

A profile of Pennsylvania's hardwood sawmill industry

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Abstract

A mail survey of all identified hardwood sawmills in Pennsylvania was conducted in the fall of 2000 to better understand firm size, species used, origin of logs, processing technology employed, the hardwood lumber grades produced, and the value-added features performed by these sawmills in 1999. An adjusted response rate of 31 percent was obtained for the study's 161 usable surveys. Pennsylvania's sawmills produced approximately 1.3 billion board feet of hardwood lumber in 1999. Responding sawmills producing over 3 million board feet (MMBF) per year (1/3 of the firms) accounted for 80 percent of total production. Red and white oak comprised 40 percent of the log volume purchased by responding sawmills in 1999 followed by yellow-poplar (13%), cherry (13%), soft maple (9%), hard maple (7%), and ash (5%). Thirty-eight percent of responding sawmills employed foresters. The vast majority (80%) of hardwood logs were purchased from non-industrial private forest land, followed by state forests (10%), industrial private forests (9%), federal forests (1%), and municipal lands (1%). Circle headrigs were used by 75 percent of responding sawmills; however, two-thirds of very large firms (10 MMBF and greater) used band headrigs. Whereas only 35 percent of all Pennsylvania hardwood sawmills used a computer-aided headrig, nearly all (94%) of the largest sawmills sampled used computer-aided headrigs in 1999. Approximately 19 percent of the hardwood lumber produced by our study respondents in 1999 was First and Seconds (FAS) & Select (SEL) grade followed by No. 1 Common (24%), No. 2 Common (17%), No. 3A and 3B Common (8%), pallet grade (23%), tie grade (6%), and other (3%). The 16 largest sawmills (10 MMBF+) produced a significantly higher percent of FAS & SEL (30%) lumber grade in 1999 as compared to the study's smaller sawmills. NHLA grading was the most common value-added process performed by responding sawmills (47%) in 1999 followed by kiln-drying (30%), surfacing (30%), custom sorting (26%), end-coating (25%), and custom grading (21%).

The global business environment has created fundamental and far-reaching changes in the U.S. hardwood lumber industry. According to Luppold (2002), U.S. hardwood lumber demand has declined by a half-billion board feet and at least 10,000 U.S. furniture workers have been displaced due to globalization of the furniture industry. In addition, the expanding international veneer industry has been buying increasing volumes of U.S. sawlog-grade material, further squeezing the sawmill's high-end lumber production. These factors, combined with the nation's weak economic business environment, have altered the competitive landscape for primary and secondary processors of hardwood lumber, their cus-

tomers, and their equipment and service vendors.

This study was conducted to better understand the hardwood sawmill industry in one of the nation's more important hardwood lumber producing states, Pennsylvania. A state-specific industry profile is provided as well as an investi-

gation into the product and processing characteristics of Pennsylvania's hardwood sawmill industry. Study results provide useful information to the hardwood sawmill industry in Pennsylvania and to other states regarding the size of firms, raw materials purchased, process technology used, hardwood lumber

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grades produced, and value-added services performed by these hardwood sawmills.

The information will be useful not only to the hardwood lumber producers, but also to key value-added business-to-business customers such as furniture, cabinet, flooring, millwork, pallet, and dimension manufacturers to assist with strategic decision making in the domestic and international marketplace. Additionally, this information will help industry specialists, researchers, and policymakers to identify alternative solutions for the industry's structure and technology-based needs, develop educational programs to enhance resource utilization, and evaluate value-added markets for Pennsylvania's (and the nation's) hardwood industry and forest resource base.

Objectives

The general objective of this study is to profile the hardwood sawmill industry in Pennsylvania in terms of size, raw materials used, and origin of the logs, and to assess the product and processing characteristics of these mills in 1999. Specifically, this study examines the size of hardwood sawmills in Pennsylvania, the species and origin (by ownership) of logs purchased by these mills, the types of processing equipment/technology used, the hardwood lumber grades produced, and the value-added processes performed by Pennsylvania's hardwood sawmills in 1999.

Pennsylvania's hardwood sawmill industry

The combination of species diversity, quality, and timber volume makes Pennsylvania a uniquely important state in the hardwood sawmill industry (Strauss et al. 2000). Almost 50 percent of the hardwood resource in Pennsylvania is desirable including black cherry, hard maple, northern red oak, white oak, and ash (Widmann 1993). Smith et al. (2003) estimated the Pennsylvania hardwood lumber industry size at approximately 1.311 billion board feet in 1999.

The hardwood sawmill industry in Pennsylvania is composed of a diverse set of manufacturers ranging from mills with annual production under 1 million board feet (MMBF) to grade mills producing an excess of 40 MMBF annually. According to Luppold (1995), Pennsylvania contains more hardwood sawmills than any other state, and has a very low

average sawmill size. The relative plethora of ultra-small and small mills in Pennsylvania may be attributed, in part, to its Amish culture (Luppold 1995). Based upon estimates of the entire Pennsylvania hardwood sawmill industry, Smith et al. (2003) found that medium to large sawmills (> 2 MMBF) represented only 27 percent ($n = 151$) of the state's 556 total operating sawmills, but produced 72 percent (945 MMBF) of the hardwood lumber volume in 1999. This diversity in sawmill size suggests a need to better understand the characteristics of both large and small sawmills and to examine differences in the technology used and other processing parameters important to Pennsylvania's hardwood sawmill industry.

Technology use in hardwood sawmills

Identification and implementation of process technology provides a means for the firms producing hardwood lumber to cut costs, obtain or maintain their competitive edge, and improve profit margins (Carino and Foronda 1987, Booth and Vertinsky 1991). The benefits of investing in advanced scanning and optimizing technology in hardwood sawmills are not fully understood, although these technologies are designed and purported to produce higher quality and consistent yield for a more efficient use of the raw material (Bowe et al. 2002).

Of late, technology in the hardwood sawmill industry has been shifting towards semi-automation; however, the basic technology for the production process has not changed appreciably (Bush et al. 1987, Bowe et al. 2002). A national survey of 494 hardwood sawmills in 1998 indicated the U.S. industry to be a relatively low technology segment (Bowe et al. 2001). Bowe et al. (2001) study results found that only 27 percent of responding mills had adopted headrig optimization technology, and a mere 10 and 5 percent used edger- and trimmer-optimizers, respectively, in their hardwood lumber operations. The main reason cited for the relatively low technology adoption in U.S. hardwood sawmills is the existence of a significant number of small sawmills that cannot afford investment in improved technology (Luppold 1996, Barrett 1999, Bowe et al. 2002).

Lumber grades and value addition in hardwood sawmills

Hardwood lumber grading practices have been shown to be extremely important for the success of a firm in the hardwood sawmill industry (Hansen and Smith 1997). Higher grades of hardwood lumber, such as First and Seconds (FAS) & Selects (SEL), and No. 1 Common are typically sold to export, millwork, and other higher valued markets; whereas most of the lower grade lumber is sold for use in pallet cants, ties, and frame-stocks (Luppold and Baumgras 1996). Luppold (1996) reported that most of the graded hardwood lumber in the northeastern United States, including Pennsylvania, is produced in large sawmills (> 5 MMBF capacity) and intermediate sawmills (2 to 5 MMBF capacity). The smaller mills mostly produce industrial products including pallets, cants, and unsorted green/air-dried lumber.

While the mainstay of the hardwood lumber industry is to cut and size logs to lumber, value-added processes (i.e., special grading, kiln-drying, surfacing, custom sorting, end-coating, etc.) have the potential to maximize returns to the manufacturers (Holland 1992). Despite the generally high quality logs produced by northern and central Appalachian states, including Pennsylvania, much of the high value hardwood is shipped out of the region with minimal processing as green lumber (Jones et al. 1992).

Methods

Data collection

Contact information for Pennsylvania's hardwood sawmills in this study was derived from a variety of sources including the following: Harris Pennsylvania Industrial Directory (2000); Harris Pennsylvania Industrial Directory (1999); Hardwood Lumber Manufacturers Assn. (of Pennsylvania) (2000); Hardwood Lumber Manufacturers Assn. (of Pennsylvania)(database) (1997-1998); Hardwood Manufacturers Association (National) Sawmill Directory (1999); 'Southern Lumberman' Directory (2000); Import/Export Wood Purchasing News (2000); Directory of the Forest Products Industry (1998); and Bureau of Forestry Directory (industrial listings for Pennsylvania - included only sawmills with capacity > 250 thousand board feet (MBF) (1995). From these sources, a comprehensive list of 921

sawmills was compiled, which represented a preliminary census of all potential hardwood sawmills in Pennsylvania.

Research instrument

Mail questionnaires were used for primary data collection in this study as they are established as the most effective means to collect data from a geographically dispersed population (Blankenship and Breen 1992, Dillman 2000). The questionnaire was pre-tested for construction, content validity, wording, format, and question flow, through on-site, in-depth interviews with 17 Pennsylvania sawmills (similar to the population for this study), which satisfies the minimum number required according to Isaac and Michael (1997).

Response rate

To increase response rates, a modified version of Dillman's (2000) tailored design method was employed. A survey booklet and a cover letter explaining the purpose of the study and other instructions were mailed to a contact person in each of our 921 identified sawmills in the second week of October 2000. A reminder postcard was mailed 1 week after the first mailing. Three weeks following the initial mailing, a second questionnaire was mailed with a cover letter requesting participation from the non-respondents. In addition, 3 weeks following the second mailing, follow-up phone calls were made to 55 non-respondents (about 10% of the final population) randomly chosen from the population of non-respondents to increase the response rate, test for non-response bias, and validate the sample frame.

Of the original database of 921 prospective sawmills, the sample frame was reduced by 365 firms,¹ resulting in an adjusted population size of 556 hardwood sawmills in Pennsylvania. An overall adjusted response rate of 31 percent ($n = 161$, representing 172 mills) was achieved, which compares favorably to those obtained in previous mail survey studies of a similar nature

¹The sample frame was reduced due to returned (undeliverable) mail, bad or changed addresses, firms that were no longer in business, firms in other businesses (pallets, distribution/concentration yards, veneer and plywood manufacturers, etc.), duplicate responses, follow-up phone call validation procedures, and insight from industry experts.

²ANOVA determines if the mean values of a dependent variable are significantly different across each other within each category of independent variable (Hair et al. 1987).

(Bratkovich and Passewitz 1991, Luppold et al. 2000, Bowe et al. 2001).

Non-response bias

Potential non-response bias was measured by comparing early respondents to respondents who returned the survey after follow-up efforts (second mailing and telephone interviews). This comparison was based on previous work where respondents who respond to follow-up appeals are assumed to be

have like non-respondents (Fowler 1984). Using one-way analysis of variance (ANOVA)² and the Mann-Whitney³ test (0.05 level of significance), early respondents of the hardwood sawmill study were compared to late respondents on the following variables: volume and grade classes of lumber produced, processing equipment/technology used, and value-added processes performed. None of these comparisons produced a significant dif-

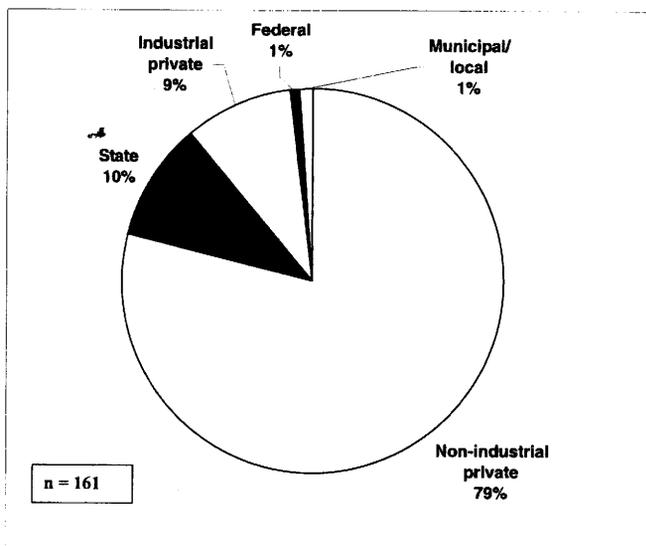


Figure 1. — Source of logs by forest land ownership for Pennsylvania's hardwood sawmills in 1999.

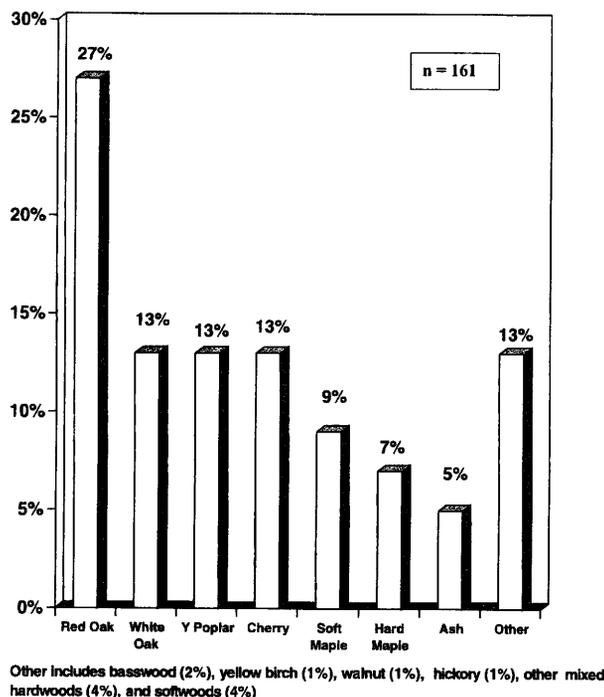


Figure 2. — Log species purchased by Pennsylvania's hardwood sawmills in 1999.

Table 1. — Size and type of headrig used by Pennsylvania's hardwood sawmills in 1999.

Class	Size range of firms (MMBF)	No. of mills	Percent of hardwood lumber by size	Percent of responding firms using headrig types		
				Band	Circle	Scragg
Ultra small	0 to 0.49	41	2	12	85	2
Small	0.50 to 1.99	38	6	13	81	6
Medium	2.00 to 2.99	28	12	15	79	6
Large	3.00 to 9.9	38	31	17	76	7
Very large	10.00 and larger	16	49	66	28	6
Total		161	100	20	75	5

Table 2. — Selected processing equipment used by Pennsylvania's hardwood sawmills in 1999.

Processing equipment	Percent of respondents using selected processing equipment ^a					
	Total	US	S	M	L	VL
Log handling						
Front-end loader	83	68	79	86	94	100
Log truck unloader	58	34	68	60	68	69
Fork truck	52	37	53	50	55	81
Straight grapple loader	20	7	11	32	37	13
Debarkers	69	15	68	96	97	94
Downstream						
Edgers	83	71	84	93	89	88
Trimmers	45	15	37	64	63	69
Band resaws	29	5	13	21	50	94
Gang resaws	15	7	18	11	21	25
Bin sorters	4	0	3	11	0	13

^a US = ultra small (0 to 0.49 MMBF), *n* = 41; S = small (0.5 to 1.99 MMBF), *n* = 38; M = medium (2 to 2.99 MMBF), *n* = 28; L = large (3 to 9.99 MMBF), *n* = 38; and VL = very large (≥ 10 MMBF), *n* = 16.

ference between the early and the late respondents, which suggests that the responding sawmills were representative of the hardwood sawmill industry in Pennsylvania.

Results and discussion

Hardwood sawmill profile

The majority of responding individuals for Pennsylvania's hardwood sawmill study were firm owners (50%), presidents and vice presidents (24%), and sawmill operators (17%). Thirty-eight percent of responding sawmills em-

ployed foresters. Nearly four-fifths of hardwood logs were purchased from non-industrial private forest land, followed by state forests (10%), industrial private forests (9%), federal forests (1%), and municipal lands (1%) (Fig. 1). Of the total volume of logs procured by responding sawmills, oak (red and white) accounted for 40 percent, followed by cherry and yellow-poplar (13% each), soft maple (9%), hard maple (7%), ash (5%), and other hardwoods (13%) (Fig. 2).

Responding hardwood sawmills (*n* = 161, representing 172 mills) employed an average of 20 full-time employees and produced an average of 3.15 MMBF of hardwood lumber in 1999. Bowe et al. (2001) found an average of 34 employees and an average production of 7.6 MMBF per sawmill respondent (in 1999) in his national study of hardwood

sawmills. This disparity may be explained by examining the study objectives, the scope of the two studies (national vs. a single state) and the resultant sample frames used. That is, Bowe et al. (2001) used two mailing lists: the National Hardwood Lumber Association (NHLA) member list (*n* = 602) and a random sample of 1,440 non-NHLA members from a second list. In our state-specific study, one of our objectives was to estimate the total size of Pennsylvania's hardwood sawmill industry (Smith et al. 2003); thus, a comprehensive database of 921 sawmills from 9 different directories was compiled. To this end, our study identified and obtained responses from a higher percent of small (< 2 MMBF) sawmills. A second explanation is that Pennsylvania may simply contain a higher percentage of small hardwood sawmills compared to the national average.

To facilitate comparison of the product and processing characteristics, five size classes were developed based on the volume of hardwood lumber produced by the 161 responding firms. The smallest firms, ultra-small mills (< 500 MBF capacity) and small mills (500 MBF to < 2 MMBF capacity), accounted for nearly half (*n* = 79) of respondents but produced only 8 percent of the hardwood lumber volume (Table 1). Pennsylvania's medium (2 to 2.99 MMBF capacity), large (3 to 9.99 MMBF capacity), and very large (≥ 10 MMBF capacity) sawmill respondents accounted for 12, 31, and 49 percent of the hardwood lumber produced in 1999, respectively (Table 1).

Processing equipment

Circle-saw headrigs were used by 75 percent of the Pennsylvania sawmill respondents, bandsaw headrigs by 20 percent, and the remaining 5 percent were scragg⁴ mills (Table 1). The circular saw headrigs were more common (over 80%) in the ultra-small and the small mills, whereas bandsaw headrigs were found in two-thirds of the very large (> 10 MMBF) sawmills (Table 1).

Table 2 shows various log handling, debarking, and downstream processing equipment used by the 161 responding hardwood sawmills in Pennsylvania. Front-end loaders were used by 83 percent of respondents followed by log truck unloaders (58%), fork trucks (52%), and straight grapple loaders (20%). Overall, 69 percent of all re-

³The Mann-Whitney test for differences, is a non-parametric analysis for all pairwise mean comparisons between groups (SPSS 1999).

⁴Scragg mills have at least two circle saws mounted on a common arbor, or on separate stub arbors. They feature simple design, low capital, high piece count capability, and low manufacturing cost (Williston 1988).

Table 3. — Advanced technology used by Pennsylvania's hardwood sawmills in 1999.

Computer-aided equipment	Percent of respondents using advanced technology ^a						p-value ^b	Difference among sizes ^c
	Total	US	S	M	L	VL		
	----- (%) -----							
Headrig	35	0.2	31	39	47	94	0.000	VL>US,S,M,L; L>US;M>US
Resaw	12	0	0.2	0.7	24	50	0.000	VL>US,S,M,L; L>US,S
Edger	12	0.2	0.5	11	16	48	0.000	VL>US,S,M,L
Trimmer	9	0	0	11	16	31	0.000	VL>US,S

^a US = ultra small (0 to 0.49 MMBF), n = 41; S = small (0.5 to 1.99 MMBF), n = 38; M = medium (2 to 2.99 MMBF), n = 28; L = large (3 to 9.99 MMBF), n = 38; VL = very large (≥ 10 MMBF), n = 16.

^b Statistically significant at 0.05 level using ANOVA.

^c Differences among the sawmill sizes based on ANOVA and Mann-Whitney paired comparison test.

Table 4. — Grades of lumber produced by Pennsylvania's hardwood sawmills in 1999.

Grades	Percent of respondents by lumber grades produced ^a						p-value ^b	Difference among sizes ^c
	Total	US	S	M	L	VL		
	----- (%) -----							
FAS & SEL	19	20	17	17	18	30	0.005	VL>US,S,M,L
No. 1 Common	24	24	24	25	24	28	0.836	
No. 2 Common	17	16	15	15	18	20	0.231	
No. 3A, 3B Common	8	8	7	6	9	9	0.798	
Pallet cant	23	23	25	28	23	13	0.118	
Tie	6	5	8	8	5	1	0.335	
Other ^d	3	5	4	1	4	0	0.563	
Total ^e	100	101	100	100	101	101		

^a US = ultra small (0 to 0.49 MMBF), n = 41; S = small (0.5 to 1.99 MMBF), n = 38; M = medium (2 to 2.99 MMBF), n = 28; L = large (3 to 9.99 MMBF), n = 38; VL = very large (≥ 10 MMBF), n = 16.

^b Statistically significant at 0.05 level using ANOVA.

^c Differences among the sawmill sizes based on ANOVA and Mann-Whitney paired comparison test.

^d Other includes mine timber and construction timber.

^e Numbers may not add to 100 due to rounding.

sponding sawmills, and about 95 percent of larger sawmills (> 2 MMBF) used a debarker in 1999 (Table 2).

Common downstream equipment used by the hardwood sawmill respondents included edgers (83%), trimmers (45%), band resaws (29%), gang-resaws (15%), and bin sorters (4%). The use of downstream secondary processing equipment generally increased as sawmill size increased (Table 2).

Computer-aided processing technology

The application of computing systems and automation can result in higher mill efficiency and productivity (Haygreen and Bowyer 1982). However, use of computer-aided equipment is not common in the U.S. hardwood sawmill industry (Bowe et al. 2001, 2002). In a nationwide survey of hardwood sawmills, Bowe et al. (2001) found optimization

technology⁵ in the headrig, edger, and trimmer in use by 27, 10, and 5 percent of respondents in 1999, respectively. Our study of Pennsylvania's hardwood sawmills, in support of these national findings, found 35, 12, and 9 percent of respondents using computer-aided headrig, edger, and trimmer equipment, respectively, in 1999.

According to Bowe et al. (2001), 15 percent of small companies (< 20 employees) and 53 percent of large hardwood sawmills in the United States had employed the advanced scanning and optimizing technology. Our Pennsylvania study supports this finding as shown in Table 3. Separate ANOVA and Mann-Whitney tests were conducted to examine differences between the sawmill size categories in their use of computer-aided equipment (heading, resaw, edger, and trimmer) and significant differences ($p < 0.05$) were found between size categories for all four types of computer-aided equipment (Table 3). That is, very large sawmills use significantly more computer-aided headrig, resaw, and edger equipment as compared to the

smaller sawmills, and similarly, large and medium sawmills use significantly more computer-aided equipment than the ultra-small and the small mills (Table 3).

Hardwood lumber grades

Of the hardwood lumber produced in 1999 by our 161 Pennsylvania respondents, 19 percent was FAS & SEL grade and 24 percent was No. 1 Common lumber (Table 4). Among the lower grades of lumber produced, pallet cants accounted for 23 percent, followed by No. 2 Common (17%), No. 3A and 3B Common (8%), tie (6%), and mine and construction timber (3%). In an earlier nationwide study of U.S. hardwood lumber purchasers (furniture, cabinet, dimension/flooring, and molding/millwork companies), Bush et al. (1990) found 18.5 percent of the hardwood lumber purchased was FAS & SEL grade followed by No. 1 Common (41%), No. 2 Common (31%), and No. 3A and 3B Common (8%). ANOVA and Mann-Whitney tests were used to examine differences ($p < 0.05$) between the five

⁵Optimization technology included a range of technologies from computer-aided networks to more advanced headrig optimization systems.

Table 5. — Value-added processes performed by Pennsylvania's hardwood sawmills in 1999.

Value-added processes	Percent of respondents by value-added processes ^a						p - value ^b	Difference among sizes ^c
	Total	US	S	M	L	VL		
	------(%)-----							
NHLA grading	47	12	37	57	68	94	0.000	VL>US,S;L>US,S;M>US
Kiln-drying	30	25	24	14	21	94	0.000	VL>US,S,M,L
Surfacing	30	30	19	18	34	69	0.003	VL>US,S,M
Custom sorting	26	8	22	18	39	63	0.000	VL>US,S,M;L>US
End-coating	25	15	19	7	32	81	0.000	VL>US,S,M,L
Custom grading	21	13	16	18	21	56	0.005	VL>US,S,M,L
Dimension manufacturing	19	18	22	11	24	19	0.738	
S4S	14	10	14	11	11	38	0.072	
Finger jointing	1	0	3	0	0	6	0.274	
Other ^d	8	10	11	4	5	12	0.718	

^a US = ultra small (0 to 0.49 MMBF), n = 41; S = small (0.5 to 1.99 MMBF), n = 38; M = medium (2 to 2.99 MMBF), n = 28; L = large (3 to 9.99 MMBF), n = 38; and VL = very large (≥ 10 MMBF), n = 16.

^b Statistically significant at 0.05 level using ANOVA.

^c Differences among the sawmill sizes based on ANOVA and Mann-Whitney paired comparison test.

^d Other includes molding, paneling, tongue and groove, specialty sawing, color sorting, double grading, timber framing, etc.

Table 6. — Additional concerns of Pennsylvania's hardwood sawmill industry in 1999.

Concerns	Percent of respondents (n = 51)	
		(%)
Raw material scarcity		45
Burdensome environment regulations		41
Lack of information on proper management of forests		25
High stumpage prices		25
Decreasing quality and diameter of logs		16
Lack of qualified labor		14
Amish pressure		12
Other ^a		6

^a Other includes increasing energy costs, non-uniform road regulations, tough competition by bigger companies, high taxes, need for public education on forest management, and lack of profitable outlet for chips.

sawmill size categories and the grades of lumber produced in 1999. **Table 4** shows that very large mills (> 10 MMBF) produced a significantly higher percentage of FAS & SEL grade of lumber as compared to the smaller sawmills in Pennsylvania in 1999.

Value-added processes

Nearly half (47%) of the 161 responding Pennsylvania hardwood sawmills performed NHLA grading, the most common value-added process employed in 1999 (**Table 5**). Other value-added processes used by these sawmills included kiln-drying (30%), surfacing (30%), custom sorting (26%), end-coating (25%), custom grading (21%), dimension manufacturing (19%), S4S (14%), and finger-jointing (1%). In the national study of hardwood sawmills by *Bowe et al.* (2001), 63 percent of sawmills offered NHLA grading followed

by end-coating (55%), kiln-drying (43%), custom sorting (39%), surfacing (35%), custom grading (32%), and dimension manufacturing (24%). One explanation for these differences is that the respondents in the study by *Bowe et al.* (2001) were, on average, larger sawmills (7.6 MMBF mean hardwood production in 1999) versus our Pennsylvania sawmill's (mean respondent size = 3.15 MMBF).

Statistical significance testing (using ANOVA and Mann-Whitney) showed differences among the sawmill size categories for NHLA grading, kiln-drying, surfacing, custom sorting, end-coating, and custom grading (**Table 5**). It is evident from **Table 5** that in 1999 Pennsylvania's very large hardwood sawmills performed many of these value-added services more frequently than smaller sawmills.

Open-ended question: respondent concerns

Fifty-one firms responded to a qualitative open-ended question asking for "any additional concerns regarding the resource, the business environment, etc." (**Table 6**). Raw material scarcity and burdensome environmental regulations were the two most critical concerns reported, followed by high (increasing) stumpage prices, and lack of information on proper management of forests. Other common concerns mentioned by study respondents included decreasing quality and diameter of logs (16%), lack of qualified labor (14%), and competitive pressure from Amish mills (12%).

Conclusions

This research profiled Pennsylvania's hardwood sawmill industry in 1999 in terms of mill demographics, raw material procurement, products produced, and processing characteristics. The study's 161 responding mills produced a total of 542 MMBF, employed an average of 20 employees, and produced an average of 3.15 MMBF in 1999. *Smith et al.* (2003) estimated the total hardwood lumber production in Pennsylvania at 1.311 billion board feet in 1999. The majority of the logs purchased (60%) consisted of highly desirable hardwood species, such as red and white oak, cherry, and hard maple and 79 percent of the logs were sourced from private non-industrial forests.

Two-thirds of the study's very large sawmills (10 MMBF) used bandsaws;

however, 75 percent of the 161 responding mills used circle saw headrigs. Only 35 percent of Pennsylvania's sawmill respondents used computer-aided headrigs, and the vast majority (88 to 91%) did not use computer-aided equipment in their resaw, edger, or trimmer. The predominant use of circular saw headrigs by responding hardwood sawmills, and the general dearth of computer-aided scanning and optimizing equipment, should be noted in view of the proven increase in volumetric yield resulting from these technologies (Holland 1992, Luppold et al. 2000). As prices rise for grade quality logs, raw material conversion efficiency will provide a distinct competitive advantage. Those firms unable or unwilling to invest in more efficient processing technologies must find other means, such as niche marketing, to compete.

Fifty-seven percent of the lumber produced by Pennsylvania's hardwood sawmill respondents is No. 2 Common, No. 3A and 3B Common, pallet, and tie grade. This underscores the importance of successfully developing and maintaining markets for lower grade hardwood lumber, including value-added processes such as custom sorting and grading, dimension manufacturing, and finger-jointing. Pennsylvania's larger sawmills most frequently employed these and other value-added processes in their hardwood lumber operations.

Future research on the U.S. hardwood sawmill industry could employ similar research methodologies to acquire data from other states and regions to compare and contrast the findings in this paper. It is important to carefully construct sample frames to include the many small, and often difficult to identify, hardwood businesses in order to properly address important issues and trends in the industry. Moreover, these small sawmill operations often represent important economic development components within their rural communities, thus providing an added incentive to policymakers to monitor their operations and help ensure their survival.

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