Pennsylvania roundwood purchases and movements by origin and destination

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Abstract

A mail survey of all identified roundwood purchasers in Pennsylvania was conducted in 2004 to quantify the roundwood purchasing industry in terms of roundwood volume, origin, destination, roundwood type, and species of 2003 purchases. An adjusted response rate of 50 percent was obtained from the estimated overall population of 334 Pennsylvania roundwood purchasers. Pennsylvania's total roundwood purchase volume in 2003 was estimated at 1.266 BBF, of which 22 percent (284 MMBF) was imported from surrounding states. Pennsylvania roundwood purchasers' imports from surrounding states in 2003 were approximately 4 times greater than their import volumes in 1988, and their exports to surrounding states and other countries of 67 MMBF increased 29 percent since the 1988 study by Wharton and Bearer (1994). Of Pennsylvania's total roundwood purchase volume, 982 MMBF was harvested from within the state; 22 percent of this volume originated in the Allegheny inventory region. Pennsylvania's roundwood purchases were 61 percent sawlogs, 29 percent pulpwood, and 10 percent veneer. The greatest percentage of Pennsylvania roundwood purchases were in red and white oak (35%), followed by hard and soft maple (18%), and black cherry (13%). Eighty-seven percent of Pennsylvania's roundwood purchase volume came from ongoing forestry operations. The results of this study provide the removal volumes for the USDA Forest Service Timber Product Output database, which is part of the Forest Inventory and Analysis program. The study also presents key information characterizing roundwood removals, purchases, and flows into and out of the nation's #1 hardwood lumber producing state.

Pennsylvania's forest products industry currently supports nearly 100,000 employees and contributes over 11 billion dollars to the state's economy on an annual basis (DCNR 2004, Strauss et al. 2007). Despite the hardwood industry's economic importance, the most recent comprehensive study examining Pennsylvania's roundwood purchases was conducted by Wharton and Bearer (1994) in 1988.

The hardwood roundwood purchasing industry is complex and diffuse; thus collecting accurate data on this industry is difficult (Luppold 1995, Bowe et al. 2001). The roundwood purchasing industry is comprised of primary wood-using mills, which vary widely both within and among states by factors such as size, production type, and capacity (Luppold 1995). Pennsylvania's hardwood industry is further complicated by distinctions between national and international markets; thus encouraging product partition and increased merchandising to meet these competing market demands (Luppold 1995, Luppold and Baumgras 1995).

Pennsylvania is unique in several facets when compared to other states in the eastern hardwood region. According to Luppold (1995), in 1991 Pennsylvania had more hardwood sawmills than any other state (578), and had a relatively low average sawmill size (1.78 MMBF), excluding mills that produced fewer than 100,000 BF or were deemed new or inactive. In addition, Pennsylvania contains the largest volume of hardwood sawtimber and, according to estimates, produces more hardwood lumber than any other state (Smith et al. 2003). The distinct arrangement of species diversity, quality, and timber volume makes Pennsylvania an exceptionally important player in the hardwood industry (Strauss et al. 2000). The bulk of Pennsylvania's hardwood growing stock is

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sawtimber-sized and much of the timber is therefore suitable for lumber and veneer production (Pennsylvania HDC 2000). Pennsylvania is known internationally for its quality hardwoods. In 2001, Pennsylvania was second in the nation in international export sales of hardwood logs (PDA 2004).

Pennsylvania roundwood origins, 1988

The last roundwood use study in Pennsylvania was done in 1988 by Wharton and Bearer (1994), who determined that Pennsylvania's total roundwood purchase volume was 1.450 BBF by more than 1,500 firms. Pennsylvania was a net importer of roundwood in 1988, as the state imported 11.3 million cubic feet (mmft^3) (68 MMBF), and exported 8.7 mmft^3 (52 MMBF) in 1988 (Wharton and Bearer 1994). Most of the imported roundwood originated in Maryland (35%) and New York (30%) (Wharton and Bearer 1994). An estimated 22 MMBF (43%) of Pennsylvania's exported roundwood volume went to Ohio, an additional 12.5 MMBF (24%) was sent to Canada, and the remaining percentage went to several other surrounding states in 1988 (Wharton and Bearer 1994).

In 1988, 39 percent (417 MMBF) of the roundwood volume harvested in Pennsylvania (1082 MMBF) originated in the North-central region (this region was later split into two inventory regions: the Allegheny and the North-central; see **Fig. 1**) (Wharton and Bearer 1994). The Western and South-central regions were the next most heavily harvested, providing 17 percent and 18 percent of the roundwood volume, respectively (Wharton and Bearer 1994). [NOTE: Wharton and Bearer did not include pulpwood harvests in their regional analysis of Pennsylvania.]

Regions of Pennsylvania

The USDA Forest Service Forest Inventory and Analysis (FIA) program has been conducting periodic forest inventories in Pennsylvania since the 1950s. In 2000, the FIA implemented a continual inventorying and monitoring system and created the eight inventory regions shown in **Figure 1** (McWilliams et al. 2004). These subdivisions were supplemented by the state's breakdown of different ecoregions at the county level that helped to facilitate the characterization of Pennsylvania's diverse forests. Ecoregions correspond with natural phenomena that create forest composition, structure, and function (McWilliams et al. 2004) (**Fig. 2**).

Pennsylvania's ecoregions differ due to their location relevant to the Warm and Hot Continental Division (bold line), and the line of glaciation (dashed line) that is located across the Northern Tier of the state (**Fig. 2**) (McWilliams et al. 2004). Landscape features such as the Appalachian Mountains and the Allegheny Plateau lend to Pennsylvania's different species compositions and forest types (McWilliams et al. 2004). The Central Appalachian Broadleaf Forest—Coniferous Forest—Meadow Province of the Appalachian Mountains has long been dominated by oak (*Quercus sp.*), yellow-poplar (*Liriodendron tulipifera*), and black cherry (*Pinus serotina*); however selective cuttings and competitive factors have led to a greater abundance of maple (*Acer sp.*), American beech (*Fagus grandifolia*), and American basswood (*Tilia americana*) (Schuler 2004). The best development for black cherry originates on the Allegheny Plateau and the Allegheny Mountain (part of the Appalachian Mountains) sections of Pennsylvania (also New York, Maryland, and West Virginia) where the black cherry–maple forest type is

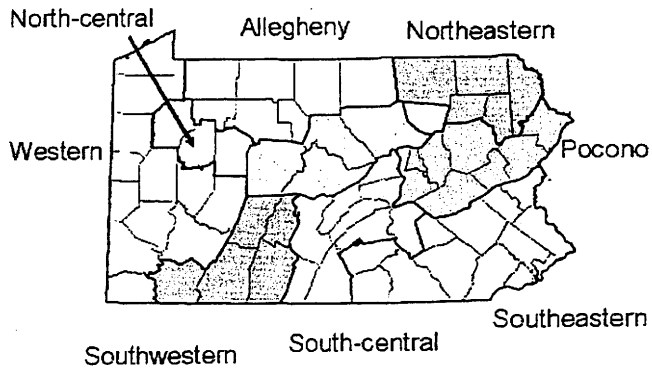

Figure 1. — Forest inventory regions of Pennsylvania.

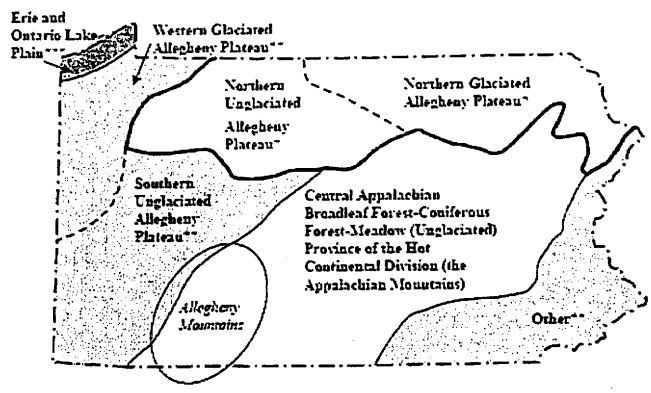

Figure 2. — Ecoregions of Pennsylvania by section and province (McWilliams et al. 2004).

found (Marquis 1998). The southern ecoregions of Pennsylvania are the most appropriate habitat for yellow-poplar, which is generally found in valleys and stream bottoms as well as on moist slopes (Olson 1969). Luppold found that regional changes in lumber production in Pennsylvania were influenced by regional changes in species composition in combination with variations of interspecies pricing (Luppold and Bumgardner 2004). Accordingly, regional characterization is also useful for the analysis of regional differences in Pennsylvania's roundwood purchasing industry. This study provides important baseline data on roundwood removals as changing markets continue to impact harvest operations across the United States.

Study objectives

The primary objective of this study is to analyze roundwood receipts from Pennsylvania's roundwood purchasers in terms of volume, origin, destination, roundwood type, and species. Origin and destination are first examined by analyzing import and export of Pennsylvania's roundwood purchase volume. The origin of Pennsylvania roundwood purchases is examined by region of harvest within the state and by whether purchases are from terminal cuts [land that is deforested and put to commercial use (e.g., buildings, new highways), industrial use (e.g., mills, factories), or private use (e.g., farmlands)] vs. ongoing forest operations [land that remains forested]. The relationship between species composition of roundwood purchases and the regional location of respondents is also examined.

This study provided the roundwood removal and use information for Pennsylvania's contribution to the USDA Forest

Table 1. — Follow-up nonresponse phone calls performed by SIC code, volume, and employee size.

Call list type	Total calls/ # firms	Unavailable	Available	Number of non-purchasers	Number of purchasers	Number (and percent) of responding purchasers (after calls)
Obscure[a] firms	69/69	10	59	39	20	7 (35.0%)
Large firms[b]	54/54	10	44	18	26	10 (38.5%)
Small firms	31/300[c]	--	31	18	13	7 (53.8%)
Total	154/423	20	134	75	59	24 (40.7%)

[a]Obscure is defined as any facility that does not have SIC code 2421 (non-sawmills).
[b]Large firms purchased greater than or equal to 2 MMBF or greater than or equal to 20 employees.
[c]These 31 calls represented a systematic sample (with a random start) of the 300 small firms (<2 MMBF and <20 employees).

Service's Timber Product Output database, which is part of the Forest Inventory and Analysis program (McWilliams et al. 2007). Results have also been utilized by The Pennsylvania Small Diameter Task Force, commissioned by the Commonwealth's Secretary of Agriculture. This Task Force explores various management and utilization alternatives for small-diameter trees (Ray 2007). Similar initiatives in other states would benefit from comparable roundwood harvest data to better respond to market demands, including alternative energy (The Nature Conservancy 2004, USDA Forest Service 2006).

Methods

Sample frame

In the winter of 2003 to 2004, a sample frame of all potential roundwood purchasers in Pennsylvania was developed. Roundwood purchasers include any Pennsylvania firm or broker that bought roundwood (sawlogs, veneer logs, and pulpwood) from Pennsylvania and adjoining states in 2003. The following sources were utilized: Harris Pennsylvania Industrial Directory (2002 to 2004); Pennsylvania Forest Products Association–Membership Directory & Buyers' Guide (2004); Hardwood Lumber Manufacturers Association (of Pennsylvania) (1998 to 2000); Hardwood Manufacturers Association (National) Sawmill Directory (1999); Pennsylvania Bureau of Forestry (BOF) Sawmill Directory (1995 and 1997). From these and other expert sources, including regional forest products utilization specialists, an all-inclusive sample frame was developed containing a total population of 784 potential roundwood purchasers in Pennsylvania.

Data collection

A mail survey, the most cost-effective means to collect data from a geographically dispersed population (Dillman 2000), was conducted in the spring and summer of 2004. The questionnaire was pretested prior to the initial mailing to check for construction, content validity, wording, format, and question flow. As suggested by Dillman (2000), various stages of pretesting were utilized including review by colleagues and analysts as well as on-site interviews. The on-site interviews were facilitated with several preselected mills from our sample frame to evaluate question perception and application, to improve the clarity and quality of the written survey, to verify time allocation, and to asses the success of response motivators. Slight modifications were made to the written survey to account for pretest findings.

The final mail questionnaire consisted of 15 questions and was created as a 4-page booklet. The survey included 4 closed-ended questions with unordered categories and 3 open-ended questions to address demographic information such as whether the mill was part of a multiple facility company, type of facility, number of employees, and other comments. The remaining questions asked respondents to estimate roundwood purchases by volume and percent into categories dealing with: raw material type, species, movement, harvest source, forest product manufactured, and residue type.

Response rates

The survey was administered to the sample frame ($n = 784$) over several mass mailings. Dillman's Tailored Design Method (2000) suggested "four contacts by first class mail, with an additional 'special' contact" in order to obtain high response rates. Though the specific contact sequence recommended by Dillman (2000) was modified slightly, his basic progression and variety of contacts were used. A cover letter, the survey, and a publication reprint from an earlier Pennsylvania sawmill study by Smith et al. (2003) were included in the first mailing package. The publication was included to illustrate the incentive for recipients to complete the survey so that they might receive similar data on the results of the roundwood study. In the following weeks a reminder postcard was sent, followed by a second survey and cover letter, a second reminder postcard, a third survey and cover letter, and finally, a third reminder postcard.

After the third survey mailing, the remaining nonrespondents ($n = 423$) in the sampling frame were grouped into three phone-call lists to further increase response rates, and to check for nonresponse bias. This "special" contact effort was distinguished from the mail surveys, as it was a different mode of correspondence, and improved response to the mail surveys (Dillman 2000).

Facilities were grouped based on whether they were considered to be: non-sawmills or obscure firms [listed with a non-sawmill SIC code, such as logging (2411), millwork (2431), and hardwood dimension flooring (2426)], large firms (purchased greater than or equal to 2 MMBF and/or had greater than or equal to 20 employees), or small firms (purchased less than 2 MMBF in volume and/or had fewer than 20 employees). We contacted (by phone) all firms within the first two groups, which included the 69 facilities listed as non-sawmills and the 54 facilities that were considered large sawmills (**Table 1**). The third group consisted of 300 potential small roundwood purchasers (<20 employees and/or <2 MMBF), from which we selected a systematic sample, with a random start, of 31 potential roundwood purchasers for subsequent phone contacts (**Table 1**).

The original sample frame of 784 potential roundwood purchasers was reduced by 294 facilities. These facilities were

Table 2. — The adjusted response rate (small firms were extrapolated) of Pennsylvania roundwood purchasers.

Original sample frame	Reduced pop. total (N =)	"Small" (n = 300) call sample (n = 31)			Extrapolated irrelevant firms (n = 300)	Extrap. pop. (N =)	Responded to survey (n =)	Extrap. response rate
		Did not buy	Not available[b]	Total irrelevant firms				
784	490[a]	11	7	18	15[c]	334	166	= 166/334 = 50 percent

[a]Population reduced by undeliverable mailings, and contacts that went out of business or did not purchase roundwood in 2003.
[b]Not available because the company or contact telephone number had been disconnected, indicating that they were out of business.
[c]Extrapolated roundwood non-purchasers were calculated by taking the percent of the small sample that were nonpurchasers ((18/31) × 100 = 58%) times the 300 represented small facilities (0.58 × 300 = 174) and subtracting the 18 that were contacted and deducted previously (174 minus 18 = 156).

deducted because they were either undeliverable by mail and had no available address, or because they indicated via mail response or phone that they no longer purchased roundwood or had not purchased in 2003. The reduced population of 490 was further condensed after a systematic sample of 31 mills was generated from the 300 small roundwood purchasing firms in our original sample frame (**Table 2**). Of the 31 sawmills contacted, 18 either did not buy roundwood in 2003 or were no longer in business. By extrapolating these 18 irrelevant firms to the 300 firms in our original small facility sample, we deducted 156 additional, possible roundwood purchasers from the population (**Table 2**). Ninety-five of these 156 mills were removed because we concluded that they did not purchase roundwood in 2003. Thus, the population was adjusted to 334 roundwood purchasers in 2003. The overall adjusted response rate was 50 percent (n = 166/ 334). This response rate is considered to be quite high compared to response rates that have been achieved in similar mail survey studies: Smith et al. (2003) 31 percent, Bowe et al. (2001) 23.5 percent, and Luppold et al. (2000) 22 percent.

Nonresponse bias

Nonresponse bias suggests that the respondents to a survey may be unrepresentative of the nonrespondents. To check for nonresponse bias the earliest group of respondents (n = 34) average purchase volume of roundwood was compared to that of the last group of respondents' (n = 34) using the parametric ANOVA (Analysis of Variance) test. It was assumed that the later respondent group acted more like nonrespondents since they had been repeatedly contacted via mail and/or phone before they finally responded. The parametric ANOVA test showed that there was no significant difference (at the 0.05 level) between the two groups (Norusis 2003).

Results and discussion

The respondent profile

The vast majority (93%; n = 155) of respondents described their facility type as a sawmill. The remaining 7 percent (n = 11) of facilities included: face veneer mills, pulp and papermills, log concentration yards, a shavings plant, a handle plant, a composites manufacturer, and a firewood manufacturer. Eighty-six percent of responding Pennsylvania roundwood purchasers were single operations, and the remaining 14 percent were part of a multiple facility company. Pennsylvania roundwood purchasers employed an average of 29 full-time production employees and 9 full-time nonproduction employees, with a standard error of the mean of 6 and 3, respectively. The mean volume of roundwood purchased by respondents was 4.8 MMBF, with a standard error of the mean of 0.8 MMBF. However, both number of employees and purchase volume figures were skewed upwards by a few very

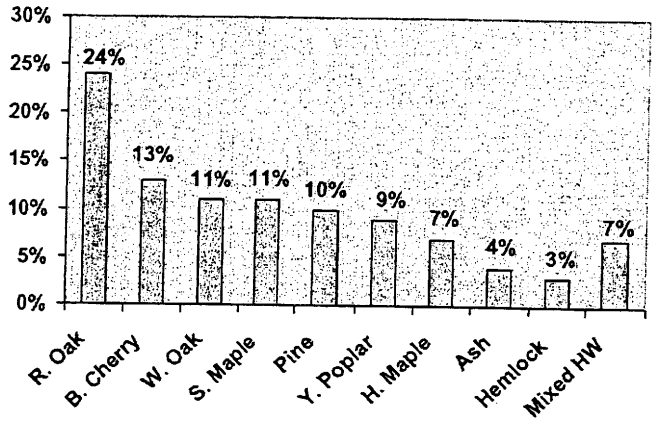

Figure 3. — Roundwood species purchased by respondents in 2003 (n = 153).

large sawmills and pulpmills. The median number of production employees was nine and the median volume of roundwood purchased was 1.6 MMBF.

Figure 3 shows the breakdown of respondent roundwood purchases by species for the entire state. Red oak accounted for the greatest portion (24%) of roundwood purchased by respondents, followed by black cherry (13%), white oak and soft maple (11% each), pine (10%), yellow-poplar (9%), hard maple (7%), ash (4%), hemlock (3%), and mixed hardwoods (7%).

Roundwood purchasers indicated that 87 percent of their purchase volume came from ongoing forest operations, 9 percent from a terminal cut, and 4 percent from a forest operation in which it was not known whether it was ongoing or terminal (**Fig. 4**). The majority of respondents' purchased roundwood volume was sawlogs (61%), followed by pulpwood (29%), and veneer logs (10%) (**Fig. 5**). The total estimated volume of veneer logs purchased for 2003 was 122 MMBF, which is nearly four times the volume of veneer log purchases in 1988 (Wharton and Bearer 1994).

Roundwood movements into Pennsylvania

There has been very little information collected on the movement of roundwood between Pennsylvania and its neighboring states since the study by Wharton and Bearer in 1988. States with current numbers on roundwood volumes tend to keep questionnaires as simple as possible and therefore do not ask for the origin of roundwood imports (Crawford 2005).

Pennsylvania's roundwood purchasers resold 3 percent (36 MMBF) of their purchase volume to surrounding states and an additional 2 percent (31 MMBF) was exported outside the United States (**Fig. 6**). By comparison to 1988, approximately 4 percent (52 MMBF) of the roundwood purchase volume was exported from Pennsylvania, including about 12.5 MMBF that was exported to Canada (NOTE: Wharton

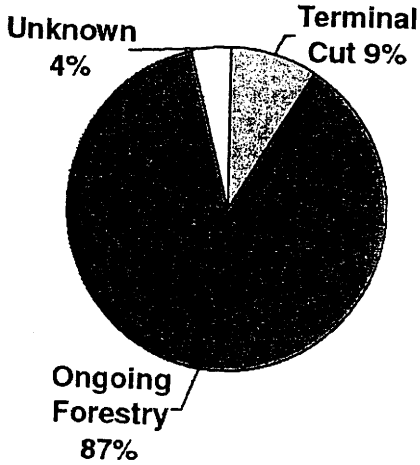

Figure 4. — Type of forest operations respondents purchased roundwood from in 2003 (n = 151).

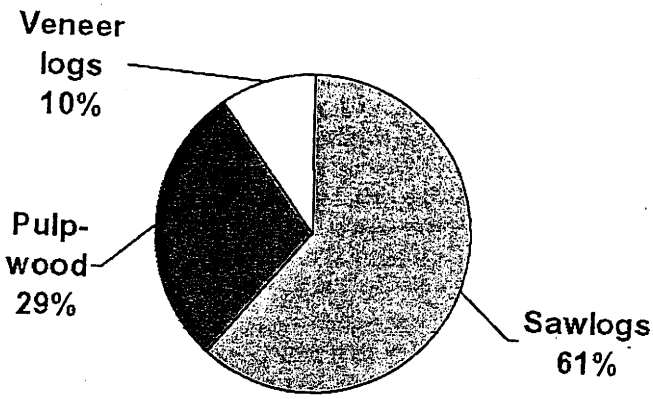

Figure 5. — Type of roundwood purchased by respondents in 2003 (n = 154).

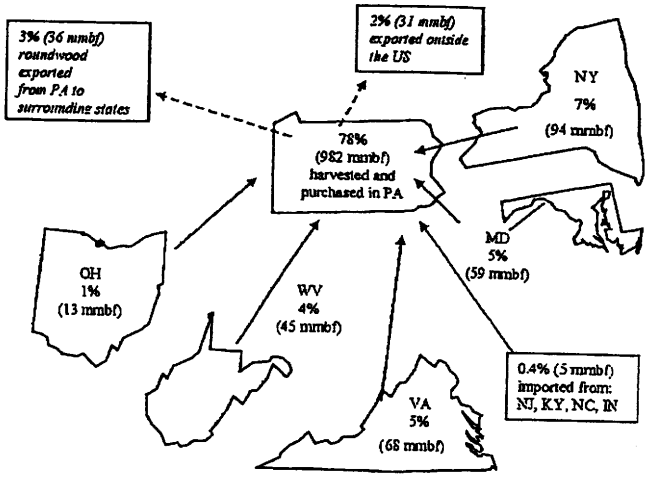

Figure 6. — Estimated roundwood purchase volumes imported and exported for Pennsylvania in 2003; out of an estimated total purchase volume of 1.266 BBF.

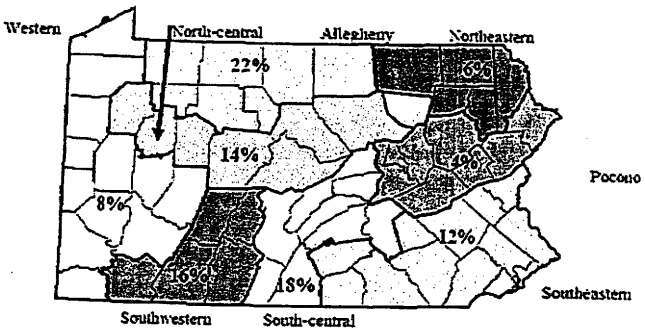

Figure 7. — Percent of purchase volume harvested from each of Pennsylvania's eight inventory regions; out of a total estimated roundwood harvest volume of 982 MMBF.

and Bearer did not track any overseas exports in 1988). Thus, Pennsylvania's roundwood purchasing industry appears to be exporting (out of state/country) about 29 percent more volume than it exported 15 years ago.

The total roundwood purchase volume from Pennsylvania harvests is estimated at 982 MMBF or 78 percent of the total 1.266 BBF of roundwood purchased in 2003 (**Fig. 6**). The remaining 22 percent (284 MMBF) originated in other states (**Fig. 6**). Pennsylvania roundwood purchasers' 2003 roundwood imports were approximately four times their 1988 roundwood import volume (68 MMBF) (Wharton and Bearer 1994). The total roundwood purchase volume decreased slightly since 1988, yet the import volume from surrounding states increased fourfold, suggesting an increasing difficulty for Pennsylvania firms to access adequate roundwood volumes within the state. Similar trends have been reported in a study of wood procurement in the Northeastern United States by Anderson and Germain, though this study included only a small portion of Pennsylvania (2007).

Roundwood harvest by region in Pennsylvania

Pennsylvania's eight inventory regions (**Fig. 7**) vary in terms of forestland area, forest type, and number of roundwood purchasing firms; thus it would be expected that the volume of roundwood harvested would vary by region. Approximately 22 percent of the 982 MMBF of roundwood purchase volume harvested in Pennsylvania originated in the Allegheny region, followed by the South-central (18%), the Southwestern (16%), the North-central (14%) and the Southeastern (12%) regions (**Fig. 7**). In 1988, the Allegheny and North-central regions were combined, and made up 39 percent of the sawlog harvest volume. Comparatively, these two regions made up 36 percent of the harvest volume in 2003, however these numbers are difficult to compare since Wharton and Bearer (1994) did not account for pulpwood harvests in their regional analysis.

Roundwood purchases by species

The eight inventory regions of Pennsylvania consist of different habitats that favor different species. It was expected that the total roundwood species volume purchased in Pennsylvania would vary by region, but these results create an important baseline to track future roundwood supply and demand fluctuations. Responding roundwood purchasers were categorized by inventory region according to their facility's primary location in order to examine the relationship between species composition of respondents' roundwood purchases and their regional location.

For each species, the percent of total volume purchased (1.266 BBF) in 2003 was examined within each of the eight ecoregions (determined by mill location). **Table 3** shows the percent of roundwood purchases broken down by species for: red oak (*Quercus rubra*), white oak (*Q. alba*), black cherry,

Table 3. — Pennsylvania roundwood purchases by region and species out of an estimated total roundwood purchase volume of 1.266 BBF.

Region	Total purchases	Percent of roundwood purchased by region and species							
		Red oak	White oak	Black cherry	Yellow-poplar	Hard maple	Soft maple	Pine/ hemlock	Mixed hdwd.[a]
North-central	10	28	8	28	3	9	14	2	8
Allegheny	19	18	5	27	4	13	20	2	12
Northeastern	8	17	9	8	0	17	12	10	27
Pocono	<1	33	24	3	4	1	5	22	8
Southeastern	26	18	17	0	16	0	3	37	10
South-central	10	33	20	3	12	3	5	14	10
Southwestern	18	32	11	15	14	7	14	1	6
Western	7	28	6	20	3	14	14	0	16
Pennsylvania[b]	99	24	11	13	9	7	11	13	11

[a]Mixed hardwoods include ash, beech, hickory, walnut, birch, aspen, and basswood.
[b]Total may not sum to 100 percent due to rounding.

yellow-poplar, hard maple (*Acer saccharum*), soft maple (*Acer rubrum*), pine (*Pinus sp.*)/hemlock (*Tsuga canadensis*), and mixed hardwood. The regions where firms purchased the greatest volume of roundwood in 2003 were the Southeastern (26%), Allegheny (19%), and Southwestern (18%) regions (**Table 3**).

Red oak and white oak are both high valued hardwood species that are common to Pennsylvania, making up 24 percent and 11 percent of respondents' total roundwood purchases, respectively (**Table 3**). The regions with the greatest percentage of roundwood purchases in red oak were the Pocono (33%), South-central (33%), and Southwestern (32%) regions, all three of which are almost entirely within the Central Appalachian Broadleaf Forest–Coniferous Forest–Meadow Province of the Appalachian Mountains (McWilliams et al. 2004). The Pocono (24%) and South-central (20%) regions also had the highest percentage of roundwood purchases in white oak (**Table 3**).

As expected, black cherry was a greater component of respondents' roundwood purchases in the regions along the Allegheny Plateau, at the heart of its commercial range (Marquis 1998). Respondents in the North-central (28%) and Allegheny (27%) regions purchased the highest proportions of black cherry followed by respondents in the Western (20%) and Southwestern (15%) regions, all of which are included in the Allegheny Plateau or Allegheny Mountains portion of the Central Appalachian Broadleaf Forest–Coniferous Forest–Meadow Province (**Table 3**). The Allegheny Plateau of northwestern Pennsylvania is renowned internationally for its high-valued black cherry.

The Southeastern (16%), South-central (12%), and Southwestern (14%) regions all purchased the greatest percentages of yellow-poplar, as was expected since the southern regions of Pennsylvania best fit its preferred habitat (**Table 3**). The native range of yellow-poplar does not include most of the Allegheny or a large portion of the North-central. The absence (0%) of yellow-poplar roundwood purchases in the Northeastern region may be due to microclimate and elevation, since this region is near the most northern limit of yellow-poplar's species range.

Regional differences for hard maple demonstrated that all regions that were primarily part of the Allegheny Plateau and/or Allegheny Mountains [Western (14%), Allegheny (13%), Northeastern (17%), North-central (9%), and Southwestern (7%)] had a considerable portion of their purchases in hard maple vs. the other regions. Respondents in the Allegheny purchased the highest percentage of soft maple roundwood (20%), followed by the North-central (14%), Southwestern (14%), Western (14%), and Northeastern (12%) regional respondents. This was expected as the Allegheny Plateau and Allegheny Mountain sections are home to the black cherry–maple forest type (Marquis 1998).

Responding roundwood purchasers in the Southeastern (37%) and Pocono (22%) regions purchased the greatest percentage of pine/hemlock roundwood, followed by the South-central (14%) and Northeastern (10%) regions. The firms in the Pocono and Northeast region purchased more hemlock (12%) than pine (10%) and the firms in the Southeastern and South-central region purchased more pine (31%) than hemlock (6%). According to Pennsylvania's DCNR, conifers range throughout the state with concentrations in the Pocono region (DCNR 2003).

The Northeastern region purchased the greatest percentage of mixed hardwoods (27%), which consisted of ash (*Fraxinus sp.*), beech, hickory (*Carya sp.*), black walnut (*Juglans nigra*), birch (*Betula sp.*), aspen (*Populus sp.*), and basswood. Respondents in all eight regions had greater than or equal to 6 percent of their roundwood purchases in these mixed hardwood species.

Though certain relationships between species composition of respondents' roundwood purchases and the purchasers' regional location could be expected, it is important to verify and continue to measure species composition of harvests given the complexity of hardwood forests and the surrounding hardwood industry. Small sawmill survivability in the Northeast has been linked to their procurement of a higher roundwood percentage from fee simple (company owned) lands and their ability to adapt to niche markets (Anderson and Germain 2007). As demands on forests increase with industry concentration and development of biomass markets it is increasingly important to track roundwood harvest by region and species composition.

Terminal cut vs. ongoing forest operation

Respondents were also categorized by regions (based on the purchasing firm's primary location) to analyze relationships

Table 4. — Roundwoood purchases by region and harvest operation out of an estimated total roundwood purchase volume of 1.266 BBF.

Region	Total purchases	Terminal cut[a]	Ongoing forest operation	Unknown harvest operation
		Percent of roundwood purchased by region and harvest operation		
North-central	10	6	91	3
Allegheny	19	4	95	1
Northeastern	8	9	89	2
Pocono	<1	16	84	0
Southeastern	26	20	78	2
South-central	10	3	96	0
Southwestern	18	5	87	8
Western	7	12	69	18
Pennsylvania[b]	99	9	87	4

[a]A terminal cut refers to land that is deforested and put to commercial, industrial, or private use.
[b]Total may not sum to 100 due to rounding.

between region and what percentage of their roundwood purchases were from ongoing forest operations vs. terminal cuts. This is an extremely important issue in Pennsylvania, a state that ranked fourth in projected volume of forestland to be subsumed by urbanization by 2050 (Nowak and Walton 2005). Nowak and Walton (2005) further estimated that Pennsylvania would lose 6,348 km^2, about 8.8 percent of its forestland between 2000 and 2050. The latest report on Pennsylvania's forests showed that between 1989 and 2004 Pennsylvania lost an average of 28,000 acres of forestland per year to residential and industrial development. This lost acreage may be considered permanent. During the same time, however, forestland gains from agricultural land reversions have offset most permanent forestland losses, keeping the total forest acreage relatively stable (McWilliams et al. 2007).

Terminal cuts were defined as harvest operations in which land was deforested and put to a commercial use (such as buildings or highways), an industrial use (such as factories or mills), or a private use (such as farm lands). **Table 4** shows that about 87 percent of all roundwood purchases in Pennsylvania were from ongoing forest operations, about 9 percent from terminal cuts, and 4 percent from a cut unknown to the responding roundwood purchaser.

The Pennsylvania regions with firms purchasing the highest percentages of roundwood from terminal cuts in 2003 were the Southeastern (20%), Pocono (16%), and Western (12%) regions. The high percentage of terminal cuts in these three regions is likely the result of urban sprawl, as Philadelphia and Pittsburgh are the two most heavily populated cities in Pennsylvania and the Pocono region is experiencing urban sprawl from New York City, New York. One of the highest state-to-state migration rates in the nation was between New York and Pennsylvania between 1995 and 2000; the fastest growing counties in Pennsylvania are Pike and Monroe, which are both in the Pocono region and among the fastest growing counties in the nation (The Reinvestment Fund 2004). Urbanization, through sprawl and development, is a severe threat to forest health and sustainability (Nowak and Walton 2005).

In 2005, according to Anderson and Germain (2007), a large percentage of roundwood purchased by hardwood sawmills in the Northeast was supplied from roadside (34%) and gatewood (34%) sources and nearly a third of purchases were from stumpage sales. Further, they found that, for small mills (purchasing <2 MMBF), almost 10 percent of purchases came from company lands (Anderson and Germain 2007).

Conclusion

The Pennsylvania roundwood purchasing industry was estimated at 1.266 BBF, including an estimated 284 MMBF of roundwood received from other states. Approximately 36 MMBF of Pennsylvania roundwood purchases were exported to surrounding states, and an additional 31 MMBF were exported outside of the United States. The volume of roundwood purchases imported in 2003 was approximately four times the volume imported in 1988 suggesting that it has become more difficult for Pennsylvania roundwood purchasers to access adequate roundwood volumes within the State. A 29 percent rise in export volume over that same 15-year period (1988 to 2003) is likely the result of the high international demand for veneer logs as the volume of veneer log purchases in 2003 is nearly four times that of 1988.

The hardwood industry in Pennsylvania is heterogeneous and has been found to vary regionally in terms of firm size, production type, and capacity. An estimated 982 MMBF of roundwood purchased in Pennsylvania in 2003 was harvested within the State. Pennsylvania roundwood purchasers received the most roundwood from the Allegheny, South-central, Southwestern, and North-central regions of the State.

The greatest percentage of total Pennsylvania roundwood purchase volume in 2003 was in oak (35%) with 24 percent red oak and 11 percent white oak, respectively. Hard and soft maple made up 18 percent, and black cherry made up 13 percent of Pennsylvania's total roundwood purchases in 2003. The Allegheny Plateau is the preferred site for black cherry as the percentage of purchases of this species was highest in Pennsylvania's North-central region (28%), followed by the Allegheny (27%), and Western (20%) regions. Similarly the percentage of roundwood purchases in yellow-poplar was highest in Pennsylvania's Southeastern (16%), South-central (12%), and Southwestern (14%) regions as these portions of the State best fit the preferred habitat for yellow-poplar.

The highest percentages of terminal cut harvests were found in Pennsylvania's Southeastern (20%), Pocono (16%), and Western (12%) regions. These higher percentages for terminal cuts were likely the result of urban sprawl from the nearby major cities, thus stressing the point that urban sprawl is a major threat to forestland.

Future research may examine the purchases and movement of roundwood throughout the hardwood region. Interstate roundwood estimates are very difficult to obtain, and better data on state exports/imports would be valuable to resource managers, policymakers, and state/federal agencies. Similar studies are needed in many other states as demand continues for more frequent research on roundwood harvests and move-

ments to better understand important trends in the forest resource and related industries.

Literature cited

Anderson, N. and R. Germain. 2007. Variations in trends in sawmill wood procurement in the Northeastern United States. Forest Prod. J. 57(10):36-44.

Bowe, S.A., R.L. Smith, and P.A. Araman. 2001. A national profile of the U.S. hardwood sawmill industry. Forest Prod. J. 51(10):25-31.

Crawford, S. 2005. Personal communication. September 19, 2005. Program Leader, New York State Forest Products Utilization and Marketing.

Dept. of Conservation and Natural Resources (DCNR), State of Pennsylvania. 2004. The state of the forest: A snapshot of Pennsylvania's updated forest inventory 2004. Pennsylvania DCNR Bureau of Forestry and the USDA Forest Serv. Pub. #NE-FR-03-04.

_____. 2003. Coniferous forest. Accessed November 1, 2005, from www.dcnr.state.pa.us/wlhabitat/forest/coniferous.htm.

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

Hardwood Lumber Manufacturers Assoc of Pennsylvania of Pennsylvania (HLMAP). 2000. Directory, 2000. HLMAP, Lebanon, Pennsylvania.

_____. 1998. Directory, 1997–1998. HLMAP, Lebanon, Pennsylvania.

Hardwood Manufacturers Assoc (HMA). 1999. Sawmill Directory. HMA, Pittsburgh, Pennsylvania.

Harris Pennsylvania Industrial Directory. 2002. Lumber and Wood Products. Harris Information Source, Twinsburg, Ohio.

_____. 2003. Lumber and Wood Products. Harris Information Source, Twinsburg, Ohio.

_____. 2004. Lumber and Wood Products. Harris Information Source, Twinsburg, Ohio.

Luppold, W.G. 1995. Regional differences in the eastern hardwood sawmilling industry. Forest Prod. J. 45(10):39-43.

_____, J.E. Baumgras, and G. Barrett. 2000. Characteristics of the eastern "grade" hardwood sawmilling industry. Forest Prod. J. 50(9): 23-27.

_____ and _____. 1995. Price trends and relationships for red oak and yellow-poplar stumpage, sawlogs and lumber in Ohio: 1975–1993. Northern J. of Applied Forestry 12(4):168-173.

_____ and M.S. Bumgardner. 2004. Regional changes in the timber resources of and lumber production in Pennsylvania. *In*: Proc. Southern Forest Economics Workshop (SOFEW). pp. 60–69.

Marquis, D.A. 1998. Black cherry. USDA Forest Serv. Accessed October 10, 2005, from www.na.fs.fed.us /spfo/pubs/silvics _manual/ volume_2/ prunus /serotina.htm.

McWilliams, W.H., S.P. Cassell, C.L. Alerich, B.J. Butler, M.L. Hoppus, S.B. Horsley, A.J. Lister, T.W. Lister, R.S. Morin, C.H. Perry, J.A. Westfall, E.H. Wharton, and C.W. Woodall. 2007. Pennsylvania's Forest 2004. USDA Forest Serv., Northern Res. Sta. 86 pp.

_____, C.A. Alerich, D.A. Devlin, A.J. Lister, T.W. Lister, S.L. Sterner, and J.A. Westfall. 2004. Annual inventory report for Pennsylvania's forests: Results from the first three years. Forest Inventory and Analysis. USDA Forest Serv., Northern Res. Sta. 95 pp.

Nowak, D.J. and J.T. Walton. 2005. Projected urban growth (2000–2005) and its estimated impact on the U.S. forest resource. J. of Forestry 103(8):383-389.

The Nature Conservancy. 2004. Nature Conservancy seeks to unite environmental and economic interests to restore ecological health of Arizona forests. Accessed January 28, 2008, from www.nature.org/ wherewework/northamerica/states/arizona/press/press1674.html.

Norusis, M.J. 2003. SPSS 12.0 Statistical Procedures Companion. Prentice Hall, Upper Saddle River, New Jersey. 614 pp.

Olson, D.F., Jr. 1969. Silvicultural characteristics of yellow-poplar. RP-SE-048. USDA Forest Serv. 16 pp.

Pennsylvania Bureau of Forestry. 1997. Pennsylvania Sawmills Directory. Bureau of Forestry, Div. of Forestry Advisory Services, Harrisburg, Pennsylvania.

_____. 1995. Pennsylvania Sawmills Directory. Bureau of Forestry, Div. of Forestry Advisory Services, Harrisburg, Pennsylvania.

Pennsylvania Dept of Agriculture (PDA). 2004. Data and statistics: Hardwood top export markets—2001. Accessed November 14, 2005, from www.agriculture.state.pa.us/agriculture/cwp/view.asp?q= 128978.

Pennsylvania Forest Products Assoc. (PFPA). 2004. Membership Directory and Buyers' Guide. Pennsylvania Forest Products Assoc. Hershey, Pennsylvania.

Pennsylvania Hardwood Development Council (HDC). 2000. Biennial report: Pennsylvania Hardwood Development Council, Pennsylvania Dept. of Agriculture. 9 pp.

Ray, C. 2007. Energy from trees! WoodPro TechNote 2006-1. Accessed January 28, 2008, from http://woodpro.cas.psu.edu/WoodPro% 20Word%20HTML%20files/WoodPro%20TechNote%202006-1.htm.

The Reinvestment Fund. 2004. Choices in Pennsylvania—developing a rational framework for housing investment in Pennsylvania. Accessed November 22, 2005, from www.trfund.com/about/publications/ Choices_in_PA/Choices _Population.pdf.

Schuler, T.M. 2004. Fifty years of partial harvesting in mixed mesophytic forest: Composition and productivity. Can. J. Forest Res. 34: 985-997.

Smith, P.M., S. Dasmohapatra, and W.G. Luppold. 2003. Estimating the size of the hardwood sawmill industry in Pennsylvania. Forest Prod. J. 53(6):19-22.

Strauss, C.H., B.E. Lord, and M.J. Powell. 2007. Res. report: Economic impact and timber requirements of the wood industry in Pennsylvania. Submitted to Pennsylvania Hardwoods Development Council, Pennsylvania Dept. of Agriculture. 111 pp.

_____, _____, _____, M. Shields, and T.W. Kelsey. 2000. Economic impact of Pennsylvania hardwood industry: Current status and proposed growth. *In*: Twenty-First Annual Hardwood Symp. of the Hardwood Res. Pennsylvania Hardwoods Development Council, Pennsylvania Dept. of Agriculture, Harrisburg, Pennsylvania. 29 pp.

USDA Forest Serv. 2006. New Mexico forest restoration principles announced by diverse task force. Accessed January 28, 2008, from www. fs.fed.us/r3/news/releases/2006/0517-principles.shtml.

Wharton, E.H. and J.L. Bearer. 1994. The timber industries of Pennsylvania, 1988. Resource Bulletin NE-130. USDA Forest Serv., Northeast. Res. Sta., Radnor, Pennsylvania. 40 pp.