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# Yield of pallet cants and lumber from hardwood poletimber thinnings

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## Abstract

Woods-run bolts in 4- and 6-foot lengths from poletimber stand thinnings were classified into five quality classes, and the absolute sweep was measured for each bolt. Cants 4 by 4 and 4 by 6 inches were sawn from these bolts. The cants were classified by an interim classification system for the production of pallet parts.

In contrast to straight bolts, sweep from 0.6 to 1.0 inches in bolts from 6 to 10 inches in diameter reduces the yield of pallet cants approximately 5 percent; 1.1 to 1.5 inches of sweep reduces the yield approximately 10 percent. The quality mix of pallet cants produced from woods-run bolts is sufficient for commercial pallet production when unsound bolts and those with sweep in excess of 1-1/2 inches are eliminated. No need for a more detailed pallet bolt classification system was indicated.

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## Cover Photo

Sawable boltwood from thinning Allegheny hardwood stands. The bolts yield a grade mix of parts suitable for commercial pallet production.

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## INTRODUCTION

Prescribed thinnings in hardwood poletimber stands yield 35 to 70 green tons of wood per acre (Craft and Baumgras 1978, 1979). Recently 40- to 60-year-old stands in three major hardwood types were thinned on medium to good sites. Product yields in the following three categories were evaluated: sawable wood—which includes standard sawlogs and boltwood 6 inches or larger in diameter by 4 feet or longer and straight enough to produce at least a 4-inch by 4-inch by 4-foot cant of Sound Square Edge (National Hardwood Lumber Association 1978) or better grade; round pulpwood from 4 to 6 inches small end diameter; and chippable wood (tops and bolewood less than 4 inches in diameter). Each product category comprised about one-third of green weight yield in each of the areas thinned.

Sawable wood yields by weight ranged from 25 to 50 percent of trees removed in the thinnings. This amounted to 2,000 to 4,500 board feet per acre, Int. 1/4" log/bolt scale basis, or 2,500 to 5,300 board feet per acre of sawed cants and lumber. About two-thirds of the sawable volume was in pieces less than 8 feet long; a similar percentage of the sawable volume was in pieces 10 inches or less in scaling diameter.

Because of the prevalence of short lengths and small diameters, we evaluated the sawable boltwood for use as pallet parts. This report summarizes the distribution of sawbolt quality and the yield and quality of pallet cants that can be expected from thinnings.

## STUDY AREAS

Sawbolts processed in the study were taken from sample plots located in Allegheny hardwood type stands on the Monongahela National Forest, in oak-hickory type stands on the Monongahela National Forest and the Jefferson National Forest, and in oak-hickory and cove types on Camp Creek State Forest in West Virginia. A total of 36 study plots were located to include a variety of site and stand conditions.

## PROCEDURE

### Bolt Selection

Study plots were marked according to the appropriate management guides to improve crop-tree spacing and reduce stand density. Trees at least 5.6 inches dbh (diameter breast high) that were designated for removal were felled and cut to a 4-inch diameter top. The full-length stems were skidded to a landing and bucked to obtain the highest yield of sawable roundwood. The minimum acceptable piece was 6 inches in

scaling diameter and straight enough to yield at least a 4- by 4-inch Sound Square Edge cant with a minimum length of 4 feet. The resulting 4- and 6-foot long sawbolts with scaling diameters of 6 to 10 inches were analyzed for this study. Sample bolts were measured for both end diameters (inside bark), total length (including trim allowance), and absolute sweep to the nearest 1/2-inch. Cubic foot volume was determined for each sample bolt.

### Bolt Quality Classification

Each bolt was assigned to a quality class, based on the number of "good" faces. For our purpose, a "good" face was defined as one free of defects. Sound knots or limb scars not exceeding one-third of the face width were not considered defects. Bolts with unsound ends (except those with defects within 1 inch of the periphery or within the trim allowance) were considered unusable for pallet stock and tallied separately. Five bolt quality classes were as follows:

- Class 4 — bolts with all good faces
- Class 3 — bolts with only three good faces
- Class 2 — bolts with only two good faces
- Class 1 — bolts with only one good face
- Class 0 — bolts with no good faces

### Bolt Conversion

Each sample bolt was sawn into either a 4- by 4-inch or 4- by 6-inch cant and side lumber. The larger cant was produced whenever possible without exceeding wane limitations. Side lumber was edged to the nearest 1 inch width with wane limited to 1/4 inch on a maximum of two corners. Cant volume was measured by NHLA (National Hardwood Lumber Association) rules. Since 4- and 6-inch widths are the predominant widths used in pallet production, only 4-inch and wider side lumber was tallied as usable for pallets. All 5-inch side lumber was tallied as 4-inch widths and all side lumber over 6 inches as 6-inch widths.

### Cant Quality Classification

Since no pallet cant grading system has been published, interim quality classes were devised for use in the study. The minimum specifications for three classes of cants were:

#### Class 1 cants

Sound knots:

Maximum dimension one-third face width. Clustered knot dimensions are additive. No knots over 1/2-inch diameter in edges or end 3 inches of the piece.

Unsound knots and holes:

Unsound or loose knots or holes may not exceed one-sixth width of cant face.

**Cross grain:**

Cannot exceed 1:10 except in vicinity of knots and burls.

**Splits, checks, shake:**

Singly or in combination may not exceed one-third cant length, except that those 3 inches or shorter are ignored.

**Wane:**

May not exceed 1/2-inch width on any edge of the cant.

**Manufacture:**

75 percent of pieces must be at least specified dimensions and may not exceed specified thickness by more than 1/4 inch; 25 percent may be within -1/8 to +1/4 inch of specified dimension.

**Class 2 cants**

**Sound knots:**

Maximum dimension is one-half face width. Dimensions of clustered knots within 3 inches of each other are additive. No knots over 1 inch in diameter in edges or end 3 inches.

**Unsound knots or holes:**

Unsound knots, loose knots, or holes may not exceed one-fourth width of cant face.

**Cross grain:**

Not greater than 1:6 except in vicinity of knots and burls.

**Splits, checks, shake:**

Singly or in combination, may not exceed one-half of cant length. Those less than 3 inches long are ignored.

**Wane:**

May not exceed 5/8-inch width on any edge of the cant.

**Manufacture:**

66-2/3 percent of pieces must be at least specified dimensions and may not exceed specified thickness by more than 1/4 inch; 33-1/3 percent of pieces may be within -1/8 to +1/4 inch of specified dimension.

**Class 3 cants**

**Sound knots:**

No size limitation.

**Unsound knots and holes:**

Unsound knots, loose knots, or holes may not exceed one-half width of cant face.

**Cross grain:**

No limitation.

**Splits, checks, shake:**

Singly or in combination, may not exceed three-fourths of cant length, except that those less than 3 inches long are ignored.

**Wane:**

May not exceed 3/4-inch width on any edge of the cant.

**Manufacture:**

All pieces must be within -1/8 to +1/4 inch of specified dimension.

**RESULTS**

**Pallet Bolt Classification and Cant Yields**

The quality class distribution of 1,628 woods-run bolts was as follows:

| <i>Bolt class</i>        | <i>4-foot bolts</i> | <i>6-foot bolts</i> |
|--------------------------|---------------------|---------------------|
| <i>---- percent ----</i> |                     |                     |
| 4                        | 29                  | 15                  |
| 3                        | 18                  | 16                  |
| 2                        | 13                  | 13                  |
| 1                        | 15                  | 15                  |
| 0                        | 25                  | 31                  |

The cant class yield from the 1,628 bolts was:

| <i>Cant class</i>        | <i>4-foot cants</i> | <i>6-foot cants</i> |
|--------------------------|---------------------|---------------------|
| <i>---- percent ----</i> |                     |                     |
| 1                        | 47                  | 47                  |
| 2                        | 32                  | 33                  |
| 3                        | 21                  | 20                  |

Bolt class distribution and cant class yields by species and bolt class are shown in Table 1. Less than 1/2 of 1 percent of all bolts harvested were unusable because of unsound

**Table 1—Pallet bolt and cant class distribution for woods-run oak-hickory and Allegheny hardwood pole-timber thinnings (Interim bolt and cant classification system)**

| Bolt<br>class              | No.<br>samples | % of<br>samples | Cant class |    |    |
|----------------------------|----------------|-----------------|------------|----|----|
|                            |                |                 | 1          | 2  | 3  |
| ----- <i>percent</i> ----- |                |                 |            |    |    |
| OAK                        |                |                 |            |    |    |
| 4                          | 94             | 34              | 85         | 13 | 2  |
| 3                          | 54             | 19              | 69         | 22 | 9  |
| 2                          | 32             | 12              | 47         | 37 | 16 |
| 1                          | 35             | 13              | 69         | 14 | 17 |
| 0                          | 61             | 22              | 38         | 32 | 30 |
| All                        | 276            |                 | 65         | 22 | 13 |
| YELLOW-POPLAR              |                |                 |            |    |    |
| 4                          | 184            | 42              | 57         | 34 | 9  |
| 3                          | 81             | 19              | 40         | 48 | 12 |
| 2                          | 43             | 10              | 40         | 44 | 16 |
| 1                          | 39             | 9               | 36         | 49 | 15 |
| 0                          | 85             | 20              | 21         | 56 | 23 |
| All                        | 432            |                 | 43         | 43 | 14 |
| CHERRY                     |                |                 |            |    |    |
| 4                          | 114            | 26              | 70         | 20 | 10 |
| 3                          | 77             | 18              | 35         | 35 | 30 |
| 2                          | 61             | 14              | 28         | 44 | 28 |
| 1                          | 70             | 16              | 29         | 31 | 40 |
| 0                          | 113            | 26              | 23         | 40 | 37 |
| All                        | 435            |                 | 39         | 33 | 28 |
| BEECH, BIRCH, MAPLE        |                |                 |            |    |    |
| 4                          | 56             | 11              | 75         | 23 | 2  |
| 3                          | 71             | 15              | 60         | 28 | 12 |
| 2                          | 76             | 16              | 50         | 34 | 16 |
| 1                          | 108            | 22              | 37         | 36 | 27 |
| 0                          | 174            | 36              | 37         | 24 | 39 |
| All                        | 485            |                 | 47         | 29 | 24 |

defects. Ninety-eight percent of all cants produced (both 4- and 6-foot lengths) were of Sound-Square-Edge or better grade. Table 2 shows cant quality yield by the different bolt classes for all species of woods-run bolts.

**Table 2—Cant quality yield by bolt quality classes**

| Bolt class          | Percent of bolts in cant class: |    |    |
|---------------------|---------------------------------|----|----|
|                     | 1                               | 2  | 3  |
| <b>4-FOOT BOLTS</b> |                                 |    |    |
| 0                   | 36                              | 30 | 34 |
| 1                   | 34                              | 36 | 30 |
| 2                   | 40                              | 38 | 21 |
| 3                   | 52                              | 30 | 18 |
| 4                   | 75                              | 18 | 7  |
| <b>6-FOOT BOLTS</b> |                                 |    |    |
| 0                   | 26                              | 47 | 27 |
| 1                   | 35                              | 42 | 23 |
| 2                   | 48                              | 33 | 19 |
| 3                   | 53                              | 31 | 16 |
| 4                   | 76                              | 22 | 2  |

Average yields per bolt of cants and side lumber were:

| Diameter<br>class<br>(inches) | Average yield per bolt<br>(all species combined) |              |
|-------------------------------|--------------------------------------------------|--------------|
|                               | 4-foot bolts                                     | 6-foot bolts |
|                               | ---- board feet ----                             |              |
| 6                             | 5.3                                              | 8.1          |
| 7                             | 6.4                                              | 9.6          |
| 8                             | 9.0                                              | 14.4         |
| 9                             | 11.8                                             | 18.0         |
| 10                            | 14.9                                             | 22.7         |

#### Pallet Stock Yields by Sweep Classes

Because of the range of cross-sectional dimensions within a single bolt diameter class, an appropriate way to express the effect of sweep on product yield is to compare product yield in cubic feet with cubic-foot volume of sample bolts. The following tabulation shows average yield of pallet cants and side lumber by sweep classes from the sample bolts:

| Sweep class<br>(inches) | Yield from<br>4-foot bolts<br>---- percent of volume ---- | Yield from<br>6-foot bolts |
|-------------------------|-----------------------------------------------------------|----------------------------|
| 0 — 0.5                 | 56                                                        | 58                         |
| 0.6 — 1.0               | 53                                                        | 55                         |
| 1.1 — 1.5               | 49                                                        | 47                         |

In some pallet-producing areas, degrade problems occur in shipping and storage of green pallet parts, especially those 4/4 inches or less in thickness; thus some processors recover only pallet cants from boltwood. (Exceptions are where the primary bolt conversion facility is adjacent to or near the pallet assembly plant). The yield of pallet cants only from the sample bolts was:

| Sweep class<br>(inches) | Yield from<br>4-foot bolts<br>---- percent of volume ---- | Yield from<br>6-foot bolts |
|-------------------------|-----------------------------------------------------------|----------------------------|
| 0 — 0.5                 | 48                                                        | 47                         |
| 0.6 — 1.0               | 44                                                        | 42                         |
| 1.1 — 1.5               | 39                                                        | 36                         |

Tables 3 and 4 show the effect of sweep on pallet stock yield by bolt diameter class.

#### DISCUSSION

The interim cant quality classes used in this study are based on an unpublished industry grading system for pallet parts, and on observations at several pallet plants that process boltwood and/or cants. Studies are now being conducted to determine the extent to which the interim cant quality classes can be used to estimate actual pallet part yields by grade. Recent field tests by cooperating pallet manufacturers indicate that woods-run bolts do yield a grade mix of parts suitable for commercial pallet production.

Two sample lots of bolts from Allegheny hardwood species (cherry, maples, birch, and beech) and one sample lot of bolts from cove hardwoods (oak, yellow-poplar, hickory, and maples) were processed through a pallet parts mill. All parts recovered from the bolts were measured and graded as to their suitability for (a) permanent pallets (high-grade parts) or (b) expendable pallets (low-grade parts). Results were as follows:

**Table 3—Pallet cant and lumber yields from 4-foot woods-run bolts by diameter and sweep class**

| Bolt<br>dia.<br>class | Sweep<br>class | Bolt<br>volume              | Product<br>yield | Product yield                      | Cant yield |     | Side lumber yield |     | Cants only |
|-----------------------|----------------|-----------------------------|------------------|------------------------------------|------------|-----|-------------------|-----|------------|
|                       |                |                             |                  |                                    | 4x4        | 4x6 | 1x4               | 1x6 |            |
| ----- inches -----    |                | ----- ft <sup>3</sup> ----- |                  | ----- percent of bolt volume ----- |            |     |                   |     |            |
| 6                     | 0-0.5          | 283.9                       | 160.3            | 53                                 | 53         | 0   | 0                 | 0   | 53         |
|                       | 0.6-1.0        | 124.0                       | 68.6             | 48                                 | 48         | 0   | 0                 | 0   | 48         |
|                       | 1.1-1.5        | 29.6                        | 16.0             | 43                                 | 42         | 0   | 1                 | 0   | 42         |
| 7                     | 0-0.5          | 200.1                       | 103.1            | 52                                 | 31         | 16  | 5                 | 0   | 47         |
|                       | 0.6-1.0        | 101.6                       | 47.8             | 47                                 | 40         | 2   | 5                 | 0   | 42         |
|                       | 1.1-1.5        | 32.1                        | 14.7             | 45                                 | 39         | 2   | 4                 | 0   | 41         |
| 8                     | 0-0.5          | 127.4                       | 72.7             | 57                                 | 3          | 44  | 7                 | 3   | 47         |
|                       | 0.6-1.0        | 88.2                        | 47.6             | 54                                 | 7          | 37  | 7                 | 3   | 43         |
|                       | 1.1-1.5        | 12.6                        | 5.8              | 46                                 | 13         | 26  | 6                 | 1   | 40         |
| 9                     | 0-0.5          | 88.5                        | 50.5             | 57                                 | 4          | 36  | 7                 | 10  | 40         |
|                       | 0.6-1.0        | 44.2                        | 24.9             | 56                                 | 0          | 39  | 7                 | 10  | 39         |
|                       | 1.1-1.5        | 12.4                        | 6.6              | 53                                 | 0          | 38  | 7                 | 8   | 38         |
| 10                    | 0-0.5          | 58.9                        | 36.2             | 61                                 | 2          | 41  | 5                 | 13  | 43         |
|                       | 0.6-1.0        | 28.3                        | 16.9             | 60                                 | 5          | 38  | 8                 | 9   | 42         |
|                       | 1.1-1.5        | 10.9                        | 5.1              | 47                                 | 4          | 25  | 7                 | 11  | 28         |

**Table 4—Pallet cant and lumber yields from 6-foot woods-run bolts by diameter and sweep class**

| Bolt<br>dia.<br>class | Sweep<br>class | Bolt<br>volume              | Product<br>yield | Product yield                      | Cant yield |     | Side lumber yield |     | Cants only |
|-----------------------|----------------|-----------------------------|------------------|------------------------------------|------------|-----|-------------------|-----|------------|
|                       |                |                             |                  |                                    | 4x4        | 4x6 | 1x4               | 1x6 |            |
| ----- inches -----    |                | ----- ft <sup>3</sup> ----- |                  | ----- percent of bolt volume ----- |            |     |                   |     |            |
| 6                     | 0-0.5          | 188.8                       | 110.4            | 54                                 | 50         | 1   | 3                 | 0   | 51         |
|                       | 0.6-1.0        | 107.4                       | 59.2             | 46                                 | 45         | 0   | 1                 | 0   | 45         |
|                       | 1.1-1.5        | 22.4                        | 11.7             | 39                                 | 39         | 0   | 0                 | 0   | 39         |
| 7                     | 0-0.5          | 211.2                       | 116.0            | 55                                 | 36         | 9   | 10                | 0   | 45         |
|                       | 0.6-1.0        | 163.2                       | 86.2             | 50                                 | 34         | 7   | 9                 | 0   | 41         |
|                       | 1.1-1.5        | 28.8                        | 11.2             | 39                                 | 31         | 3   | 5                 | 0   | 34         |
| 8                     | 0-0.5          | 53.2                        | 31.2             | 60                                 | 1          | 46  | 11                | 2   | 47         |
|                       | 0.6-1.0        | 46.0                        | 26.2             | 57                                 | 8          | 37  | 10                | 2   | 45         |
|                       | 1.1-1.5        | 14.6                        | 7.8              | 53                                 | 14         | 27  | 9                 | 3   | 41         |
| 9                     | 0-0.5          | 45.1                        | 27.5             | 61                                 | 6          | 35  | 13                | 10  | 35         |
|                       | 0.6-1.0        | 21.2                        | 11.7             | 55                                 | 3          | 33  | 8                 | 11  | 36         |
|                       | 1.1-1.5        | 8.0                         | 4.1              | 51                                 | 0          | 37  | 8                 | 6   | 37         |
| 10                    | 0-0.5          | 36.0                        | 22.2             | 62                                 | 2          | 43  | 10                | 7   | 45         |
|                       | 0.6-1.0        | 19.6                        | 11.7             | 60                                 | 0          | 40  | 9                 | 11  | 40         |
|                       | 1.1-1.5        | 3.3                         | 1.2              | 36                                 | 21         | 0   | 15                | 0   | 21         |

| <i>Sample lot</i>        | <i>Total parts<br/>yield<br/>board feet</i> | <i>Distribution of<br/>parts yield</i> |                   |
|--------------------------|---------------------------------------------|----------------------------------------|-------------------|
|                          |                                             | <i>Permanent</i>                       | <i>Expendable</i> |
|                          |                                             | <i>percent of total yield</i>          |                   |
| Allegheny<br>hardwoods 1 | 8,268                                       | 77.6                                   | 22.4              |
| Allegheny<br>hardwoods 2 | 3,761                                       | 87.4                                   | 12.6              |
| Cove hardwoods           | 6,220                                       | 86.6                                   | 13.4              |

Three sample lots of cants from woods-run bolts totaling 10,000 board feet (cant measure) were processed at a plant making medium-size expandable pallets. The species mix included approximately equal amounts of oaks, beech-maple-cherry, and yellow-poplar. Less than 3 percent of the parts produced were unusable.

Both cooperating firms concluded that the quality yield from the sample wood was equal to or better than that from the wood raw material they normally process.

## CONCLUSIONS

Woods-run bolts produced from hardwood poletimber thin-

nings are well suited for commercial pallet production. Bolts containing unsound heart defects and those containing absolute sweep that exceeds 1-1/2 inches should be eliminated. Otherwise, there is no need for segregating bolts. The resulting bolts yield approximately 55 percent of cubic-foot volume in acceptable pallet cants and boards. When only 4- by 4- and 4- by 6-inch cants are produced (no side lumber), product yield is approximately 45 percent of the cubic-foot bolt volume. The quality mix of cants produced from sound woods-run bolts is adequate for the production of permanent or returnable warehouse pallets.

## Literature Cited

Craft, E. Paul, and John E. Baumgras.

1978. Products derived from thinning two hardwood timber stands in the Appalachians. USDA For. Serv. Res. Pap. NE-422. 8 p.

Craft, E. Paul, and John E. Baumgras.

1979. Weight and volume yields from thinning two oak-hickory stands. USDA For. Serv. Res. Pap. NE-448. 7 p.

National Hardwood Lumber Association.

1978. Rules for the measurement and inspection of hardwood and cypress lumber. Natl. Hardwood Lumber Assoc., Chicago, Ill. 115 p.

Craft, E. Paul, and David M. Emanuel.

1981. Yield of pallet cants and lumber from hardwood pole-timber thinnings. Northeast. For. Exp. Stn., Broomall, PA.

6 p.

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Four- and six-foot long bolts from poletimber thinnings were classified into five quality classes and three sweep classes. Cants and lumber for pallet parts were sawn. The effects of sweep and sound defects in the bolts on pallet part quality are described.

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**Keywords:** Product quality yields, hardwood thinnings