What is low-value and/or low-grade hardwood?

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Abstract

The utilization of low-value and low-grade hardwood material is a recurrent concern in forest products research. This paper clarifies and expands on this topic and provides a framework to help researchers isolate specific researchable problems in this area and to discuss potential products that might be produced from this resource. Although low-value and low-grade issues often are interrelated, these terms represent two distinct concepts. Low-value is an economic concept, i.e., a product is low-value when the market determines the price of that product is low relative to similar products. Low-grade is a physical concept; a product grade is based upon an agreed on protocol (grading system) that classifies material into a quantitative group. At the beginning of the market chain, low-value and low-grade material consists of trees not considered growing stock and sawtimber trees of Grades 4 and 5. These trees have been utilized historically for industrial products such as pallets and pulpwood. More recently, they have been used increasingly in the manufacture of engineered wood products. Grade 3 trees and their subsequent logs are by far the most plentiful and expanding portion of the hardwood resource and yield proportionally large volumes of lower grade lumber. Since it is economically inefficient to process such logs at mills designed to gain maximum grade yield from high-grade logs, a process that directly transforms them into dimension parts might be an option. Although considerable research has been completed on utilization of low-grade hardwood lumber, such research needs to continue.

How to profitably utilize low-value and/or low-grade hardwood material seems to be a recurrent issue discussed by economists and forest products researchers (e.g., Gephart et al. 1995, Reynolds et al. 1983, and Reynolds and Gatchell 1970). This issue takes many names, including small-diameter utilization, greater use of non-select species, or parts yield from low-grade lumber. This range of terms points to the fact that the concepts of low-value and low-grade hardwood material are vague, have different meanings to different people, change as products move through the market chain, and may change over time. The fact is that the often-used terms low-value and/or low-grade are not synonymous but refer to a number of issues that often are interrelated. This lack of clarity makes it difficult to isolate a researchable problem in the area of hardwood utilization, especially for researchers examining these problems for the first time.

This paper clarifies and expands on the concepts of low-value and low-grade hardwood material and provides a framework to help researchers isolate specific researchable problems and discuss potential products that may be produced from this resource. This framework also will be useful in explaining problems and solutions in precise terms to policymakers and legislators concerned with these issues.

Two distinct terms

Although low-value and low-grade issues sometimes are related, these terms are not interchangeable since they refer to two different concepts. **Table 1** contrasts definitions of low-value and low-grade, providing a framework for discussion of these concepts.

Low-value is, by definition, an economic concept. A product may be termed low-value when the market has determined the price of that product to be low relative to similar products. At the root of the low-value concept is

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Table 1. Contr asts between low-value and low-grade hardwood material.

Term	Basic criteria	Mechanism	Temporal aspect?	Low price?	Low quality?
Low-value	Economic	The market-supply and demand	Often: especially in the case of immature trees	By definition	Not necessarily
Low-grade	Physical	Agreed upon protocol for classification	Generally no: immature timber can be an exception	Normally but not always	By definition

Table 2. Number of live trees and growing stock trees in Maine, West Virginia, and Missouri.

	Maine[a]		West Virginia[b]		Missouri[c]	
Diameter class	Live trees	Growing stock trees	Live trees	Growing stock trees	Live trees	Growing stock trees
(in.)	(billions of trees)					
5.0 to 6.9	604.1	535.0	582.2	491.8	620.0	408.1
7.0 to 8.9	370.0	342.4	379.5	340.0	368.0	231.7
9.0 to 10.9	209.5	195.1	252.1	235.9	235.7	144.8
11.0 to 12.9	109.9	92.0	160.3	147.7	151.3	89.5
13.0 to 14.9	56.7	47.3	109.4	101.9	94.1	54.9
15.0 to 16.9	29.1	23.3	71.1	66.0	53.1	29.5
17.0 to 18.9	12.8	10.2	41.4	38.1	26.6	13.4
19.0 to 20.9	7.9	5.8	23.7	21.5	12.8	5.7
21.0 to 28.9	8.1	5.9	26.6	22.8	13.4	4.9
29.0 +	0.7	0.3	3.4	2.3	1.5	0.5

[a] Source: Griffith and Alerich 1996.
[b] Source: DiGiovanni 1990.
[c] Source: USDA 2001.

supply and demand. A long-term biological protocol controls the supply side and changing preferences control the demand side. Consequently, value can be a concept affected by time. A species may become lower in value as it becomes biologically more abundant or when furniture styles that incorporate the species decline in popularity. Species also can increase in value as consumers find visual attributes of that species desirable or secondary manufacturing practices favor use of certain species. One of the best examples of the temporal aspects of preferences for species is provided by a comment made by Wray (1952) in reference to the red oak inventories of West Virginia: "The oak types are the most extensive; they occupy half the forest land . . . Many of the red oak stands are red only because the more desirable species such as white oak, yellow-poplar, and basswood have been removed." The value of red oak continued to be low through the 1950s and 1960s, but by the late 1980s red oak was considered a high-value species.

A species or specific type of material also may become more valuable if a production process is developed to utilize the material. A case in point is the use of aspen in the production of oriented strandboard. Also, demand for material may change, resulting in an increase in value. Since the mid 1960s, hardwood pulpwood production has increased nearly four times faster than softwood pulpwood, resulting in large increases in hardwood pulpwood prices, especially in the South (Luppold et al. 2002, Howard 1999).

Low-grade is, by definition, a physical concept. A product is termed low-grade when an agreed-upon process (such as a grading system) classifies material into a quantitative group based on visual or physical characteristics. Economics is tangentially associated with the concept of low-grade in that production efficiency and product serviceability are part of the criteria on which material classifications or "grades" are based.

Low-grade material also can become more valuable over time, especially in the case of standing timber. Small-diameter timber is inherently low-grade because tree grading definitions discount for smaller diameter in addition to apparent defects. As timber ages, it not only increases in diameter but also defects are covered over with layers (rings) of new fiber.

Types of low-value and low-grade material along the market chain

Live standing trees

At the beginning of the hardwood market chain are live standing trees, although in areas of recent widespread biological disturbance the market can also utilize dead standing trees. Most live standing trees are considered growing stock by the USDA Forest Service and are included as part of the forest inventory. Trees not considered growing stock include rough or rotten culls and non-commercial species. These low-value and low-grade non-growing stock trees are seldom used to produce grade hardwood lumber but in many cases are used in the production of crossties, pallets, pulpwood, and engineered wood products.

As shown in **Table 2**, the proportion of growing stock to live trees varies by diameter class and state. Because of the practice of harvesting the desirable trees and leaving the rest (high grading), the percentage of live trees that are classified as growing stock declines as diameter class increases (**Table 2**). This percentage varies by state and most likely varies between survey regions[1] within a state.

Growing stock hardwood trees over 11 inches in diameter are considered sawtimber, while trees less than 11 inches are considered pole timber. Normally, the existence of pole timber classified as growing stock is only temporarily a low-quality issue because such timber may eventually mature into high-quality sawtimber-size trees. However, the value of even high-quality pole timber is relatively low. Pole timber that is classified as non-growing stock is normally both low-value and low-grade.

The existence of non-commercial species also contributes to the low-value and low-grade issue. Trees of such species (e.g., striped maple, fire cherry, hawthorn, etc.) are seldom utilized and the USDA Forest Service does not con-

[1] The USDA Forest Service Forest Inventory and Analysis Unit divides states into two or more forest survey regions that are currently termed survey units

Table 3. Quality of hardwood sawtimber in Pennsylvania, West Virginia, and New York for red oak, hard maple, soft maple, black cherry, and yellow-poplar for the most recent survey year.

Species and state	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
			(%)		
Red oak					
Pennsylvania[a]	16.9	30.0	34.6	13.5	5.0
West Virginia[b]	22.4	28.3	28.8	15.1	5.3
New York[c]	26.0	30.1	33.0	4.0	7.3
Hard maple					
Pennsylvania	5.5	15.6	41.9	23.2	13.8
West Virginia	6.3	17.3	36.9	27.2	12.3
New York	9.6	22.5	43.6	8.0	16.3
Soft maple					
Pennsylvania	2.2	12.3	43.2	28.2	14.1
West Virginia	4.1	12.9	38.2	32.3	12.5
New York	4.8	17.1	46.4	11.7	20.0
Black cherry					
Pennsylvania	15.8	26.3	37.9	9.5	10.5
West Virginia	24.5	23.1	28.3	11.2	12.9
New York	12.6	22.9	39.8	4.3	20.4
Yellow-poplar					
Pennsylvania	28.4	21.6	23.6	21.9	4.5
West Virginia	22.6	20.6	25.8	27.3	3.7
New York	38.9	34.5	23.3	2.3	1.0

[a] Source: Alerich 1993.
[b] Source: DiGiovanni 1990.
[c] Source: Alerich and Drake 1995.

sider them part of the growing stock volume regardless of individual tree quality characteristics. These trees are almost always of inherently poor form and small size at maturity, resulting in low economic value, but specialized uses can sometimes be developed. The proportion of non-growing stock trees classified as non-commercial species varies by location. In West Virginia, 50 percent of the trees not considered growing stock are of non-commercial species (DiGiovanni 1990). In Maine, non-commercial species make up 18 percent of non-growing stock trees (Griffith and Alerich 1996).

Sawtimber and roundwood

Sawtimber quality is measured by tree grades, with Grade 1 being the best and Grade 5 the poorest. Tree grades are a function of diameter and clarity of the butt log. The distribution of trees among the grades varies by species (**Table 3**) and is influenced by growing site index, method of regeneration, and other variables inherent to each species. Usually the butt log that emanates from a Grade 1 or 2 tree is most desirable in terms of quality, with its value depending on the species. Butt logs that come from trees of Grades 4 and 5 are used to manufacture industrial products such as crosstie and pallet parts or are processed by smaller sawmills. For nearly every species and state, the percentage of Grade 3 trees is higher than for any other single tree grade.

Although a stand of hardwoods might be purchased based on tree grade, the resulting "roundwood" material is normally sold on the basis of log grades. Tree grades correspond to the grade of the butt (first) log. However, most stems contain two or more logs before they limb out into a crown. As logs from higher parts of the stem are bucked (processed), they tend to decline in quality. Unfortunately, there is no universal set of log grades because different log consumers may apply different grading standards. In this paper we use USDA Forest Service rules (Rast et al. 1973), which define three factory grades of logs with Grade 1 being the highest and Grade 3 being the lowest.

If the butt log of a specific tree is Grade 3 or poorer, there is a high probability that logs higher up in the stem will be Grade 3 or culls (cull logs also may be termed construction logs, local-use logs, industrial logs, etc.). The fact is that a large proportion of potentially usable roundwood or fiber contained in a high-quality tree may be of low quality. When markets do not exist for the lower quality roundwood material in a tree, it is left in the woods unless removal of such material is specified in the logging contract.

In many cases, the value of sawtimber is as much a function of species as grade. The role of species and value is most evident when examining log prices in an area where a large number of sawmills processing higher grade sawlogs compete for logs or stumpage (**Table 4**). For example, a Grade 2 cherry log is similar in value to a veneer grade northern red oak log. The value of different species varies primarily because of the price of the resulting lumber and the grade lumber yield from the log. Most people familiar with the hardwood market realize that black cherry lumber historically has sold for higher prices than yellow-poplar. What is less understood is that logs of identical grades and diameters have, on average, different grade lumber yields depending on species (**Table 5**). The differences in grade yield among species are mainly the result of the self-pruning characteristics of the individual species.

Hardwood lumber

Different species of hardwood lumber command different prices in the marketplace. Still, much of this difference is transitory because of changes in furniture and cabinet fashions and is not within the purview of this paper except to note that marketing efforts have been mounted to promote the use of underutilized species. Other species are less valued because they produce lumber of less desired properties such as hickory, which is difficult to machine (Lincoln 1986). However, the 50 percent increase in the price of hickory lumber in the 1990s,[2] due to an apparent increase of use in kitchen cabinets (Ohm 2001), again demonstrates that even a historically low-priced species can increase in value.

[2] Hardwood lumber price data base maintained at the Northeastern Research Station's Forestry Sciences Laboratory at Princeton, WV, under the agreement with the Hardwood Market Report, Memphis, TN.

Table 4. Price of sawlogs in northwest Pennsylvania by species and grade, fourth quarter, 2000.[a]

Species	Veneer	Grade 1	Grade 2	Grade 3
	(converted to $/MBF, Doyle log scale)			
Northern red oak	1,425	966	622	275
White oak	1,134	588	307	173
Mixed oaks	1,000	466	249	149
Black cherry	4,849	2,066	1,512	749
White ash	1,083	537	364	225
Hard "sugar" maple	1,700	1,025	644	302
Soft "red" maple	524	500	354	176
Yellow-poplar	NA	383	256	142
Misc. hardwoods	NA	285	225	131

[a] Source: Pennsylvania State University 2000.

Table 5. Grade yield of Grade 1 sawlogs 20 inches in diameter and Grade 3 sawlogs 12 inches in diameter.[a]

Species	FAS, FIF and Sel	1 Common	2 Common (A and B)	3 Common (A and B)
	(percentage yield)			
Grade 1, 20 in.				
Northern red oak	50.5	28.6	13.5	7.4
Black oak[b]	38.4	34.9	12.6	14.1
White oak	37.9	25.5	21.4	15.2
Black cherry	58.9	19.3	13.5	8.3
Hard "sugar" maple	42.4	25.8	15.6	16.2
Soft "red" maple[c]	59.4	19.0	19.5	2.1
Yellow-poplar[d]	29.6	43.9	24.5	2.0
Grade 3, 12 in.				
Northern red oak	2.6	14.9	34.7	47.8
Black oak	0.7	10.4	33.4	55.5
White oak	2.0	7.9	37.6	52.5
Black cherry	4.7	24.0	37.4	34.0
Hard "sugar" maple	3.7	14.0	29.1	53.2
Soft "red" maple	3.1	13.3	63.4	20.2
Yellow-poplar	1.4	14.3	73.6	10.7

[a] Based on Hanks et al. 1980.
[b] Includes sound wormy as 2 Common.
[c] Based on less than 10 observations.
[d] Includes saps grade as FAS.

Table 5 highlights another aspect of the low-value/low-grade issue in hardwoods: low-grade lumber exists even in high-grade logs. Low-grade lumber is low priced (i.e., low-value) because of its relatively small yield of clear material and associated increases in processing time (Steele et al. 1999). Since low-grade lumber constitutes a large proportion of material contained in most sawlogs, there has been considerable research aimed at its utilization (Gatchell and Thomas 1997, Gatchell et al. 1995).

The hardwood resource is changing

The utilization of low-value and low-grade material may already be occurring in Missouri and other areas with large relative volumes of such material and production facilities such as crosstie mills that can use shorter logs or pallet mills that can use cull logs (**Table 2**). In other areas of the hardwood region, there have been adequate supplies of quality roundwood of desired species at apparently reasonable prices. However, the availability of high-quality sawtimber may be slowly changing, especially in the Northeast, as red maple becomes more dominant. This trend is reflected in increasing sawtimber volume of red maple (**Table 6**) and its inherent low proportion of Grades 1 and 2 sawtimber (**Table 3**).

It should be noted that the shade-intolerant species (red oak, black cherry, and yellow-poplar) have a much greater proportion of sawtimber volume in Grades 1 and 2 than the shade-tolerant maples (**Table 3**). This would be expected since a great proportion of the shade-tolerant species regenerated in even-aged stands after the era of massive cutting (1880 to 1920) (Carvell 1986). Of the species in **Table 3**, soft maple had the greatest proportion of timber in Grades 4 and 5, primarily because this species has, for the most part, regenerated in the understory and has grown in stands after higher value trees were selectively harvested (high-graded). Examination of growing stock volumes for Pennsylvania reveals that red maple volume in trees less than 15 inches is considerably greater than for red oak, while red oak volume in trees larger than 15 inches in diameter is greater than that of red maple (Alerich 1993). What this indicates is a transition from red oak to red maple that is occurring in many areas of the central and northern Appalachian regions.

The potential dilemma with this change is not the transition from red oak to red maple per se. As discussed previously, red oak has not always been the popular species it is today. As late as the early 1970s, soft maple lumber was similar in price to red oak, white oak, and hard maple, and not far below cherry. The potential dilemma concerns the lower quality of red maple versus red oak stems. In Pennsylvania for instance, 4.6 percent of the red maple 15 inches and larger in diameter is in tree Grade 1 compared to 24.8 percent of the northern red oak. Similarly, 17.6 percent of the red maple 15 inches and larger is in tree Grade 2 compared to 35 percent of the red oak (Alerich 1993). This indicates that even if the smaller diameter red maple is allowed to mature into a large tree, only a relatively small proportion of the tree will be of Grades 1 or 2.

Another agent of change in hardwoods is the introduction of biological processes that ultimately reduce the value of the remaining timber through

Table 6. Sawtimber volume and proportion of major hardwood species in the Northeast.[a]

Species	Volume			Proportion of major hardwoods		
	1962	1977	1992	1962	1977	1992
	(million BF)			(%)		
Select white oak	6,517	8,826	13,038	7.0	7.6	6.0
Select red oak	2,083	16,828	26,307	13.0	14.4	12.2
Other white oak	5,259	7,049	10,443	5.7	6.0	4.8
Other red oak	6,093	10,528	14,777	6.6	9.0	6.9
Hickory	3,363	3,841	6,323	3.6	3.3	2.9
Hard maple	12,322	14,219	26,321	13.3	12.2	12.2
Soft maple	7,076	12,867	30,458	7.6	11.0	14.1
Yellow birch	7,702	4,876	7,393	8.3	4.2	3.4
Beech	8,733	7,506	14,053	9.4	9.4	6.5
Yellow-poplar	4,948	6,398	17,558	5.3	5.5	8.1
Aspen/cottonwood	939	1,996	5,992	1.0	1.7	2.8
Black cherry	NA	5,542	12,507	NA	4.8	5.8

[a]Source: Powell et al. 1994.

stem degradation. Poor logging practices can gash young timber, causing instantaneous damage and continual degrade as the tree attempts to heal the wound or as fungus or other pathogens use the wound as a vector of attack. Timber degrade may occur even when traditional silvicultural practices are used because not all species are affected by intervention in a similar manner. For example, when exposed to increased sunlight, white oak will develop epicormic branching that will subsequently show up as pin knots in lumber (Sonderman and Rast 1988). Logging activity may also result in root or limb damage, allowing pathogens to enter and eventually cause facultative heartwood such as the dark wood associated with sugar maple (Burns and Honkala 1990, Shigo 1975).

Implications for utilization and research

Low-grade and low-value hardwood timber is the most prevalent part of the hardwood resource. A huge portion of the hardwood roundwood existing in the eastern United States is in live trees classified as Grades 4 or 5, or in trees and portions of trees that are not considered part of the growing stock. Some of this material can be used to produce industrial products such as pallet stock (Serrano and Cassens 2000). There also has been a considerable increase in hardwood pulpwood production over the last 35 years, although this increase has been limited to areas with existing pulp mills (Luppold et al. 2002). A newer market for this material is engineered wood products such as oriented strandboard and laminated veneer lumber. Low density hardwood species, such as aspen and later yellow-poplar, have primarily been used to produce these products.

The wild card resource is the large volume of Grade 3 sawlogs. Low prices for low-grade lumber coupled with the cost of extracting such lumber from Grade 3 logs have made processing of such logs at conventional modern sawmills marginal in economic terms. Development of processes, such as green dimensioning (Bratkovich et al. 2000, Lin et al. 1995), and markets, such as character-marked products (Bumgardner et al. 2000), which can utilize this material will remain a major part of wood products research.

Understanding the various issues surrounding low-grade and low-value hardwoods is crucial to development of new products and processes for these materials. Low-grade material does not necessarily have to be of low value if value-added uses and production techniques can be found. Perhaps clarification of low-grade and low-value concepts can help the progress of research in these areas.

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