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Ring Flakes from Small-Diameter Eastern Hardwoods

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Abstract

Ring-cut flakes were produced from stems of six species of eastern hardwoods. Stems were 6 in. or smaller in diameter and were not debarked. Despite the fact that meticulous care was exercised to keep stems and chips clean, flaker knives dulled rapidly. The rapid dulling appears to result from the high silica content in chips of most of the species and probably reflects bark content. Bulk density measurements and screen analyses were performed, and results of these evaluations are reported. Flakes from the larger screen fractions were measured. The vibratory screener used in this study appeared to sort flakes more effectively by width than by length.

Keywords: Ring flakes, hardwoods, bulk density, screen analysis, flake measurement, silica, ash, screen classification

Introduction

An abundance of low quality hardwood timber is found in the eastern United States. A potential use for some of this timber is in the manufacture of structural flakeboard. Flakeboard plants in the southeastern United States already use some low to medium density hardwood species. The author has been informed, however, of intermittent curling problems in strands commercially cut by disk flakers from medium density hardwoods. More severe curling problems would be expected in cutting strands (and especially wafers) from high density hardwood species using disk or drum flakers (Beer 1982, Carll 1984, Johns and Maloney 1981). Ring flakers, on the other hand, apparently do not yield curled flakes, although they do produce a higher proportion of fines than do disk or drum flakers (Price and Lehmann 1978, 1979).

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Price and Lehmann (1978, 1979) reported that bending properties of panels made with oak and hickory ring-cut flakes (species prone to flake curling) from large chips (sometimes called maxichips) were not appreciably different from bending properties of matched oak or hickory panels made from disk- or drum-cut flakes. Furthermore, the panels Price and Lehmann made with ring-cut flakes were of slightly lower density and had superior internal bond strengths than panels made from disk- or drum-cut flakes. This suggests that ring flaking might allow more successful use of hardwood species, which tend to produce curled flakes when processed with disk or drum flakers. Most successful use of ring-cut flakes would be expected in core or intermediate layers because of the superior internal bond properties afforded by ring-cut flakes and because high quality (large) flakes are not required in these layers. Hunt and others (1978) used oak ring-cut flakes for the core of structural flakeboard with apparent success. Finally, ring flakers process chips at a fast rate (Maloney 1977), and this usually translates into flakes at lower cost.

The study described in this paper was conducted to examine the ring flaking characteristics of some eastern hardwoods. Small-diameter eastern hardwood stems of various densities were maxichipped and ring flaked. The flakes were evaluated by screen analysis and measured for length, width, bulk density, and ash and silica content.

Procedure

Raw Material

Six species of eastern hardwoods were evaluated: aspen (*Populus grandidentata*), American beech (*Fagus grandifolia*), red maple (*Acer rubrum*), white oak (*Quercus alba*), tupelo (*Nyssa sylvatica*), and yellow-poplar (*Liriodendron tulipifera*). Wood stems were 6 in. or less in diameter at the larger end. Aspen and red maple stems were of slightly smaller diameter than stems of the other species and were 4 in. or less in diameter at the larger end. The stems were kept clean of mud and dirt to reduce wear on the maxichipper and flaker. The bark was not removed because debarking would probably not occur in a woods chipping operation.

Chipping and Flaking

Unfrozen stems were chipped (each species separately) with a helical screw maxichipper (Kopo model PH-10). This chipper was used because it is portable and is designed specifically for small-diameter stems. In addition, preliminary work had shown the chipper capable of producing chips substantially larger than pulp chips but small enough to be flaked well by our knife-ring flaker. The chipper has a tapered helical screw that shears the wood into chips and chunks, and a paddlewheel ejection fan. The fan apparently breaks fractured chunks into chips. During chipping and handling, efforts were taken to keep grit out of the maxichips.

Maxichips (Fig. 1) were stored at 36°F until shortly before flaking. Some bark was easily separated and removed from chips; large chunks of bark were manually discarded from yellow-poplar chips (leaving these chips essentially bark-free), and some crumbly bark was removed from oak chips by screening.

Approximately 3,200 green pounds of maxichips were flaked. Each species of flakes was flaked separately on a Pallmann model PZ-8 knife-ring flaker with knives set at

0.025 in. projection. Knives were freshly sharpened and honed at the start of the experiment. Figures provided by the flaker manufacturer indicated that the flaker (if fed continuously) would have processed all maxichips for this study in a little over 1 h. The flaker manufacturer also stated that knife resharpening on this flaker (assuming clean chips) would be required after 4 to 6 h of continuous operation. Because stems and maxichips had been kept clean, I anticipated that all the maxichips could be flaked without seriously dulling the knives. Knife condition was checked after flaking each species. After flaking five of the six species, the knives required resharpening. Although knife condition was never very dull at any point during the study, the knives dulled at a much faster rate than anticipated. Therefore, ash and silica contents of flake samples of each species and of a sample of screened oak bark were determined.

Moisture content of flakes was monitored as flakes were discharged from the flaker; moisture content was always in excess of fiber saturation. Yellow-poplar and aspen flakes were the wettest species (100 percent moisture content), and red maple flakes were the driest (53 percent moisture content). Flakes were dried to 5 percent moisture content in a laboratory steam-heated, rotating-drum dryer.

Furnish Evaluation

A 20-lb sample of dry flakes of each species was evaluated by screen analysis. Screen fractions were +1, -1 +1/2, -1/2 +1/4, -1/4 +1/8, -1/8 + 1/16, -1/16 + 1/32, and -1/32 in. Samples of flakes from all but the two smallest screen fractions were selected, and flakes in each sample were measured for length and width. Flake length was measured as the longest chord in a direction along the wood grain. Flake width was measured as the longest chord in a direction across the wood grain that did not cross a split.

Flakes other than those in the screen analysis samples were screened (each species separately) to remove the -1/16 in. fraction. Bulk density measurements were made on samples of screened material of each species by the method described by Beer (1982). This method consisted of dropping furnish into a 5-gal round bucket through a serpentine chute. Furnish was dropped into the chute one handful at a time, and the chute was rotated 90° between each handful of furnish. Bulk density was determined in the unsettled condition, after settling by shaking, and after shaking followed by compaction. Shaking was performed by attaching the bucket to a piece of plywood, suspended by coil springs, that was shaken by a pneumatic vibrator, Flakes were compacted with a 50-lb weight and a flakeboard disk of diameter slightly smaller than that of the bucket. Compaction pressure with this arrangement was approximately 0.5 lb/in^2. Flake moisture content at time of bulk density measurements was 5 ± 1 percent.

Results and Discussion

Chipping Properties

The helical screw chipper produced maxichips of size appropriate for our knife-ring flaker from all but the last 3 in. of the stems. Apparently the end piece of a stem could pass between screw flights without being reduced to maxichips (Fig. 1). Our knife-ring flaker proved able to cut these chunks. However, because a chunk probably represented a moderately large unbalanced load on the impeller or the

knife ring, we prudently discarded most of these stem-end chunks. When chipping yellow-poplar stems, most of the bark neither remained attached to individual maxichips nor broke into small pieces, but hung together in clumps. As indicated previously, these clumps were manually removed from the maxichips.

Furnish Evaluation

Ash and silica contents of unscreened flake samples and of oak bark are listed in Table 1. Ash and silica contents were substantially higher in the bark than in the flakes, which are composed primarily of wood but which also include varying amounts of bark. Silica contents of beech flakes and yellow-poplar flakes were lower than those of the other flakes and were below 0.03 percent. Lehmann and Geimer (1974) suggested that values above 0.03 percent result in excessive knife wear. The yellow-poplar bark separated from the maxichips, hung together in clumps, and was therefore easily removed. This probably accounts for the relatively low silica content of yellow-poplar flakes. Because the bark remained tightly attached to beech maxichips, the relatively low silica content of beech flakes cannot be explained by bark removal. With the exception of beech and yellow-poplar flakes, flake silica contents were higher than the values Lehmann and Geimer (1974) found for debarked Douglas-fir stems of less than 4 in. diameter. As indicated above, the flaker knives dulled rapidly. The silica content of (most) maxichips from nondebarked wood appeared to be the cause of the rapid dulling.

Results of screen analyses are presented in Table 2. The most noteworthy observation pertains to oak flakes, Oak flakes were the sixth species flaked and were thus flaked with freshly sharpened knives (knives were resharpened after flaking five of the six species), Nevertheless, oak flakes had a greater proportion of fines than any other species.

Results of length and width measurements are shown in Figures 2 to 7. These figures are box plots; a box surrounds the central 50 percent of the data. The lower edge of the box indicates the 25th percentile, the upper edge the 75th percentile, and the horizontal dash within the box the 50th percentile (median). Vertical lines extending from the box indicate the range of the data.

The box plots are useful for showing how the screening operation sorted flakes. However, the plots probably do not indicate what could be expected in flaking woods (barky) chips in industrial practice, and they do not allow precise species-to-species comparisons. These limitations on the utility of the box plots are due to the bedeviling influence of knife dulling. Knives were resharpened after flaking just a little over a green ton of maxichips (much sooner than could be expected in industrial practice), and although knives were never very dull, knife condition was not identical for all species.

The box plots suggest that screening was a more effective sorter by width than by length, which is particularly evident in the comparison of the length and width distributions of aspen flakes (Fig. 2). The interquartile ranges of flake lengths in the 1-, 1/2-, and 1/4-in. screen fractions are similar, but the interquartile ranges of flake widths in these fractions become progressively narrower and smaller as screen opening decreases. This may reflect the characteristics of the screener, in which

the vibrational component normal to the screen plane is as great as the vibrational component parallel to the screen plane. Given this mode of vibration, flakes with a large length-to-width ratio are more likely to pass endwise through a screen opening than they would in a gyratory screener: The box plots also suggest that length and width distributions within a given screen fraction are not greatly different for different species. Variability in flake width decreases in progressively smaller screen fractions, whereas variability in flake length does not appear to do so. Lastly, width distributions in the 1/16-in. fractions usually show substantial skewness (median values toward one or the other end of the interquartile range). I can think of no plausible explanation for the skewness other than that measurement of flakes in the 1/16-in. fraction was at the limit of precision of the measurement device. I probably would have obtained more accurate measurements in this screen fraction had I made measurements from magnified images.

Furnish bulk density values are listed in Table 3. Bulk densities reflect wood species densities. Shaking resulted in a fairly consistent increase in bulk density (11 to 15 percent). The influence of shaking and compaction was more variable; shaking and compaction increased bulk density by 21 to 39 percent. Vidrine and Woodson (1982) reported a moderately higher percentage of compaction (with wetter flakes cut in a different manner) at a substantially higher compaction pressure. In the work reported here, bulk density values of flakes were substantially lower than the values Chow and others (1973) reported for oak sawdust, commercial Southern Pine particleboard furnish, and hammer milled oak chips and more similar to the values they reported for maple planer shavings. Uncompacted bulk density values reported in this paper ranged from equivalent to moderately in excess of the 3- to 4-lb/ft^3 values reported by Snodgrass (1977) for “best quality” strands produced on ring flakers from maxichips of debarked softwoods.

Concluding Remarks

Flake furnishes were produced from nondebarked hardwood stems of 6 in. or smaller diameter. Despite the fact that meticulous care was exercised to keep stems and chips clean, flaker knives dulled rapidly. The rapid dulling appears to result from the high silica content of chips of some species (aspen, maple, tupelo, and oak), and probably reflects chip bark content. These results suggest that with many species, silica content will be a serious problem in maxichips produced from nondebarked logs.

Screen analyses indicated that oak maxichips yielded a higher proportion of fines than did maxichips of the other species. Measurement of flake samples from the larger screen fractions indicated that screening (with the equipment used) was a more effective sorter by flake width than by length. Bulk density values ranged from 3.6 to 7.6 lb/ft^3 and depended on wood density, shaking, and compaction.

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Table 1—Ash and silica contents of flakes and bark

Material	Ash content (percent)	Silica content (percent)
Aspen flakes	0.95	0.07
Beech flakes	0.89	0.02
Maple flakes	1.17	0.07
Oak flakes	2.19	0.04
Tupelo flakes	1.82	0.05
Yellow-poplar flakes	0.77	0.02
Oak bark	11.83	0.95

Table 2—Mass proportions of dry ring-flake furnishes retained on screens with geometrically decreasing opening size

Screen opening (in.)	Proportion retained					
	Aspen	Beech	Maple	Oak	Tupelo	Yellow-poplar
+1	0.005	0.010	0.006	0.001	0.001	0.008
-1 + 1/2	0.109	0.109	0.091	0.037	0.052	0.091
-1/2 + 1/4	0.415	0.357	0.379	0.198	0.301	0.356
-1/4 + 1/8	0.246	0.234	0.243	0.280	0.243	0.203
-1/8 + 1/16	0.096	0.129	0.139	0.247	0.179	0.142
-1/16 + 1/32	0.058	0.072	0.069	0.119	0.107	0.088
-1/32	0.071	0.089	0.073	0.118	0.117	0.112
Total	1.000	1.000	1.000	1.000	1.000	1.000

Table 3—Wood and flake bulk densities

Species	Wood density[a] (lb/ft^3)	Flake bulk densities[b] (lb/ft^3)		
		Unshaken	Shaken	Shaken and compacted
Aspen	26.2	4.0	4.6	5.3
Beech	41.6	5.6	6.2	6.9
Maple	40.5	4.9	5.6	6.5
Oak	44.3	6.3	7.2	7.6
Tupelo	37.4	4.9	5.6	6.5
Yellow-poplar	26.2	3.6	4.1	5.0

[a] Wood density measured on disks cut from stem ends. Values based on mass and volume of ovendry wood.

[b] Bulk densities based on mass and volume at test moisture content (5 ± 1 percent).

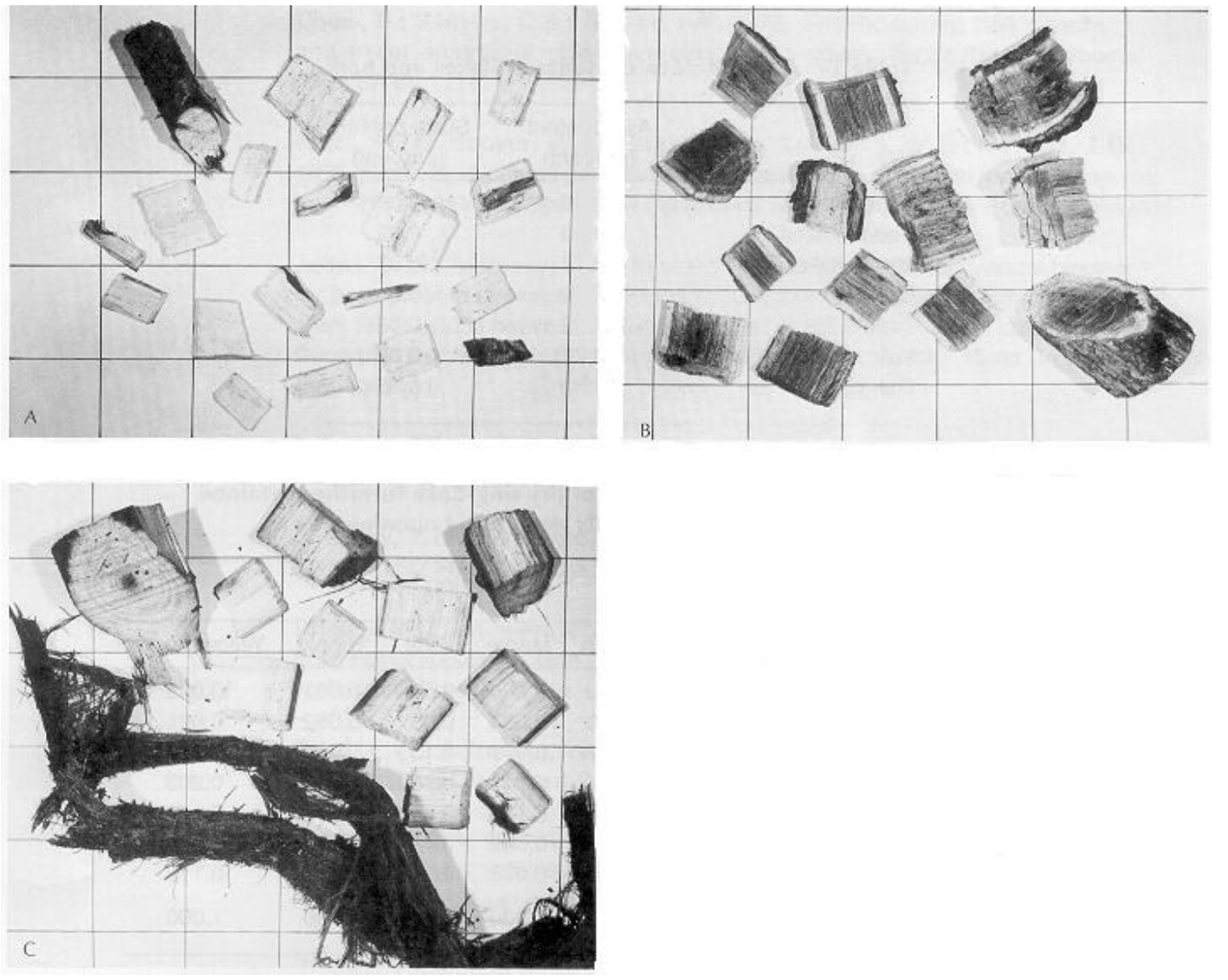

Figure 1—Chipper output including chips, stem-end pieces, and a bark chunk (yellow-poplar). Grid lines are spaced 4 in. apart. A, aspen; B, white oak; C, yellow-poplar. Beech, red maple, and tupelo chips were of similar appearance. (M85 0303, M85 0304, M85 0305)

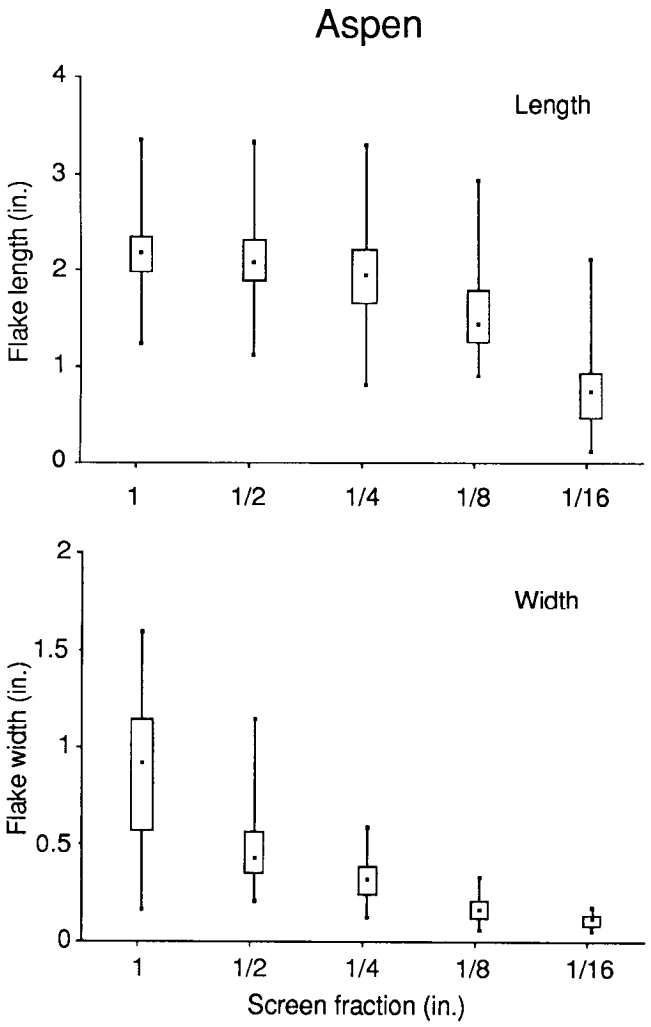

Figure 2—Length and width distributions of aspen flakes in screen fractions.

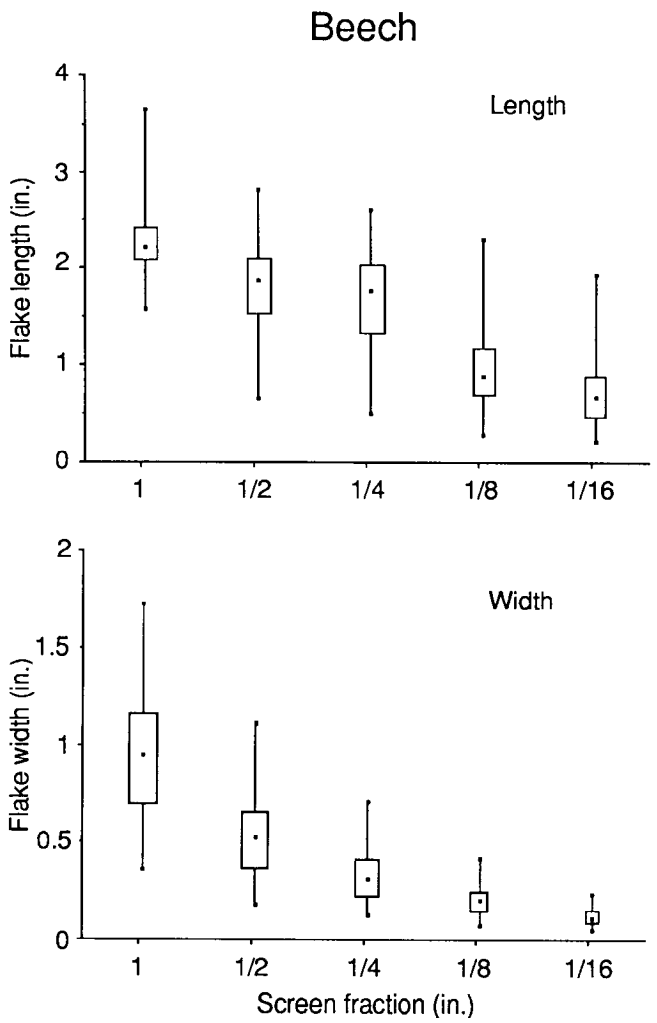

Figure 3—Length and width distributions of beech flakes in screen fractions.

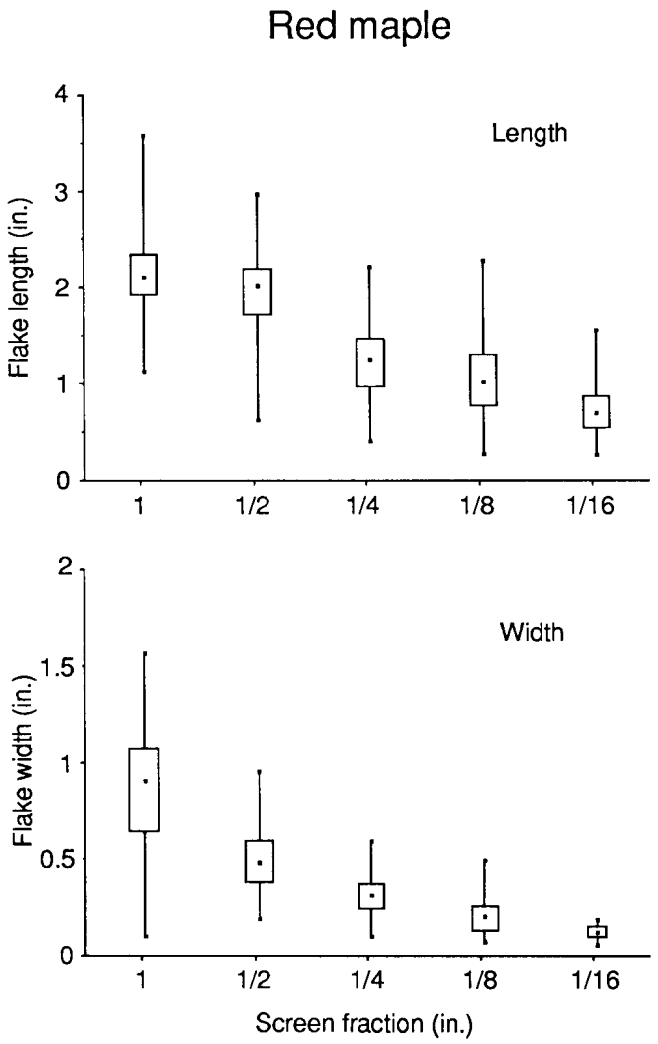

Figure 4—Length and width distributions of red maple flakes in screen fractions.

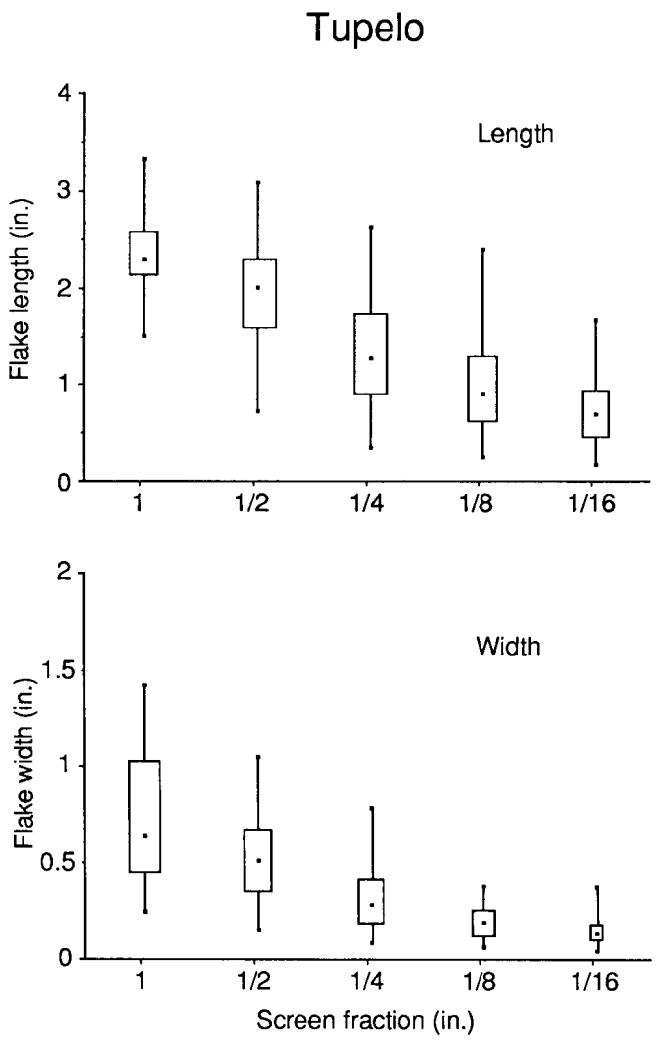

Figure 5—Length and width distributions of tupelo flakes in screen fractions.

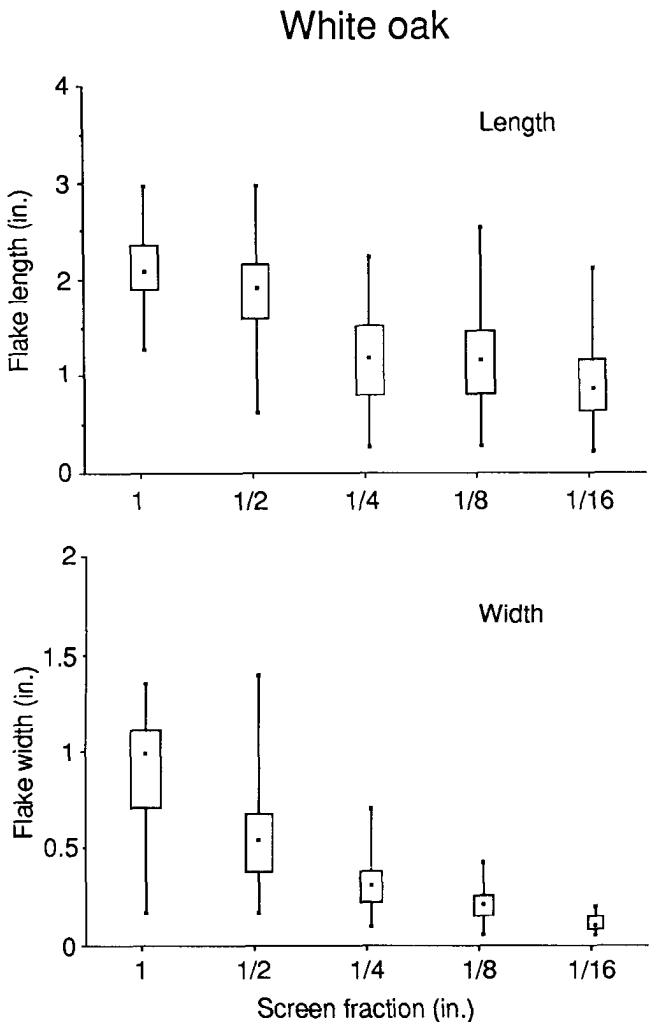

Figure 6—Length and width distributions of white oak flakes in screen fractions.

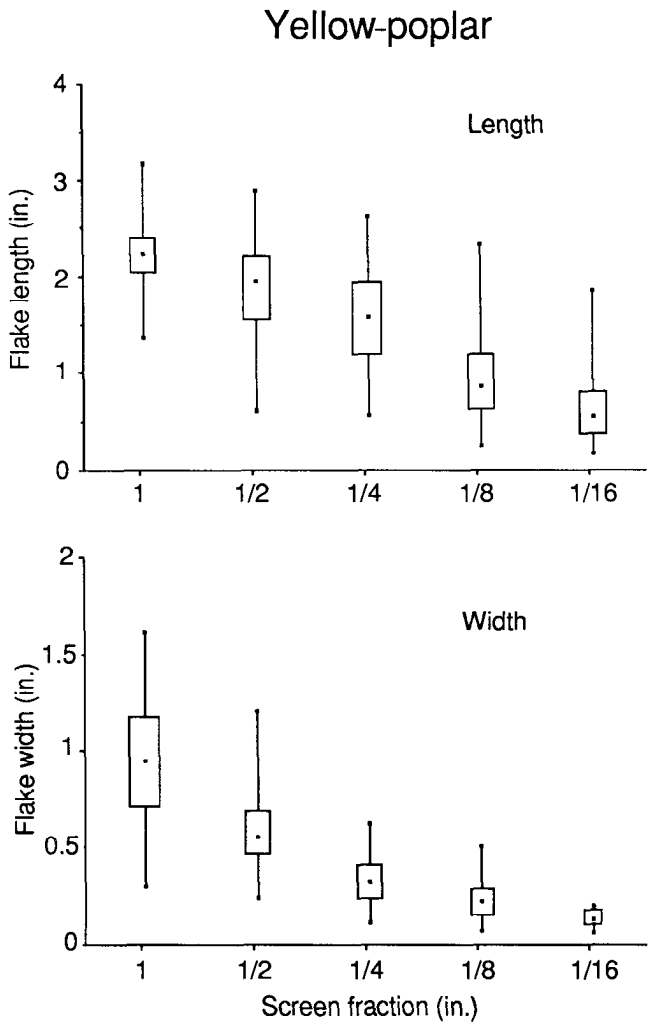

Figure 7—Length and width distributions of yellow-poplar flakes in screen fractions.

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