

High-quality Wood from Low-quality Trees: Bolts/Short Logs

By Dan Bousquet
Extension Forest Resources Specialist
University of Vermont Extension

Tree utilization

Introduction

A major forest management challenge for both landowners and foresters in Vermont and the Northeast is to find new, cost-effective, and ecologically friendly ways to improve utilization of the significant volume of low-quality trees growing in our forests.

Field observation of hardwood forests and current logging practices seems to indicate that improved tree stem utilization and higher total tree value can be obtained in many situations by producing *bolts or short logs* as an integral part of the total tree product mix. Of course, markets for bolts and short logs must also be available.

Note: The terms "bolt" and "short log" are used interchangeably.

Tree product mix

Bolts or short logs are portions of the tree stem that are less than the usual, commercially acceptable minimum log length of 8 feet plus a trim allowance of 3 or 4 inches. By producing short logs between 2 and 7 or more feet in length, but with significant diameters, it is possible to use more of the clear, high-quality wood that exists between log defects. Such high-quality wood can be used for dimension components for furniture, paneling, flooring, sporting goods, specialty wood products, and other high-value items.

Currently, this wood is either wasted in the woods, used as firewood, or chipped for pulp and paper markets. These are relatively low-value products for the landowner, logger, trucker, and forester. Bolts have potential to add considerable value to trees where sawlogs and veneer logs are also produced.

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Sawing bolts and high-value wood dimension

A number of published and unpublished field studies have been conducted by various organizations whose results have indicated the potential of bolt and short log utilization for high-value wood products.

One U.S. Forest Service and University of Vermont study by Huyler and Turner of six logging sites with a total of fifteen log landings in north central and northwestern Vermont evaluated the frequency of occurrence of bolts in tree stems. Their results are typical of the situation in Vermont's Northern Hardwood forests.

From a total of 161 tree stems monitored, 94—or 58.4%—had at least one potential bolt. For the 94 stems containing potential boltwood, 260 bolts between 2 and 7 feet in length were recorded. The average small-end diameter inside bark for these bolts was 7.7 inches with a range in diameter from 6 to 16 inches. With such a diameter range, a significant amount of clear, higher-quality wood was available for utilization.

Of the six species having stems with

boltwood potential, three species made up 86.2% of the stems having bolts: sugar maple (51.1%), red maple (21.3%), and yellow birch (13.8%). American Beech, white ash, and red oak represented less than 8% each.

For sugar maple, red maple, and yellow birch, 55.8%, 62.5%, and 72.2%, respectively, of the stems measured in each species group contained boltwood. These species have favorable physical and mechanical characteristics demanded in the high-value wood product marketplace.

Improved tree utilization

Processing short logs into alternative solid wood products can improve the efficiency of processing small, crooked, and defective trees. Additionally, new products can add value to processing.

For example, sawing hardwood logs for maximum volume and grade yield becomes a lot easier when you know in advance the final end product for which the lumber will be used. Logs and lumber can be cut to match the size of the end product. Logs can be bucked and sawn to unusually short lengths, such as 4 feet. Of course, the equipment to efficiently handle and saw the short logs is required. Short log lengths would range from 3 or 4 to 7 feet plus any trim allowance required.

Organizational setup, handling, and mill layout

Organizational setup and mill layout depends mostly on the product being manufactured. Handling dimension stock from short logs presents challenges not generally encountered in handling lumber. Although no universal system is employed, it is generally agreed that sorting dimension stock by grade and length is a necessary first step to efficient handling.

Where there are only a few widths, such as in squares, sorting is also done by widths. In the case of flat dimension stock, such as that used in furniture manufacturing, sorting is generally by length and grade with random widths for packaging. The material is end coated to prevent checking and stickered in piles to be air dried, pre-dried, and/or kiln dried. Bundles are strapped prior to shipping.

Equipment

An automatic short-log carriage with double-cut bandsaw, followed by a vertical and/or horizontal band

resaw, rip, and crosscut saws is a system that has been used successfully with short logs. Such an arrangement can be used alone or with a long-log sawing system option. Flexibility is key.

Scragg saws and bolter saws have also been successfully used as primary breakdown machines for short logs.

Some of the *major benefits* of producing short logs in the tree stem product mix are that it upgrades the total tree value in the following ways.

- Removes sweep and crook from long logs.
- Minimizes the effects of log taper on yield.
- Eliminates major log defects by cutting short lengths between them.
- Increases the total solid wood log volume recovered from the tree stem.

Yield and productivity

It has been shown that the two principal factors affecting wood recovery and processing productivity are *sawing method* and *log and bolt size*.

Bolt sawing method

Bolt sawing method and sawing time are important factors affecting productivity and board quality no matter what sawing system is chosen.

Automatic short-log carriage with double-cut bandsaw

In an extensive plant study by Bousquet, a commercial production machine system consisting of an automatic short-log carriage, double-cut bandsaw, multiple rip saw with fixed width setups, and three circular crosscut saws was used to process short logs into 1-inch thick unedged boards and dimension stock. Two bolt sample groups—consisting of 126 straight (less than 10% sweep) yellow birch bolts in each group—were randomly selected.

Bolt diameter and length ranged from 9 to 22 inches and 2.5 to 9 feet, respectively. Average length and diameter were approximately 5 feet and 12 inches, respectively. Bolts in each sample group averaged two clear faces and were taken from various heights along the merchantable stem.

One bolt sample group was sawn using a through-and-through or “*Live sawing*” method,

Table 1. Effect of sawing method on average values for selected bolt breakdown time elements on automatic short-log carriage.

	No. of bolts	Time in saw cut (minutes)		Turning and squaring time (minutes)		Total sawing time* (minutes)				Output rate (sq. ft./minute)
		Avg.	Var.	Avg.	Var.	Avg.	Var.	Avg.	Var.	Avg.
Live	126	0.47	0.08	0.15	0.02	1.52	0.39	0.349	0.014	21.68
Grade	126	0.53	0.11	0.39	0.02	2.08	0.94	0.446	0.016	15.47

Avg.=Average Var.=Variance *Measured from moment bolt contacts carriage **Gross cubic feet

while the second group was sawn using a sawing-around or “Grade sawing” method. The first method involved placing the bolt on the carriage with the poorest of four sawing faces up and then sawing Live. The second sawing method involved successive sawing and turning steps in an attempt to maximize board value output for each bolt.

A time study of the bolt sawing operation resulted in a variety of quantitative relationships involving bolt quality, sawing pattern, and timing elements.

Some average values and their variance are shown in **Table 1**. The data show that the saw blade spent less time in the cut when Live sawing than when Grade sawing. Considerably less time was spent turning and squaring for Live sawing. Total sawing time (excluding delay time) and time per unit bolt volume was about 25% less for Live than for Grade. Average productivity of Live sawing was about 25% higher than for Grade. Board output rate was 21.68 square feet per minute for Live compared to 15.47 for Grade.

Sawing methods and bolt quality

Short log bolter saw

The short log bolter has an application niche in improving the utilization of hardwoods. Bolters can be advantageously used to produce dimension stock and short boards from small, crooked, and defective trees that could not be satisfactorily used in a conventional sawmill. Also, the percentage or “yield” of the

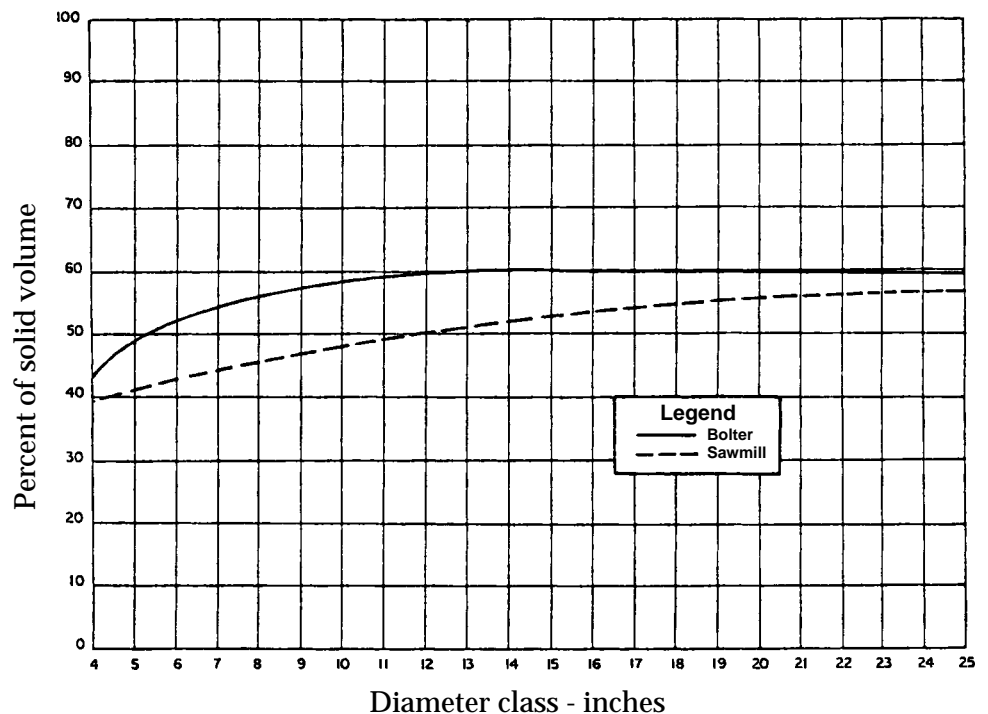


Figure 1. Percentage of solid volume converted into lumber from sound, straight hardwood logs and bolts.

log or bolt volume converted into “lumber” is greater for the bolter than the sawmill. This is apparent in **Figure 1** and, moreover, it is seen that the increase in yield from bolter saws is more pronounced in the *smaller diameters*. **Figure 1** presents nominal values recorded for sound, straight hard maple logs

Automatic short log carriage and band headsaw

In the extensive plant studies referred to above, a number of bolt quality factors proved to have a major effect upon yield and productivity of unedged lumber and dimension stock.

Among bolt quality characteristics used, *diameter*, *length*, and *scaled defect* provided dependable estimates of unedged board and dimension stock yield per bolt, and of sawing productivity for both Live and Grade sawing yellow birch bolt groups.

Table 3 shows surface area yield of unedged boards and dimensioned components from Live-sawn and Grade-sawn yellow birch bolts of varying length and diameter, sawn on an automatic short-log carriage. Bolt-scaled defect averaged 10%.

Exterior bolt quality, as expressed by the *number of clear faces*, influenced unedged board dollar value per gross cubic foot of bolt volume and per minute of sawing time for Live-sawn bolts. It also directly affected

Table 2. Recovery of clear cuttings for bolter saw and circular sawmill by tree diameter class.

	Bolter d.b.h.* class (inches)		Sawmill d.b.h. class (inches)	
	8	14	8	14
Total tree volume (ft. ³)	16.14	52.18	15.93	51.79
Total volume of lumber (bd. ft.)	92.0	330.5	72.60	315.6
Total volume of clear cuttings (bd. ft.)	63.81	213.54	32.25	187.13
Tree volume converted into clear cuttings (%)	32.95	34.10	16.87	30.11
Lumber volume converted into clear cuttings (%)	69.36	64.61	44.42	59.29

*Diameter breast height

converted into lumber and flat dimension stock. The bolter saw produced an average increase in wood volume recovery of about 8%.

With hard maple logs and bolts containing up to 30% (of gross volume) defect, wood recovery was lower at each diameter for both bolter saw and circular sawmill, but the *spread* between values remained similar as for sound, straight material.

Also, an increase in total tree volume recovered is often experienced on logging operations where bolts are part of the product mix. Various unpublished recovery studies have shown solid wood yield increases from tree stems ranging from 8 to 12%. **Table 2** shows recovery of hard maple clear cuttings for bolter and circular sawmill production expressed as a percent of total tree volume and as total lumber volume recovered by tree diameter class.

dimension stock value per gross cubic foot.

Figure 2 illustrates the relationship between unedged board value per gross cubic foot, bolt diameter, and number of clear faces for Live and Grade sawing.

Although little difference in average board and dimension stock volume yield between Live and Grade sawing was indicated, performance of Grade sawing relative to Live improved as scalable bolt defect increased.

Productivity was considerably greater for Live than for Grade sawing. Live sawing generated an average of 40% more board area per minute and 24% more board value per minute of productive sawing time than did Grade sawing.

Table 4 summarizes the quality grading system applied to the yellow birch bolts sawn.

Short lumber drying effects

The natural characteristics of short lumber from bolts will require certain modifications in the drying procedures to minimize defects. The physical characteristics of short lumber with respect to drying behavior have certain attributes that differ from those of longer lengths:

- the shorter lengths alone have an effect on drying behavior;
- a greater portion of the lumber will contain a

mixture of sapwood and heartwood or juvenile wood when Live-sawing small logs;

- knots, pith, bark pockets, and other natural defects are more abundant in small-diameter and lower-quality logs;
- more boards will have a mixture of flat- and edge-grain wood; and
- the lumber may contain a greater percentage of narrow boards depending on the size and type of logs.

Table 3. Surface area yield of unedged boards and dimensioned components from Live-sawn and Grade-sawn yellow birch bolts of varying length and diameter, sawn on automatic, short log carriage.*

Bolt length (ft.)	Surface area (sq. ft. per bolt)					
	3		5		7	
Bolt diameter class (inches)	Unedged boards					
	Live	Grade	Live	Grade	Live	Grade
8	—	—	8.9	6.8	19.1	20.8
10	7.5	3.9	19.5	18.0	31.6	32.0
12	18.1	15.1	30.1	29.2	42.2	43.2
14	28.8	26.3	40.8	40.3	52.9	54.4
16	39.4	37.5	51.4	51.5	63.5	65.6
18	50.0	48.7	62.0	62.7	74.2	76.8
20	60.7	60.0	72.7	73.9	84.8	88.0
22	71.3	71.1	83.3	85.1	95.4	99.2
Bolt diameter class (inches)	Dimensioned components					
	Live	Grade	Live	Grade	Live	Grade
8	—	—	3.6	1.8	10.5	10.5
10	3.1	0.7	10.3	9.5	17.4	18.2
12	10.0	8.4	17.3	17.2	24.3	25.9
14	16.9	16.1	24.1	24.9	31.2	33.6
16	23.8	23.8	31.0	32.6	38.1	41.3
18	30.7	31.5	37.9	40.3	45.0	49.1
20	37.6	39.3	44.8	48.0	52.0	56.8
22	44.5	47.0	51.7	55.7	58.9	64.5

*Data from a sample of 126 bolts in each of two sawing methods. Adjusted to average scaled defect of 10% for each group.

Drying quality

How do these characteristics affect the quality of the dried product? In any drying operation, *end checking* results in a loss of material. However, end checks in short lumber can result in much higher losses. For example, a 3-inch check on a 4-foot board represents a trimming loss of 6%, whereas in an 8-foot board, this loss represents only 3%. When end checking occurs in longer boards, a sizeable portion still remains from which to obtain useable cuttings; however, if a 4-foot board is trimmed several inches at each end, the remainder may not be suitable for the intended product. Therefore, in addition to a greater *volume loss*, you may also experience a *value loss* in reduced cutting sizes.

A higher percentage of short lumber will be more prone to *warp* compared to long lumber. Short boards cannot tolerate as much warp simply because there are fewer options to salvage cuttings from short lumber. Since warp is more critical to short lumber, sticker spacing at 1-foot intervals is preferable.

Stickers supporting the ends of the boards should be placed as close to the end as is practical. This will tend to reduce the amount and severity of end checking.

Drying schedule

For short lumber, the only schedule requirement is that the drying schedule for the species and thickness be modified to give a milder start, which minimizes warp and checking.

nal spaces and, therefore, piling density is increased from about 70 to 90% compared to random-length box piling. Consequently, more lumber can be dried in a given kiln space. Short-lumber stacks also provide greater flexibility in utilizing the total kiln capacity. In other words, large gaps inside the kiln may be avoided.

The *second alternative* is to include the short boards with the normal mill-run lumber, in which case the short material is stacked on the inside of random-length box piles. The short lumber is given no special consideration with the exception of shorter sticker spacing and a modification of the drying schedule.

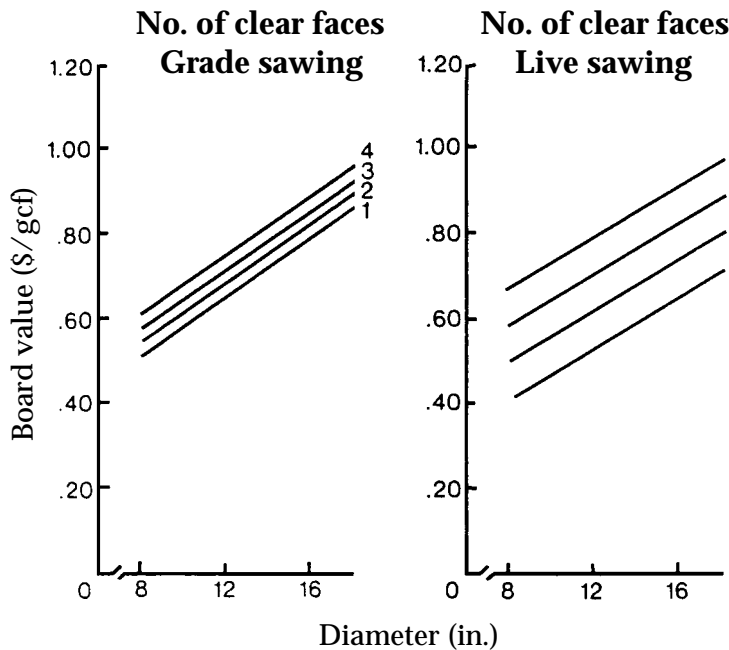


Figure 2. Relationship between unedged board value per gross cubic foot, bolt diameter, and number of clear faces for Live and Grade sawing.

From: Bousquet, D.W. Unpublished plant studies.

To do so, reduce the dry-bulb temperature and, in some cases, increase the humidity at each schedule step until the moisture content of the wood is reduced to about 25%. Modified drying schedules have not been published specifically for short lumber; however, personnel at the U.S. Forest Service, Forest Products Research Lab, Madison, Wisconsin, can provide appropriate schedules upon request.

Piling

There are *two alternatives* to piling short lumber. *First*, if the lumber is sawn or sorted into uniform length, it can be box-piled in small fork-lift packages on bunks or pallets. There are no large inter-

Handling

A major objection to processing short lumber is the prospect of handling twice or three times as many boards, especially the lower-grade material. Also, mill equipment needs to be designed to handle short lumber.

Drying systems

The type of drying system ultimately used will depend on the specific requirements of each lumber producer. An economic feasibility analysis would have to consider such variables as annual production, capital investment, species and grade mix, product markets and value, return on investment, payback periods for equipment, and other factors.

Low-temperature pre-driers have given good results in cases where the pre-dryer has reliable temperature and humidity control. Dehumidification kilns also show good potential for successfully drying short lumber.

Drying short lumber with conventional dry kilns with steam humidification would require that the drying schedule for the species and thickness be modified to give a milder start. The dry-bulb temperature is reduced and in some cases the humidity is increased at each schedule step until the moisture content of the wood is reduced to about 25%.

Figure 3 shows a low-cost method of air drying short hardwood lumber (indoors and outdoors) requiring little or no equipment that can be carried out in many locations. These boards were cut from 5-foot-long bolts, from trees 12 to 18 inches in diam-

Table 4. Summary of the quality grading system (bolt grades) applied to the yellow birch bolts sawn.

	B-1	B-2	B-3
Diameter	11+”	9+”	9+”
Length	31"-9'	31"-9'	31"-9'
Faces clear	3 or 4	2 or 3	0 or 1
Scalable defect	40%	40% (60% if faces clear)	60%
Dark brown heart	1/2 diameter or less; if more, drop to B-2	9" logs, 1/2 diameter or less; if more, drop to B-3. 10+” logs, otherwise B-2 3/5 diameter; if more, drop to B-3	Any amount
Sweep	None	6-9': slight 1" deflation; 31"-5': no sweep	6-9': 2" deflection; 31"-5': 1" deflection

Source: Bousquet, Dan. 2000. "Dimension Yields from Short Logs of Low-quality Hardwood Trees." Unpublished plant studies. UVM Extension.

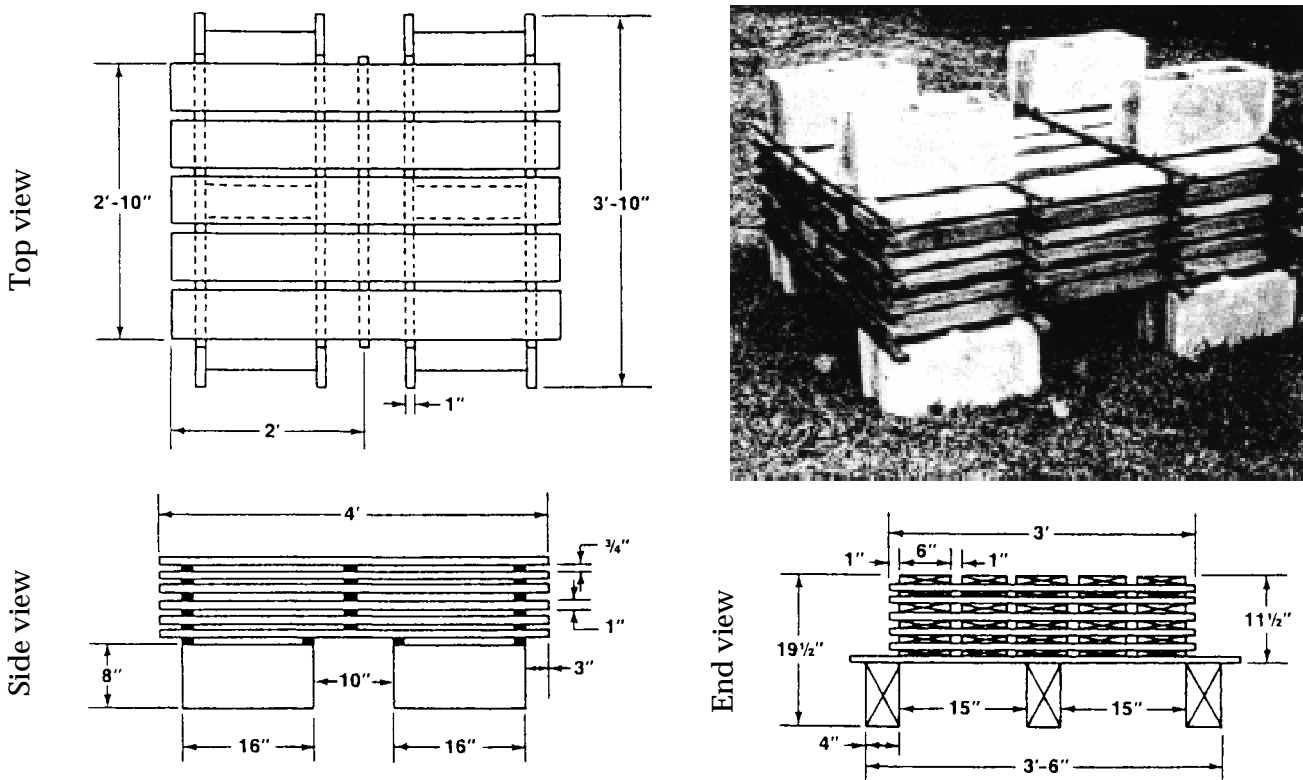


Figure 3. Typical lumber stack and arrangement when drying small amounts of short lumber.

eter breast height in a study by Micelli, et. al.

The bolts were sawn on a portable bolter saw into boards 4/4 and 8/4 thick and edged on a table saw to 6 inches wide. Boards were end coated with paraffin to reduce end checks and stacked between 3/4 inch stickers to promote air flow across the surface of the boards. The stacks were arranged in alternate rows of 4/4 and 8/4 lumber with the species arranged randomly in each row. Cement blocks were placed on top of the pile to help keep the boards flat. When air-dried outdoors, the relative humidity of air is often too high to dry wood quickly much below 18 to 20% moisture content. Drying can continue indoors to lower the moisture content.

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