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A Quality Classification System for Young Hardwood Trees—the First Step in Predicting Future Products

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Abstract

Forest managers have no objective way to determine the relative value of culturally treated forest stands in terms of product potential. This paper describes the first step in the development of a quality classification system based on the measurement of individual tree characteristics for young hardwood stands.

INTRODUCTION

In the past, many studies have been made to determine log and tree quality in mature timber. But one important aspect of timber quality research has not received adequate attention—estimating the quality of young hardwood stands and predicting their future product potential. Boyce and Carpenter (1968) described a technique for grading hardwood growing stock trees in terms of potential log grades. The system is based on the correlation between the number of surface defects and the probability that the future butt log will be a certain grade. Ward (1964) developed a clear volume index to evaluate the potential log grade of young trees. However, both of these systems are based on standard log grades that are applicable only to factory lumber yields. Two additional papers (McCormack 1957, Barger and Ffolliott 1970) describe techniques that relate the measurement of individual tree characteristics to current potential products for conifers, but these systems do not consider the quantification of future product potential. Forest managers, silviculturists, and economists need to know the quality of young stands so that their current and future value can be estimated.

Recently a multidiscipline project was begun to evaluate the economic implications of silvicultural practices in the central hardwoods. As a part of this project, we have begun a study to develop a quality classification system based on empirical measurements of individual tree characteristics that can be related to the future product potential of a stand.

This paper presents our ideas on how the development of such a system should be approached; it is the first step in quantifying tree characteristics that are important to the development of quality trees.

We believe that the classification system should not be oriented to specific current products, but should be based on a biological description of the tree. End-product specifications and utilization standards change; therefore a classification system that assigns grades based on current products soon becomes obsolete. However, if each tree characteristic can be ascribed a numerical value and aggregated for the stand, then these values can be interpreted in terms of products at any point, regardless of a change in standards.

THE STUDY

To test our approach and to develop techniques to describe tree characteristics related to quality potential, we established our study in timber stands on the Vinton Furnace Experimental Forest in southern Ohio. Detailed records of the history of the stand are available, and they provided information on the natural variation in the stands and were an aid in establishing study plots. These stands are primarily of mixed oaks, black cherry, red and sugar maple, white ash, elm, hickory, and yellow-poplar.

The study area is an 8-acre hardwood stand that regenerated 21 years ago after it was completely clearcut. Thirty 1/10-acre plots were established, and all trees larger than 3.5 inches dbh were numbered and then measured for specific characteristics. All trees less than 3.5 inches dbh were tabulated by 1-inch dbh classes for each species.

Groups of plots were assigned treatments that represented 70, 50, and 30 percent stocking, crop tree release, and a control. After the treatments, the residual trees were again measured. The measurements of these trees are the basis for evaluating changes in the individual tree characteristics that result from stocking treatments. (Additional stands are also being treated by various cultural methods, and will be reported on later).

Tree characteristics and their measurement

We have tried to quantify the tree characteristics that we feel will affect potential product quality and quantity. Because we envision a total evaluation system, these characteristics must be relatively easy to measure or estimate under operating conditions. These characteristics and their interactions can then be integrated to form a quality profile that is more descriptive of a tree or stand than just a single, numerical grade that is assigned in the field. The interpretation of these variables and their significance in terms of future products will depend on the species composition and age of the stand. However, the characteristics and assigned values will provide a common framework in which to make the interpretations. Additional studies on the changes in tree characteristics over time will be required to more accurately correlate the numerical value assigned to the characteristic and the future product potential.

The characteristics that we initially selected as variables and which we measured or estimated for our quality classification system are:

Dbh (diameter at breast height). All trees with diameters ranging from 3.5 to 12.0 inches were measured to the nearest 1/10 inch. Trees with smaller diameters were not measured for stem characteristics.

Crown class. Trees were classified as dominant, codominant, intermediate, or suppressed. Generally, the dominant and codominant trees will remain in the stand and will be the final crop trees. However, there may be situations where the intermediate and suppressed trees will be more desirable, particularly if tolerant species are abundant in the stand. Therefore, crown class along with species composition is an important indicator of gross stand quality.

Crown ratio. This is the ratio of live crown length to total tree height. This measurement combined with the tally of limb-related defects in the bottom 16 feet of the tree will provide a complete picture of the entire stem in terms of limb characteristics.

Total height. Total height is measured in feet from a 1-foot stump to the top of the tree. We chose total height rather than height to some minimum diameter because it can be more easily and consistently measured. Total height is needed to compute volume as well as to determine bole length, both of which are related to product potential.

Fork height. Fork height is defined as the length in feet from a 1-foot stump to the junction of the first main fork; this measurement reflects the primary bole length. Also, cross-grain and tension wood are often associated with forks, so they are important indicators of wood quality.

Sweep and crook, Sweep and crook are quantified by measuring the number of inches that the tree bole deviates from a straight line in the butt 16 feet of the tree. These characteristics are important factors because they indicate the possible development of tension wood which results in warp and cup in end products. The general quality of the stand will be increased if trees with excessive sweep and crook are removed at an early age.

Table 1a.—Percentage of study trees that show quality indicators.

Characteristic	Percent
Crown class	
Dominant	30
Codominant	55
Intermediate	12
Suppressed	3
Forks[a]	12
Sweep and crook (inches)[a]	
1-2	30
3-4	35
5-6	14
7-8	7
9+	8
Faces affected by rot and seam (number)[a]	
One	7
Two	2
Three	<.5
Four	<.5

[a] In butt 16-foot section.

Table 1b.—Percentage of trees with live and dead limbs, by section.

Section	Live limbs (number)				Dead limbs (number)			
1-2		3-4	5-8	9+	1-2	3-4	5-8	9+
Butt 8-feet	<.5	—	—	—	30	15	11	1
Upper 8-feet	3	2	1	—	25	20	31	8

Table 1c.—Percentage of trees with limb overgrowths and epicormic branches.

Defect (number)	Percent
Overgrowths[a]	
1-3	18
4-6	20
7+	36
Overgrowths with associated epicormics[a]	
1-3	10
4-6	1
7+	1
Epicormics[b]	
1-6	8
7+	1
Epicormics[c]	
1–6	11
7+	2

[a] Butt 16-foot section.
[b] Butt 8-foot section.
[c] Upper 8-foot section.

Rot and seams. These are quantified by visually squaring the butt 16 feet of the tree into four faces so oriented that most indications of rot and seams appear in one of the faces. The number of faces affected is then counted and the length of the visible defect is measured in feet. Trees that contain visible rot and seams are poor candidates for survival in the residual stands. Overgrown rot and seams usually cover up more serious trouble as the tree matures.

Limb count and limb-related defects. Each 8-foot section of the butt 16 feet of the tree, which is the most important portion when considering quality indicators, is evaluated. The limbs that are $\geq$ 1/3 inch in diameter at the point of attachment to the stem are quantified as follows:

1) All live and dead limbs are counted and recorded separately.

2) The diameters of the single largest live and single largest dead limb are measured to the nearest 1/4 inch.

There are two types of limb-related surface defects that can result in product defects in larger trees—limb overgrowths and epicormic branches. For the purpose of this study, we quantified these two characteristics by counting the number of overgrowths and epicormic branches in each 8-foot section of the butt 16 feet of the stem.

These characteristics, selected because of their consistent relationship with use requirements for most products, should reflect the utility of a tree for veneer, lumber, structural timbers, pulp, etc.

Development of a tree classification system

The individual trees that have been measured and tallied provide a descriptive record that can be aggregated to form a profile of an entire stand. We have done this for the initial study area (Table 1 a, b, c).

Additional information such as tree size and species within treatment area, average size of live and dead limbs, number of limb-related defects per square foot of surface area, and average crown ratio can also be developed from the basic data and summarized to provide a basis for a qualitative estimate of the product potential of the stand. By accumulating data on the changes in tree characteristics over a period of time, functions with associated probabilities can be developed as a basis to make quantitative estimates of the future product potential of the stand.

APPLICATION OF THE SYSTEM

A quality classification system for young trees based on a single numerical grade is not sufficient. However, for some uses of this information, it may be desirable to aggregate the individual characteristics in such a way so that a relative index could be expressed for a group of trees within a stand.

We have developed a somewhat arbitrary index system for the purpose of quickly ranking sample trees as good, medium, or poor. This index is based on crown class, stem curvature, and number of limbs. We combined the individual indexes (Table 2) to establish relative quality classes:

Sum of individual indexes	*Relative quality class*
10–12	Good
8–9	Medium
1–7	Poor

We are using this relative quality index as a stratification technique for selecting sample trees within each treatment category for more detailed measurements.

After the detailed measurements have been made on the sample trees, descriptive statistics can be developed for the group of trees. For example, Tables 3 a, b and c list several of the descriptive statistics for the groups of plots that were thinned to the 50 percent stocking level. These data indicate why the trees are graded as good, medium, or poor (index class 1, 2 and 3), and show the distribution of the individual characteristics both before and after treatment. This information could also be analyzed by species groups and tree size.

The relative quality class can also be used to show the gross changes that result from treating a stand or group of plots (Table 4). Thinning to a 30 percent stocking level resulted in the highest increases of quality trees; however, these differences can be expected since the 70 percent stocking treatment caused very little change in the number of residual stems.

Table 2.—Index of numerical values assigned to selected tree characteristics to determine tree quality.

Characteristic	Value
Crown class	
Dominant	4
Codominant	3
Intermediate	2
Suppressed	1
Sweep and crook (deviation in inches)[a]	
1	4
2-4	3
5-6	2
7-8	1
9+	0
Limb count (no. live and dead limbs $\geq$ 1/3 inch)	
1-2	4
3-4	3
5-8	2
9-16	1
17+	0

[a] If tree has forks, rot or seams then numerical value = 0.

The indexing system provides a technique for ranking the relative quality of trees that exhibit high variability within and between stands. The indexes for the individual characteristics could be weighted in various ways to satisfy specific objectives. The more detailed summary of individual characteristics, combined with information on their development over a period of time, will indicate the potential products that the stand may yield.

In future studies we plan to investigate sampling methods for applying the quality classification system under operating conditions and to develop numerical techniques for relating the array of tree characteristics to future product potential. The ultimate goal is to develop techniques to merge a numerical system of this type with volume estimation equations so that quality and volume changes can be evaluated simultaneously.

Table 3a.—Percentage of trees in relative quality class before and after treatment on plots thinned to 50 percent stocking, by quality characteristic.

Characteristic	Quality class					
	Good		Medium		Poor	
	Before	After	Before	After	Before	After
Crown class						
Dominant	37	37	46	50	3	8
Codominant	63	63	50	45	59	77
Intermediate	—	—	4	5	28	15
Suppressed	—	—	—	—	10	—
Forks	—	—	—	—	41	23
Sweep and crook (inches)						
1-2	47	47	50	50	31	38
3-4	53	53	44	47	31	31
5-6	—	—	6	3	31	23
7-8	—	—	—	—	7	8
9+	—	—	—	—	—	—
Faces affected by rot and seams (number)						
One	—	—	—	—	7	7
Two	—	—	—	—	—	—
Three	—	—	—	—	—	—
Four	—	—	—	—	—	—

Table 3b.—Percentage of trees in relative quality class before and after treatment on plots thinned to 50 percent stocking, by live and dead limb count.

Limb count	Quality class					
	Good		Medium		Poor	
	Before	After	Before	After	Before	After
In butt 8-feet						
Live						
1-2	—	—	—	—	3	—
3-4	—	—	—	—	—	—
5-8	—	—	—	—	—	—
9+	—	—	—	—	—	—
Dead						
1-2	32	32	42	42	17	23
3-4	10	10	21	26	31	23
5-8	—	—	15	8	17	30
9+	—	—	2	3	—	—
In upper 8-feet						
Live						
1-2	5	5	2	3	7	—
3-4	—	—	2	—	7	8
5-8	—	—	2	3	4	—
9+	—	—	—	—	—	—
Dead						
1-2	47	47	10	3	28	8
3-4	26	26	23	21	28	38
5-8	10	10	54	63	24	31
9+	—	—	10	10	17	23

Table 3c.—Percentage of trees in relative quality class before and after treatment on plots thinned to 50 percent stocking, by defect.

Defect (number)	Quality class					
	Good		Medium		Poor	
	Before	After	Before	After	Before	After
Overgrowths (butt 16-feet)						
1-3	16	16	12	13	4	8
4-6	16	16	17	18	10	15
7+	5	5	2	3	14	8
Epicormics (butt 8-feet)						
1-6	21	21	10	8	10	15
7+	—	—	2	3	4	8
Epicormics (upper 8-feet)						
1-6	10	10	6	5	14	15
7+	5	5	—	—	—	—

Table 4.—Percentage of trees in each relative quality class before and after treatment.

Treatment	Number of plots	Quality Class								
		Good			Medium			Poor		
		Before	After	Percent change	Before	After	Percent change	Before	After	Percent change
Thin to 70% stocking	6	22	23	+1	44	45	+1	34	32	−2
Thin to 50% stocking	5	20	27	+7	50	54	+4	30	19	−11
Thin to 30% stocking	6	26	37	+11	32	37	+5	42	26	−16
Crop tree release	8	15	21	+6	38	40	+2	47	39	−8
Control	5	26	26	0	35	35	0	39	39	0

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