
Small-Diameter Timber Utilization in Wisconsin: A Case Study of Four Counties

Scott A. Bowe, *Department of Forest Ecology and Management, University of Wisconsin-Madison, Madison, WI 53706-1598*; and **Matthew S. Bumgardner**, *Northeastern Research Station, USDA Forest Service, Princeton, WV 24740*.

ABSTRACT: *The state of Wisconsin has numerous forest ownership types. These include national, state, and county forests, as well as privately owned industrial and nonindustrial forests. In addition to sawlog markets, portions of the state also have substantial pulpwood markets associated with paper and panel mills. Combined, these attributes make Wisconsin a good location for studies of how different markets and ownerships influence small-diameter timber utilization in the Midwest. In the fall of 2003 and the spring of 2004, recent timber sales were examined in four selected counties in Wisconsin. Data on harvest contracts, cut types, silvicultural practices, forester involvement, residual stand characteristics, and fiber utilization were gathered. These data were examined based on ownership types, proximity to pulpwood markets, and forest cover in the counties. Findings suggested that each of these factors influenced harvest activities. Examining these factors will increase our understanding of the role small-diameter timber plays in forest management and expose opportunities resulting from its utilization. North. J. Appl. For. 23(4):250–256.*

Key Words: Small-diameter timber, Wisconsin, utilization, management, ownership.

Small-diameter timber issues have played a prominent role in discussions of forest management in recent years, particularly with regard to public lands. Much of the attention has been focused in the western United States, where wildfires have burned millions of acres of forestland. The particularly intense 2000 fire season saw 6.5 million ac burn (Glickman, D., and B. Babbitt. 2000. Managing the impact of wildfires on communities and the environment. A report to the President in response to the wildfires of 2000. Unpublished document for the Secretaries of the U.S. Department of Agriculture and the US Department of Interior). Throughout the interior West, forestlands have been characterized as densely stocked with small-diameter timber and lacking in vegetative and structural diversity, thus being especially susceptible to attack from insects and disease. Mortality from competition, insects, and/or disease results in high fuel concentrations that contribute to the risk of major wildfires (Skog et al. 1997). In the West, small-diameter timber has become synonymous with wildfire risk, loss of property, and loss of life. A key to reducing the intensity of these

wildfires is to improve forest health through silvicultural treatments such as thinning.

In other parts of the country, such as the Midwest and Appalachians, higher annual rainfall amounts and different forest types moderate the risk of catastrophic wildfires. Yet small-diameter timber management can affect forest health and revenues through commercial and precommercial thinning, timber stand improvement, and other silvicultural activities. As in the West, the presence of profitable markets and uses for small-diameter material is an important driver for treatment decisions in eastern hardwood forests (Baumgras 1992, Willits et al. 1996). Portions of the Appalachian hardwood forest are dominated by poorly stocked stands of small-stemmed, low value hardwoods, often the result of past cutting practices (McCay and Wisdom 1984, Douglas 2000).

In Wisconsin, there are about 350 sawmills located across the state purchasing logs and bolts for conversion into lumber (Bowe and Mace 2004). In addition to Wisconsin's sawlog markets, portions of the northern part of the State also have substantial markets for pulpwood-sized material associated with paper and oriented strandboard (OSB) mills (Figure 1). Pulpwood is the dominant roundwood material removed from Wisconsin forests on a volume basis (Figure 2). Traditionally, small-diameter and other low-value materials have furnished Wisconsin's large paper industry, but trends suggest that there also has been an increase in the use of low-grade hardwoods in OSB

NOTE: Scott A. Bowe can be reached at (608) 265-5849; Fax: (608) 262-9922; sbowe@wisc.edu. Funding for this research came from the USDA Forest Service. We thank Don Peterson of Renewable Resource Solutions, LLC, for data collection. Thanks also go to Bruce Hansen and Philip Araman for their assistance with the project. Copyright © 2006 by the Society of American Foresters.

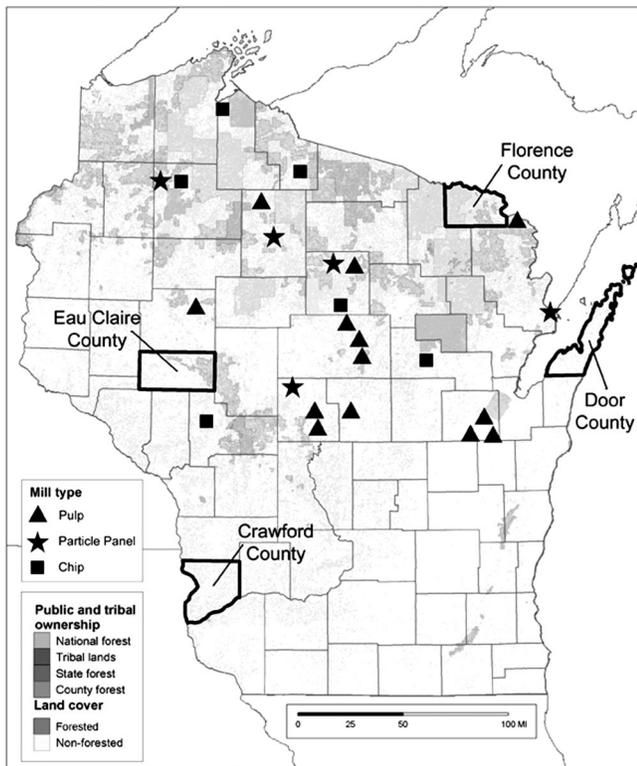


Figure 1. Wisconsin forest cover, forest ownership, pulp mill locations, and case study counties.

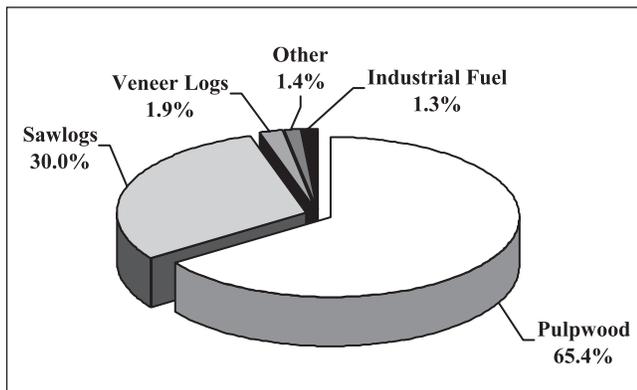


Figure 2. Wisconsin roundwood removals by product type, volume basis (Reading and Whipple 2003).

throughout the eastern United States (Bumgardner et al. 2001, Schuler et al. 2001). In the East, it has been shown that composite wood products such as OSB have a large proportion of their roundwood furnish supplied from pole timber-sized material (Luppold and Bumgardner 2004).

Forest management is more complex than just finding suitable markets. Forest ownership patterns might affect management objectives. The state of Wisconsin, for instance, has many types of forest ownerships, including national, state, tribal, and county forests, as well as privately owned industrial and nonindustrial forests (Figure 1). On an acreage basis, private nonindustrial lands represent 57% of the forestland in Wisconsin. This is followed by counties and municipalities with 15%; federal, 10%; forest industry,

7%; state, 5%; private corporations, 4%; and tribal lands, 2% (Finan 2000). Each ownership type generally has different objectives for how forestland should be managed, which, along with other factors, affect how small-diameter timber will be used. Based on the large amount of acreage under private ownerships, 72% of the wood fiber harvested comes from these ownership types; an additional 16% comes from county ownerships (Mace 2004).

To encourage forest management on privately held lands, many states have enacted incentive-based forest management laws. In Wisconsin, tax incentive programs have been available to forestland owners since 1927 and currently have about 29,000 forestland owners enrolled, representing 20 percent of Wisconsin's forestland (Wisconsin Department of Natural Resources 2004). The current version of the law, called the Managed Forest Law (MFL), offers forestland owners reduced annual property taxes in exchange for active forest management. Key components of the MFL include a required written forest management plan and a 5% yield tax during the forest harvests (excluding firewood harvests). The Wisconsin Department of Revenue estimates that MFL program participants can reduce their property tax an average of 80%, even after paying harvest taxes (Nielsen and Bergmann 2004).

Given that treatment of small-diameter timber is of consequence in sustaining healthy forests in a variety of landscapes, it is important that we know more about how various forestland ownership types differ in their utilization of small-diameter timber. Understanding utilization by ownership in the Midwest will enable forestland managers to better assess small-diameter management options and opportunities in this region. The objective of this paper was to compare how small-diameter utilization was affected by differences in ownership patterns, distance to pulpwood markets, and predominant forest cover.

Methods

Four counties in Wisconsin were selected based on their forestland ownership types, forest cover and active timber sales, and proximity to pulpwood markets. Each county was treated as a case study on small-diameter utilization, combining quantitative data from randomized plot analysis conducted in the field with qualitative assessments of field observations. The case study counties included Crawford, Door, Eau Claire, and Florence (Figure 1). Cutting notices on file with each respective county were obtained for 2003 (and in some cases 2002 or 2004) to identify recently completed harvests. In each county, 10% of the sales by ownership category were randomly selected to be included in the sample using a field visit for data collection.

Utilization data were gathered on 1/5-ac fixed plots. To randomize sampling, plot location was determined based on a 10 × 10 chain grid pattern starting at the southeast corner of the sale. A plot center was established for every 10 ac at the site for sales of 50 ac or less. For sales greater than 50 ac, five plots were established to represent the entire area. (In Florence County, two county forest sales were mechanized clearcuts, and due to the uniformity of practices in

these clearcut areas, only two plots were taken on each sale even though both sales were over 40 ac in size.) Data concerning the species of trees harvested, average stump diameter, average top diameter (the point at which utilization of the top log stopped), and pulp sticks left in the woods (sticks left beyond the top diameter) were collected. Plots to measure residual basal area were variable and made with a basal area stick (10 factor). Also, at the plot center, observational field notes of harvesting activities and stand characteristics were made on 1-ac plots. Recording of the ownership category, type of harvest, and silvicultural prescription completed data collection.

Table 1 presents summary information for data collected in each county. A total of 1,664 tree stumps were measured on 40 sites and 96 plots. In addition, a total of 851 tops were measured on the 96 plots. The top data were sometimes independent of the stump data; specifically, with mechanized harvests, it was impossible to match tops with their corresponding stumps. On plots with mechanized operations, a separate sample of tops was taken. On plots with chainsaw operations, stump and top diameter was taken on the same tree as the top was often left near its associated stump. In addition to the wood fiber measures, measurements of residual basal area also were made on several plots at each site. These data included total residual basal area broken down into large sawlog trees (greater than 15 in. dbh), small sawlog trees (9–15 in. dbh for softwoods; 11–15 in. for hardwoods), and pulpwood trees (5 in. minimum dbh).

Results and Discussion

Before proceeding to a detailed discussion of each county, it is useful to compare summary data for the four counties surveyed (Table 2). It is clear that Crawford County had, on average, the largest stump and top diameters. This translated into the lowest stump-to-top ratio. These findings for Crawford County seem to be a function of the distance to pulp markets, local market conditions (geared toward hardwood sawlogs), harvesting operations (chainsaw rather than mechanized), and predominant forest cover.

Crawford County

One hundred three cutting notices were filed with the Department of Natural Resources (DNR) forester for Crawford County in 2003. Crawford County consists entirely of nonindustrial private forestland (NIPF) ownership. Ten sales were randomly selected for data collection, resulting in

24 plots and 155 harvested trees (at least 5 in. stump diameter). When the selected sales sites were visited, two were not yet cut, and an owner denied access at another site. Each of these was replaced in the sample. Additionally, one site was a pine plantation, and its data were excluded from analysis, since it was unlike other harvests in the county. Seven species accounted for 90% of the harvested trees sampled; oaks accounted for 48%, and an additional 13 and 12% were accounted for by basswood and walnut, respectively. All harvests were chainsaw operations.

Five of the nine sale sites fell under Wisconsin's MFL program. Timber sales on MFL lands must have a management plan prepared by a forester and have a harvest plan approved by the local DNR forester. All five MFL sites (involving 13 plots and 73 harvested trees) were selection harvests for silvicultural thinnings. The remaining four sites were not under MFL contracts, and no forester was involved. All non-MFL sites (involving 10 plots and 40 trees) were diameter-limit and/or single-tree selection harvests.

Data obtained in Crawford County are shown in Table 3. The amount of pulpwood being left in the woods was striking and reflects the lack of local markets for the pulpwood material, much of which is oak. Both MFL and non-MFL sales tended to have relatively large stump diameters and top diameters. Interestingly, the average top diameter was significantly larger on MFL lands, but both types were similar in pulp sticks left per tree harvested.

Even though there were more trees cut per acre on MFL sales (as reflected in more pulp sticks left per plot even though pulp sticks left per tree harvested was similar to non-MFL sales), median residual basal area was the same on MFL and non-MFL sales (Table 3). Although the greatest proportion of residual basal area was in pulpwood trees for both ownership types, this proportion was substantially higher on non-MFL sales. Also notable was the large difference in proportional residual volume in small sawlog trees, with MFL sales having substantially more proportional volume in this category than non-MFL sales.

Door County

Thirty-three cutting notices were filed with the DNR forester for Door County in 2003. All were on NIPF lands. Three sales were randomly selected for data collection, resulting in six plots and 118 harvested trees (of at least 5 in. stump diameter). Of the original sales selected for visits, one owner denied access, and two owners could not be reached. Each of these sales was replaced in the sample. Six species accounted for more than 90% of the harvested trees

Table 1. Number of timber sale sites, plots, and trees (>5 in.) measured^a in each county by ownership type.

County	Private			County			Industrial			Federal		
	Sites	Plots	Trees	Sites	Plots	Trees	Sites	Plots	Trees	Sites	Plots	Trees
Crawford	10	24	155									
Door	3	6	118									
Eau Claire	7	16	333	5	15	356						
Florence	9	15	352	2	4	219	3	13	81	1	3	50
Total	29	61	958	7	19	575	3	13	81	1	3	50

^a Based on the number of stumps measured.

Table 2. Average stump and top diameters, stump-to-top ratios, predominant species, and distance to nearest pulp mill by county.

County	Stump diameter ^a	Top diameter ^a	Stump-to-top ratio	Predominant species ^b	Nearest pulp mill
Crawford	16.7 (5.0)	11.2 (2.2)	1.5	Red oaks (30.1%)	126 miles
Door	9.9 (4.1)	4.2 (1.4)	2.4	Sugar maple (51.7%)	80 miles
Eau Claire	8.9 (3.1)	4.2 (1.0)	2.1	Red pine (29.8%)	40 miles
Florence	9.8 (4.0)	4.5 (1.6)	2.2	Aspen (18.9%)	31 miles

^a Standard deviations in parentheses.

^b Proportion of species of the county sample in parentheses.

Table 3. Crawford County wood fiber measures and residual basal area, private Managed Forest Law (MFL) sales and private non-MFL sales.

Variable	MFL	Non-MFL	P value ^a
Pulp sticks cut and left in woods (8 ft) per tree harvested	3.1 (1.4) ^b	2.9 (1.6)	0.43
Pulp sticks cut and left in woods (8 ft) per plot	16.4	11.3	
Average stump diameter (in.)	16.4 (5.1)	17.2 (4.8)	0.45
Average top diameter (in.)	11.9 (2.3)	10.2 (1.7)	<0.01
Median residual basal area (ft ² /ac) ^c :	80.0	80.0	
Proportion in large sawlog trees ^d (%)	19.5	23.4	
Proportion in small sawlog trees (%)	36.3	16.9	
Proportion in pulpwood trees (%)	44.2	59.7	

^a Based on two-sample *t*-tests ($\alpha = 0.05$).

^b Standard deviations in parentheses.

^c Based on 13 plots for MFL sales and 10 plots for non-MFL sales.

^d Large sawlogs were greater than 15 in. dbh; small sawlogs were 9–15 in. dbh for softwoods or 11–15 in. dbh for hardwoods. Pulpwood was a minimum of 5 in. dbh.

sampled, including 52% sugar maple, 18% paper birch, 8% hemlock, and 7% red oak.

All sale sites fell under the MFL program and therefore had a forester involved in marking trees for cutting. Door County, located on Wisconsin's peninsula into Lake Michigan, is unique in the state in its high property and recreational values, and much of the forested land is under MFL management due to these qualities. All three sales were selection harvests for silvicultural thinnings.

Data obtained for Door County are shown in Table 4. Compared with Crawford County, very little pulpwood was left in the woods, and the average top diameter was quite low. Although the average stump diameter also was somewhat smaller, the stump/top ratio was much higher than in Crawford County (Table 2), suggesting fuller utilization. Utilization of hardwood pulpwood is somewhat unique to this area of the state due to the distance from pulp mills,

Table 4. Door County wood fiber measures and residual basal area, private Managed Forest Law (MFL) sales.

Variable	MFL
Pulp sticks (8 ft) cut and left in woods per tree harvested ^a	0.2 (0.7) ^b
Pulp sticks cut and left in woods (8 ft) per plot	1.5
Average stump diameter (in.)	9.9 (4.1)
Average top diameter (in.)	4.2 (1.4)
Median residual basal area (ft ² /ac) ^c :	85.0
Proportion in large sawlog trees ^d (%)	13.7
Proportion in small sawlog trees (%)	51.0
Proportion in pulpwood trees (%)	35.3

^a Pulp stick data based on trees cut in chainsaw operations only ($n = 18$).

^b Standard deviations in parentheses.

^c Based on six plots.

^d Large sawlogs were greater than 15 in. dbh; small sawlogs were 9–15 in. dbh for softwoods or 11–15 in. dbh for hardwoods. Pulpwood was a minimum of 5 in. dbh.

although Door County is closer to pulp markets than Crawford County is (Table 2). This pulpwood utilization might have something to do with the marketing abilities of the forester(s) involved. It also could be that the high property values (and subsequent property taxes) in Door County that help to encourage MFL enrollment result in overall better management and fuller resource utilization.

It is interesting that the residual basal area in Table 4 is largest in the small sawlog tree category, a finding similar to the MFL sales in Crawford County. Taken together, results from these two counties suggest that when a forester is involved in the sale, a greater emphasis is placed on the future stand quality.

A last point regarding Door County and small-diameter utilization was a comparison of mechanized versus chainsaw operations, as the sales sampled were split between mechanized and chainsaw operations. The mechanized operations had a significantly smaller ($P = 0.02$) top diameter (mean = 3.7; number of trees = 35) than did chainsaw operations (mean = 5.1; number of trees = 25). However, it should be noted that the mechanized operations were composed of about 58% maple and 22% birch, whereas the chainsaw operations were composed of about 52% maple and 32% oak.

Eau Claire County

Eau Claire County consists of a mix of private and county-owned forestland. Eighty-five cutting notices were filed for private timber sales in 2003 and 2004 in Eau Claire County; there were also 53 active county timber sales in 2003 and 2004 (in addition, there were three timber sales on industrial lands, but these were not surveyed). On private

lands, seven sales were randomly selected for data collection, resulting in 16 plots and 333 harvested trees (at least 5 in. stump diameter). On county lands, five sales were randomly selected, resulting in 15 plots and 356 harvested trees (at least 5 in. stump diameter). When the selected sales sites were visited, three had not had a timber sale, and two owners could not be reached. These were replaced in the sample. Most trees in the sample were mechanically harvested and four of the sites were pine plantations (two each on private and county land, plantations accounted for 18.8% and 20.0% of the plots, respectively). Five species groups accounted for over 90% of the harvested trees sampled, including 30% red pine, 20% red maple, 19% eastern white pine, 12% red oak, and 9% white oak.

Timber sales in Eau Claire County generally have more pulpwood than sawlogs because of timber types. However, more than half of the sales surveyed had some sawlogs taken. Only two of the 12 sales were total chainsaw operations, and three others had some chainsaw cutting. The rest were mechanized operations. Of the seven private timber sales, three were on MFL ownerships, and two others involved a forester. All five of the sales involving a forester were selection thinnings, whereas the remaining two private sales without forester involvement were diameter-limit cuts that removed only larger merchantable trees and were heavy to sawlog removal.

Of the five county timber sales, four were thinnings and one was a 13-ac clearcut with 2 ac of thinning. The clearcut showed that 9 of 30 trees cut were submerchantable. The practice of requiring loggers to fell submerchantable stems and leave them on-site has become standard in timber sale contracts on county lands to prepare the site for natural regeneration, whereas 20–30 years ago, agencies paid \$30–\$40/ac to have submerchantable trees cut after a timber sale. The effect of this practice was shown quantitatively by the fact that small sawlog trees made up the largest proportion of the residual basal area in county forests, whereas pulpwood makes up the largest proportion of the residual basal area in private forests (Table 5).

Data obtained in Eau Claire County are shown in Table 6. Because hardwoods accounted for 57% of the trees harvested on county sales and only 36% of the trees harvested on private sales, analysis of hardwoods and softwoods was conducted separately by ownership category. Similar to Door County, little pulpwood was left in the woods, and the average stump and top diameters were relatively small compared to Crawford County. With harvested softwood

trees, both the average stump diameter and average top diameter were significantly smaller on county timber sales. This suggests earlier removals of thinned material and better utilization of small-diameter tops on county lands. The stump-to-top ratios in Eau Claire County were similar to those in Door County and somewhat higher than those in Crawford County.

Florence County

Florence County consists of a mix of private nonindustrial, county, industrial, and federally owned forestland. Ninety-four cutting notices were filed for NIPF timber sales in 2002. Additionally, there were 16 active county timber sales, and 32 cutting notices were filed for sales on industrial timberlands. Finally, there were six active federal sales. On NIPF lands, nine sales were randomly selected for data collection, resulting in 15 plots and 352 harvested trees (at least 5 in. stump diameter). On county lands, two sales were randomly selected, resulting in four plots and 219 harvested trees. On industrial lands, three sales were randomly selected, resulting in 13 plots and 81 harvested trees. Finally, one federal sale was randomly selected, resulting in three plots and 50 harvested trees. Eight species accounted for 88% of the harvested trees sampled, including 19% aspen, 16% red pine, 13% sugar maple, 11% jack pine, and 8% each of paper birch, red maple, and balsam fir. About 56% of the sample trees were hardwoods, and 44% were softwoods. The surveyed sales included both mechanical (10 sites) and chainsaw (five sites) operations. Only one (red pine) plantation was encountered, that being in the federal sale.

A unique feature of Florence County, compared to the other case study counties, was the prevalence of clearcuts. This was the case in four of the NIPF sales and in both county sales. This complicates comparisons between ownership types, as average stump diameter becomes a function of stand composition, age, and past management practices, resulting in less impact by current management decisions. The number of clearcuts in Florence County also made comparisons between ownership types difficult in terms of residual basal area.

Comparisons by ownership type were further complicated in Florence County by other factors. Only three industrial sales and one federal sale were surveyed, and all were selective thinning harvests. To compare ownership types based on selective thinning harvests, only NIPF and industrial sales could be compared, but NIPF sales were composed of 42% hardwoods, and industrial sales were composed of 79% hardwoods. Furthermore, all of the industrial sales were chainsaw operations, whereas the NIPF sales were a mix of mechanical and chainsaw operations. For these reasons, only general field observations for Florence County are noted below, with the summary quantitative results shown in Table 2. The results suggest that Florence County was more like Door and Eau Claire counties in terms of average stump and top diameter; it also was the county closest to the nearest pulp mill (Table 2).

Table 5. Eau Claire County residual basal area, private and county sales.

Variable	Private	County
Median residual basal area (ft ² /ac) ^a :	100.0	80.0
Proportion in large sawlog trees ^b (%)	7.6	26.9
Proportion in small sawlog trees (%)	31.7	38.7
Proportion in pulpwood trees (%)	60.7	34.5

^aBased on 13 plots for private sales and 14 plots for county sales.

^bLarge sawlogs were greater than 15 in. dbh; small sawlogs were 9–15 in. dbh for softwoods or 11–15 in. dbh for hardwoods. Pulpwood was a minimum of 5 in. dbh.

Table 6. Eau Claire County wood fiber measures, private sales and county sales.

Variable	Private	County	<i>P</i> value ^a
Hardwoods			
Pulp sticks (8 ft) cut and left in woods per tree harvested ^b	0.4 (0.7) ^c		
Pulp sticks cut and left in woods (8 ft) per plot	3.2		
Average stump diameter (in.)	9.9 (4.4)	9.3 (3.1)	0.17
Average top diameter (in.)	4.6 (1.7)	4.5 (0.8)	0.70
Softwoods			
Pulp sticks (8 ft) left per tree harvested			
Pulp sticks left (8 ft) per plot			
Average stump diameter (in.)	8.9 (2.7)	7.4 (1.7)	<0.01
Average top diameter (in.)	4.3 (0.9)	3.3 (0.7)	<0.01

^a Based on two-sample t-tests ($\alpha = 0.05$).

^b Pulp stick data based on trees cut in chainsaw operations only ($n = 30$).

^c Standard deviations in parentheses.

- Even with the prevalence of clearcuts in Florence County, it was useful to consider top diameters as a measure of small-diameter utilization. For the NIPF clearcuts, average top diameter was 4.5 in. (SD = 1.3), with 68% of the harvested trees consisting of hardwoods. For the county clearcuts, average top diameter was 4.2 (SD = 1.1), with 58% being hardwoods. This difference was not statistically significant ($P = 0.29$).
- An interesting aspect of Florence County was the large number of trees cut on the plots that were less than 5 in. in diameter ($n = 198$). More than one-third of the 212 trees cut on two 1/5-ac plots on county sales were submerchantable (dropped and left on-site). Similar to what was noted for Eau Claire County, this is partly a function of developments in county forest policy. In the past, cutting of inferior smaller trees to promote regeneration was regarded as postsale treatment work.
- Of the nine NIPF sales, two were MFL and two others involved a forester to some extent. Two of the NIPF sales were diameter-limit cuts, and neither of these involved a forester.
- The federal sale had residual densities that averaged over 146 ft²/ac. This can make harvesting more difficult and does not use the site to its full production potential but likely reflects multiple management objectives. It was also noted that there were six active sales on 85,000 ac of national forests, compared with 16 active sales on 36,000 ac of county forests, suggesting more-intensive management on county lands.

Limitations

This study sought to determine whether proximity to pulp using facilities and different ownerships and forest cover affected small-diameter timber utilization. The study was based on a small sample of recent harvests in four selected Wisconsin counties. Although it is recognized that more-intensive sampling in a larger set of counties would have been desirable, this study represents a case-based preliminary effort to determine variables that influence small diameter utilization. The study design resembled a static-group comparison whereby observations were made after treatment with no data available regarding precutting stand conditions. Researchers designing future studies would do well to consider collection of preharvest stand

conditions and to focus on hardwood or softwood harvests exclusively while controlling for harvesting method. This would allow for more quantitative assessments of specific causal relationships. Finally, although the study was conducted in Wisconsin for reasons stated previously, the results should be applicable (with caution) to similar regions throughout the Midwest. With these limitations in mind, some conclusions can be drawn from the current study, as outlined below.

Conclusions

1. Crawford County harvests were primarily hardwood (e.g., oaks) chainsaw operations and were farthest from pulp markets. Thus, Crawford County was clearly different from the other counties in terms of average stump diameter, average top diameter, and the number of pulp sticks left in the woods. Given that Crawford County was selected as the case to represent conditions in southwestern Wisconsin, the data suggest that substantial amounts of hardwood small-diameter material were being left in the forests of the region.
2. As discussed in each county case analysis, it was observed that NIPF harvests were less likely to be diameter-limit harvests and more likely to be selective thinnings when a forester was involved in the sale (e.g., MFL lands), suggesting a possible link between forest health and professional management.
3. There was some evidence of better residual stand characteristics on managed lands (MFL and county ownerships), as reflected by the proportional residual volumes in sawlog-sized trees. Also related to residual stand characteristics, the federal sale surveyed seemed to have excessive residual basal area.
4. It was observed during data collection that policy was having an impact on county forests. Specifically, loggers were expected to cut unmerchantable trees for the sake of future forest health and productivity. This observation also seemed to show up in the data as proportionally less residual basal area in pulpwood-sized trees on county forests.

5. There was some evidence of more-intensive small-diameter utilization on public ownerships, as evidenced by smaller stump and top diameters for softwoods on county sales in Eau Claire County. However, this finding was not apparent for hardwoods in the county. Nor was it apparent for top diameters on NIPF versus county clearcuts in Florence County.
6. The apparently high utilization of hardwood pulpwood in Door County suggested that in areas with widespread active and professional management of private forestlands, opportunities could be created for small-diameter utilization.
7. Mechanical harvesting operations might result in better small-diameter utilization than chainsaw operations, as reflected in lower average top diameters. However, this also may have been a function of the species being cut.

Literature Cited

- BAUMGRAS, J.E. 1992. Effects of silvicultural prescriptions and roundwood markets on the economic feasibility of hardwood thinnings. P. 131–142 in *Proc. of Twentieth annual hardwood symposium of the Hardwood Research Council*. Cashiers, NC, June 1992. 175 p.
- BOWE, S.A., AND T.L. MACE. 2004. www.woodindustry.forest.wisc.edu.
- BUMGARDNER, M., B. HANSEN, A. SCHULER, AND P. ARAMAN. 2001. Options for small-diameter hardwood utilization: Past and present. P. 1–7 in *Hardwoods—An underdeveloped resource?* Proc. of the Annual meeting of the Southern Forest Economics Workers, Mar. 26–28, 2000, Lexington, KY, Pelkki, M.H. (ed.). Arkansas Forest Resources Center.
- DOUGLAS, T. 2000. Harvesting green gold. *Timber Processing* 25(9):10–14.
- FINAN, A. S. (ED.). 2000. Wisconsin forests at the millennium: An assessment, November 2000. Wisconsin Department of Natural Resources, Division of Forestry, Madison, WI. 125 p.
- LUPPOLD, W., AND M. BUMGARDNER. 2004. An examination of eastern U.S. hardwood roundwood markets. *For. Products J.* 54(12):203–208.
- MACE, T.L. 2004. Internal documents. Wisconsin Department of Natural Resources, Division of Forestry, Madison, WI. 1 p.
- MCCAY, T.D., AND H.W. WISDOM. 1984. Feasibility of small mill investments for utilizing small-diameter hardwood from coal lands in southwestern Virginia. *For. Products J.* 34(6):43–48.
- NIELSEN, C., AND S.A. BERGMANN. 2004. www.dnr.state.wi.us/org/land/forestry/ftax/MFLFactSheet.pdf; last accessed Jan. 3, 2005.
- READING, W.H. IV, AND J.W. WHIPPLE. 2003. Wisconsin's timber industry: An assessment of timber product output and use, 1999. Resource Bulletin NC-218. USDA Forest Service, North Central Research Station, St. Paul, MN. 91 p.
- SCHULER, A., M. BUMGARDNER, B. HANSEN, AND W. LUPPOLD. 2001. Species shift: Implications of the rising use of hardwoods in OSB. *Engineered Wood J.* 4(2):29–32.
- SKOG, K.E., R.J. BARBOUR, J. BAUMGRAS, AND A. CLARK III. 1997. Identifying wood utilization options for ecosystem management: Summary of a national research project. P. 31–36 in *Role of wood production in ecosystem management*. Proc. of the sustainable forestry working group at the IUFRO All Division 5 Conference, Pullman, WA, July 1997, R.J. Barbour and K.E. Skog (eds.). Gen. Tech. Rep. FPL-GTP-100. USDA Forest Service, Forest Products Laboratory, Madison, WI. 98 p.
- WILLITS, S., R.J. BARBOUR, S. TESCH, D. RYLAND, J. MCNEEL, R. FIGHT, S. KUMAR, G. MYERS, B. OLSON, AND A. MASON. 1996. The Colville study: Wood utilization for ecosystem management. Preliminary results of study of product potential from small-diameter stands. Res. Pap. FPL-RP-559. USDA Forest Service, Forest Products Laboratory, Madison, WI. 11 p.
- WISCONSIN DEPARTMENT OF NATURAL RESOURCES. 2004. www.dnr.state.wi.us/org/land/forestry/ftax/Index.htm; last accessed Jan. 3, 2005.