EFFECT OF TWO DRYING SCHEDULES ON SPRUCE PINE LUMBER DEFECTS

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ABSTRACT

A local millwork facility was interested in an alternative, less expensive species as a raw material. They specified crook, bow, and twist as major concerns in accepting any alternative species. Therefore, two spruce pine (*Pinus glabra* Walt.) trees were felled, bucked into 8-foot logs, and milled for optimal grade on a Wood Mizer portable bandsaw mill. The lumber was milled into dimensions of 2 by 4 inches and 2 by 6 inches. Each dimension class was divided into two groups. The groups were dried to an average moisture content of 8 percent ± 2 percent. One group was dried according to a conventional schedule, the other to a high-temperature, southern yellow pine schedule. Single factor t-tests revealed no statistical difference for final width and crook. The conventional schedule yielded significantly less bow, bow per foot, and crook per foot. These preliminary results indicate that spruce pine can be dried with minimal defects using a conventional southern yellow pine drying schedule. Therefore, because of spruce pine's ability to grow rapidly in mixed hardwood stands and its slightly less favorable wood properties, it should become a competitive alternative at a much lower stumpage price for the millwork industry.

Spruce pine (*Pinus glabra* Walt.) grows on acidic sandy loam soils high in organic matter, intermediate between dry sandy soils and alluvial bottomland sites (1,10). Pine is rarely found in pure stands and often is established in the shade of upland hardwoods such as magnolia (*Magnolia* spp.), black gum (*Nyssa* spp.), hickory (*Carya* spp.), beech (*Fagus* spp.), and oak (*Quercus* spp.) where it may eventually overwhelm the hardwoods (7). According to the Society of American Foresters Forest Cover Types (2) spruce pine includes: loblolly pine-shortleaf pine, loblolly pine, loblolly pine-hardwood, slash pine, and slash pine-hardwood (2). The species favors poorly drained upland areas and may be found along minor stream banks or on rich moist hummocks from southeast Louisiana eastward through northern Florida and north into the southern tip of South Carolina (3). There is a total of 92.6 million ft.^{3} of live spruce pine growing stock in Louisiana, mainly in the southeast (13).

The Southern Pine Inspection Bureau (SPIB) considers southern yellow pine (SYP) to consist of: loblolly pine (*Pinus taeda* L.), shortleaf pine (*Pinus echinata* Mill.), longleaf pine (*Pinus palustris* Mill.), and slash pine (*Pinus elltiottii* Engelm.).[1] Spruce pine, south Florida slash pine (*Pinus elliottii* var. densa Little and Dorman), Virginia pine (*Pinus virginiana* Mill.), Pond pine (*Pinus serotina* Michx.), sand pine (*Pinus clausa* Chapm. ex Engelm. Vasey ex Sarg.), and table-mountain pine (*Pinus pungens* Lamb) are minor, commercially less important members of the SYP group (4). The growth rate of spruce pine is similar to traditional SYPs. It is one of the larger eastern North American pines, reaching a maximum of 125 feet in total height and 48 inches in diameter at breast height (DBH) in 60 to 75 years (7). The modulus of elasticity (MOE) of spruce pine is about 75 to 80 percent less than traditional SYP species (11). A com-

[1] Moore, R. 1995. Southern Pine Inspection Bureau. Pensacola, Fla. Personal communication with O.V. Harding.

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TABLE 1. — Comparison of selected wood properties of spruce pine and loblolly pine.

Specie	MOR[a]	MOE[a]	Specific gravity[a]	Fiber length[b]
	- - - - - - - - - - (psi) - - - - - - - - - -			(mm)
Spruce pine	10,400	1.23×10^6	0.44	3.5
Loblolly pine	12,800	1.79×10^6	0.51	4.0

[a] Data from (11), based on ovendry conditions.
[b] Data from (8).

parison of the mechanical properties of spruce pine and loblolly pine is presented in **Table 1**. It is difficult to separate spruce pine wood from the SPIB SYP species because of similarities in the anatomical features of both species. Additionally, Manwiller (8) found that the anatomical and chemical properties of fast- and slow-grown spruce pine were similar to values reported for other more common SYP species. This study also reported that modulus of rupture and MOE were 18 and 31 percent less, respectively, for spruce pine than traditional SYP.

Despite the favorable growth properties of spruce pine, it has traditionally been viewed as a trash species by foresters and as an inferior species for dimension lumber by sawmill and dry kiln operators. Foresters often give low bids on spruce pine stumpage because of its tendency to develop crooked boles, warp when dried, and its lower strength properties. Because spruce pine growth is somewhat similar to loblolly pine and it self prunes readily to a height of 50 to 60 feet (10), it should perform favorably in a plantation. The SPIB includes spruce pine in a separate grade from other southern yellow pines because of its lower strength properties and sometimes higher resin content.[1]

It is interesting that most trade journals consider spruce pine an SYP species, but SYP lumber has traditionally been much more expensive than spruce pine lumber and stumpage. The current stumpage price for spruce pine in southeastern Louisiana is \$100 to \$150 per 1,000 board feet (MBF), and loblolly pine stumpage often brings \$300 to \$500 per MBF. While the literature is voluminous concerning SYP dry kiln operations, research particularly concerning drying spruce pine is lacking. Most SYP drying research has not identified a particular species but is considered applicable for all SYP species (6). Because spruce pine is an SYP species with anatomical properties similar to those in more common SYP species, it should be able to be dried with an SYP kiln schedule with minimal defects. Therefore, one objective of this research was to determine if spruce pine lumber can be dried with minimal defects using either a conventional SYP schedule or a high-temperature drying schedule.

This research was initiated as a result of requests to investigate the feasibility of using less expensive species for millwork. Spruce pine was considered to be a species that could compete with the western white pines for millwork applications. Therefore, our main objective was to investigate the possibility of using spruce pine for millwork applications. We milled and dried our lumber so a local millwork facility could resaw and further process it into millwork. The comments from the millwork personnel were critical in planning this study and their feedback will hopefully guide further and more in-depth investigations.

MATERIALS AND METHODS

Two spruce pine (*Pinus glabra* Walt.) trees were felled in the winter from a rolling, upland site with sandy loam soil in Livingston Parish, La. The first tree yielded one 16-foot log, was 25 years old, measured 70 feet in total height, and had a DBH of 12 inches. The other tree yielded two 16-foot logs, was 48 years old, measured 90 feet tall, and had a DBH of 32 inches. Both trees contained straight boles with no visual defects. The trees were bucked into 8-foot logs and milled for optimal grade on a portable Wood Mizer bandsaw mill. The lumber was milled into dimensions of 2 by 4 or 2 by 6 inches.

We recovered 21 and 38 lumber samples from the 2 by 4 and 2 by 6 classes, respectively. All the lumber was sawn to the nominal dimension plus 1/16 inch to allow for shrinkage. The millwork facility resawed the lumber to rough 7/8-inch-thick material. The lumber was separated into two groups. One group was dried according to the conventional schedule for 8/4 SYP lumber (T12-C5), and the other charge was dried according to the high-temperature schedule (DH) recommended for 2-inch SYP dimension lumber (12) in an Irvington Moore model MDK-365-R dry kiln with a capacity of approximately 500 BF. The high-temperature charge contained 18 pieces from the 2 by 6 group and 12 pieces from the 2 by 4 group. The conventional charge consisted of 20 pieces from the 2 by 6 group and 9 pieces from the 2 by 4 group. The DH schedule is a time-driven schedule with a single step consisting of a dry-bulb temperature of 240°F and a wet-bulb temperature of 180°F. Each charge was dried to an average moisture content (MC) of 8 percent ± 2 percent, according to the recommended MC for interior wood (9). Kiln conditions were maintained within ± 3°F. The drying defects measured were crook, bow, and twist. Crook and bow readings were recorded every linear foot. Bow per foot and crook per foot are the summation of all bow and crook values for an individual sample divided by the total length of that sample and are indicators of mean bow and crook per foot. Twist was measured by holding three corners of the lumber down on a plane surface and measuring the distance from the surface to the other corner of the piece. All recordings were obtained with a digital caliper to the nearest 0.0001 inch.

All lumber pieces in a particular drying schedule were treated collectively in the statistical analysis, regardless of width class. Measurement of the effect of the drying schedule on shrinkage was accomplished by measuring the difference between the two different width classes. Unpaired t-tests were performed on each dependent variable to determine significant differences between the two drying schedules.

RESULTS AND DISCUSSION

Basic statistical results for each dependent variable measured for each drying schedule are presented in **Table 2.** Each mean value represents 30 samples from the high-temperature group and 29 samples from the conventional group.

Both drying schedules yielded mean lumber widths near the target of 4.0 and 5.5 inches for our 2 by 4, and 2 by 6

TABLE 2. — Basic statistical results for a conventional and high temperature schedule of spruce pine lumber.

Schedule	Mean	Standard deviation	Minimum	Maximum	Median
Width (in.) – 2 by 4 lumber					
High temperature	4.042[a]	0.6091	3.293	4.210	4.235
Conventional	4.001[b] (4.192)[c]	0.5803	3.33	4.699	4.209
Width (in.) – 2 by 6 lumber					
High temperature	5.658[d]	0.913	5.1215	5.826	5.699
Conventional	5.653[e] (5.922)	0.963	5.101	5.826	5.694
Moisture content (%)					
High temperature	8.332[f]	0.888	6.600	10.100	8.500
Conventional	9.283[g,h] (9.725)	0.773	6.200	10.500	9.400
Bow (in.)					
High temperature	0.587[h]	0.598	0.025	1.9975	0.354
Conventional	0.309 (0.3237)	0.241	0.082	0.918	0.186
Bow per ft. (in./ft.)					
High temperature	0.187	0.211	0.008	0.774	0.104
Conventional	0.099[i] (0.1037)	0.084	0.022	0.351	0.060
Crook (in.)					
High temperature	0.336	0.313	0.076	1.535	0.225
Conventional	0.198 (0.2074)	0.221	0	0.788	0.1412
Crook per ft. (in./ft.)					
High temperature	0.102[i]	0.089	0.023	0.450	0.073
Conventional	0.057 (0.0597)	0.055	0	0.205	0.045
Twist (in./ft.)					
High temperature	0.2477	0.296	0	0.985	0.1545
Conventional	0.1726	0.111	0	0.4275	0.1435

[a] Average of 12 samples.
[b] Average of 9 samples.
[c] Mean values in parentheses represent theoretical values if the conventional charge were dried to the same average moisture content as the high-temperature charge.
[d] Average of 18 samples.
[e] Average of 20 samples.
[f] Average of 30 samples.
[g] Average of 29 samples.
[h] Significant at $\alpha = 0.01$ and 1.54 degrees of freedom.
[i] Significant at $\alpha = 0.05$ and 1.54 degrees of freedom.

groups, respectively. The large standard deviation of the width values for both charges and dimension classes can largely be attributed to our desire to include as many boards as possible in the study, regardless of specific dimensions. Lumber dried with the high-temperature schedule was slightly higher than the target 8 percent MC, and that dried with the conventional schedule was significantly higher than the mean MC for the high-temperature schedule. These results are acceptable because we dried each charge to a target of 8 percent ±2 percent MC.

The results were somewhat mixed for crook and bow. The high-temperature schedule yielded a highly significant greater mean incidence of bow and a significantly greater mean occurrence of crook per foot than the conventional schedule. However, the conventional schedule had a significantly higher occurrence of bow per foot. There was no statistically significant difference detected between the two schedules with regard to crook or twist. The results for bow per foot and crook per foot are of particular interest because they represent a true assessment of the magnitude of bow and crook. The measured drying defects were present in all lumber except in one sample from the conventional charge that failed to show any crook or twist and one sample from the high-temperature charge that did not show any twist.

An interesting study was done by Hopkins et al. (5) on No. 2 Common and better 2 by 6, flatsawn, SYP lumber. The mean bow for the mild, moderate, and severe kiln charges from this study were 0.0094, 0.0344, and 0.0031 inch, respectively. The mean crook for the mild, moderate, and severe kiln charges were 0.0281, 0.0844, and 0.0813 inch, respectively. Hopkins' values are much lower than those obtained by either the conventional or high-temperature charge from this study (**Table 1**). It should be noted that the kiln schedules used for our study and those used by Hopkins are different, and other differences related to age may also influence the results. Also, Hopkins measured only the maximum bow and crook for each sample.

A shortcoming of our study was the inability to have equal average MC values from the two lumber charges. The conventionally dried charge was dried to an average of 9.283 percent (approximately 9%) MC, and the high-temperature charge was dried to an average of 8.332 percent (approximately 8%) MC. Therefore, we assume a linear relationship exists between shrinkage and MC in the hygroscopic range (i.e., from 0% to 30% MC). We can predict the effect an additional 1 percent MC loss from the conventional charge on shrinkage by dividing the conventional mean value for a particular dependent variable by 21 and adding the result back to the original mean value. We select the value 21 because the conventional charge had gone approximately 21 percent into the hygroscopic range:

$$\text{Theoretical response value} = MCV/21 + MCV \qquad [1]$$

where:

Theoretical response value = predicted response value for the conventional charge if it were dried to 8 percent, and there is a linear relationship between shrinkage and MC in the hygroscopic range

MCV = Mean conventional value for any dependent variable

At the conclusion of this study, all the lumber was given to a local millwork operation to determine the potential of using spruce pine for millwork. The results were described as very favorable by the millwork facility personnel in terms of processing and finishing with the spruce pine lumber.[2] Conventionally dried lumber performed better than high-temperature dried lumber,

[2] Perschall, D. 1995. Acadian millwork. Manderville, La. Personal communication with O.V. Harding.

but the high-temperature dried lumber was considered acceptable by the production manager.

Conclusions

This initial study has shown that spruce pine lumber dried using a high-temperature schedule has significantly higher bow and crook than lumber dried with a conventional SYP schedule. Spruce pine can be used as an alternative for moulding and millwork with favorable results for processing and finishing. The conventional schedule reduced the incidence of bow and crook. There was no significant difference for twist between the conventional and high-temperature charges. Based on these favorable, preliminary results, further investigation on a larger scale is recommended.

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