods

The high-temperature drying schedule was developed by Boone and Maeglin at FPL and uses a time schedule of about 28 hours at 240° F dry-bulb and 190° F wet-bulb followed by about 44 hours of equalizing at 10 percent equilibrium moisture content (EMC) (200° F dry--188° F wet). A paper describing this schedule development has recently been published.

Conventional drying was done, using FPL moisture content schedule T11-D4. Four to five sample boards were used per load.

All drying was done to achieve an average MC of 12 percent, ± 3 percent.

Ripping and Planing

After drying, the flitches were ripped into 2 by 4's, 2 by 3's, and 2 by 2's, maximizing yield, and then planed to ALS dimensions. Conventionally sawn studs were planed after drying to ALS dimensions.

Measuring Warp

After the studs were dressed, they were measured for warp (crook, bow, and twist). Crook is the deviation edgewise from a straight line drawn from end to end of a piece. Bow is the 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 (fig. 3). Each piece was measured for the three types of warp, measuring to the nearest 1/32 inch.

Acceptance of studs was determined using the National Grading Rule for dimension lumber, STUD grade.

Other Species

Data for aspen, sycamore, cottonwood, sweetgum, and blackgum are from drying trials, not from comparative study. Because there are no developed high-temperature drying schedules for these species, we must develop them as we did for yellow-poplar before comparative study can be conducted.

All material was prepared using the S-D-R system. After drying--even though not properly dried in all cases--the studs were ripped from flitches, planed, and measured for warp as with the yellow-poplar.

Results and Discussion

Does S-D-R work? You bet it does! Let's look at the comparative results for yellow-poplar. The control material is that from the conventionally sawn-conventionally dried treatment combination. All comparisons are against this treatment.

The most important warp factor is crook because it determines whether or not a stud wall will be flat.

Comparing the average 2 by 4 data, we see that the S-D-R high-temperature combination had 1/64 inch of crook, and the conventional-conventional control over 1/4 inch of crook (fig. 4).

The S-D-R high-temperature combination had 86 percent less crook than the control. The SDR conventional-drying combination had 67 percent less crook than the control, and the conventionally sawn high-temperature combination had 20 percent less crook than the control (table 1).

Looking at averages by treatment combinations, we see that the S-D-R high-temperature combination is much better than the other two treatments. S-D-R conventional, while not as good as the S-D-R high-temperature, is much better than the conventional high-temperature combination (fig. 5).

An even more dramatic comparison is that for reject studs of all sizes, (fig. 6). The rejects are those that exceeded the NGR warp limit for STUD grade. Those not. making STUD grade would be placed in the ECONOMY grade at a much lower value.

There were NO rejects for the S-D-Rhigh-temperature combination. This treatment yielded 417 studs for a total volume of 1,800 board feet.

By contrast, the conventional-conventional control had 64 rejects. The control treatment yielded 356 studs with a total volume of 1,700 board feet. On a piece basis, the rejection rate was 18 percent, and on a volume basis, the rate was 18.2 percent.

The S-D-Rsystem, regardless of drying schedule, had 11 rejected studs from 820 studs, or 98.7 percent of all studs cut met the STUD grade on a piece basis.

For the conventionally sawn studs, regardless of drying treatment, there were 103 rejects for a rejection rate of 14.1 percent. Only 85.9 percent of the studs sawn met the STUD grade on a piece basis.

On a volume basis, the rejection rate was 1.4 percent for S-D-Rand 14.3 percent for conventionally cut studs.

The volume yields for the two systems were for all intents the same at just over 3,450 board feet each. Both systems yielded over 70 percent overrun; and the Lumber Recovery Factor for both systems was the same, 8.5 board feet per cubic foot of logs.

Other Species

As mentioned earlier, the other species were not comparatively studied, so only warp data and rejection statistics will be discussed.

Aspen

We have conducted seven drying trials with aspen and have not yet arrived at a suitable drying schedule. However, even with drying not at an optimum, the results have been excellent (table 2).

Average crook for three hundred eighty six 2 by 4 studs amounted to about 1/32 of an inch. Only one 2 by 4 exceeded the limit of 1/4 inch of crook. Of the aspen studs, 99.7 percent met the NGR STUD grade.

Average bow for aspen was higher than for yellow-poplar, but only one piece, a 2 by 2, exceeded the warp limits.

Twist was about the same as that recorded for yellow-poplar and had no rejects.

For all sizes combined, 99.7 percent were acceptable from a warp standpoint.

Aspen has wet pockets scattered within many trees. These wet pockets are very difficult to eliminate and subsequently cause warp or collapse due to drying, and may leave wet streaks exceeding moisture content requirement.

To evaluate the effect of this delayed drying, studs were remeasured after 30 days or more of storage. The remeasure revealed 31 reject pieces. However, even with the increase in rejects, the rate was still only 5.1 percent. Commercial mills, cutting aspen, talk of rejection rates as high as 60 percent. All mills of which we are aware have closed or are now sawing softwoods.

Sycamore

Sycamore is not found in large volumes but is frequently encountered in the range of yellow-poplar. For this reason, we tried a sample to see how it would respond to S-D-R treatment. The drying trial schedule, which was the same one used for yellow-poplar, was not the best. The stock had moderate honeycomb in most pieces. A milder schedule would be necessary for commercical use.

The straightness of the studs was very good. Crook for 2 by 4's averaged just over 1/64 inch. Bow was lowest for all species tested, averaging a bit under 1/4 inch, and twist was just over 1/32 inch (table 3). From the 59 pieces cut, sycamore looks like a possible species for stud use if a proper drying schedule can be found.

Cottonwood

Cottonwood, one of our fastest growing species, is found in local abundance throughout the south, the Mississippi River Valley, and other major drainages. The species has good stud properties. Locally, it could be combined for manufacture with gums, soft maple, yellow-poplar, and aspen.

The small sample which we tested dried well at the high-temperature schedule used for yellow poplar. For thirteen 2 by 4's, average crook was slightly higher than for yellow-poplar, aspen, or sycamore, at about 1/16 inch. There were no rejects. Bow, at about 5/32 inch, was about the same as aspen and yellow-poplar, as was twist, at 1/32 inch (table 4).

Sweetgum

Sweetgum, if used for studs, could be mixed with many of the species listed for cottonwood. However, sweetgum is a problem species for warp, especially twist.

Of all the species evaluated, sweetgum had the highest average crook and second highest twist for 2 by 4's. The fourteen 2 by 4's average about 1/4 inch in crook with one reject. In twist, the 2 by 4's averaged about 1/4 inch, but had no rejects (table 5). Bow was slightly higher than the previously mentioned species but lower than blackgum. Because of the small sample size, it is still not sure that sweetgum would make good studs. More work will have to be done to determine how well the species will perform.

Blackgum

Blackgum is found over a large range and could therefore be mixed with numerous species for studs. It does not occur in great quantities, however.

The sample of blackgum was very small, only nine pieces in total, so results must be considered tenuous at best. The average 2 by 4 crook was about 1/16 inch, which is comparable to cottonwood and better than sweetgum. Bow for the seven 2 by 4 studs was higher than for the other species at over 7/32, but this may be an artifact of sample size. Twist in blackgum is a problem as it is in sweetgum. Blackgum has the highest twist of all the species tested, nearly 1/4 inch (table 6).

Mill Layout

The layout for an S-D-R mill is different than that for a conventional sawmill. After the flitches come off the headrig, they are lightly edged and sent to the kiln. The flitches are then, after drying, returned to a straight line ripsaw where studs are cut. Finally, the studs are planed to dimension.

It is envisioned that a Best Opening Face type computer-controlled gang headrig will saw flitches for the green edgers to rough edge before stacking and loading into the kiln. After drying, the flitches will be fed into a computer-controlled edger that, following width scanning, will maximize the yield of studs. From the edger, the studs will go to a precision end trimmer and then through the planer for final dressing.

A manual ripping line will be necessary to salvage flitches that split from growth stress during drying.

A new mill for S-D-R, capable of producing 25 million board feet per year, would probably cost in excess of $10 million.

Adapting an existing mill has been shown to be possible.

Summary and Conclusions

Sawing narrow width lumber from many hardwoods results in severe warpage, due to release of stresses within the log. Many hardwood species of low or medium density would make good studs if the warp problem could be solved.

The S-D-R system uses wide flitches to restrain the stresses in lumber from warping. By drying the flitches rather than studs, it is believed that drying stresses may offset the growth stresses. By high-temperature drying, it is believed that stresses are relieved when lignin bonding the stressed fibers plasticizes. The fibers are thought to slip into a neutral or nonstressed position, and on cooling remain unstressed.

Results of research on several hardwoods (yellow-poplar, aspen, sycamore, cottonwood, sweetgum, and blackgum) indicate that the S-D-R system does work and reduces crook, bow, and twist substantially.

Data for yellow-poplar show that crook in 2 by 4's is reduced nearly 90 percent.

Implementation of S-D-R technology could (1) utilize part of the surplus hardwood resource, (2) relieve some of the current pressure on the softwood resource, (3) save energy through lessened transportation needs, and (4) provide a quality product to consumers.

Table 1.--Improvement in warp over conventionally sewn-conventionally dried studs

Stud size	Treatment								
	SDR-high temperature			SDR-conventional			Conventional high-temperature		
	Crook	Bow	Twist	Crook	Bow	Twist	Crook	Bow	Twist
In.	Pct			Pct			Pct		
2 x 4	86	34	43	67	15	28	20	38	42
2 x 3	77	52	72	48	39	45	11	43	47
2 x 2	74	39	77	38	36	82	45	18	26
All size average	79	42	64	52	30	52	25	33	38

Table 2.--Aspen S-D-R warp data

Stud size	Number	Average 1/32 inch	High 1/32 inch	Rejects
In.				
		CROOK		
2 x 4	386	0.97	11	1
2 x 3	84	1.57	6	0
2 x 2	135	1.85	10	0
		BOW		
2 x 4	386	5.22	24	0
2 x 3	84	4.88	19	0
2 x 2	135	5.70	28	1
		TWIST		
2 x 4	386	1.06	11	0
2 x 3	84	0.58	10	0
2 x 2	135	0.17	4	0

Table 3.--Sycamore S-D-R warp data

Stud size	Number	Average 1/32 inch	High 1/32 inch	Rejects
In.				
		CROOK		
2 x 4	30	0.67	2	0
2 x 3	16	1.88	6	0
2 x 2	13	2.00	5	0
		BOW		
2 x 4	30	3.73	8	0
2 x 3	16	3.50	10	0
2 x 2	13	4.69	8	0
		TWIST		
2 x 4	30	1.27	6	0
2 x 3	16	2.00	7	0
2 x 2	13	1.15	6	0

Table 4.--Cottonwood S-D-R warp data

Stud size	Number	Average 1/32 inch	High 1/32 inch	Rejects
In.				
		CROOK		
2 x 4	13	1.62	3	0
2 x 3	6	0.83	3	0
2 x 2	2	2.50	4	0
		BOW		
2 x 4	13	5.38	13	0
2 x 3	6	5.50	9	0
2 x 2	2	4.00	5	0
		TWIST		
2 x 4	13	0.62	2	0
2 x 3	6	0.83	3	0
2 x 2	2	0.00	0	0

Table 5.--Sweetgum S-D-R warp data

Stud size	Number	Average 1/32 inch	High 1/32 inch	Rejects
In.				
		CROOK		
2 x 4	14	3.50	12	1
2 x 3	1	0.00	0	0
2 x 2	1	0.00	0	0
		BOW		
2 x 4	14	6.28	12	0
2 x 3	1	3.00	3	0
2 x 2	1	4.00	4	0
		TWIST		
2 x 4	14	3.78	12	0
2 x 3	1	6.00	6	0
2 x 2	1	1.00	1	0

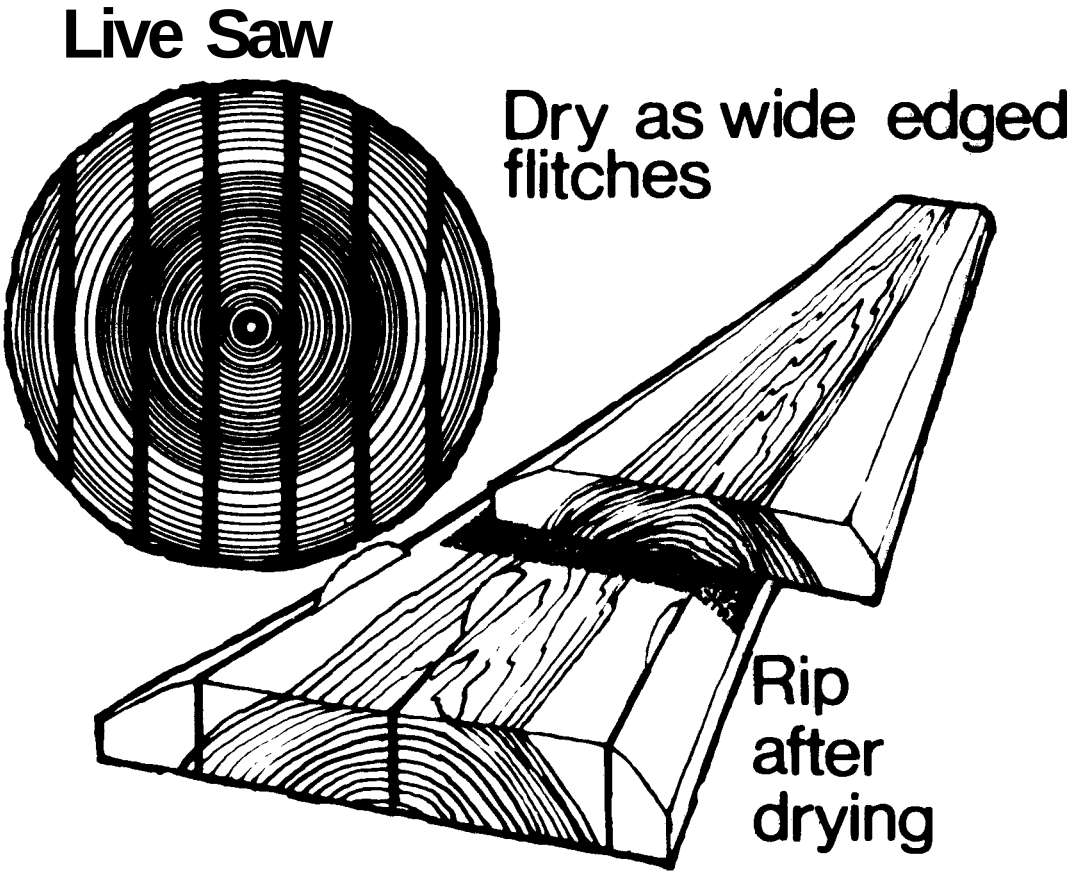

Figure 1.--S-D-R Concept, Live Sawing-Drying-Ripping.

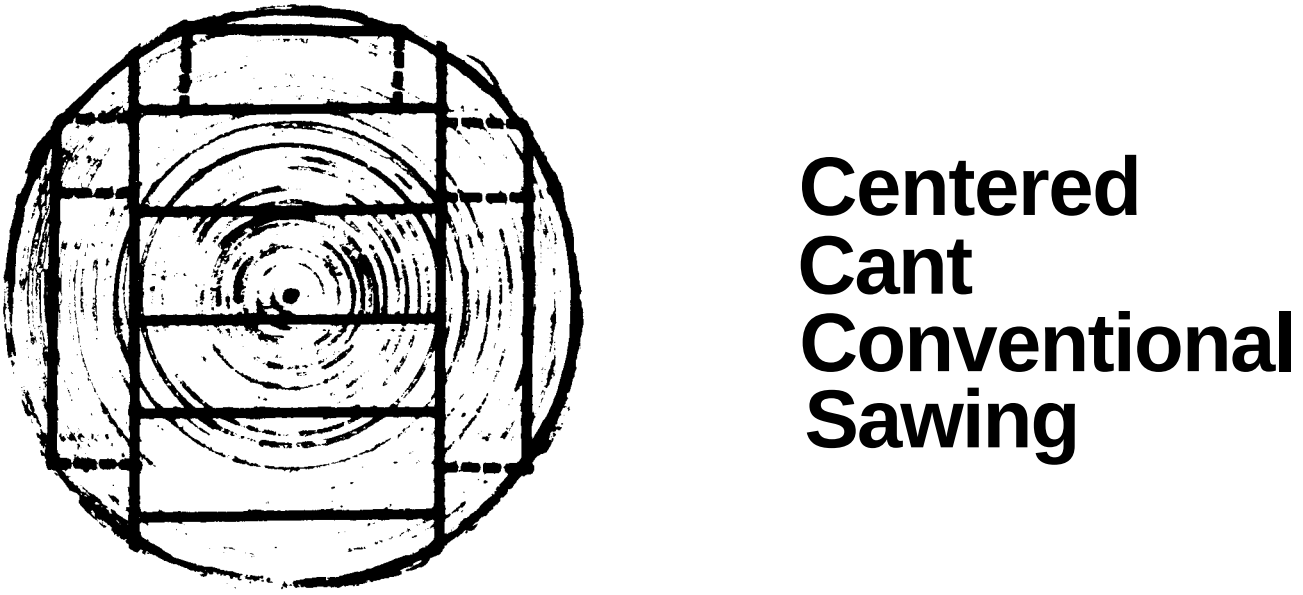

Figure 2.--Typical conventional sawing pattern using centered cant.

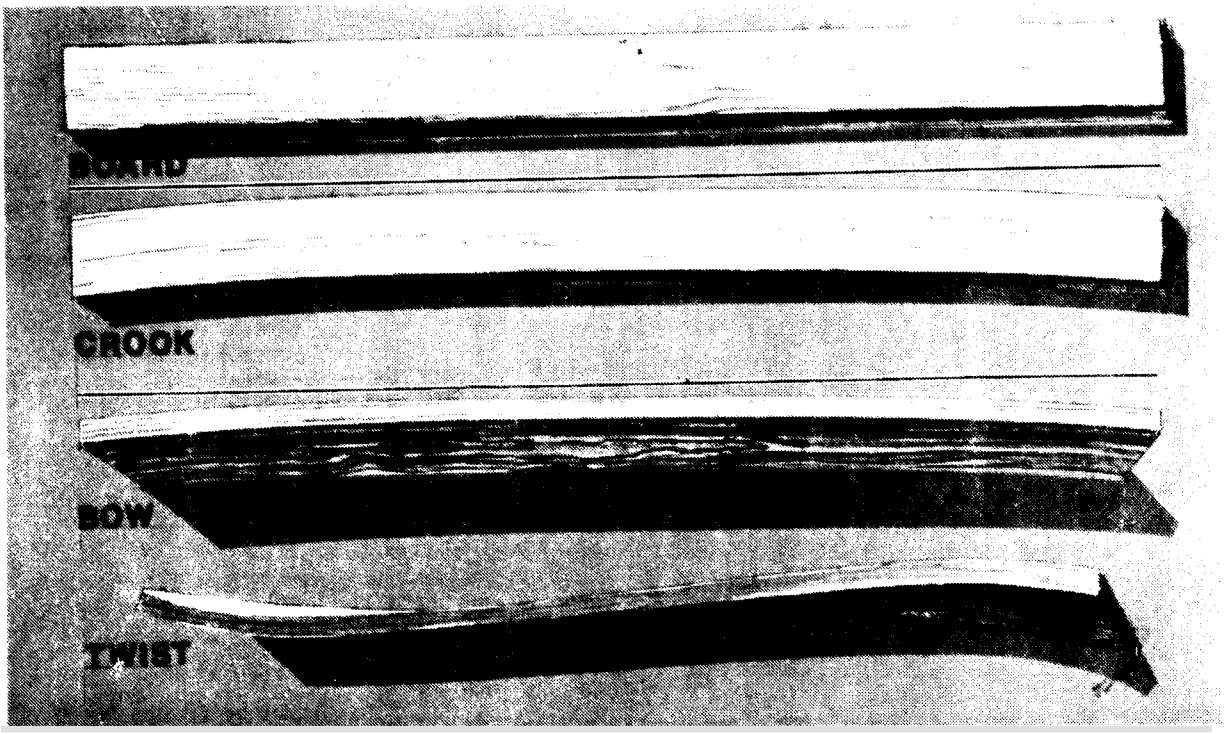

Figure 3.--Typesof warp important in stud manufacture.

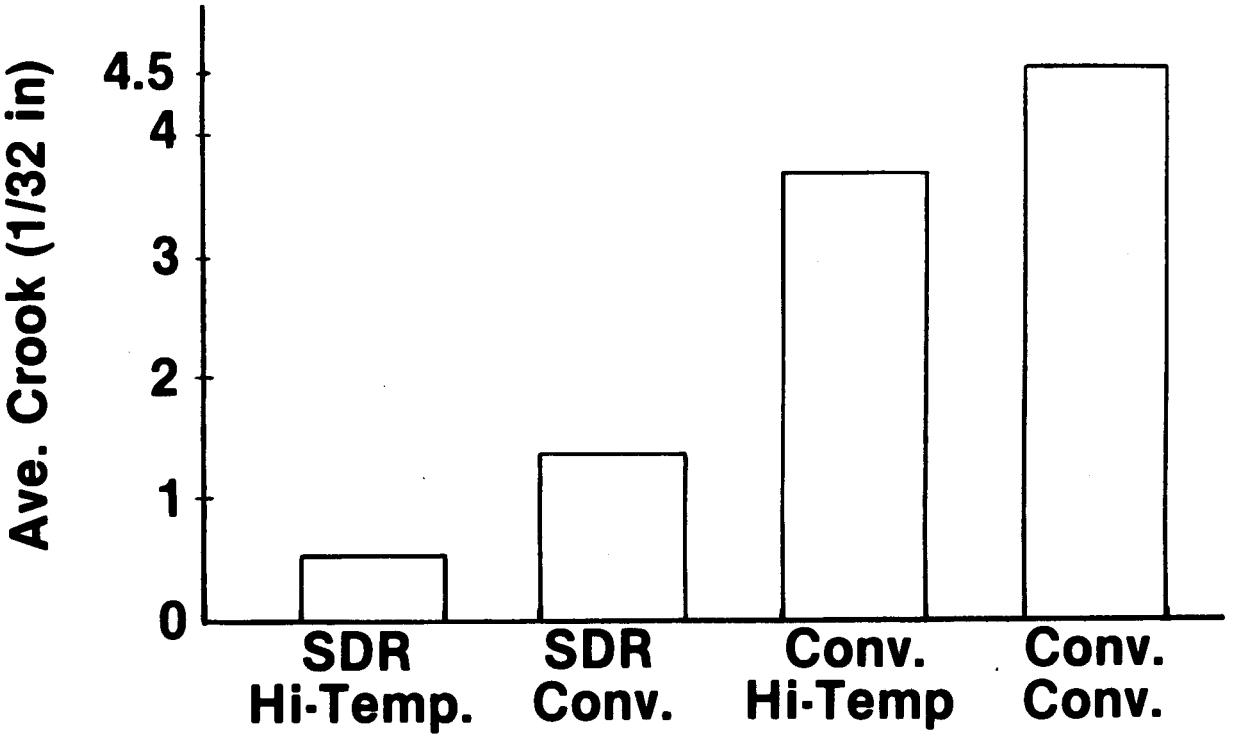

Figure 4.--Averagecrook in 32nds of an inch for 2 x 4 yellow-poplar studs (200 pieces/trt.).

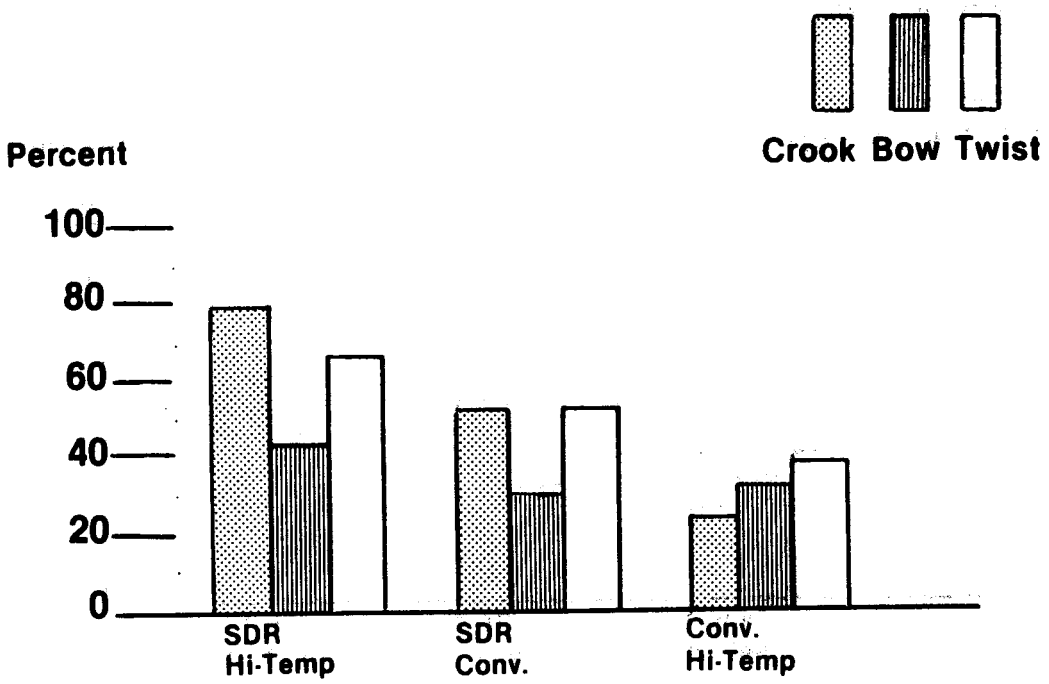

Figure 5.--Average reduction in warp over control (conventionally sawn and dried) for all sizes of studs (400 pieces/trt.).

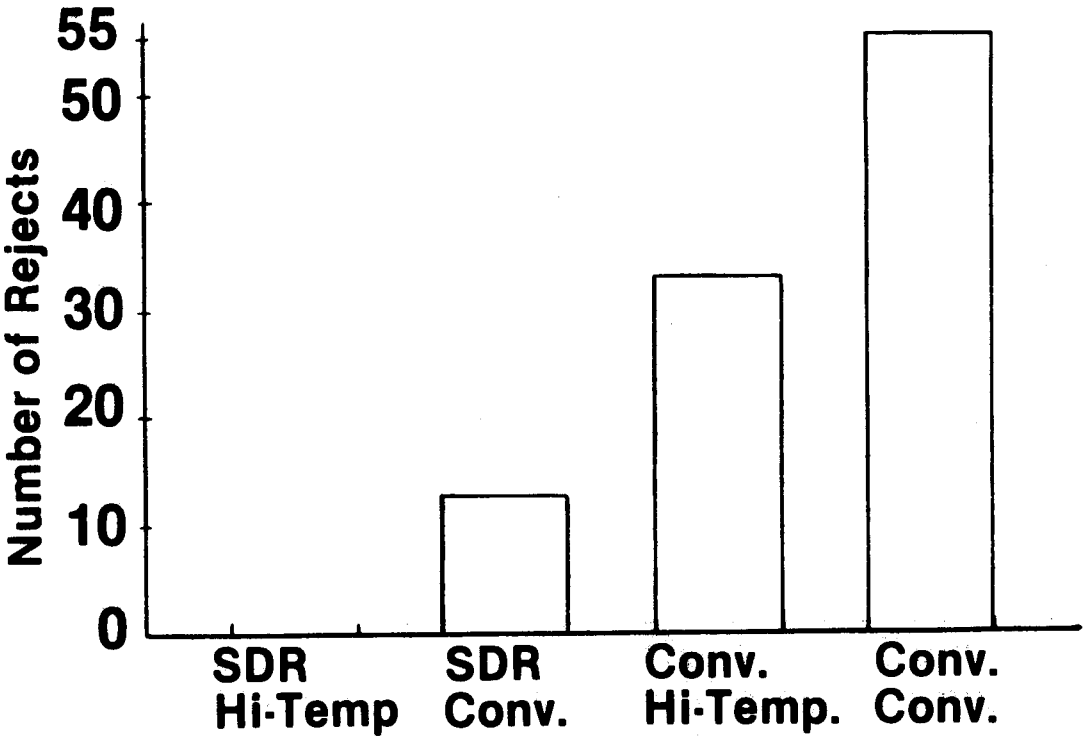

Figure 6.--Number of rejects by treatment (400 pieces/ treatment).