

U.S. Hardwood Sawmill Log Procurement Practices

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U.S. hardwood sawmill log procurement practices are evolving because of the recent economic recession, market and supply chain shifts, and changing landowner objectives, among other factors. The objective of this study was to characterize the log procurement practices of hardwood sawmills and to characterize the role that log brokers play in supplying the sawmill industry with raw material. To meet this objective, a mail survey on hardwood log procurement practices in the U.S. hardwood sawmill industry was conducted. Survey respondents highlighted several factors that had major effects on their businesses, including “Increasing fuel and trucking cost,” “High logging cost,” “Unpredictable log supply,” “Log shortages,” “Logger shortages,” and “Low log quality,” among others. Results showed that large sawmills tend to rely more on gatewood from loggers and stumpage harvested by company contract loggers than do small- and medium-sized sawmills. This study failed to find an increase in the role of log brokers as an intermediary between landowners and hardwood sawmills during the last decade. Moreover, sawmills indicated only a limited demand for log broker services, with log delivery and the procurement of specialty logs identified as being the most highly demanded broker services.

Keywords: Forest products supply chain; Hardwood sawmills; Log procurement; Log broker

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INTRODUCTION

The primary forest products supply chain consists of six major participants, including forest landowners, professional foresters, loggers, log brokers, sawmills, and lumber distributors (Wiedenbeck *et al.* 2004; Damery *et al.* 2008). While not every transaction involves all these partners, all of them add value to the chain and serve specific functions. However, starting in 2007, because of the economic downturn, sawmill log demand decreased and many loggers were forced to cease business (Hardwood Market Report 2012). Today, with the economy recovering and demand for hardwood products increasing at healthy rates, decreased supply chain capacity has created challenges in supplying sufficient sawlogs for sawmills.

Primary wood producers, especially sawmills, depend on a stable, reliable supply of logs with specific characteristics to maximize mill efficiency and to remain competitive (Dramm *et al.* 2002; Anderson and Germain 2007). The main challenges of sawmill log procurement operations are in (1) finding reliable sources of raw materials to guarantee

consistent log supply; (2) building relationships with a range of timber suppliers to procure a wide variety of desired log products; and (3) locating operations in close proximity to markets with good transportation infrastructure (Dramm *et al.* 2002, 2004). Log brokers can serve an important role in the log supply chain as they have the flexibility of procuring logs from many different suppliers, which can help address these three challenges. The objective of this study was to identify the log procurement practices of hardwood sawmills, with a special focus on log brokers' role from a sawmill point-of-view.

RESEARCH BACKGROUND

Since the 1990s, the primary forest products supply chain in the United States has been continuously adjusting to changing market conditions (Buehlmann *et al.* 2007, 2010, 2012; Espinoza *et al.* 2011; Woodall *et al.* 2011). Economic globalization has brought considerable market share losses for U.S. manufacturers in the primary forest products supply chain (Luppold and Bumgardner 2006, 2013; Buehlmann *et al.* 2007, 2010, 2011; Buehlmann and Schuler 2009). Hardwood sawmills reported declining annual production levels from 1999 to 2003 (Luppold and Bumgardner 2006; Hardwood Market Report 2012) and then again from 2007 through 2012 (Buehlmann *et al.* 2007, 2010, 2012; Woodall *et al.* 2011; Hardwood Market Report 2012). The production levels of sawmills reached their lowest point in 2009 and only started to show substantiated growth in 2012 (Hardwood Market Report 2012). Today, while hardwood lumber demand continues to recover, the housing market, arguably an important consumer of hardwood lumber, remains volatile due to macroeconomic factors such as rising interest rates, lack of well-paying jobs, declining real median annual household incomes, strict home loan lending standards, and new banking regulations (Buehlmann and Schuler 2013).

In order to provide green or dried hardwood lumber in multiple species, sizes, and qualities, hardwood sawmills rely on a stable and competitively-priced hardwood log supply to remain competitive (Dramm *et al.* 2002; Anderson and Germain 2007; Buehlmann *et al.* 2010). Historically, sawmills, especially large ones, grew much of their timber on land owned by their company and purchased the remaining standing timber directly from other private landowners (McClure 2009). In the late 1980s, these large sawmills divested their timberlands and began relying more on purchased wood from "gatewood" loggers and from other private landowners (McClure 2009). Gatewood refers to wood hauled to a sawmill by independent landowners or loggers, which was not pre-purchased as standing timber by the sawmill (McClure 2009). Conversely, the sawmill can also offer landowners a price for timber standing "on the stump", often referred to as stumpage. Landowners may enter into agreements with sawmills to supply their stumpage to their mill over a long period of time. Loggers, who may be employees of the sawmill or contracted by the sawmill, harvest the stumpage that has been purchased by the sawmill from landowners. The stumpage, however, can also be purchased and harvested by independent loggers or purchased by log brokers before being sold to the sawmill. Typically, hardwood sawmills in the United States procure logs within 25 to 100 miles of the mill, depending on product requirements, log availability, and production needs (Anderson and Germain 2007; Anderson 2008; Grushecky *et al.* 2011; Grushecky *et al.* 2012). Fragmentation of private forestlands, exploitative harvesting practices, changes in

landowner objectives in favor of recreational and conservation values, and the decreasing number of logging companies (Kenefic and Nyland 2005; Anderson and Germain 2007; Timber Harvesting 2011; Riitters *et al.* 2012), have negatively affected the ability of sawmills to find reliable, consistent sources of logs in close proximity to their mills. Thus, log brokering businesses, with their focus on wholesale log procurement, appear to be well-positioned to fill the gap as intermediaries between landowners (loggers) and sawmills. Theoretically, log brokers could ease the challenges faced by sawmills by providing a wide variety of logs to sawmills, especially when procuring logs of uncommon sizes, species, and quantities, even if this requires procurement from longer distances.

Montague *et al.* (2013) reported that log brokers' procurement activities represent approximately one percent of the total U.S. hardwood log procurement. Despite the small number of log brokers, they maintain a diverse log procurement base as they obtain gatewood; stumpage procured from loggers, landowners, and broker-owned lands; logs procured from other yards or mills, and logs harvested by company contract loggers or independent loggers, as well as from other log brokers (Montague *et al.* 2013). The role of log brokers in the export log market is growing; by 2011, 61% of U.S. log brokers reported to have export activities to Asia, Canada, and/or Europe (Montague *et al.* 2013). Log brokers who participated in this study reported white oak, red oak, walnut, hard maple, and soft maple as the top five procurement species in 2011. When log brokers were asked about Chain-of-Custody certification, only 16% of the responding log brokers reported procuring logs from certified sources and even fewer (7%) reported selling logs as certified. Finally, Montague *et al.* (2013) reported that log brokers perceived timely and efficient log delivery to be their most highly-demanded service, followed by short lead times on log deliveries and the provision of hard-to-obtain species.

This manuscript identifies log procurement activities and strategies of U.S. hardwood sawmills. The six objectives of this study were: 1) to characterize the log procurement activities of hardwood sawmills in 2011; 2) to evaluate factors affecting hardwood sawmills' decision-making in regards to log procurement activities; 3) to characterize issues related to the log procurement activities of hardwood sawmills in 2011; 4) to characterize the sources of logs procured by hardwood sawmills in 2011; 5) to assess any changes in the log procurement sources of hardwood sawmills between 2007 to 2011; and 6) to evaluate hardwood sawmills' demand toward various log brokerage services in 2011.

RESEARCH METHODOLOGY

This project consisted of two phases. In the first phase, semi-structured phone interviews (Dillman *et al.* 2009) were conducted to collect information from State Utilization and Marketing (U&M) specialists about the log procurement practices of hardwood sawmills and log brokers located in their respective states. During these interviews, issues that have considerably affected the log supply chain in the past 5 to 10 years were addressed. The phone interviews were performed in February and March 2012 with eight U&M specialists located in CT, IN, KY, MN, NY, VA, VT, and WV. The phone interviews were designed as semi-structured yet informal interviews, *e.g.*, prior to the interview a set of interview questions were developed to guide the discussion but

interviewees were allowed to freely talk about the topics. All phone interviews were recorded with the permission of the participants, and then transcribed. Also, during the interviews, notes were taken and following the interviews a report was created of what had been discussed. This initial report was then used to provide the basis for designing and conducting a mail survey capturing the eastern U.S. in the second phase of this study. For this phase, two nearly-identical questionnaires, one addressed to log brokers (Montague *et al.* 2013) and a second one to hardwood sawmills (subject of this manuscript), were developed to investigate the opportunities and challenges of hardwood sawlog procurement.

Questionnaire Design

Both the log broker questionnaire (Montague *et al.* 2013) and the hardwood sawmill questionnaire were designed based on Dillman's Tailored Design Method (Dillman *et al.* 2009). To avoid bias, achieve accuracy, and build equivalency, nearly identical questions were formed in both questionnaires. However, whenever it was strategically necessary, questions were phrased in different ways (Dillman *et al.* 2009). Both questionnaires consisted of a total of 24 questions covering three main areas including company characteristics, log procurement activities, and domestic log distribution. The survey asked for data for 2007 and 2011. Filling out the questionnaires took approximately 20 to 30 minutes. To accurately assess respondents' opinions and behavior, three types of questions were used (closed-ended questions, partially open-ended questions with an "Other" option, and open-ended questions with short answers). To ensure that the surveys met their purposes, feedback was obtained from academic experts at Virginia Tech, research scientists at the USDA Forest Service, U&M specialists, and industry experts. Based on the feedback provided, minor adjustments to the questionnaires were made.

Data Collection

The survey sampled hardwood sawmills in 24 eastern states (CT, DE, IA, IL, IN, KY, MA, MD, ME, MI, MN, MO, NC, NH, NJ, NY, OH, PA, RI, TN, VA, VT, WI, and WV), which was the same region used for the related log broker survey (Montague *et al.* 2013). These states represent the preponderance of hardwood logging and sawmilling operations in the eastern U.S. For this hardwood sawmill survey, an address list was compiled using databases from the National Hardwood Lumber Manufacturers' Association (NHLA); Appalachian Hardwood Manufacturers, Inc. (AHMI); and cooperative extension specialists, universities, and online industry directories. The final sample frame consisted of 2,823 hardwood sawmills. The survey was mailed on May 2012 with a tracking number, a return envelope with pre-paid postage, and a personalized cover letter explaining the objectives of the study. Two weeks later, a reminder postcard was sent out to those companies who had not yet replied. Four weeks after the initial mailing, a second survey (identical to the first one) was mailed to all non-respondents. Two weeks after that, another reminder postcard was sent out to non-respondents. Eight weeks after the initial mailing, the survey was closed.

Response Rate

From the original 2,823 mailings, 302 were returned by survey participants because they were not hardwood sawmills, 260 because they were wrong addresses, and 48 because

they were businesses that had closed. Therefore, the adjusted sample frame was comprised of 2,213 sawmills. An additional 29 respondents refused participation in the survey. A total of 276 valid responses were received during the survey time frame, which resulted in a 12.5% adjusted response rate.

Non-response Bias

After closing the survey on July 10, 2012, 30 randomly selected non-respondents from the hardwood sawmill address list were contacted by phone and fax to obtain answers to four survey questions including geographical region (categorized as Northeast, Midwest, and South (U.S. Census Bureau 2000)), number of full-time employees (categorized as less than 5 employees, 5 to 9 employees, 10 to 19 employees, 20 to 99 employees, and more than 99 employees (U.S. Census Bureau 2008)), volume of logs processed (categorized as $x < 2$ mmbf, $2 \text{ mmbf} \leq x \leq 5$ mmbf, $x > 5$ mmbf (Anderson 2008, Smith *et al.* 2003)), and whether they purchased any specialty logs in 2011 (categorized as “yes” and “no”). The responses from this phone survey were used to test for non-response bias (Malhotra 1996; Armstrong and Overton 1977). Verbal and fax responses to these questions were recorded and entered into the database. To evaluate non-response bias, the 30 responses extracted from non-respondents for the four questions were analyzed using a nominal logistic regression in JMP (SAS Institute, Inc. 2012) at $\alpha = 0.05$. No statistically significant differences between respondents and non-respondents were found ($p = 0.0631$). Individual p -values ranged from $p = 0.2210$ for geographical region, $p = 0.4279$ for number of full-time employees, and $p = 0.8529$ for volume of logs processed to $p = 0.2691$ for whether or not they purchased any specialty logs in 2011.

Statistical Analysis

Descriptive statistics were used to summarize the data set and to measure central tendency (mean) and variability (standard deviation). Nominal rankings and five-point Likert-scale ratings are presented in two different formats: in terms of the rating mean score (*e.g.*, “Likert-score” displayed in figures), and as frequency counts (*e.g.* bases of Chi-Square test).

As the availability, quality, and prices of logs may differ among hardwood sawmills located in different regions of the U.S., the effect of geographical location on log procurement activities is investigated as an important factor of this study. Also, as increasing log prices may favor larger hardwood sawmills with sufficient production and capital to survive the volatility of the market, company size is investigated as an important factor of this study. To investigate whether geographical region (Northeast [CT, MA, ME, NH, NJ, NY, PA, RI, VT], Midwest [IA, IL, IN, MI, MN, MO, OH, WI], or South [DE, KY, MD, NC, TN, VA, WV]), and production volume ($x < 2$ mmbf, $2 \text{ mmbf} \leq x \leq 5$ mmbf, $x > 5$ mmbf) have an effect on log procurement strategies and systems, a one-way analysis of variance (ANOVA) test was performed with categorical predictor variables and continuous response variables. To ensure that the assumptions of the ANOVA test are met, a Goodness of Fit test was performed to test for normality of the residuals, followed by a two-sided F-test for equal variances. When the assumption of normality failed (caused by the large proportion of zero responses), a Kruskal-Wallis non-parametric test was performed. To further elaborate on significant differences indicated by the ANOVA tests, further Kruskal-Wallis tests were performed with $\alpha = 0.05$. When both predictor and

response variables were categorical, a nominal logistic regression model was used to analyze the data.

To further elaborate on significant differences indicated by the nominal logistic regression model, contingency analysis combined with correspondence analysis were used to plot which rows or columns of the contingency table have similar patterns of counts. Also, a Pearson's Chi-Squared test was used to establish significant differences among responses addressing the log procurement practices of the companies, the factors affecting sawmills' business activities, and the level of demand toward log broker services based on geographical region (Northeast, Midwest, and South) and production volume ($x < 2$ mmbf, $2 \text{ mmbf} \leq x \leq 5$ mmbf, $x > 5$ mmbf). Because analyzing responses based on a five-point Likert-scale violates the assumptions of expected cell counts of the Pearson's Chi-Square test (five or more responses in each response category for each group (Lehman *et al.* 2005)), responses were analyzed using a Fisher's Exact test in JMP ® Pro software 10.0 (SAS Institute, Inc. 2012).

Limitations of the Study

As with all mail surveys, "single response bias" can occur by receiving responses from only one person per sawmill. Also, not all respondents were directly involved with log procurement, and thus some misinformation may have been conveyed by a few of the respondents on certain questions. Another limitation of this study is that only the hardwood sawmill industry from 24 eastern states was queried, so results cannot be generalized beyond that segment. Given the response rate of this survey (12.64%), one has to be cautious about generalizing its findings. Also, the study covered a time when the worst recession since the Great Depression was occurring (Ferrara 2014), which may have disproportionately affected respondents' answers.

RESULTS

Study results obtained from the hardwood sawmills queried are presented as follows: 1) characterization of log procurement activities; 2) characterization of log suppliers in 2011; 3) assessment of changes that occurred in the log procurement from 2007 to 2011; 4) evaluation of factors affecting decision making in regards to log procurement activities; 5) characterization of issues related to log procurement; and 6) evaluation of demand for log broker services.

Characteristics of Responding Hardwood Sawmills and Their Log Procurement Activities

The majority (76%) of the total 276 survey respondents were owners, CEOs, or partners of responding companies; 12% were mill operation managers; and 7% were log procurement managers; while 5% had other titles such as office managers, general managers, financial representatives, or sales representatives. All 276 respondents answered the question about mill location. Most of the responses were received from the Midwest followed by the South and the Northeast (50, 28, and 22%, respectively). The vast majority of the responding sawmills (71%) reported having been in business for over 20 years, 25%

for over 6 years, and 4% had been in operation for 5 or fewer years. Twenty-five percent of the 276 respondents reported having fewer than 5 employees, 18% between 5 and 9 employees, 23% between 10 and 19 employees, 31% between 20 and 99 employees, and 3% more than 99 employees. Responding sawmills (N=276) operated an average of 9 hours per day for an average of 210 days in 2011.

The demographic question that asked the total volume of logs processed in 2011 received 241 valid responses. Missing responses occurred for confidentiality reasons or when the log scale associated with the volume was not provided. Forty percent of the respondents were categorized as “small sawmills” (processing less than 2 mmbf International ¼-inch scale annually), 24% as “medium sawmills” (2 mmbf \leq log volumes processed \leq 5 mmbf), and 36% as “large sawmills” (processing more than 5 mmbf annually). Respondents were asked to list their most commonly-sawn hardwood log species in 2011. The 10 most common hardwood species sawn by the 271 responding hardwood sawmills were: red oak (29%), white oak (15%), yellow poplar (11%), hard maple (10%), white ash (7%), soft maple (7%), walnut (3%), cherry (2%), hickory (2%), and aspen (2%). Out of the 276 responses to the question “How many species did your mill saw in 2011?,” 52, 38, and 10% indicated that their mill sawed 1 to 5, 6 to 10, and more than 10 species, respectively.

There were 276 responses addressing specialty log procurement (*e.g.*, logs of special sizes, uncommon species, special color, and/or special character), with 74% of respondents indicating their company did not procure large volumes of specialty logs. Hardwood sawmills that procure specialty logs reported that, on average, 22% of all logs procured were specialty logs. Fifty-one percent of 276 respondents reported that an average of 10% of all hardwood logs procured were subsequently resold. Two hundred and seventy-two sawmills responded to the question as to what log grades they procured, while four mills did not respond to this question as they procured their logs from their own land. Results indicate that 40% of the logs procured by responding firms were intermediate-grade logs, 33% were lower grades, 19% were prime grades, 4% were veneer grades, and 4% were other log grades, such as mixed grade logs, or ungraded logs.

Sources of Logs Procured by Hardwood Sawmills in 2007 and 2011

Because one of the main objectives of log procurement operations is finding reliable sources of raw materials that satisfy the size, species, and quality requirements of the sawmill, respondents were asked to indicate the sources of logs they procured in 2011. Mean responses to this question are listed in Table 1. A total of 275 hardwood sawmills provided information about the proportions of logs procured from different sources, including: 1) gatewood from loggers; 2) gatewood from landowners; 3) stumpage harvested by company-employed loggers; 4) stumpage harvested by independent loggers; 5) stumpage harvested by company contract loggers; 6) logs from other yards or mills; 7) logs from land owned by their company; 8) logs from log brokers; and 9) other log sources. Significant differences were found among the respondents' log source procurement choices (Kruskal-Wallis non-parametric test for equality of means, $p < 0.0001$). Further investigation using the Tukey-Kramer HSD test showed that respondents procured significantly more gatewood from loggers (Table 1, Column 2) than from any other log sources. Furthermore, respondents procured significantly more gatewood from landowners, stumpage harvested by company-employed loggers, stumpage harvested by

independent loggers, and stumpage harvested by company contract loggers than logs from land owned by respondents' companies. Finally, respondents procured a significantly lower percentage of logs from other yards or mills, from log brokers, and from other sources than they did from other providers.

To test whether the region in which the sawmill was located had an effect on the selection of log sources, a Kruskal-Wallis non-parametric test was conducted. Results showed significant log source differences among both different region categories ($p < 0.0001$) and among different production volume categories ($p < 0.0001$). To further elucidate the significant differences detected for region, mean responses between regional categories were compared using the Kruskal-Wallis non-parametric test (Table 1, Column 7). Significant differences in the proportion of logs procured as gatewood from loggers ($p = 0.0006$), stumpage harvested by company contract loggers ($p = 0.0028$), and logs from other yards or mills ($p = 0.0207$) were detected among regions. Further investigation using the Tukey-Kramer test shows that the proportion of gatewood procured from loggers tends to be significantly lower in the Northeast states (Table 1, Column 4-6) than in any other states, while the proportion of stumpage harvested by company contract loggers tends to be significantly lower in the Midwest states as compared with the Northeast states. Also, the proportion of logs procured from other yards tends to be significantly lower in the Midwest states than in the Northeast states; however, the Tukey-Kramer test did not detect this difference (Table 1, Column 8-10).

Results of the Kruskal-Wallis non-parametric test for differences in log sources based on sawmill production levels (Table 1) indicated significant differences in the proportions of logs procured as gatewood from loggers ($p = 0.0189$) and stumpage harvested by company contract loggers ($p < 0.0001$). Further investigation of these differences using a Tukey-Kramer test revealed that the proportion of stumpage harvested by company contract loggers tends to be significantly lower for small size hardwood sawmills than for medium- and large-size sawmills. Also, the mean proportion of gatewood procured from loggers was lower for small-sized hardwood sawmills than for medium- and large-sized sawmills; however, the Tukey-Kramer test was not able to detect any significant difference.

This study also assessed changes in log procurement sources for hardwood sawmills from 2007 to 2011. Because seven respondents started their business after 2007, only 269 responses were analyzed. To investigate trends in log procurement sources, paired t-tests were performed for each of the nine log source categories. No significant differences between log source proportions between 2007 and 2011 were found.

Factors Affecting Hardwood Sawmills' Decision-making with Respect to Log Procurement Activities

Survey participants were asked to rate their level of agreement with nine statements related to their companies' log procurement practices (Fig. 1). The two highest-ranked statements were: "Our company purchases logs on a consistent basis" with an average response of 3.89 on a Likert-scale from 1 (strongly disagree) to 5 (strongly agree); and 2)

Table 1. Distribution and analysis of hardwood logs procured from different log sources in 2011 for region and volume categories using the Kruskal-Wallis non-parametric test. Significant differences are marked using a star for those log sources that were different among log sources, region, and volume categories. An * indicates a significant p-value based on the Kruskal-Wallis test. A, B, C, and D superscripts indicate class groupings based on the Tukey-Kramer test.

Log Source Category (2011)	Mean Response (%)	Standard Deviation (%)	Northeast (%) N = 61	Midwest (%) N = 137	South (%) N = 78	Region P-value	Volume Response (x < 2 mmbf, %) N = 96	Volume Response (2 mmbf < x ≤ 5 mmbf, %) N = 57	Volume Response (x > 5 mmbf, %) N = 88	Volume P-value
Gatewood from Loggers	33.09 ^A	33.55	20.26 ^B	34.28 ^A	41.05 ^A	0.0006*	27.79 ^A	33.89 ^A	35.20 ^A	0.0189*
Gatewood from Landowners	14.69 ^B	24.16	15.88 ^A	13.51 ^A	15.84 ^A	0.2835	19.47 ^A	11.80 ^A	11.46 ^A	0.5564
Stumpage Harvested by Company Contract Loggers	14.32 ^B	26.29	21.32 ^A	10.09 ^B	16.28 ^{AB}	0.0028*	6.96 ^B	19.63 ^A	19.79 ^A	< 0.0001*
Stumpage Harvested by Independent Loggers	13.00 ^B	22.78	10.52 ^A	15.41 ^A	10.71 ^A	0.5520	12.05 ^A	17.19 ^A	11.65 ^A	0.1912
Stumpage Harvested by Company-Employed Loggers	10.57 ^{BC}	23.92	15.98 ^A	11.20 ^{AB}	5.25 ^B	0.1581	11.95 ^A	10.68 ^A	9.17 ^A	0.7794
Logs from Land Owned by their Company	5.61 ^{CD}	17.29	6.54 ^A	6.34 ^A	3.62 ^A	0.4675	10.16 ^A	2.01 ^B	4.25 ^{AB}	0.2578
Logs from Other Yards or Mills	3.34 ^D	13.23	5.47 ^A	1.83 ^A	4.33 ^A	0.0207*	4.94 ^A	1.45 ^A	3.21 ^A	0.0529
Other Log Sources	3.13 ^D	15.39	2.34 ^A	5.12 ^A	0.25 ^A	0.0854	4.93 ^A	1.50 ^A	2.29 ^A	0.6045
Logs from Log Brokers	1.86 ^D	8.97	1.44 ^A	2.18 ^A	1.65 ^A	0.5719	1.65 ^A	1.82 ^A	1.94 ^A	0.2192

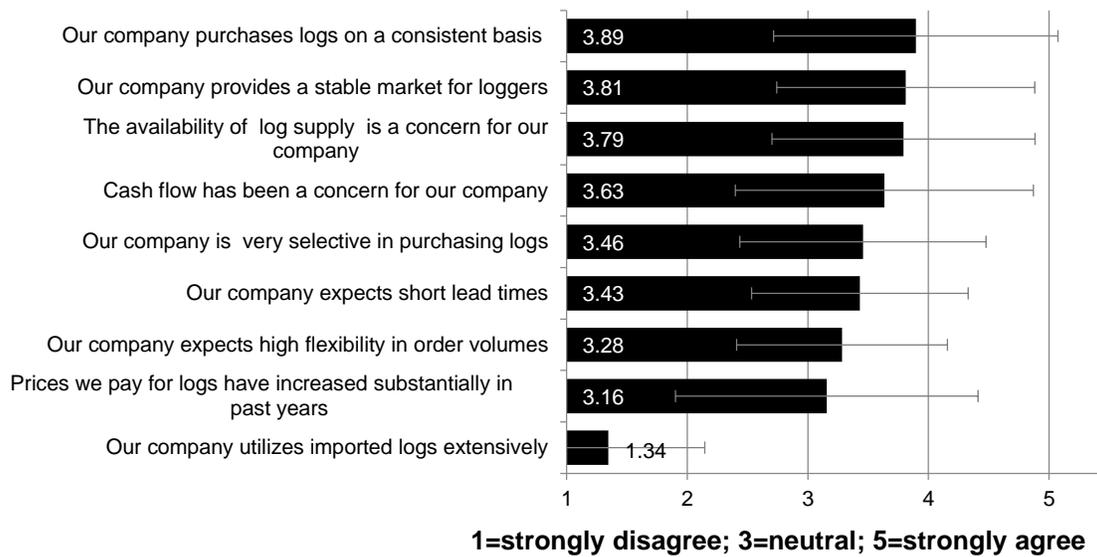


Fig. 1. Levels of agreement with statements related to respondents' log procurement practices and requirements. Mean response ratings and standard deviation bars are shown for each statement.

“Our company provides a stable market for loggers” with an average response of 3.81. Respondents also indicated that “The availability of log supply” and “Cash flow” has been a concern for their companies. Respondents also expressed their agreement with the statements of “Our company is very selective in purchasing logs,” “Our company expects short lead times,” and “Our company expects high flexibility in order volumes.” Respondents were slightly less in agreement with the statement “Prices we pay for logs have increased substantially in the past years.” The lowest ranked statement by respondents is “Our company utilizes imported logs extensively” with an average response of 1.34.

Results of a Chi-squared test and Fisher’s Exact test showed significant differences among responses provided for the statements “Our company provides a stable market for loggers” and “Our company purchases logs on a consistent basis” by both region (Fisher’s Exact test, $p = 0.0394$ and Chi-square test, $p = 0.0411$, respectively) and production volume (Fisher’s Exact test, $p < 0.0001$ and Chi-squared test, $p < 0.0001$, respectively). Using a correspondence analysis plot, it appears that sawmills located in the South had significantly higher levels of agreement with both statements than those located in the Midwest. Results also indicated that medium- and large-size hardwood sawmills had significantly higher levels of agreement with the statement “Our company provides a stable market for loggers” than small-size sawmills, while large-size hardwood sawmills indicated significantly higher levels of agreement with the statement “Our company purchases logs on a consistent basis” than medium-size sawmills, and they both indicated significantly higher levels of agreement than small-size sawmills.

Also, significant differences exist among responses to the statement of “The availability of log supply is a concern for our company” by the production volume category (Chi-squared test, $p = 0.0053$). The correspondence analysis plot indicated that medium- and large-size hardwood sawmills had significantly higher levels of agreement with this statement than small size ones. Lastly, significant differences exist among responses

provided to the statement of “Our company expects short lead times” among the different region categories (Fisher’s Exact test, $p = 0.0473$); however, the correspondence analysis plot did not indicate any clearly separable tendencies.

Issues Related to the Log Procurement Activities of Hardwood Sawmills in 2011

Survey respondents were asked to indicate the three factors that most strongly influence their log procurement practices. A total of 222 sawmills responded to this question. Responses to this open-ended question were grouped into 13 main categories, listed in Fig. 2. The most frequently-cited factors were: uncertain market conditions (104 respondents), raw material prices (e.g., log and timber, 89 citations), and transportation distance from the mill and its costs (76). Respondents also listed the availability (71) and quality (66) of desired log species as factors that affect their procurement decision-making. The remaining factors, cited less than 40 times each, included weather that prevents logging, cash-flow concerns, logging cost, standing inventory, lack of qualified loggers, governmental regulations, increasing competition, and customer value.

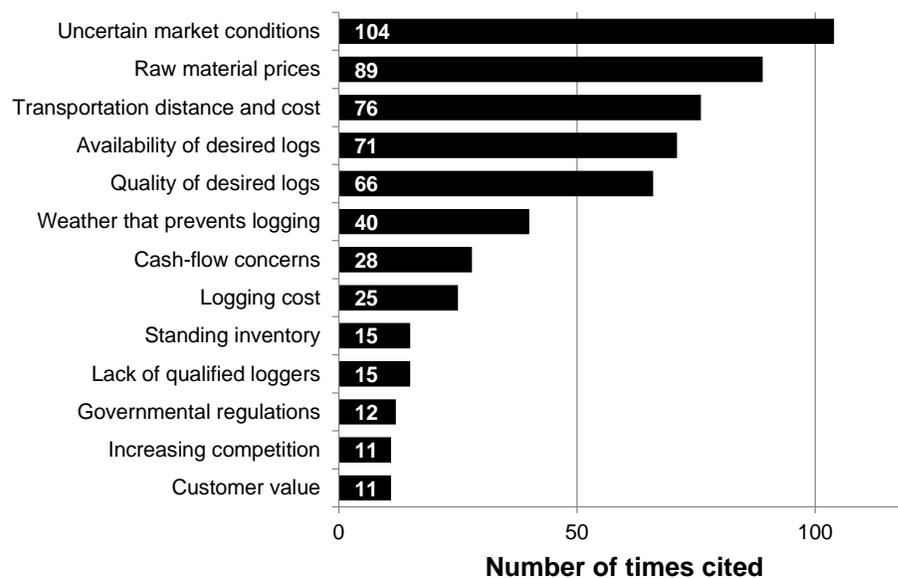


Fig. 2. Factors affecting respondents' log procurement decisions and practices

To gain a deeper understanding of the challenges that respondents face in regards to their log procurement practices, survey respondents were asked to provide more details about the log procurement issues currently affecting their sawmill businesses. Results from 276 responses to this question are displayed in Fig. 3. Respondents reported struggling with “Increasing fuel and trucking cost” (average response of 1.79 on a Likert-scale from 1 (major negative effect) to 5 (major positive effect) and “High logging cost” (average response of 2.13) the most. Furthermore, “Unpredictable log supply,” along with “Log shortages,” “Logger shortages,” and “Low log quality” also were regarded as problematic (Fig. 3). Respondents were also concerned that “Stumpage bids are turned down due to low prices.” Factors like “Increasing log exports,” “Availability of certified logs,” and “Local wood bioenergy markets” received, on average, relatively neutral ratings.

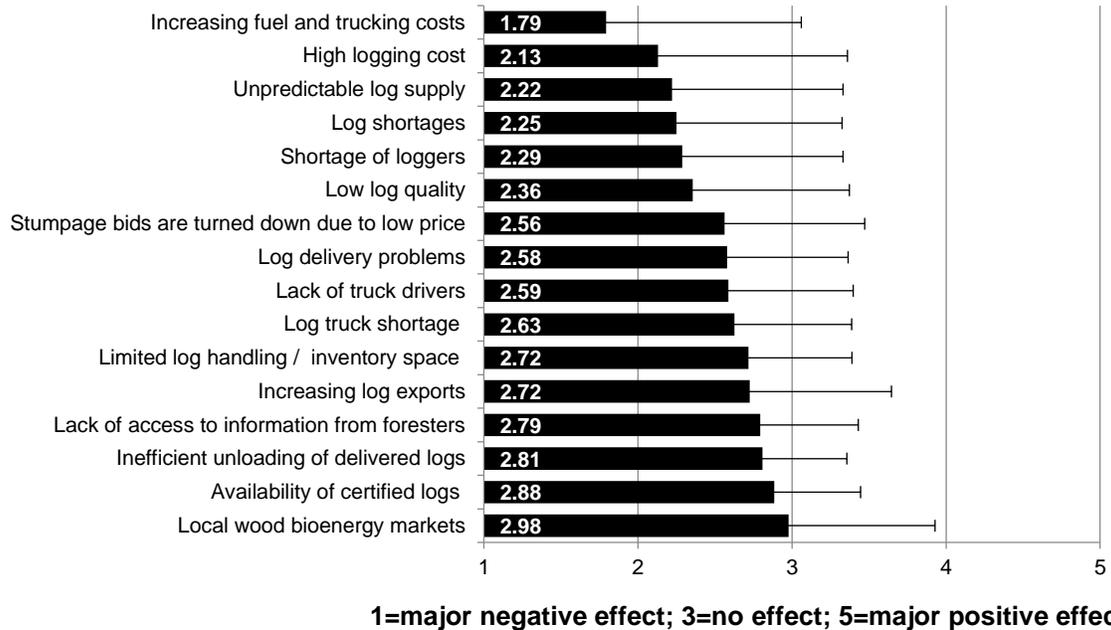


Fig. 3. Factors affecting respondents' business activities. Mean response ratings and standard deviation bars are shown for each statement.

Significant differences exist among responses provided to the statement of “Increasing fuel and trucking cost” in different production volume categories (Chi-squared test, $p = 0.0160$). A correspondence analysis plot was used to further investigate the differences and indicated that large hardwood sawmills experienced significantly greater negative effects of “Increasing fuel and trucking costs” than small sawmills. Another difference found among respondents of different production volume categories was related to the effect of “Logger shortages ($p < 0.0001$).” Further investigation with a correspondence analysis plot showed that large hardwood sawmills experienced significantly greater negative effects of “Logger shortages” than small sawmills. Lastly, significant differences were found in regards to the statement of “Increasing log exports” for both region ($p = 0.0022$) and production volume ($p = 0.0145$); however, the correspondence analysis plot did not indicate any clearly separable tendencies.

Although survey participants indicated above that the “Availability of certified logs” has almost no effect on their businesses (rating of 2.88 on the 1 (major negative effect) to 5 (major positive effect) Likert scale, Fig. 3), the topic of Chain-of-Custody certification was further investigated in this study. Ten percent of all hardwood sawmills questioned reported having Chain-of-Custody certification, 85% of which reported to having a Forest Stewardship Council (FSC) certification and 14% a Sustainable Forestry Initiative (SFI) certification. Only 43% of the hardwood sawmills who reported to have a certificate claimed that it is financially beneficial for them. Respondents were also asked to indicate the percentage of certified logs they procure and the percentage of certified products they sell on a yearly basis. Hardwood sawmills reported that an average of 31% of their logs come from certified sources and that they sell an average of 16% of their products as certified. Linear logistic regression was used to investigate whether region and/or production volume have an effect on having a Chain-of-Custody certificate. The

effect of region was not found to be significant ($p = 0.3890$); however, large-size hardwood sawmills show a higher tendency to have Chain-of-Custody certification than medium- or small-size hardwood sawmills ($p = 0.0050$).

Hardwood Sawmills' Demand toward Log Broker Services in 2011

To investigate the log broker's role in hardwood sawmills' log procurement activities, respondents were asked to indicate whether they used any log broker services in 2011 and on what scale (Likert-scale of 1 = very low demand, 3 = medium demand, and 5 = very high demand). A total of 114 hardwood sawmills indicated having some level of demand for log broker services in 2011, while the remaining 162 respondents did not indicate any demand. However, in general, sawmills indicated very low or low demand for such services (Fig. 4).

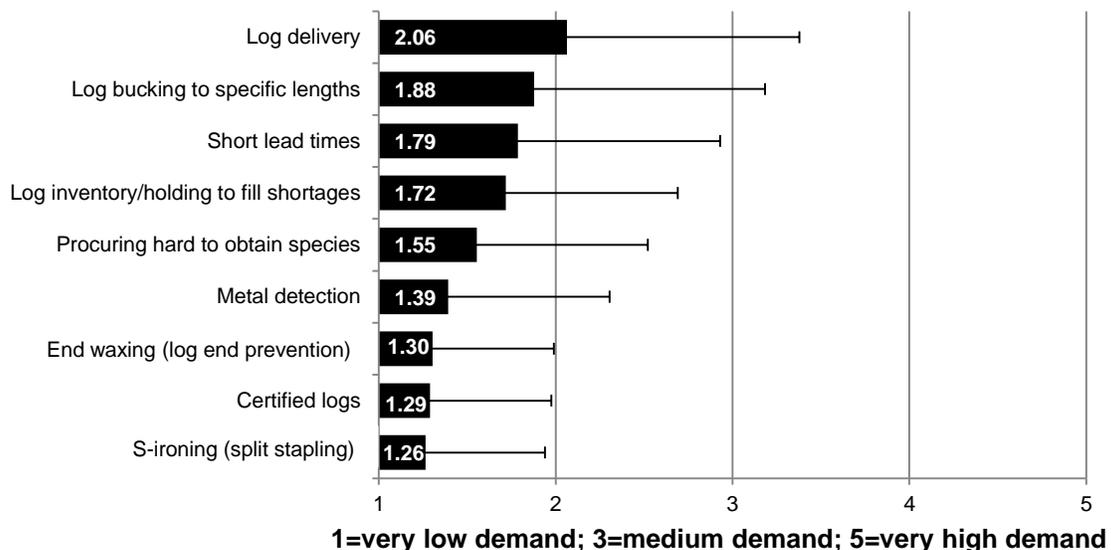


Fig. 4. Hardwood sawmills' mean demand toward log broker services in 2011. Mean response ratings and standard deviation bars are shown for each statement.

Fisher's Exact test was used to examine significant differences among responses about the level of demand for log broker services by hardwood sawmills from different regions and by hardwood sawmills with different production volumes. A significant difference was found in the level of demand toward the log broker service of "Log inventory/holding to fill shortages" among sawmills in different regions ($p = 0.0370$) and volume ($p = 0.0326$) categories. The correspondence analysis plot revealed that sawmills located in the Northeast region tend to show higher levels of demand than sawmills located in the South, while large-size sawmills tend to have higher demands for the service of "Log inventory/holding to fill shortages" than small size sawmills. Furthermore, significant differences were found among responses to the level of demand toward log broker services by hardwood sawmills from different regions in regards to the services of "Log bucking to specific length" ($p = 0.0449$), "Log delivery" ($p = 0.0069$), and "Shorter lead times" ($p = 0.0453$), where the correspondence analysis plot revealed that sawmills located in the Midwest tend to show a higher level of demand than sawmills located in the South; and

also of “End waxing” ($p = 0.0423$), a service that is essential to prevent rapid drying of log ends, where the correspondence analysis plot revealed that sawmills located in the Midwest and in the Northeast tend to show higher levels of demand than sawmills located in the South.

DISCUSSION

Sources of Logs Procured by Hardwood Sawmills in 2011

Results of this study showed that especially small- and medium-size hardwood sawmills procure a larger percentage of gatewood from landowners, a larger percentage of stumpage harvested by independent loggers, and a larger percentage of logs from other log sources than their larger-sized competitors. The relatively high reliance on landowners, independent loggers, and other log sources may come from the inability of small- and medium-size sawmills to compete with larger sawmills for the more expensive logs and stumpage sales. With lumber consumption remaining depressed in 2010, small and mid-sized sawmills were forced to remain in survival mode, which for some meant selling more products locally and developing closer relationships with local landowners and loggers. Therefore, it is expected that for small sawmills, independent loggers, independent log yards, and log brokers will continue to play an essential role in log distribution. Large sawmills, on the other hand, tend to procure a large percentage of gatewood from loggers and also a large percentage of stumpage harvested by company contract loggers. Eventually, it is expected that large sawmills will rely less on independent loggers and more on company contract loggers and that their own logging crews will be able to guarantee the desired stumpage quality and availability. Log brokers may represent such a small source of hardwood supply to sawmills because as intermediaries between landowners and sawmills, their services come with a price, which increases the cost of logs.

Regional differences in log procurement sources for hardwood sawmills were detected, with the results indicating that the vast majority of hardwood sawmills in the Midwest buy gatewood from loggers or stumpage harvested by independent loggers and company contract loggers (Table 1, Column 5). Interviews conducted with State Utilization and Marketing Specialists in 2012 revealed that most loggers in these states work independently; however, large-size sawmills may have informal or verbal contracts with regular suppliers. Also, log brokers in the Midwest have their own well-established marketplace; 2.19 percent of hardwood sawmills located in these states procure logs from log brokers. In the Northeast, the vast majority of sawmills receive their logs as gatewood or through company contract loggers or company-employed loggers (Table 1, Column 4). State Utilization and Marketing Specialists located in the Northern states supported this finding by asserting that the number of independent loggers in the Northeast states has been continuously decreasing and most loggers in the region are contract loggers under contract with sawmills. In fact, the number of contract loggers in the Northeast states is higher than in any other region.

Log brokers play only a small role in the Northeast – 1.66% of hardwood sawmills located in these states procure logs from log brokers. According to State Utilization and Marketing Specialists, log brokers in the Northeast obtain their logs (primarily veneer logs) from landowners or loggers and send them to concentration yards or export. It is believed

by the State Utilization and Marketing Specialists located in the Northeast states that log brokering is increasing because brokers offer a full range of raw materials, *e.g.*, pulp, veneer, and cheaper wood for sawmills.

In the South, the vast majority of sawmills buy gatewood from loggers and landowners and stumpage harvested by company contract loggers (Table 1, Column 6). In the South, sawmills procure considerably more gatewood from loggers than in any other states. State Utilization and Marketing Specialists state that the logger who offers the best price and is closest gets the business. Also, there are very few log brokers in the South (1.45%) and they also tend to buy from loggers.

Hardwood Sawmills' Log Procurement Activities

During the past decade and especially during the past five years, the economic downturn and the resulting volatile market conditions forced hardwood sawmills to reduce their production volumes and adjust to declining customer demand (Hardwood Market Report 2012). For this study, 40% of responding hardwood sawmills were small, processing less than 2 mmbf annually. Such small mills tend to offer more customized services and products than do their larger competitors (Anderson 2008; Espinoza *et al.* 2011) as they are targeting custom and contract sawing jobs and serve niche markets. Thus, their log consumption is limited (Anderson 2008; Espinoza *et al.* 2011), which may explain the persistence of many small sawmills disagreeing with statements of procuring logs on a consistent basis and providing stable markets for loggers.

The availability of logs is a concern for numerous companies, with medium (2 mmbf \leq log volumes processed \leq 5 mmbf) and large-size hardwood sawmills (processing more than 5 mmbf annually) particularly concerned about the issue. Possible explanations may lie in the increasing competition for logs with growing export markets in Canada and Asia. A study conducted by the North East State Foresters Association (2007) reported that approximately 15% of logs harvested in the Northern Forest are shipped to Canada for processing. Opportunities in export, especially to China and other developing nations, are continuously growing. This is consistent with China's demand for wood products, in both log and lumber form (UNECE 2012). While growing export opportunities may be beneficial to log brokers or other traders, they can further intensify localized increases in procurement costs. Such trends may cut into profit margins and result in cash flow problems for hardwood sawmills unless they are compensated by rising lumber prices (Anderson 2008). To better compete in these volatile economic conditions, sawmills tend to develop closer and better relationships with existing log suppliers to be able to remain selective in log purchases, keep short lead times, and maintain flexibility in order volumes (Fig. 1).

Issues Related to Log Procurement Activities of Hardwood Sawmills in 2011

Survey respondents highlighted increasing fuel and transportation costs as the most pressing issues related to log procurement as of 2011 (Fig. 3). Raw material procurement accounts for approximately 60 to 65% of the total manufacturing cost for a sawmill (Gustafsson and Rask 2010; IBISWorld 2013), of which approximately 15 to 40 represents the costs of moving the log from the stump to the mill (Schuler 2005; Siry *et al.* 2006; Anderson and Germain 2007, 2009). In today's highly competitive environment for logs, stumpage bidding can be so competitive that increased fuel costs can erase the razor-thin

profit margins (Timber Harvesting 2011). It is therefore crucially important for sawmills to have strong relationships with nearby landowners, loggers, and log brokers to control their transportation costs (Luppold and Bumgardner 2006; Anderson and Germain 2009).

Survey respondents also revealed their concerns about the unpredictable nature of log supply, log shortages, and logger shortages (Fig. 3). When demand for hardwood logs and lumber from 2006 to 2009 drastically declined during the recent economic downturn, the number of available loggers declined as loggers found alternative employment in other industries (Timber Harvesting 2011; Hardwood Market Report 2012). After the recession, as demand for logs started increasing again, the lack of loggers may have impeded harvesting activities and may continue to do so today. However, given the current strong demand for hardwood lumber, sawmills have some leeway to adjust prices to compensate for increasing procurement costs.

The export of unprocessed logs has received considerable attention over the past decade and has been a source of some concern, particularly in the hardwood sawmill sector (Anderson 2008; Anderson *et al.* 2009). The fact that the manufacture of many solid hardwood products moved overseas also created increasing export demand for logs and lumber. Although, veneer logs are the principal type of log being traded internationally in the United States, saw-grade logs have seen an increase in trade as well (NEFA 2007; Anderson 2008; Anderson *et al.* 2009; Buehlmann and Schuler 2013). Export is especially a concern in the New England states, where competition with Canada is constant and approximately half of the region's hardwood logs are exported to Canada (NEFA 2007; Anderson 2008; Anderson *et al.* 2009).

Respondents of this study reported that, currently, certification programs do not have any effect on hardwood sawmills' decision-making processes with respect to log procurement. During the primary interviews, Jeff Settle, forest certification coordinator of the Indiana Division of Forestry, indicated that if certified wood is demanded, it is veneer or upper-quality sawn logs). Furthermore, representatives of Kentucky, Minnesota, and Virginia emphasized that certification programs are important primarily for large pulp and paper companies and, to some extent, pallet companies, as their customers are becoming more cautious about where the log comes from, but these companies are also becoming more concerned because very limited certified lands exist in the United States.

Although numerous studies have investigated the energy market's impact on procurement activities and the supply chain (Gold and Seuring 2011; Conrad *et al.* 2011), as of 2011, hardwood sawmills did not sense that energy markets would have any effect on their day-to-day operations. Interviewed State Utilization and Marketing Specialists also admitted that much speculation exists on this topic; several biomass plants are opening their doors nationwide, which can provide a market for low-grade wood, but as of 2011 only a very few, smaller operations had actually come on-line.

Hardwood Sawmills' Demand for Log Broker Services in 2011

Log brokers are processing and merchandising primarily high-quality and specialty logs for hardwood sawmills and export markets (Wiedenbeck *et al.* 2004). Because log brokers are procuring logs primarily from small, fragmented, non-industrial private forestlands and from independent loggers, they have the ability to provide a continuous log supply in the desired product mix for hardwood sawmills (Wiedenbeck *et al.* 2004; Damery *et al.* 2008). Moreover, they are able to provide small quantities of logs to small businesses

who cannot afford to purchase large volumes, as well as specialty and character wood logs (Wiedenbeck *et al.* 2004; Damery *et al.* 2008).

One objective of this study was to investigate whether the log broker's role in the primary forest products supply chain has changed during the past five years. The results of this study did not produce any evidence that the log broker's role as an intermediary between landowners and hardwood sawmills has increased over this time frame. Study outcomes indicated that in 2011, only 41% of the responding hardwood sawmills reported having any demand for log broker services. The sawmills that showed a larger interest in log broker services were those that procured specialty logs, *e.g.* special sizes or uncommon species, or needed the logs delivered with short lead times. Volatile economic conditions, however, may increase hardwood sawmills' demand for procuring specific grades and sizes of logs, as their customers are becoming more and more specific on their orders. Also, if the export of logs continues to increase, the role of log brokers in export activities may increase. Based on this study's results, however, it is unclear what long-term effect log brokers may have on the procurement activities of hardwood sawmills.

SUMMARY AND CONCLUSIONS

1. Two parallel surveys, a log broker survey (Montague *et al.* 2013) and a hardwood sawmill survey (current paper) were conducted in the eastern U.S. to investigate log trading mechanisms between landowners and hardwood sawmills and to investigate the role of log brokers as intermediaries. This study used data collected from 276 hardwood sawmills in 24 states to characterize hardwood sawmills' log procurement activities in 2011.
2. The results of this study showed that small- and medium-size hardwood sawmills tend to procure a larger percentage of gatewood from landowners, a larger percentage of stumpage harvested by independent loggers, and a larger percentage of logs from other yards or mills than their larger competitors. In contrast, large sawmills tend to rely more on loggers to procure gatewood and on company contract loggers to harvest stumpage. Study respondents indicated that less than 2% of their hardwood logs were procured from log brokers in 2011.
3. Hardwood sawmill respondents raised some concerns about the unpredictable nature of log supply, log shortages, and logger shortages. The most commonly cited issues of today's sawmills, however, included uncertain market conditions (104 respondents cited), continuously increasing raw material prices (89 respondents cited), continuously increasing fuel and trucking costs (76 respondents cited), and high logging costs, all of which may highly affect operating costs and profitability. As of 2011, the presence of Chain-of-Custody certification programs and energy markets had little effect on hardwood sawmills' decision-making process with respect to log procurement.
4. This research also aimed to investigate log brokers' roles in the primary forest products supply chain. Results did not indicate any increase in log brokers' roles as an intermediary between landowners and hardwood sawmills over the past five years. Moreover, this survey found only a limited demand for log broker services (mostly for

log delivery and procurement of specialty logs) from hardwood sawmills. However, log brokers role in the export markets may be more significant; therefore, it should be further investigated in future studies.

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REFERENCES CITED

- Anderson, N. (2008). "Sawmill wood procurement in the northeast United States," Doctor of Philosophy, Syracuse, NY: State University of New York College of Environmental Science and Forestry. pp.196.
- Anderson, N., and Germain, R. (2007). "Variation and Trends in Sawmill Wood Procurement in the Northeastern United States," *Forest Products Journal* 57(10), 36-44.
- Anderson, N., and Germain, R. (2009). "Land cover, land use, and mill characteristics as predictors of wood procurement range," *Forest Products Journal* 59(11-12), 100-107. DOI: 10.13073/0015-7473-59.11.100
- Anderson, N., Germain R., and Bevilacqua E. (2009). "Characteristics of transborder wood flow to sawmills in eastern Canada." *Forestry Chronicle* 85(1), 1-10. DOI: 10.5558/tfc85110-1
- Armstrong, S. J., and Overton T. S. (1977). "Estimating nonresponse bias in mail surveys," *Journal of Marketing Research* 14(3), 396-402. DOI: 10.2307/3150783
- Buehlmann, U, Bumgardner M., Schuler A., and Barford M. (2007). "Assessing the impacts of global competition on the Appalachian hardwood industry," *Forest Products Journal* 57(3), 89-93.
- Buehlmann, U., Bumgardner M., and Sperber M. (2012). "Current status of the US hardwood industry," in: *2nd Biennial International Conference on Processing Technologies for the Biobased Products Industries*; 2012 November 6-7; St. Simons Island, GA. PTF BPI: 23-25.
- Buehlmann, U., Espinoza O., Bumgardner M., and Smith B. (2010). "Trends in the US hardwood lumber distribution industry: Changing products, customers, and services," *Forest Products Journal* 60(6), 547-553. DOI: 10.13073/0015-7473-60.6.547
- Buehlmann, U., Espinoza O., Smith R., and Bumgardner M. (2011). "Hardwood lumber distribution yards: output, demands, and perceptions of their role," in: *Proceedings of*

- the 17th Central Hardwood Forest Conference*; 2010 April 5-7; Lexington, KY; GTR NRS-P-78.
- Buehlmann, U., and Schuler A. (2009). "The US household furniture industry: Status and opportunities," *Forest Products Journal* 59(9), 20-28.
- Buehlmann, U., and Schuler A. (2013). "May 2013 housing commentary," *Virginia Tech Housing Report*. <http://woodproducts.sbio.vt.edu/housing-report/casa-2013-05-may.pdf>. Accessed on: August 6, 2013.
- Conrad IV, J. L., Bolding, M. C., Smith, R. L., and Aust, W. M. (2011). "Wood-energy market impact on competition, procurement practices, and profitability of landowners and forest products industry in the US south," *Biomass and Bioenergy* 35(1), 280-287. DOI: 10.1016/j.biombioe.2010.08.038
- Damery, D., Yadav L., and Zhao Y. (2008). "Finding and removing barriers to sustainable harvest and primary processing of Massachusetts native woods," USDA Federal State Market Improvement Grant Report, Amherst, MA. pp. 68.
- Dillman, D. A., Smyth J. D., and Christian L. M. (2009). *Internet, Mail, and Mixed-Mode Surveys: The Tailored Design Method*. 3rd Edn., Wiley and Sons, Inc., Hoboken, NJ, pp. 500.
- Dramm, J. R., Govett R., Bilek T., and Jackson G. L. (2004). "Log sort yard economics, planning, and feasibility," GTR FPL-GTR-146. Madison, WI: U.S. Department of Agriculture, Forest Service. pp. 31.
- Dramm, J. R., Jackson, G. L., and Wong, J. (2002). "Review of log sort yards," GTR FPL-GTR-132. Madison, WI: U.S. Department of Agriculture, Forest Service. pp. 39.
- Espinoza, O., Buehlmann, U., Bumgardner, M., and Smith, B. (2011). "Assessing changes in the US hardwood sawmill industry with a focus on markets and distribution," *BioResources* 6(3), 2676-2689.
- Ferrara, P. (2014). "The worst years since the Great Depression," *Forbes*. <http://www.forbes.com/sites/peterferrara/2013/02/07/the-worst-five-years-since-the-great-depression/print/>. Accessed on: February 3, 2014.
- Gold, S., and Seuring, S. (2011). "Supply chain and logistics issues of bio-energy production," *Journal of Cleaner Production* 19(1), 32-42. DOI: 10.1016/j.jclepro.2010.08.009
- Grushecky, S., Wiedenbeck, J., and Spong, B. (2011). "Roundwood markets and utilization in West Virginia and Ohio," in *Proceedings of the 17th Central Hardwood Forest Conference*; 2010 April 5-7; Lexington, KY. GTR NRS-P-78.
- Grushecky, S. T., Wiedenbeck, J., and Hassler, C. C. (2012). "Examination of roundwood utilization rates in West Virginia," *Forest Products Journal* 62(7/8), 507-515. DOI: 10.13073/fpj-d-12-00101.1
- Gustafsson, Å., and Rask L. O. (2010). "Distribution channel structure and integration - contingency variables in the sawmill industry," in NOFOMA Proceedings; 2010 June 10-11; Kolding, Denmark: Linnaeus University, Faculty of Science and Engineering, School of Engineering. pp. 17.
- Hardwood Market Report. (2012). "The North American Hardwood Marketplace 2012 Mid-Year Update," *Hardwood Market Report Publication* 6(8), 1-6.
- IBISWorld. (2013). "Sawmills & Wood Production in the US," *NAICS 32111. IBISWorld Industry Report*. www.ibisworld.com. Accessed on: December 13, 2013.

- Kenefic, L. S., and Nyland R. D. (2005). "Diameter-limit cutting and silviculture in Northeastern forests: A primer for landowners, practitioners, and policymakers." NA-TP-02-05, Newtown Square, PA: U.S. Department of Agriculture, Forest Service, pp. 22.
- Lehman, A., O'Rourke N., Hatcher L., and Stepanski E. J. (2005). *JMP for Basic Univariate and Multivariate Statistics: A Step-by-Step Guide*, SAS Institute, Cary, NC, pp. 481.
- Luppold, W. G., and Bumgardner M. (2006). "Influence of markets and forest composition on lumber production in Pennsylvania," *Northern Journal of Applied Forestry* 23(2), 87-93.
- Luppold, W. G., and Bumgardner M. (2013). "Factors influencing changes in U.S. hardwood log and lumber exports from 1990 to 2011," *BioResources* 8(2), 1615-1624.
- Malhotra, N. (1996). *Marketing Research: An Applied Orientation*, 2nd Edn., Prentice Hall, Upper Saddle River, NJ, pp. 890.
- McClure, N. (2009). "A general description of the timber supply chain in Georgia and the Southern United States," <http://www.gfc.state.ga.us/utilization/forest-biomass/biomass-for-industry/TimberSupplyChaininGeorgiaandtheSouthernUnitedStates-July2009.pdf>. Accessed on: November 26, 2014.
- Montague, I., Andersch, A., Wiedenbeck, J. K., and Buehlmann, U. (2013). "Hardwood supply chain and the role of log brokers in 2012," *Forest Products Journal* 63(5-6), 182-189. DOI: 10.13073/fpj-d-13-00058
- North East State Foresters Association (NEFA). (2007). "The economic importance and wood flows from the forests of Maine, New Hampshire, Vermont and New York, 2007," North East State Foresters Association, Concord, NH, pp. 8.
- Riitters, K. H., Coulston, J. W., and Wickham, J. D. (2012). "Fragmentation of forest communities in the eastern United States," *Forest Ecology and Management* 263, 85-93. DOI: 10.1016/j.foreco.2011.09.022
- SAS Institute Inc. (2012). *Jmp: The Statistical Discovery Software* (version Version 10).
- Schuler, A. (2005). "Economic environment: A comparison of global lumber manufacturing costs," *Structural Building Components Magazine* 22-25.
- Siry, J., Greene, D., Harris, T., and Izlar, R. (2006). "Wood supply chain efficiency and fiber cost: What can we do better?" in: *2006 Council on Forest Engineering (COFE) Conference Proceedings: Working Globally – Sharing Forest Engineering Challenges and Technologies around the World*; 2006 July 22-Aug 2; Coeur d'Alene, ID, pp. 455-461.
- Smith, P. M., Luppold, W. G., and Dasmohapatra, S. (2003). "Estimating the size of the hardwood sawmill industry in Pennsylvania," *Forest Products Journal* 53(6), 19-22.
- Timber Harvesting. (2011). "2011 Logging business survey: Big squeeze," <http://www.timberharvesting.com/2011-logging-business-survey-big-squeeze/>. Accessed on: August 5, 2013.
- UNECE. (2012). "UNECE/FAO forest products annual market review, 2011-2012," <http://www.unece.org/fileadmin/DAM/timber/publications/06.pdf>. Accessed on: November 20, 2014.

- U.S. Census Bureau. (2000). "Census regions and divisions of the United States," http://www.census.gov/geo/maps-data/maps/pdfs/reference/us_regdiv.pdf. Accessed on: May 1, 2014.
- U.S. Census Bureau. (2008). "Statistics about business size from the U.S. Census Bureau," <http://www.census.gov/econ/smallbus.html>. Accessed on: May 1, 2014.
- Wiedenbeck, J., Wiemann, M., Alderman, D., Baumgras, J., and Luppold, W. (2004). "Defining hardwood veneer log quality attributes," GTR NE-313 Newtown Square, PA: U.S. Department of Agriculture, Forest Service, pp. 40.
- Woodall, C.W., Piva, R. J., Skog, K. E., Ince, P. J., and Luppold, W. G. (2011). "An assessment of the downturn in the forest products sector in the northern region of the United States," *Forest Products Journal* 61(8), 604-613. DOI: 10.13073/0015-7473-61.8.604

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