

Impact Assessment of the 2008 to 2010 Economic Downturn Period on Appalachian Hardwood Sawmill Operations

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Abstract

A mail survey was conducted in the fall of 2010 to investigate the impacts of the 2008 economic downturn on sawmill production, employment, and marketing in the Appalachian region. The mail survey was sent to 776 hardwood sawmills in the region and 58 valid responses were used in the study. It was determined that the average number of employees per mill had decreased from 42 to 30, a reduction of 29 percent during the period. At the same time, annual operating hours decreased 9 percent and weekly lumber production fell by 26 percent. Additional information collected with the survey indicated that the average log inventory reported by the responding mills was sufficient to allow production for 6 weeks. Weekly chip and sawdust production was reported as 139 and 81 tons, respectively. Sixty-seven percent of the reporting mills indicated they had changed their marketing strategies as a result of the downturn. Forty-six percent of the respondents reported they were exporting production to overseas markets.

The Appalachian region is known for its diverse and valuable hardwood timber resources. As one of the most important hardwood lumber-producing regions in the United States, it supplies 68 percent of the eastern hardwood sawtimber (Powell et al. 1993). In addition, more than 70 percent of the hardwood lumber produced in the United States is manufactured at mills located in this region.

Hardwood sawmills are the foundation of the Appalachian hardwood industry. The production capacity of hardwood sawmills in the region ranged from less than 100,000 board feet (BF) to more than 50 million board feet (MMBF) per year (Luppold 1995, Luppold et al. 2000). From 2000 to 2007, the production of US hardwood lumber declined approximately 25 percent, due in part to globalization (American Hardwood Export Council 2006, Parhizkar et al. 2009). Meanwhile, eastern US hardwood lumber production dropped 23 percent between 1997 and 2008 (Luppold 2009). Furthermore, the current economic downturn and the reduction in furniture manufacturing are adding to the challenges that US hardwood sawmills are facing. The economic recession has slowed demand for wood products, causing a reduction of housing units from 2.2 million units in 2005 to less than 500,000 units in 2009 (United Nations

Economic Commission for Europe [UNECE] 2009). To compensate for the lower demand of hardwood products, approximately one-half of US sawmills had to temporarily curtail production or close (UNECE 2009). Specifically, during the recent economic downturn, Appalachian hardwood production was reduced by more than 40 percent (Wang et al. 2010).

It is evident that the economic downturn has caused many Appalachian hardwood sawmills to change business practices. Many sawmill owners are actively diversifying their marketing strategies and shifting partial domestic shares to

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overseas markets. Wang et al. (2010) reported that there are concerns over nonpayment and the high cost of transportation when exporting hardwood lumber. These two issues have resulted in significant entry barriers for many Appalachian sawmills. To survive in the current turbulent economic conditions, it is essential for Appalachian hardwood producers to change their management strategies and become more market oriented by identifying new markets that have high demand for their products.

The objective of this study was to better understand the impact that the 2008 to 2010 economic downturn had on the Appalachian hardwood lumber industry and its sawmilling practices. Specifically, the study examined changes in operating hours, employment, production volume, wood residue amount, log inventory, break-even or money-losing production, and marketing and exporting practices before and after the economic downturn.

Methods

The survey was designed using the Dillman's tailored design method due to the large number of questions involved (Dillman 2000). Each mail survey contained a cover letter, a questionnaire, and a postage-paid return envelope. The cover letter explained the nature and importance of the survey and stressed firm anonymity for any information provided. The questionnaires were designed to gather information on the Appalachian hardwood sawmill industry before and after the 2008 economic downturn. A total of 59 questions were asked, covering general company information, processing and production, energy consumption and efficiency, management strategies, and marketing and export strategies. A pretest questionnaire was sent to five firms in West Virginia in the summer of 2010, and changes were made as a result of the pretest. The mailing list of hardwood firms was obtained from the National Hardwood Lumber Association, the Appalachian Regional Commission, and other state agencies. Approximately 776 firms, identified as hardwood sawmills in the Appalachian region, were selected as the sample population. In the summer of 2010, formal mail surveys were conducted to collect data from US hardwood firms in the Appalachian region. All nonrespondents, except for nondelivery from the first survey, were sent a second questionnaire in the fall of 2010.

Returned surveys were examined for completeness and usability and then entered into Excel spreadsheets and analyzed using the Statistical Analysis System (SAS). The responding mills were categorized by years in operation: long-term (more than 50 y), medium-term (25 to 50 y), and short-term (25 or fewer y) operations. Mills were also categorized based on their production in board feet per week: high (more than 200,000 BF), medium (40,000 to 200,000 BF), and low (less than 40,000 BF) production.

Results and Discussion

Response

A total of 238 responses were received, of which 58 surveys were usable. One hundred twenty-three surveys were undeliverable or returned due to address change. Fifty-seven surveys were returned blank, with insufficient information, or from firms that were no longer in the hardwood sawmill business. Thus, the adjusted response rate of this survey was 9.7 percent (the adjusted response

rate was calculated by dividing the number of returned and completed questionnaires by the total number mailed after subtracting unusable and undeliverable questionnaires). The low response rate is attributed to the following reasons: (1) the mailing list included primary and secondary wood products manufacturers, however, the survey only focused on the primary processors (i.e., sawmills); and (2) the list was last updated 5 years ago and some operations may have gone out of business or moved without a forwarding address or had an expired forwarding address.

Nonresponse bias

Nonresponse bias was assessed by comparing the responses of the early and late respondents based on the method presented by Smith et al. (2004). This practice assumes that there is a continuum from early respondents to late respondents. Early respondents were those who responded to the first survey, while late respondents were those who responded to the second survey. The results indicated that there were no significant differences in nonresponse bias for the interested variables between the early and the late respondents (such as firm size [$P = 0.166$], operation years [$P = 0.6548$], and production levels [$P = 0.4739$]) when using the analysis of variance (ANOVA), which suggests that a nonresponse bias was not a significant factor in the study. Our sample characteristics (such as average number of employees, operating hours, and lumber production) were found to be consistent with the real industry parameters. For example, the average number of employees, operating hours per year, and lumber production (thousand board feet) per year for sawmills located in West Virginia in the years 2008 and 2010 were 40, 2,332, and 8,558, respectively, in our survey. According to another investigation on hardwood sawmills in West Virginia that was conducted by the Industrial Assessment Center at West Virginia University from 2008 to 2010, these numbers were 34, 2,278, and 7,234, respectively (B. Gopalakrishnan, Department of Industrial and Management Systems Engineering, West Virginia University, Morgantown, personal communication, 2010). Therefore, the responding sawmills were representative of the hardwood sawmill industry in the Appalachian region.

Hardwood sawmill profile

A majority of the responding sawmills (57%) used circle-saw headrigs and the remaining (43%) used bandsaw headrigs. When collecting information on production volume and number of employees, it was important to know if the respondents included information from one or more facilities. Among the respondents, 74 percent reported being a single facility while 26 percent of the respondents owned multiple facilities. Most of the sawmills included in the survey were medium size (46%) in terms of weekly lumber production volume, while small and large size accounted for 25 and 29 percent, respectively. The majority of the respondents in the Appalachian region (70%) were short- and medium-term operations in terms of years in business. When asked how many shifts per week in their current operation, most respondents (89%) reported they were running one shift per week.

General information about production and employment statistics of sawmills is presented in Table 1. The average number of employees per mill decreased from 42 in 2008 to

Table 1.—Production and employment statistics of sawmills in 2008 and 2010 year.

Variable	Year	Mean ± SD (range)
Operating hours	2008	2,336 ± 578 (1,440–4,032)
	2010	2,132 ± 515 (768–4,032)
No. of employees	2008	42 ± 64 (1–400)
	2010	30 ± 39 (0–200)
Production (BF/wk) ^a	2008	196,792 ± 274,051 (800–1,500,000)
	2010	145,610 ± 150,490 (700–600,000)

^a BF = board feet.

30 in 2010, a reduction of 29 percent. Even though four sawmills hired new employees during 2008 to 2010, the total number of new employees was still relatively small in this survey. These four respondents stated that they had changed their marketing strategies under the tough economic circumstances. From 2008 to 2010, average yearly operation hours decreased by 9 percent. In 2010, the weekly lumber production decreased by 26 percent compared with 2008. Based on the decline in employment, operating hours, and lumber production, it was clear that drastic changes had occurred since the economic downturn in the Appalachian sawmills.

A paired *t* test was used to determine whether or not there was a difference (at the 5% significance level) in annual operating hours, number of employees, and weekly production between 2008 and 2010 for the surveyed sawmills (Table 2). Results indicated that the number of employees ($P = 0.0267$), annual operating hours ($P = 0.0005$), and weekly lumber production ($P = 0.0248$) changed significantly from 2008 to 2010.

Table 2.—Operation hours, employees, and production changes between 2008 and 2010.

Variable	<i>t</i> value	<i>P</i> value	Range	SD	SE
Change in operation hours	-3.74	0.0005	-2,000–0	393.4	54.56
Change in employees	-2.28	0.0267	-265–2	37.85	5.15
Change in production (BF/wk) ^a	-2.32	0.0248	-1,000,000–6,650	163,389	23,106.7

^a BF = board feet.

Table 3.—Changes in number of employees by different years and production level category.

Year	Years in operation category, mean (range) ^a			Production level category, mean (range) ^b		
	Long	Medium	Short	High	Medium	Low
2008	32 (4–53)	58 (1–400)	19 (1–67)	97 (27–400)	29 (5–105)	9 (1–30)
2010	26 (4–50)	39 (1–200)	15 (1–53)	73 (27–200)	21 (0–50)	6 (1–30)

^a Years in operation: long-term (>50 y), medium-term (25 to 50 y), and short-term (<25 y) operation.

^b Production levels (board feet per week): high (>200,000), medium (40,000 to 200,000), and low (<40,000) production.

Table 4.—Changes in operating hours by different years and production level category.

Year	Years in operation category, mean (range) ^a			Production level category, mean (range) ^b		
	Long	Medium	Short	High	Medium	Low
2008	2,269 (1,960–4,032)	2,321 (1,440–4,000)	2,463 (1,440–4,000)	2,824 (2,000–4,032)	2,156 (1,920–3,250)	2,123 (1,440–3,016)
2010	2,160 (1,600–4,032)	2,141 (960–4,000)	2,072 (768–2,600)	2,438 (1,800–4,032)	2,032 (1,600–2,340)	1,976 (768–3,016)

^a Years in operation: long-term (>50 y), medium-term (25 to 50 y), and short-term (<25 y) operation.

^b Production levels (board feet per week): high (>200,000), medium (40,000 to 200,000), and low (<40,000) production.

Changes in employment, operating hours, and production

Changes in employment.—Given the lower demand for hardwood lumber, many sawmills went out of business and most of the remaining mills curtailed production. Decreased production directly relates to increases in unemployment throughout the whole hardwood industry. Changes in employment were evaluated from data representing the period before and after the economic downturn (Table 3). The average number of employees in long-term operating sawmills was reduced by 19 percent between 2008 and 2010. However, the decline rates were 33 and 21 percent for medium- and short-term sawmill operations, respectively. The results indicated that more employment opportunities were lost in short- and medium-term operating sawmills.

Additionally, the change in employment numbers for each production level was analyzed. Reduction in employment from 2008 to 2010 was determined to be, on average, 33, 28, and 25 percent for low, medium, and high production sawmills, respectively. Therefore, the number of employees had drastically decreased in sawmills in all the different production levels during the economic downturn.

Changes in operating hours.—The changes in annual operating hours by different operating years and production levels are shown in Table 4. The responding sawmills experienced a decline in operating hours from 2008 to 2010. Specifically, average annual operating hours for short-, medium-, and long-term operating sawmills was 16, 8, and 5 percent, respectively. These results suggest that long-term operating sawmills may have had more capability to deal with economic downturn, as they were able to keep their mills running without significantly reducing operating hours.

Table 5.—Weekly production (board feet) changes of surveyed sawmills by different years and production level category.

Year	Years in operation category, mean (range) ^a			Production level category, mean (range) ^b		
	Long	Medium	Short	High	Medium	Low
2008	143,212 (25,000–350,000)	261,358 (800–1,500,000)	128,983 (3,000–400,000)	489,700 (240,000–500,000)	110,974 (53,200–250,000)	19,041 (800–80,000)
2010	117,324 (25,000–350,000)	181,454 (800–600,000)	103,716 (700–300,000)	349,120 (225,000–600,000)	87,511 (40,000–199,500)	12,263 (700–36,000)

^a Years in operation: long-term (>50 y), medium-term (25 to 50 y), and short-term (<25 y) operation.

^b Production levels (board feet per week): high (>200,000), medium (40,000 to 200,000), and low (<40,000) production.

When comparing the changes of operating hours by different production levels, the most significant decrease in annual operation hours was found in high production sawmills. Specifically, high production sawmills had a 14 percent decline in operating hours between 2008 and 2010. Sawmills at lower and medium production levels operated at an average of 7 and 6 percent, respectively.

Changes in production.—The weekly change in lumber production of surveyed sawmills by operating years and production level is presented in Table 5. The results indicate that almost all the responding sawmills experienced some lumber production decline from 2008 to 2010. The changes in weekly lumber production by operating years were analyzed. In 2010, the average weekly lumber production among long-term operating sawmills was reduced by 18 percent, as compared with 2008, and was less than sawmills in medium-term (31%) and short-term (20%) operating sawmills. The results indicate that in terms of weekly lumber production, the economic downturn likely had a more negative impact on sawmills with medium- and short-term years in operation.

By comparing the average weekly lumber production decrease in terms of different production levels, sawmills at a low production level showed the most decline (36%) as compared with those at medium (22%) or high (29%) production levels. Based on the study results, of the respondents, lumber production decreased the most at low production level sawmills.

Wood residue production

Information on wood residue (i.e., chips and sawdust) production at Appalachian sawmills in 2010 was collected in this study (Table 6). Average residue production in the responding sawmills was 139 tons per week for chips and 81 tons per week for sawdust. Chips and sawdust production in hardwood sawmills was also analyzed based on different years in operation and production levels (Table 7). The results indicated that more wood residue was produced from sawmills with medium-term years in operation, as compared with those with long- or short-term years in operation. Similarly, chips and sawdust production in high production

level sawmills was more than those at medium or low production level sawmills. Effective handling and utilization of wood residue can help improve the profits of hardwood sawmills. The survey result on the utilization of wood residues in the Appalachian region showed that most of the wood residue (37%) was used for animal bedding and litter, followed by boiler fuel (34%), and pulp and paper (23%; Fig. 1). Other wood residue uses included landscape mulch, wood pellets, and medium-density fiberboard. Some smaller size sawmills stated that they gave away the wood residue, mainly because they could not produce enough residue to warrant selling.

In the last few years, the housing slump and the global economic downturn have seriously affected the lumber industry. This downturn resulted in reduced availability of wood residues. Although wood residues are being utilized for pulp chips, composite production, and fuel for energy production, a significant amount of wood residues enters the waste stream (Wang et al. 2007). There may be potential for sawmill owners to sell waste material for use in value-added products, rather than disposing of their residue. Managers should actively seek new markets for residual products currently viewed as waste.

Log inventory

The surveyed mills were asked questions related to their typical log inventory. Log inventory of the respondent sawmills in the Appalachian region averaged 6 weeks in 2010 (Table 6). Sixty-four percent of the respondents stated that their log inventories decreased, 28 percent held the same inventory level, and the remainder (8%) increased their log inventory. The reasons for decreasing log inventory included insufficient capital for purchasing logs, increased competition for raw material supply, higher log prices, and weather-related issues. To meet customers' orders, a mill manager has to select the logs to process and decide on a sawing procedure and schedule production to meet the demand on time and at a minimum cost (Mendoza et al. 1991). Since log inventory management is important and difficult, using computer control software systems or operation research methods to manage log inventory may be necessary for hardwood sawmills to improve profit.

Log inventory in the responding sawmills was analyzed in terms of different years in operation and production levels (Table 7). It was found that sawmills with medium-term years in operation had more log inventory compared with sawmills with long- or short-term years in operation. Low production sawmills held approximately two times more log inventory (10 wk) than medium or high production sawmills. While specific reasons between the relationships in production size to log inventory found in this study was somewhat unclear, it was thought that perhaps lean

Table 6.—Log inventory, residue production, and break-even and lose money statistics of sawmills in 2010.

Variable	Mean ± SD (range)
Log inventory (wk)	6 ± 8 (0–50)
Chips/wk (tons)	139 ± 166 (0.2–1,000)
Sawdust/wk (tons)	81 ± 101 (0–500)
Break even (mo)	18 ± 19 (0–60)
Lose money (mo)	13 ± 15 (0–60)

Table 7.—An average of wood residue, log inventory, and break-even and lose money statistics by years and production level category.

Variable	Years in operation category ^a			Production level category ^b		
	Long	Medium	Short	High	Medium	Low
Chips (tons/wk)	94	167	145	257	91	48
Sawdust (tons/wk)	71	94	62	152	55	18
Log inventory (wk)	4	8	5	4	5	10
Break even (mo)	27	19	8	35	13	9
Lose money (mo)	16	15	6	19	14	7

^a Years in operation: long-term (>50 y), medium-term (25 to 50 y), and short-term (<25 y) operation.

^b Production levels (board feet per week): high (>200,000), medium (40,000 to 200,000), and low (<40,000) production.

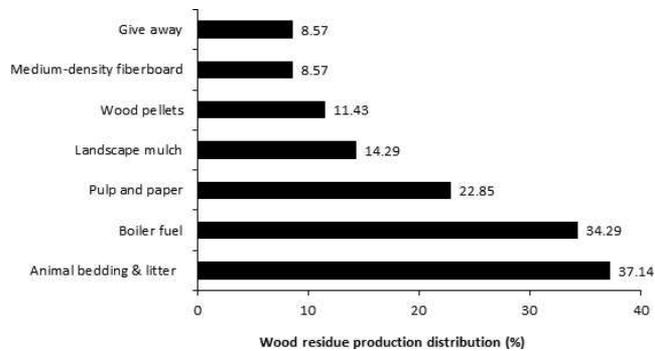


Figure 1.—Percentage of respondents reporting sales and disposition of chips and sawdust for selected products and applications.

manufacturing principles may have played a role. In this study, 33 percent of the large sawmills reported utilizing lean manufacturing principles. This finding suggests that the application of lean manufacturing principles in hardwood sawmills has been slow, as compared with other industries, and is consistent with that indicated by Hansen (2005).

The survey also asked whether there were problems in finding/purchasing logs or raw materials between 2008 and 2010. Approximately 60 percent of the respondents answered “Yes.” The major reasons included shortage of loggers, profit margin decrease, competition, raw material price increase, and insufficient raw material supply. Not being able to find a secure log supply may become a critical factor if or when the hardwood industry recognizes an increased demand in future years.

Break-even analysis

In general, sawmills have been struggling to make profits due to the economic downturn that started in 2008. Many sawmills that are still in operation are finding it difficult to break even while operating in this challenging economic time. To address this issue, the survey asked “How long would you be willing to break even or lose money before shutting your company down (months)?” The average “break-even” and “lose money” times were 18 and 13 months, respectively (Table 6). The break-even operation time in months among the responding sawmills was analyzed based on different years in operation and production levels (Table 7). Long-term years in operation sawmills allowed for more time in the break-even or lose money time frame compared with sawmills with medium- or short-term years in operation. Long-term years in

operation sawmills seemed to be more optimistic about the future as it relates to improving markets and demand. Sawmills at the high production level were willing to operate almost four times longer at break-even production and twice as long when losing money compared with mills at the low production level. Typically a large amount of capital is invested into large facilities. If the owners are making payments, it is better for the mill to continue operating while losing some money, rather than closing.

Market distribution and strategies

The typical end-use customers for the hardwood industry include construction, industrial, and exports markets (Manchester et al. 2009). These industries experienced great difficulty during the economic downturn, which significantly impacted the hardwood market. The traditional markets for hardwood lumber, such as furniture and cabinetry, have declined sharply. Mill owners have been forced to find new markets such as railroad ties to compensate for reduced demand in other areas (Buehlmann et al. 2010). Typical secondary markets such as pallet stock, railroad ties, and mine timbers also became a larger percentage of hardwood end use, especially pallet manufacturing (Manchester et al. 2009). Hardwood sawmills should develop relationships with their customers and search for new markets with higher demand, especially in the turbulent times.

In the survey, the types of wood products produced in the Appalachian sawmills in 2010 were evaluated (Fig. 2). The results showed that 88, 40, 66, and 28 percent of the respondents produced lumber, railroad ties, pallet stock, and veneer, respectively. About 21 percent of respondents also produced other products such as rail fence, post, and mine cribbing. The results showed that sawmills usually diversify their wood product types to meet the market demand. The top three wood products produced by the surveyed sawmills were lumber, pallets, and railroad ties, which accounted for 36, 30, and 18 percent of the total, respectively. In addition, 65 percent of the respondents stated that producing lumber can achieve the greatest profit margin. However, it is important to note that many sawmills are making good profit from the secondary products such as pallet stock since lumber prices have decreased sharply.

It was noted that the current economic downturn had dramatically decreased the profit margins of some previous high-profit lumber. For example, the prices of yellow-poplar Firsts and Seconds (FAS) boards dropped by 18 percent from January 2008 to August 2010 (Hardwood Market Report 2008, 2009, 2010). While the price of yellow-poplar FAS boards slightly increased during the second half of

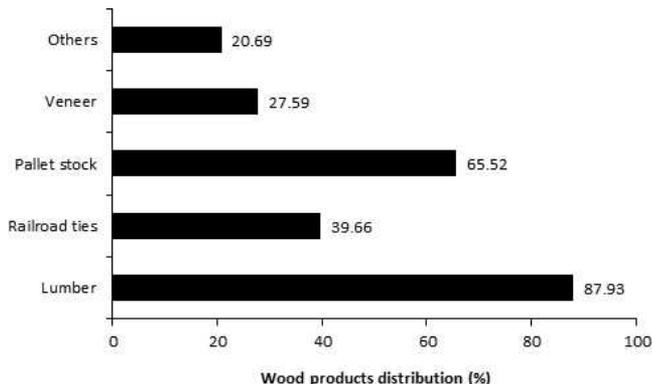


Figure 2.—Percentage of mills reporting production of selected products.

2009, it again decreased after August 2010. The hardest hit species was black cherry, whose market prices fell almost 33 percent (FAS board) from January 2008 to August 2010. During the same time frame, the price of No. 1 Common (1C) black cherry boards decreased by 47 percent, and the lowest price occurred at the end of 2009. The lumber price drop coupled with high fuel surcharges of 2008, caused a significant burden on many sawmill owners in Appalachia and other regions in the United States (Hardwood Market Report 2008, 2009, 2010). The lumber species that generated the greatest or lowest profit margins among the Appalachian sawmills were analyzed based on the survey responses (Fig. 3). Oak was the highest profit species, which accounted for 38 percent of the total respondents, followed by hard maple, ash, and walnut. Yellow-poplar was the lowest profit species (36%), followed by cherry, soft maple, and hickory.

Efficient marketing is very important in maintaining sawmill profitability in the ever changing economy. Current economic conditions are challenging the commonly used marketing strategies by many hardwoods sawmills because they are insufficient in the current economy. Therefore, traditional commodity marketing strategies used by many hardwoods sawmills need to change to weather current economic downturn and housing marketing conditions. The surveyed respondents were asked to list the marketing strategies they currently used. The results showed that exporting products (46%) and advertising (38%) were the major strategies, followed by contacting customers and finding new markets. Additional revenue can be realized by improving export strategies. To compensate for the decline

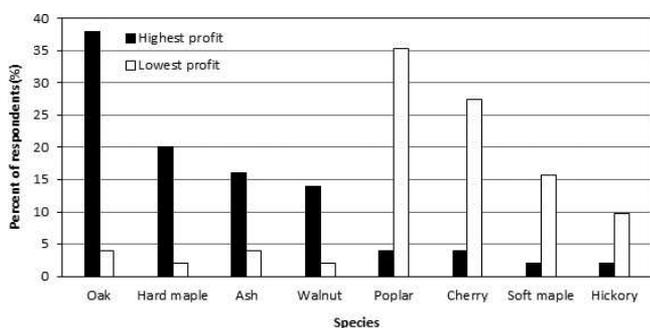


Figure 3.—Respondents' ranking of species for highest and lowest profit.

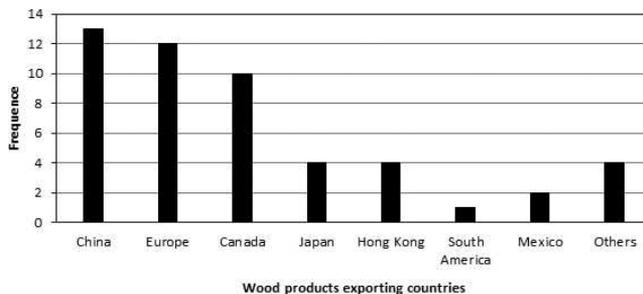


Figure 4.—Percentage of respondents reporting exports to selected foreign countries.

in the domestic housing and furniture markets, many hardwood companies have begun exploring international markets. The respondents were also asked, “Have your company’s marketing strategies changed because of the tough economic times?” More than half of the responding sawmills (67%) stated that they have changed their marketing strategies. To adequately meet the needs of changing market conditions, mill managers must become more market oriented. Managers should contact customers to make sure their product adequately meets the customers’ needs.

Exporting can offer several advantages for hardwood sawmills, including the potential for increased profit, market expansion, disposing of excess products, and economic stability resulting from diversification (McMahon and Gottko 1989). Among the exporting sawmills, more than half (55%) exported both logs and lumber, 9 percent exported only logs, and 36 percent exported only lumber. Results of the survey showed that the most frequent export destinations of the Appalachian hardwood products were China, Europe, and Canada (Fig. 4), which were consistent with the findings of a previous survey conducted in 2008 by Wang et al. (2010). When asked how they export their hardwood products, most of the respondents sold products to a middleman in the United States who would then export them. Respondents indicated that the second-most likely export method was direct export to foreign manufacturers, and the third method was that the respondents sold products to a middleman in a foreign country who would sell to the customer.

To gain insight into how hardwood producers feel about the duration of the industry’s recovery, respondents were asked, “How long do you believe it will take for the forest products markets to improve?” The answers tended to be diverse. Most of the respondents (46%) indicated between 1 and 2 years, followed by 2 to 5 years (28%), less than 6 months (13%), and never (13%). The results indicated that there are still a large percentage of sawmills that are confident in the hardwood market. This optimism in the time frame for a turnaround in demand may also help explain why many sawmills kept running even at the risk of losing money.

Conclusions

This study profiled Appalachian hardwood sawmills in 2008 and 2010 in terms of employment, operating hours, production volume, wood residue production, log inventory, break-even or money-losing production, and marketing and exporting strategies. The survey results show that hardwood

sawmills in Appalachia have experienced significant changes since the economic downturn starting in 2008. The average number of employees has decreased by 29 percent, the average yearly operating hours have decreased by 9 percent, and the average weekly lumber production has decreased by 26 percent in the Appalachian region. It should be noted that the generalization of the findings from this study may be limited due to the small sample size.

The changes caused by the economic downturn varied among different years in business and production levels. Decreases in employee numbers, operating hours, and weekly lumber production occurred in sawmills with fewer years in business. Log inventories can have a great impact on the health of the wood industry. In this study, log inventory across the industry averaged 6 weeks in 2010. Due to the economic uncertainty of log prices, managers were more likely to keep inventory at a minimum level to reduce the risk of losing money when market prices changed. Average residue production in the responding sawmills was 139 tons per week for chips and 81 tons per week for sawdust in 2010.

More than half of the responding sawmills (67%) stated that they have changed their marketing strategies. The traditional markets for hardwood lumber changed in the past few years. Pallets became a larger percentage of hardwood end use. The results found that almost half of the respondents (46%) stated they exported their wood products to an overseas market. In consideration of the demand for hardwood lumber from foreign countries and globalization of the wood products market, it is recommended that hardwood sawmills diversify marketing strategies, and in particular increase their wood products export percentage, to survive in the current tough economic times.

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Literature Cited

American Hardwood Export Council. 2006. Another record year for U.S. hardwood lumber exports. *American Hardwood News*. February, Issue 4. 2 pp.

Buehlmann, U., O. Espinoza, M. Bumgardner, and B. Smith. 2010. Trends in the US hardwood lumber distribution: Changing products, customers, and services. *Forest Prod. J.* 60(6):547–553.

Dillman, D. A. 2000. *Mail and Internet Surveys: The Tailored Design Method*. 2nd ed. John Wiley and Sons Inc., New York. 464 pp.

Hansen, B. 2005. A more competitive hardwood industry economic and environment benefits. USDA Forest Service, Northeastern Research Station. *Forest Science Review*. Issue 4.

Hardwood Market Report. 2008. Lumber newsletter, vol. LXXXVI(1–52). Hardwood Market Report, Memphis, Tennessee.

Hardwood Market Report. 2009. Lumber newsletter, vol. LXXXVII(1–52). Hardwood Market Report, Memphis, Tennessee.

Hardwood Market Report. 2010. Lumber newsletter, vol. LXXXVIII(1–52). Hardwood Market Report, Memphis, Tennessee.

Luppold, W. G. 1995. Effect of the hardwood resource on the sawmill industry in the central and Appalachian regions. *In: General Technical Report NE-197, Proceedings of the 10th Central Hardwood Forest Conference*, K. W. Gottschalk and S. L. C. Fosbroke (Eds.), March 5–8, 1995, Morgantown, West Virginia; USDA Forest Service, Northeastern Forest Experiment Station, Radnor, Pennsylvania. pp. 481–487.

Luppold, W. G. 2009. The North American hardwood market: Past, present, and future. http://www.fcba.fr/ischp/ischp.ca/FR/pdf/1_comession1/Luppold_northamerican.pdf. Accessed May 1, 2011.

Luppold, W. G., J. Baumgras, and G. Barrett. 2000. Characteristics of the eastern “grade” hardwood sawmilling industry. *Forest Prod. J.* 50(9): 23–27.

Manchester, B., W. Adrian, M. Jason, and T. James. 2009. The hardwood sawmill market—A time for consolidation. http://www.mcgladrey.com/Portals/0/InTheNews_PDF/MCMHardwoodsReport.pdf. Accessed May 1, 2011.

McMahon, R. O. and J. Gottko. 1989. Export marketing activities of small-firm lumber manufacturers. *Studies in Management and Accounting for the Forest Products Industry Monograph No. 31*. College of Business and College of Forestry, Oregon State University, Corvallis.

Mendoza, G. A., R. J. Meimban, P. A. Araman, and W. G. Luppold. 1991. Combined log inventory and process simulation models for the planning and control of sawmill operations. *In: Proceedings of the 23rd CIRP International Seminar on Manufacturing Systems*, June 6–7, 1991, Nancy, France; US Forest Service, Washington, D.C. 8 pp.

Parhizkar, O., R. L. Smith, and C. Miller. 2009. Comparison of important competitiveness factors for small- to medium-sized forest enterprises. *Forest Prod. J.* 59(5):81–86.

Powell, D. S., J. L. Faulkner, D. R. Dan, Z. Zhiliang, and D. W. MacCleery. 1993. Forest resources of the United States, 1992. Technical Report RM-234. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 132 pp.

Smith, R., P. Wibke, P. Araman, and D. Cumbo. 2004. Characterizing the adoption of low-grade hardwood lumber by the secondary wood processing industry. *Forest Prod. J.* 54(12):15–24.

United Nations Economic Commission for Europe (UNECE). 2009. Forest products annual market review 2008–2009. <http://timber.unece.org/fileadmin/DAM/publications/ExecutiveSummary2009FPAMR.pdf>. Accessed May 1, 2011.

Wang, J., S. Grushecky, and J. McNeel. 2007. Biomass resources, uses, and opportunities in West Virginia. *Biomaterials and Wood Utilization Research Center, Division of Forestry and Natural Resources*, West Virginia University, Morgantown. 116 pp. <http://www.wdscapps.caf.wvu.edu/biomatwurctr/files/wvbiomass09102007.pdf>. Accessed August 5, 2011.

Wang, J., J. Wu, D. DeVallance, and J. Armstrong. 2010. Appalachian hardwood product exports—An analysis of the current Chinese market. *Forest Prod. J.* 60(1):94–99.