Variation and trends in sawmill wood procurement in the Northeastern United States

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Abstract

The sawmill industry in the Northeastern United States is represented by a wide variety of mills with highly variable roundwood requirements and diverse procurement operations. Data collected from 211 sawmills in seven states are used to characterize wood procurement, with an emphasis on quantifying variation in operations among different types of firms. In general, respondent mills procured 90 percent of their total 2005 roundwood supply from within 30 to 70 miles of the mill, but often ranged 200 miles or more to meet requirements. Of the 1.2 BBF of log procurement reported in the survey, gatewood was the most dominant log source (54%), followed by roadside sources (23%) and stumpage (16%). Fee simple lands, leases, easements and all other sources combined made up less than 8 percent of the total reported volume. A majority of mills reported declines in log quality and volume per log between 1994 and 2005. Results are discussed in the context of regional trends in industry concentration, log exportation, forest parcelization, urbanization, and exploitative harvesting practices.

In the Northeastern United States, the location of firms in the primary forest products industry is closely linked to their proximity to raw materials (Luppold 1995a, Bowe et al. 2004, Luppold and Bumgardner 2006). Generally, sawmills in this region have well-defined woodsheds to procure stumpage and logs, often acquiring much of their roundwood supply from within 25 to 100 miles of the mill, depending on product requirements and production (Germain 1998). In contrast, pulpmills can have much larger woodsheds, often supplementing local roundwood sources with deliveries by rail or boat from great distances. Despite the importance of local woodsheds in supplying raw materials to this industry, there is very little empirical information available to characterize sawmill procurement operations, evaluate the effects of woodshed attributes on procurement, and assess changes in wood procurement over time.

Quality baseline data are especially important in anticipating and adapting operations to the effects of large-scale ecologic, economic, and social changes that can impact the quality and availability of roundwood. Among these changes, the divestment of industrial forest ownerships to institutional investors and the parcelization of nonindustrial private forests (NIPF) have been of central concern in the Northeast in recent years (Decoster 1998, Block and Sample 2001, Butler and Leatherberry 2004, LaPierre and Germain 2005, Germain et al. 2006). In many parts of the country, including the Northeast, urbanization has been recognized as a major threat to the timber supply (Wear et al. 1999, Sampson and DeCoster 2000, Munn et al. 2002, Kline et al. 2004, Nowak and Walton 2005). In addition, past and ongoing exploitative harvesting practices (Fajvan et al. 1998, Nyland 2001, Kenefic and Nyland 2005), as well as changes in landowner objectives in favor of amenity values (Dennis 1989), can have direct impacts on the yield of sawlogs from forestlands. Nonindigenous invasive species (Pimentel et al. 2000), forest-related municipal ordinances (Mortimer et al. 2006), log exports (Jones et al. 1994), and many other factors also have been identified for their potential to affect the timber supply.

In general, factors that diminish the potential of a sawmill's woodshed to supply sawlogs are likely to have negative impacts on the effectiveness and efficiency of procurement operations. Sawmills operating in woodsheds characterized by parcelization, fragmentation, exploitative harvesting, and urbanization may experience a decline in the sawlog resource

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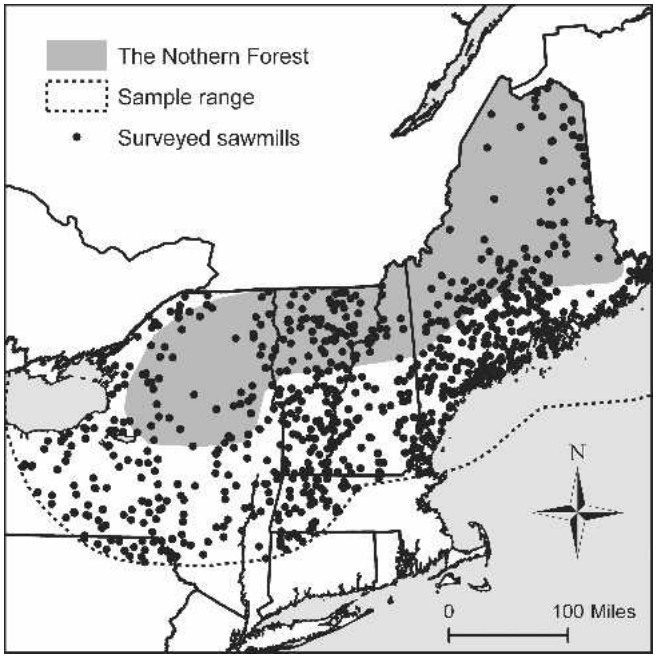

Figure 1. — The approximate boundary of the Northern Forest and distribution of sawmills across the study region (NFLC 1994, Prestemon et al. 2005).

and expand their woodsheds to meet production requirements. Depending on trends in industry structure and competition, procurement costs would be expected to rise in such an environment because of increasing transfer costs and declines in economies of scale in management and purchasing (Bressler and King 1970, Cubbage 1983). However, testing predictions of this nature is difficult, if not impossible, without baseline procurement data.

Objectives

This study quantified the attributes of wood procurement operations for sawmills in four Northeastern states: New York, Vermont, New Hampshire, and Maine. Specifically, we surveyed sawmills within 100 miles of the approximate boundary of the Northern Forest, an area of almost contiguous mixed-hardwood and spruce-fir forest stretching across these four states (**Fig. 1**). The sawmill industry in this region covers a broad range of mill types and production levels, and includes woodsheds in both rural and urbanizing areas. Though some woodsheds have a significant component of state, federal, and industry-owned lands, most are dominated by nonindustrial private forests.

In this paper, we: (1) quantify the geographic extent of the wood procurement operations of sawmills in this region, (2) quantify the relative importance of different roundwood sources, (3) evaluate the degree of variation in procurement operations among different types of firms, and (4) evaluate perceptions of changes in log quality and availability within woodsheds over a 10-year period. These data provide insight into potential limits to concentration in the industry and serve as a baseline for future studies of changes in procurement operations. They also shed light on the potential of ownership and land use changes to affect log supply. Characterizing wood procurement operations contributes to our ability to understand and predict industry trends at regional and subregional scales. This is especially true in areas that are dominated by NIPF, and in areas experiencing significant changes in resource ownership and use. For individual mills, understanding the factors that affect log supply and adapting procurement operations to a changing landscape can have a measurable impact on competitiveness and profitability.

Methods

We used Dillman's Tailored Design Method (Dillman 2000) to survey all sawmills within the study region that were in operation in 2005. The sample frame consisted of sawmill operations listed in State and industry directories, including directories provided by the Univ. of New Hampshire Cooperative Extension (2002); Vermont Dept. of Forests, Parks and Recreation (2001); New York State Dept. of Environmental Conservation (2005); the Maine Forest Service (2000); the Northeastern Lumber Manufacturers Association (2005); and the Hardwood Manufacturers Association (2005). Because some of these publications were not up to date at the time of the survey, we sought updates from state agencies, and cross-referenced our master list with several internet-based telephone directories, as well as listings from Prestemon et al. (2005). There was no minimum production volume necessary to be included on the mailing list, but we did not include mills that were identified as "hobby" or "seasonal" mills in these directories. In general, if we could not confirm that a mill was still in operation at the time of the survey, it was included in the sample frame rather than dropped from the list. Our goal of a complete census of all sawmills within 100 miles of the Northern Forest also required us to survey a small number of mills in Massachusetts, Connecticut, and Pennsylvania, which accounted for 7 percent of the mills in the sample frame.

A four-page survey instrument was designed to collect information about woodshed extent, annual procurement volumes, roundwood sources, and other data relevant to characterizing woodsheds and procurement operations. The survey was developed with feedback from 14 industry professionals, including mill managers, procurement foresters, log buyers, and industry association representatives, and was pilot-tested by a group of attendees at the annual meeting of the New York Society of American Foresters in early February 2006. Three continuous response variables based on open-ended questions were used to evaluate the geographic extent of wood procurement operations. Based on a regional map and a distance scale presented in the survey instrument, respondents were asked to estimate the radius of their woodshed by drawing a line around the area that supplies the closest 90 percent of their total annual log volume, then estimating the average distance to the drawn boundary. They also provided the farthest distance from the mill that they have ever purchased stumpage and the farthest distance a load of logs has traveled to the mill. Unlike some previous studies that have used landownership as a primary category for characterizing log supply, this study focused on five alternative sawlog sources related to the point of ownership transfer: fee simple lands (owned by the company or mill proprietor), timber leases and easements, stumpage, roadside wood, and gatewood (Mayer and Wiedenbeck 2005). Stumpage is purchased by the firm as standing timber, roadside wood includes logs purchased by bid or direct sale from a log landing or concentration yard not owned by the firm, and gatewood includes logs purchased at the mill at the time of delivery. Respondents were asked to estimate the percentage by volume of their total 2005 log supply that was

procured from each of these sources. We also included an "other" category, with a space for explanation.

In addition to the open-ended, quantitative responses, respondents were asked to offer their perceptions of changes in log supply within their woodshed since 1994, the year of release of the recommendations of the Northern Forest Lands Council (NFLC 1994), which offered comprehensive recommendations regarding forest management and policy across the study region. The questions evaluated:

— Change in the total volume of logs available for purchase,

— Change in the quality of logs available for purchase,

— Change in the average volume per log,

— Change in the average distance from the mill to stumpage purchases,

— Change in the average volume of an individual stumpage purchase.

These questions solicited responses on an ordinal scale with five response options: increased significantly (by more than 10%), increased a little (by less than 10%), stayed the same, decreased a little (by less than 10%), and decreased significantly (by more than 10%).

Beginning in late February 2006, four separate mailings were sent to 783 valid addresses on the mailing list. In addition, after the final mailing, phone calls were made to nonrespondent mills for two reasons: to validate the sample frame by estimating the number of nonrespondent mills that are no longer in business, and to assess nonresponse bias. Nonresponse bias was evaluated by comparing responses between respondents and 33 potential nonrespondents, who participated in the study after the mail survey was complete, and only after being contacted by telephone (Smith et al. 2004).

Statistical analysis

We examined the effects of mill type and annual procurement volume on procurement variables using a two × three factorial treatment design. Using a 50 percent threshold, mills were categorized as either softwood or hardwood based on the reported percentage of their total 2005 log volume that was hardwood. Mills were also placed in three procurement volume categories based on production volume thresholds used by Smith et al. (2003). Large volume mills reported a total annual procurement volume greater than or equal to 5 MMBF in 2005, medium mills reported 2.0 to 4.9 MMBF, and small mills reported less than 2.0 MMBF. Two-way multivariate analysis of variance (MANOVA) and univariate analysis of variance (ANOVA) were used to test for treatment effects on normally distributed continuous variables, including measures of woodshed radius. Due to the unbalanced sample sizes, type III sums of squares and least-squares means were used in these analyses. We used F approximations based on Wilks' Lambda to determine significance in MANOVA. Tukey's HSD was used for mean comparisons, with experiment-wise error rate held at $\alpha = 0.10$ for multiple comparisons. A significance level of $\alpha = 0.10$ was also used in assessing interaction between mill type and mill size, and in discussing other differences among groups. Comparisons of ordinal survey responses were based on three aggregate response categories (increased, stayed the same, and decreased), and were evaluated using the Chi-square statistic of the Kruskal-Wallis test, a generalized form of the nonparametric Wilcoxon-Mann-Whitney test. This approach was also used for data that were not normally distributed, including percentage estimates for alternative roundwood sources. SAS® software version 9.1 (SAS Inst. Inc. 2004) was used for all calculations and statistical tests.

Table 1. — Sample sizes for the six sawmill groups.

	Mill type		
Volume	Hardwood	Softwood	Total
(MMBF/yr)			
< 2.0	31	68	99
2.0 to 4.9	27	18	45
≥ 5.0	30	33	63
Total	88	119	207

Results

The respondents

A total of 781 valid mill addresses were surveyed, and 211 sawmills returned completed questionnaires. Of the remaining 570 mills in the sample frame, 193 contacted us by mail, e-mail, or phone to let us know that the survey did not apply to them. In most cases, the survey was not applicable because the mill was not in operation in 2005, has never or no longer processes roundwood, or was described by the mill owner as a seasonal or hobby mill. Based on telephone calls to a random sample of 180 nonrespondents, less than 35 percent of the nonrespondents were still in operation and eligible at the time of the survey. We also attempted to contact 150 mills for which we had a mill name, but no valid mailing address. Accounting for 211 responses and an estimated 168 true nonrespondents, the survey response rate is 56 percent. More important, the 201 mills that reported their annual log procurement in 2005 represent a total of 1.2 BBF of log volume. The 64 sawmills that reported at least 5MMBF in log procurement in 2005 represent 85 percent of the total reported volume, but only 30 percent of the respondents—a distribution which is consistent with other studies (Luppold 1995a, Hansen et al. 2002). For comparison, the North East State Foresters Assoc. (2004) reported 2.4 BBF of sawlogs harvested from the four Northern Forest states in 2002. Our sample represents half of that estimate; however, it is important to note that our sample did not include mills in western or southeastern New York, nor did it include sawlogs that were exported directly from a landing or concentration yard to other states or countries, including Canada. Consequently, we estimate that our sample accounts for at least three-quarters of the total sawlog procurement by sawmills within the study region.

The resulting sample sizes for the six mill groups are shown in **Table 1**. Total sample sizes for means and statistical tests are generally less than 211, because some respondents did not answer all the survey questions. Wood procurement patterns generally support the use of two mill types. Though 8 percent of respondents reported mixed procurement, with hardwood volume ratios between 30 percent and 70 percent (inclusive), over three quarters of respondents reported hardwood ratios greater than 90 percent (heavy to hardwood) or less than 10 percent (heavy to softwood). Of the 18 mills that reported mixed procurement, 13 were small or medium hardwood mills, and 5 were small or medium softwood mills. Of the 99

Table 2. — Main effects of mill annual volume on three measures of woodshed radius.

Variable		Mill volume (MMBF/yr) < 2.0	2.0 to 4.9	≥ 5.0	F	p-value
Distance encompassing 90 percent of log supply (mi)	Mean[a]	39.5 C	50.6 B	65.1 A	16.81	<0.0001
	Median	30	45	60		
	SE	2.6	4.6	3.3		
	No.	93	45	62		
Farthest distance to stumpage (mi)	Mean[a]	72.5 B	89.7 B	133.4 A	15.47	<0.0001
	Median	50	80	130		
	SE	7.3	8.7	8.1		
	No.	65	37	50		
Farthest distance to logs (mi)	Mean[a]	106.4 B	132.6 B	205.8 A	17.02	<0.0001
	Median	65	115	180		
	SE	9.3	12.1	16.8		
	No.	92	44	62		

[a]Means in the same row that share a letter are not significantly different.

small mills in the sample, 21 reported less than 0.5 MMBF in procurement in 2005. Though we made an effort to exclude part-time, seasonal and hobby mills from the study, it is probable that these mills are part-time sole proprietorships, even if they were not identified as such by their owners.

Of the 19 survey questions for which nonresponse bias is relevant, three show possible nonresponse bias. Nonrespondents reported significantly larger average distance to stumpage purchases than respondents, with means of 49 miles and 37 miles, respectively ($p = 0.0485$). The two response groups also differed significantly with regards to perceived change in the total volume of logs available for purchase since 1994 ($p = 0.0888$), and perceived change in the average volume of an individual stumpage purchase since 1994 ($p = 0.0967$). Nonrespondents were more likely to report that the total volume of logs available for purchase in their woodshed declined, with 56 percent of nonrespondents reporting this trend compared to only 38 percent in the respondent group. Nonrespondents were also more likely to report that the average volume of an individual stumpage purchase declined (55%), when compared to the respondent group (34%). ANOVA and Kruskal-Wallis tests showed no significant nonresponse bias for any of the other 16 variables examined.

Woodshed size and sawlog sources

Respondents provided three measures of woodshed radius: the average distance encompassing 90 percent of log supply, the farthest distance to stumpage, and the farthest distance to logs. When all three measures were considered simultaneously in MANOVA, both mill volume ($p < 0.0001$) and mill type ($p = 0.0246$) had significant treatment effects, with weak interaction between the two factors ($p = 0.1314$). When each measure was considered independently in ANOVA, mill volume had a significant main effect on all three variables, with larger mills going farther for wood, though small and medium mills did not differ with regards to the farthest distance to stumpage or the farthest distance to logs (**Table 2**). Mill type was a significant factor for the average distance encompassing 90 percent of log supply ($p = 0.0001$) and the farthest distance to logs ($p = 0.0933$), but was not a significant factor for farthest distance to stumpage ($p = 0.1009$). Hardwood mills had higher average distance to 90 percent of log supply (mean = 59 miles) and higher maximum distance to logs (161 miles), compared to softwood mills, which averaged 44 miles and 135 miles, respectively. Among the six treatment groups, small softwood sawmills had the smallest average woodshed radius, with an average of 32 miles to 90 percent of log supply (**Table 3**). Large hardwood mills had the greatest average radius encompassing 90 percent of their log supply (70 miles) and the greatest average maximum distance to stumpage (138 miles), but large softwood mills had the greatest average maximum distances to logs (211 miles). Based on this sample, sawmills in the study region procure 90 percent of their total roundwood requirements from within 30 to 70 miles of the mill, depending on products and production levels, but may go as far as 200 miles or more to meet requirements.

Examining the relative importance of different sources of logs within these woodsheds, stumpage, roadside and gatewood are the dominant log sources for most mills (**Table 4**). For large hardwood mills, each of these three sources account for about one third each of total log supply, on average. Medium hardwood mills appear to be less dependent on roadside wood, which accounts for an average of 17 percent of their supply, than on stumpage or gatewood when compared to large hardwood mills. Medium and large softwood mills are much more dependent on gatewood, which comprises 74 percent and 70 percent of their supply, respectively. In general, small mills are more dependent on fee simple lands as a component of their log supply. Of the 211 mills in the sample, 70 mills reported procuring a portion of their annual log supply from land owned by their company. The 41 small mills in this group secured an average of 37 percent of their log supply from fee simple lands in 2005, compared to averages of 6 percent and 12 percent by large and medium mills that own land. Average acreage of landownership among the 70 mills ranged from 3,293 for the large mills, to 685 acres for the medium mills, down to 298 acres for the small mills. Timber leases and easements were only reported as a source of logs for seven of the mills in the sample, and in those cases this source accounted for an average of 10 percent of supply. Of the 19 mills reporting procurement from other sources, 14 operations were small or medium sized mills, with "custom sawing" or "contract sawing" accounting for half of the responses in this group. In most cases the precise meanings of these terms is not

Table 3. — Simple effects of mill type and annual volume on three estimates of woodshed radius.

		Mill attributes					
	Mill type	Hardwood mills			Softwood mills		
	Volume (MMBF/yr)	< 2.0	2.0 to 4.9	≥ 5.0	< 2.0	2.0 to 4.9	≥ 5.0
Variable	Mill group	1	2	3	4	5	6
Distance encompassing 90 percent of log supply (mi)	Mean[a]	46.9 BC	60.9 AB	70.3 A	32.2 C	40.3 C	59.8 AB
	Median	40.0	50.0	70.0	27.5	37.5	60
	SE	5.1	6.8	5.4	2.9	3.5	3.7
	No.	29	27	29	64	18	33
Farthest distance to stumpage (mi)	Mean[a]	81.0 B	101.2 AB	138.0 A	64.0 B	78.2 B	128.9 A
	Median	55.0	100.0	125.0	50.0	70.0	135.0
	SE	13.0	12.0	8.0	8.8	10.3	14.4
	No.	20	24	25	45	13	25
Farthest distance to logs (mi)	Mean[a]	143.8 ABC	139.6 BC	200.8 AB	68.9 D	125.6 CD	210.8 A
	Median	120.0	125.0	200.0	55.0	100.0	170.0
	SE	23.5	16.4	16.5	6.8	17.7	29.3
	No.	29	27	30	63	17	32

[a]Means in the same row that share a letter are not significantly different.

Table 4. — Comparison of six alternative roundwood sources across six mill groups.

		Mill Attributes						
	Mill Type	Hardwood			Softwood			
	Volume (MMBF/yr)	< 2.0	2.0 to 4.9	≥ 5.0	< 2.0	2.0 to 4.9	≥ 5.0	
	Mill group	1	2	3	4	5	6	All mills
Source	Sample size	31	27	30	68	18	33	207
Lease/easement	Mean reported %	0.3	0.7	1.0	0.0	0.3	0.0	0.3
	Total volume (MMBF)	0.1	0.6	2.8	0.0	0.1	0.0	3.6
	% of column total vol.	0.5	0.7	0.7	0.0	0.2	0.0	0.3
Fee lands	Mean reported %	12.5	4.9	2.2	15.9	0.8	0.5	8.6
	Total reported volume	1.9	3.7	9.0	2.8	0.4	2.2	20.0
	% of column total vol.	9.9	4.2	2.3	9.1	0.8	0.4	1.7
Stumpage	Mean reported %	20.9	37.4	28.7	19.1	14.4	7.8	20.7
	Total reported volume	2.7	32.6	100.8	5.4	7.6	39.2	188.3
	% of column total vol.	14.1	36.9	25.7	17.6	14.7	6.3	15.7
Roadside	Mean reported %	31.2	16.5	32.2	8.7	8.1	16.4	17.4
	Total reported volume	5.9	15.5	153.6	3.2	3.9	92.6	274.7
	% of column total vol.	30.7	17.6	39.2	10.4	7.5	14.9	22.9
Gatewood	Mean reported %	29.3	36.3	35.9	44.7	74.0	69.6	46.8
	Total reported volume	8.1	32.1	125.4	17.5	39.6	426.3	649.0
	% of column total vol.	42.2	36.4	32.0	57.0	76.6	68.8	54.0
Other[a]	Mean reported %	5.7	4.3	0.0	7.2	2.4	5.8	4.8
	Volume (MBF)	0.5	3.8	0.0	1.8	0.1	59.6	65.8
	% of group total vol.	2.6	4.3	0.0	5.9	0.2	9.6	5.5
All sources	Volume (MBF)	19.2	88.3	391.6	30.7	51.7	619.9	1201.4
	% of survey total vol.	1.6	7.3	32.6	2.6	4.3	51.6	100%

[a]"Custom sawing" and "contract sawing" accounted for half the responses in this category.

clear, however based on several respondents who included more information, these characterizations include very small-scale projects, such as producing rough lumber for landowners' personal use under contract or in trade for logs or stumpage.

Differences among groups for the alternative sources of roundwood discussed thus far have been based on the percentage of total annual volume in each category reported by each sawmill in the sample. Examining each wood source as a percentage of the 1.2 BBF of total log volume reported in the survey provides a better picture of the overall importance of each source to the sawmill industry in the Northeast. If each mill's response is weighted by its reported annual volume, gatewood accounts for nearly 54 percent of the total roundwood volume across the entire sample, with roadside supplying 23 percent of total log volume, and stumpage supplying 16 percent (**Table 4**). However, among the hardwood mills, stumpage, roadside and gatewood each comprise roughly a third of the total 511 MMBF reported by hardwood mills, with percentages of 27 percent, 34 percent and 34 percent,

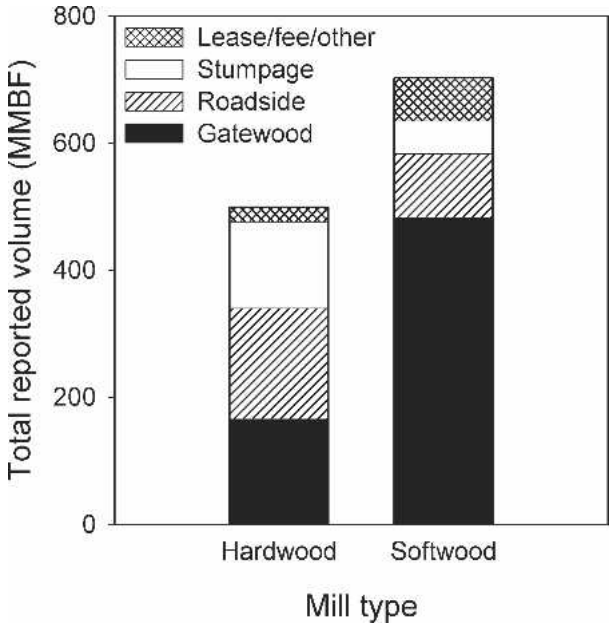

Figure 2. — Comparison of wood procurement and roundwood sources reported by 88 hardwood mills and 119 softwood mills.

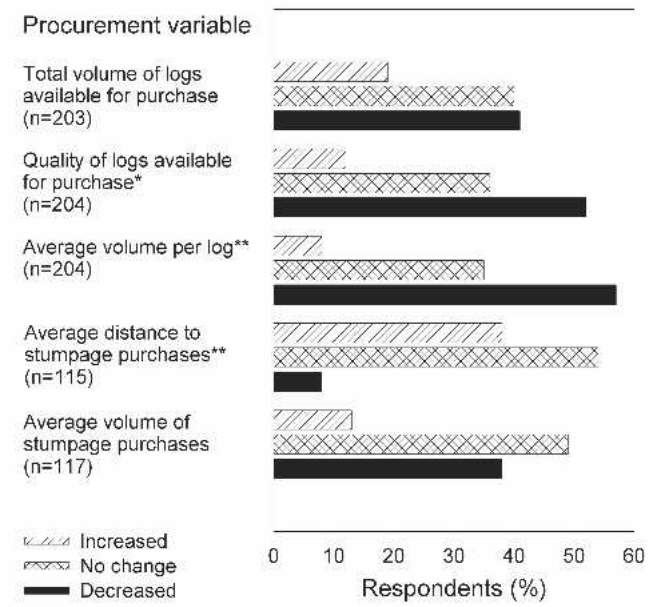

*Figure 3. — Perceptions of changes in log supply within respondent woodsheds between 1994 and 2005. (*Mill type has a significant effect on this variable. ** Mill type and volume both have a significant effect.)*

respectively (**Fig. 2**). In contrast, gatewood makes up 69 percent of the total 702 MMBF reported by softwood mills, followed by 14 percent roadside and 7 percent stumpage. Timber leases and easements, fee lands and "other" sources combined account for about 7 percent of the total 1.2 BBF of log procurement reported in the survey. It is also important to point out that 105 of the mills in the sample, or about 50 percent, reported reselling logs to brokers and other mills in 2005. Four mills left the question blank, and the remaining 102 mills reported that they sawed 100 percent of their total annual log procurement in 2005. Among the 105 mills that resold logs, small softwood mills reported reselling the highest percentage of their total annual procurement, reselling almost 50 percent of their 2005 procurement, on average. Large softwood mills resold the smallest percentage of their log supply, at 9 percent on average. Medium and large hardwood mills resold about 15 percent, and small hardwood and medium softwood resold an average of 28 percent and 39 percent, respectively. Weighting responses by reported volume and including mills that did not resell logs, at least 9 percent of the 1.2 BBF reported in the survey was resold as logs rather than used directly by the purchasing mill or another mill owned by the same company.

The 111 mills that reported stumpage as a log source in 2005 also answered several other questions regarding stumpage as a log supply. Mill type was not a significant factor in determining average distance to stumpage purchases (p = 0.7216), however large mills had a mean distance of 60 miles to stumpage, medium mills averaged 36 miles, and small mills averaged 21 miles, with all means significantly different from one another. Data for the average volume of each stumpage purchase follow a similar trend. Mill type is not significant in determining the average volume of individual stumpage purchases (p = 0.4821), but mill size is a significant factor (p = 0.0174). Large mills have significantly larger average stumpage purchases than small mills, with a mean stumpage purchase volume of 103 MBF per purchase vs. 61 MBF per purchase (p = 0.0126), but medium mills are not significantly different from either group, with mean purchase volume of 83 MBF per purchase. Overall, the mean percentage of stumpage purchases represented by bid sales offered by consulting foresters is 30 percent. Large mills and medium mills are equally likely to purchase stumpage facilitated by a consulting forester. On average, 40 percent of stumpage purchases within these groups were bid sales offered by a consulting forester. This figure contrasts with only 9 percent for small mills.

Perceptions of changes in log quality, volume and availability

Overall, a slight majority of respondents reported that the total volume of logs available for purchase within their woodshed declined between 1994 and 2005, but 40 percent reported no change (**Fig. 3**). Over half of the respondents reported that the quality of logs and volume per log within their woodshed declined during that period. Though half of the mills that purchase stumpage reported that the distance to stumpage and the average volume of individual stumpage purchases did not change the number of respondents who reported increased distance to stumpage and decreased volume per stumpage purchase outnumbered those who reported the opposite by three to one. Comparing softwood and hardwood mills, there is no significant difference in response trends between the different mill types for responses related to the change in the total log volume available for purchase (p = 0.2031), or for the change in the average volume of individual stumpage purchases (p = 0.5845). The mill types do differ significantly with regards to opinions about the change in the quality of logs available for purchase (p = 0.0915), the change in average volume per log (p = 0.0091), and the change in distance to stumpage purchases (p = 0.0119). Hardwood mills were more likely to report a decline in log quality, a decline in volume per log, and an increase in distance to stumpage purchases since

Table 5. — Comparison of perceptions about changes in wood procurement between hardwood and softwood mills.

Variable	Trend between 1994 and 2005 (% of respondents reporting in each category)					
	Hardwood mills (n = 86,86,56)			Softwood mills (n = 116,113,57)		
	Incrsd.	Same	Decrsd.	Incrsd.	Same	Decrsd.
Quality of logs available for purchase (p = 0.0915)[a]	10	33	57	14	38	48
Volume per log (p = 0.0091)[a]	7	27	66	10	41	49
Average distance to stumpage purchases (p = 0.0119)[a]	53	37	10	25	68	7

[a]*p-value* tests the null hypothesis that mill type has no effect on the response.

Table 6. — Comparison of perceptions about changes in wood procurement among small, medium and large volume mills.

Variable	Trend between 1994 and 2005 (% of respondents reporting in each category)								
	Annual volume (MMBF/yr)								
	< 2.0 (n = 94,51)			2.0 to 4.9 (n = 44,26)			≥ 5.0 (n = 63,38)		
	Incrsd.	Same	Decrsd.	Incrsd.	Same	Decrsd.	Incrsd.	Same	Decrsd.
Volume per log (p = 0.0251)[a]	8	47	45	9	18	73	9	30	61
Distance to stumpage purchases (p = <0.0001)[a]	18	70	12	35	62	3	68	24	8

[a] *p-value* tests the null hypothesis that volume group has no effect on the response.

1994 (**Table 5**). There were no significant differences among the three volume groups regarding change in the total volume of logs available for purchase (p = 0.6763), change in the quality of logs available for purchase (p = 0.4376), or the change in the average volume of individual stumpage purchases since 1994 (p = 0.1395). However, large and medium volume mills were more likely to report a decline in volume per log (**Table 6**). In addition, large mills were also more likely to report that the average distance to individual stumpage purchases has increased since 1994.

Discussion

This snapshot of sawmill procurement operations in 2005 represents approximately 75 percent of the total log procurement in the study region and provides some insights into the interactions between wood procurement and industry trends. Certainly it is intuitive that larger mills go farther for logs and stumpage and have larger average stumpage purchases. However, as woodsheds expand, the increased costs of wood procurement may limit the size of firms by offsetting decreases in production and distribution costs attributable to economies of size (Bressler and King 1970, Luppold 1995b). If the costs of procurement operations limit woodshed extent, and if large firms are at a point of efficiency between procurement costs and gains attributable to economies of size, distances for the large volume mills may represent the upper limit for efficient procurement operations in this region. If not, all else being equal, sawmills may be able to expand their woodsheds to meet demand in response to any local declines in roundwood quality and availability.

Despite overall trends toward greater industry concentration (Diamond et al. 1999, Spelter 2002, Luppold 2005), the Northeast continues to support a large number of small sawmills. Overall, results show that small mills procure a larger percentage of roundwood from fee simple lands, broker a larger percentage of their overall log supply, and capture niche markets, such as small volume "custom" or "contract" sawing jobs that are not profitable for larger operations. Such adaptations may explain the persistence of so many small mills despite concentration, but there is some indication that harvesting from fee simple lands may not be sustainable. When viewed in aggregate, the 41 small sawmills with fee simple forestlands own an average of 298 acres per mill and secure an average of 37 percent of their log supply from these lands. Keeping in mind that this study represents the industry at a single point in time, this reported percentage seems high given the small average land base. For example, the estimated annual allowable cut on 300 acres of well stocked forestland is 45 MBF per year, assuming growth of 150 BF/ac/yr (Eyre and Zillgitt 1953, Trimble 1961, Nyland 2004). At these harvest levels, 300 acres is capable of providing roughly 2 percent of the roundwood needs of sawmills at the upper volume limit of the small mill category, and close to 10 percent for a mill operating at 0.5 MMBF per year. The inability of small mills to compete with larger mills for expensive logs and stumpage may explain the relatively high reliance on fee simple lands and the apparently unsustainable harvest levels.

The export of unprocessed logs from Northeastern forests has received a lot of attention over the last 20 years, and has been a source of some concern, particularly in the hardwood sawmill sector. For example, Hansen et al. (2002) determined that 285 MMBF, or about 32 percent of total veneer and sawlog production, was exported from New York in 1999, mostly to Canada. Though we do not have data on the specific grades of logs that were sold, or the final destination of those logs, at least 9 percent of the 1.2 BBF reported in this survey was resold by sawmills as logs. The medium and large hardwood mills that reported reselling logs brokered an average of 15 percent of their annual procurement volume in 2005. This average is probably an underestimate because of the number of mills that did not provide resale estimates. Debate surrounds the conventional wisdom that log exports have a dampening effect on domestic lumber production (Jones et al. 1994, Luppold 1994), and the issue remains a sore topic for those convinced that export restrictions would boost value-added processing in the United States. The specific impacts of log exports on the sawmill sector are beyond this discussion, but these data do show that the industry is capitalizing on log exports to some extent by brokering logs when it is profitable to do so. Given that the overall capacity in the industry is projected to increase well into this century (Turner et al. 2005), it is unclear what long-term effect, if any, trends in

reselling logs may have on the production of sawn products in this region.

In general, a majority of hardwood mills reported declines in log quality and volume per log accompanied by an increase in the average distance to stumpage purchases. Though there is some debate over the true condition of the hardwood sawlog resource (Luppold and Dempsey 1996), the observed responses would be expected if roundwood sources within respondent woodsheds have been degraded by exploitative practices, or have become limited due to changes in forest ownership and use. Regardless of the causes, if the reported trends are representative of long-term trends in the wood supply, it is reasonable to conclude that increasing procurement costs associated with locally declining log quality and availability will become an important issue for many firms, if it has not already. Increased competition for logs from growing export markets would further aggravate localized increases in procurement costs. Such trends may cut into profit margins for sawmills if increasing procurement costs are not accompanied by rising lumber prices. In such an environment, robust, industry-based landowner assistance programs may help address short-term changes in landowner objectives, as well as long-term degradation of the resource due to exploitative harvesting. When viewed in aggregate, survey responses do not appear to emphasize the same trends in the softwood sector. However, from a qualitative perspective, many individual softwood mills reported declines in log quality and availability within their woodsheds, and may have to confront the challenges related to such trends. This highlights the fact that, while it is possible to view variation and trends in wood procurement among different types of firms across the region as a whole, individual sawmills must adapt to changing conditions within their woodshed to stay competitive in dynamic markets.

If the sawlog resource is actually in decline in the majority of woodsheds across the study region, long-term competitiveness may be at risk. Currently, we are using geospatial analysis to examine connections among log supply, procurement, and woodshed attributes. Linking survey responses and other sawmill data to woodshed characteristics will allow us to test hypotheses about the relationships between forest ownership patterns, harvest rates, competition, and wood procurement operations. Against the backdrop of dynamic global markets for logs and lumber, further research should work to confront challenges to the industry and help maintain a vibrant sawmill sector closely connected to the working forests of the Northeast.

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