Relationship of U.S. Department of Agriculture Grades to the Value of Fraser Fir Christmas Trees

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Abstract. Wholesale values, retail values of five eastern United States lots, U.S. Dept. of Agriculture (USDA) Christmas-tree grades, and measurements of various growth and quality traits were obtained on ≥ 1400 Fraser fir [*Abies fraseri* (Pursh) Poir.] (8 years old) Christmas trees. Retail lot values were similar, but average retail value correlated poorly with wholesale value within merchandising height classes. For each of the current wholesale categories (defined by the combination of 30.5-cm interval height classes and USDA grades), average values ranged widely. Some cull-grade trees, which would be unmerchantable according to USDA standards, had moderate retail value. Also, the retail mean of any one wholesale category generally was not significantly different from that of adjacent categories. Some tree quality defects that have equal impact on USDA grade, and consequently wholesale value, differed widely in their effect on retail values. This study indicates that current USDA Christmas-tree grade standards do not adequately differentiate Fraser fir trees with respect to their retail value. We propose a new method of Christmas-tree quality certification that involves computed Christmas-tree quality index values that offer greater accuracy in describing quality with respect to retail value.

Fraser fir is one of the most desirable Christmas tree species in the United States (Cook, 1990). Its combined attributes of superior natural shape, pleasing aroma, strong branches, excellent needle retention, and appealing dark-green needles have created a strong consumer demand and consequently high market values. Although these values are typically 50% to 100% higher than for most other species (Hockman et al., 1990; Schultz-Hilliker, 1992), quality Fraser fir Christmas trees are also more expensive to produce than those of most other tree species.

During the 1970s, strong demand and a stable supply of Fraser fir Christmas trees enabled North Carolina growers to sell their trees without strict attention to quality and with little marketing effort (Cook, 1990). However, in recent years, increased competition due to the increased national supply of Fraser fir and other species plus the appeal of arti-

cial trees has forced the North Carolina industry to focus more attention on tree quality and national marketing.

Christmas tree quality for wholesale and retail trade frequently is described in terms of U.S. Dept. of Agriculture (USDA) grades. These grades first were developed for Christmas trees by the industry in 1957. Grading provides useful trading definitions and quality descriptions (Littleton, 1964). The grades provide subjectively derived quality categories that should enable buyers and sellers to communicate accurately on quality factors such as height, density, shape, and various crown (foliage and limbs) defects. The grade standards are defined by concise written definitions that have been published widely, officially adopted by industry, and enforced by the USDA Federal inspection program (USDA, 1989).

On request and for a fee, official USDA inspectors will examine Christmas trees at either the point of shipping or receiving and officially certify tree quality and size. Such certification can be used either to market trees or to ascertain fulfillment of contract terms.

Four distinct USDA grades are defined for Fraser fir Christmas trees: premium, no. 1, no. 2, and cull. To qualify as a premium tree, a Fraser fir must be fresh, have characteristics of the species and a normal taper, be dirt and debris free, well shaped, and dense ($\geq 70\%$ of main stem masked by foliage), and have not more than one minor defect (USDA, 1989). Requirements for no. 1 trees are similar, except that one noticeable defect on one face is allowed and trees must be of at least medium density ($\geq 50\%$ main stem coverage). A no. 2 tree is allowed up to two noticeable defects,

with at least light density (40% main stem covered). Cull trees fail to meet the requirements of at least grade no. 2 and may be unmerchantable. As now defined, these grades provide some flexibility in categorization because no two trees are exactly identical.

Most growers market their trees wholesale. Of real Christmas trees, $\approx 25\%$ are sold direct from growers to the public through either choose-and-cut operations or grower retail outlets (Baumann, 1992). Wholesale trade is commonly based on tree categorization using a combination of USDA grade and height class, with a standard description of height class expressed in whole feet [e.g., 6 to 7 ft (1.82 to 2.13 m), 7 to 8 ft (2.13 to 2.44 m), etc.]

North Carolina, the leading state in production of fresh-cut Fraser fir Christmas trees, has the distinction of shipping more trees officially certified by USDA grades than any other state (Sorrels, 1986). Although grade and size categorizations may or may not be assigned by an official USDA grader (Koelling, 1992), the usefulness of the standards cannot be judged solely on the number of trees inspected. USDA grades tend to influence production and trade terms, even when trees are not officially certified.

Despite the 1989 industry-led revisions of the standards, some resistance to the USDA grading system exists in the Christmas tree industry. The opinion is often expressed that the Christmas tree grades are imprecise indicators of true retail value. At the wholesale level, many Christmas trees are classified in mixed grade lots (e.g., premiums and no. 1s), and buyers often state there is little or no consistent retail quality differential between the grades involved. Therefore, this study was initiated to investigate the relationships of current USDA grades to wholesale and actual retail value. In addition, the contribution of various tree quality and growth traits in determining USDA grade and retail value also were investigated.

Materials and Methods

Study area. This research was conducted in a plantation established in 1983 as a Fraser fir genetic test in Crossnore, N.C., located in Avery County (long. 36°00'N, lat. 82°00'W). Details concerning propagation and layout of this plantation are in previous reports (Jett et al., 1993; Li et al., 1988).

At final assessment in 1991, the plantation contained 1472 trees on a flat uniform site, with a 1.83 $\times$ 1.83-m tree spacing. Weed, pest, and nutritional management programs had been uniformly maintained throughout the study following standard practices. Commencing after the fourth growing season in the field, each tree was pruned annually to produce a uniform density and a single stem. Trees were basal-pruned after the sixth growing season to ensure that all trees had uniform, complete basal whorls. Typically, basal pruning consisted of pruning off the limbs from the bottom 20 to 25 cm of the bole until the first, complete, uniform branch whorl was reached.

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Tree measurements. In 1991, after eight growing seasons, each tree in the plantation was assessed for the following traits: 1) total height; 2) crown diameter; 3) branch diameter (the diameter of the longest branch in the top whorl measured just beyond the point of its basal swelling); 4) crown density [scored on a subjective scale of 1 = heavy to 3 = light in accordance with USDA grading standards (USDA, 1989)]; straightness of the visible portion of the main stem during the last 2 years (also scored subjectively on a scale of 1 = straight to 3 = crooked in accordance with the USDA standards). Also, taper was computed as maximum crown diameter divided by total height.

Following a year-8 go-to-market shear, consisting of a light crown shaping and removal of multiple leaders, each tree was assigned a USDA grade by a certified USDA grader. The grade, numbers and types of defects, and merchantable height (total sheared height less a 7.6-cm stump) were recorded for each tree. Because height class is routinely specified in 30.5-cm (1 ft) intervals, trees were categorized into height classes as follows (in feet; meters): 4 to 5 (1.22 to 1.49; 4.0 to 4.9), 5 to 6 (1.52 to 1.80; 5.0 to 5.9), 6 to 7 (1.83 to 2.10; 6.0 to 6.9), 7 to 8 (2.13 to 2.41; 7.0 to 7.9), 8 to 9 (2.44 to 2.71; 8.0 to 8.9), 9 to 10 (2.74 to 3.02; 9.0 to 9.9).

In addition to USDA grades, retail values were assigned by five retail lot operators, who scored tree values independently with no discussion or knowledge of either the other retailers' evaluations or of the USDA grade previously assigned to each tree. The markets that these retailers represented were 1) Lafayette, La.; 2) Richmond, Va.; 3) Birmingham, Ala.; 4) Johnson City, Tenn.; and 5) Naples, Fla.

Statistical analyses. Wholesale values were computed for each tree based on USDA grade and merchantable height. The value scale used represented average, 1991 wholesale prices at the Western North Carolina Farmers Market, Asheville (Table 1).

The correlation coefficient (r) between the different retailers' values and the retail and wholesale values were investigated with the correlation procedure (SAS Institute, 1985). The same procedure also was used to investigate the relationship of tree quality traits with USDA grade. Relationships between average retail value and USDA grade were investigated with the general linear models procedure (SAS Institute, 1985). The significance of differences between the average values of different grades were evaluated by Duncan's multiple range test. Finally, identification of traits important in defining quality as measured by average retail value, along with the relative influence of each, was achieved using the SAS step-wise regression procedure. Coefficients and terms for the equation resulting from the step-wise regression to describe Christmas tree quality [Christmas tree quality index (CTQI)] were expressed in English units to ensure maximum use of the equation for the Christmas tree industry. A statistical probability level of $P \leq 0.05$ was used throughout this study, except where otherwise specified.

Results and Discussion

Quality and tree value. In this study, a combination of good site quality and careful management resulted in good, uniform growth. Merchantable height after 8 years averaged 2.3 m with a coefficient of variation of 11.0%. Quality was also uniformly high. Of the trees, 62% were USDA premium quality, 29% no. 1s, 6% no. 2s, and 3% culls.

Of all the quality traits evaluated, density and straightness were the most variable, with means of 1.6 and 1.5, respectively, and coefficients of variation of 40% and 46%, respectively. In contrast, height and taper had coefficients of variation of 10% and 12%, respectively.

Incidence of defects, such as holes, gaps, or discolored foliage, was low. Consequently, with the exception of holes (spaces in the crown out of proportion with the uniform branching characteristics of the balance of the tree) and uneven density, other defects were excluded from further analyses.

Values assigned by each retailer correlated closely ($r \geq 0.93$) with the average of the five retail values (Table 2). This result indicated strong consistency among the retailers in judging tree quality. Because the diverse market locations involved sustain distinctly different retail price levels, the retail prices assigned to each tree varied widely, but there was consistent ranking among the different retailers. The correlation among retailers also indicates that traits that establish the individual Fraser fir trees as being of better quality in one location, tend to be favored equally in all locations. The correlation of retail values with wholesale values was somewhat lower than the correlation of the value of individual retailer with average retail value (Table 2).

Average retail value was poorly correlated with wholesale values ($r \leq 0.67$) (Table 3). Height had a dominant influence on retail and wholesale values. Correlations of height with wholesale value was 0.84, and the correlation of average retail value with wholesale value was 0.71. USDA grade was of secondary importance relative to height in determining values and showed only moderate correlation with wholesale value ($r = -0.67$) and with average retail value ($r = -0.52$). The negative values of these latter correlations indicate that superior, numerically lower grades are associated with higher retail values.

Correlations of average retail to wholesale values decreased substantially and steadily with increasing height class (Table 3). Wholesale values related best to actual retail values for 1.52- to 1.83-m-high trees. The height class $\times$ USDA grade categories used for wholesale trade clearly provided less precise discrimination of average tree retail value for taller trees. This deficiency arises partly because retail values are more sensitive to height than are wholesale values (Fig. 1).

Quality and value differences by grades. Correlations between wholesale and average retail values decreased substantially with decreasing USDA grade (Table 3), indicating that the relationship of USDA grade to retail

value is more precise for higher quality trees. Imprecision in poorer grade trees is due largely to the variable impact that different defects have on retail value (Table 4). For example, either a visible main stem curve of 10 to 15 cm from vertical or medium density (50% to 70% of the main stem covered) can degrade a tree from a premium to a no. 1. Although these two defects have equal effect on wholesale value for trees of a given height, their effects are substantially different. Average retail values by defect type of height class 7 to 8, no. 1-grade trees varied from \$33.98 for medium density to \$38.68 for trees with one hole, even though all trees of this category have an equal wholesale value of \$18 (Table 4).

Average retail values of premium-grade trees also did not differ significantly ($P \leq 0.05$) from no. 1s, with the exception of the 7 to 8 height class (Table 5). There was also no significant difference between no. 1s and 2s in the 6 to 7 and the 8 to 9 height classes. The cull grade was the only grade that consistently and

Table 1. Wholesale dollar value for fresh-cut Fraser fir Christmas trees based on 1991 averages at the Western North Carolina Farmers' Market, Asheville.²

Ht class	USDA grade			
	Premium	No. 1	No. 2	Cull
4-5	9 ^y	6	4	2
5-6	13	10	8	3
6-7	17	14	12	5
7-8	25	22	20	9
8-9	33	30	28	11

²Source = personal communication, D. Massee, North Carolina Dept. of Agriculture.

^yValue in dollars.

Table 2. Correlation² of individual retailers' Fraser fir Christmas tree values with wholesale value and average retail tree values for all height classes combined.

Retailer ^y	Value	
	Wholesale	Avg retail
1	0.78	0.94
2	0.78	0.94
3	0.79	0.94
4	0.80	0.93
5	0.78	0.93

²All correlations significant at $P \leq 0.05$.

^y1 = Lafayette, La.; 2 = Richmond, Va.; 3 = Birmingham, Ala.; 4 = Johnson City, Tenn.; 5 = Naples, Fla.

Table 3. Correlations of Fraser fir Christmas tree retail values and wholesale values by height class and U.S. Dept. of Agriculture (USDA) grade.

Ht class	USDA grade	Correlation avg retail value vs. wholesale value ²
5-6	Combined	0.66
6-7	Combined	0.42
7-8	Combined	0.49
8-9	Combined	0.46
9-10	Combined	0.28
Combined	Premium	0.82
Combined	No. 1	0.74
Combined	No. 2	0.68
Combined	Cull	0.34

²All significant at $P \leq 0.05$.

significantly differed in retail value from other grades for all height classes.

Lack of effective differentiation of retail value by the current USDA grades arises due to wide retail value ranges encountered within height class $\times$ USDA grade categories (Fig. 2). Substantial overlaps occur between adjacent grades (Table 5; Fig. 2). Many trees of one grade have higher retail values than some trees of superior grade and equal height class. Whereas wholesale prices are higher for better-grade trees within a height class, such trees may not be worth more in retail value.

Defects affecting one face only are of less consequence to retail quality and value than those affecting several faces or whole-tree appearance. For example, a hole on one face affected retail value less than medium crown density (Table 4). Averaged over all height classes, trees with single defects on one face had average retail values only 11% lower than trees with four perfect faces, whereas their average wholesale value was 19% lower. Clearly, trees with three instead of four perfect faces are discriminated against more by retail than by USDA grade and associated wholesale value. This result reflects retailer sentiment that defects on one face only, though deleterious to USDA grade, have minor effect on retail quality. From retail prices, it seems that most consumers are well satisfied by trees with only three good faces; most trees are placed against walls or in corners of rooms (Duncan et al., 1960; Winch, 1963), with fewer than 10% placed where all sides are visible. However, USDA grade standards only allow trees with four faces free of noticeable defects to be classed as premium.

Relation of traits to grade and value. Correlations of specific traits to wholesale values and to average retail values clearly indicate that various traits differentially affect average retail value compared to wholesale value (Table 6). Using the 7 to 8 height class as an example, holes have substantially greater influence on USDA grade and wholesale value ($r = -0.56$, the negative value indicating fewer holes are associated with higher values) than average retail value ($r = -0.21$). Uneven density also had greater influence on grade and wholesale value than on average retail values. Density, however, had approximately equal correlations with grade, wholesale, and average retail value. It was apparent from these relationships that consumers in eastern U.S. markets will pay more for higher-density trees.

Height variation within any one trade height class was correlated weakly with wholesale value but proved to be the trait most highly correlated with average retail value within a height class (Table 6). Retail value is sensitive to any change in height, but wholesale value is constant within 30.5-cm height classes (Fig. 1). For example, premium-grade trees 2.1 m and 2.4 m tall, in the same height class $\times$ USDA grade category, have equal wholesale values of \$25. However, average retail values for 2.1-m and all 2.4-m premium trees were \$35.45 and \$44.45, respectively, a 25% difference.

Branch diameter in the top whorl had little impact on quality or value. However, this and

other such traits sometimes influence USDA grade, wholesale value, or retail value. For example, trees grown on different sites, under different cultural practices, and from different

seed sources often can show more variation in branch diameter and other traits (Jett et al., 1993) than they did in our study. Small branch diameter could affect USDA grade and subse-

Fig. 1. Average (■) wholesale and (+) retail values by merchantable height (for all grades combined) of Fraser fir Christmas trees.

Table 4. Examples of retail value differentials associated with U.S. Dept. of Agriculture (USDA) grading defects (7 to 8 height class trees).

USDA grade	Defect	Wholesale value avg (\$)	Differential from premium grade (%)	Retail value avg (\$)	Differential from premium grade (%)
Premium	None	21	---	40.88	---
No. 1	Hole ^z	18	14.3	38.04	6.9
	Uneven density	18	14.3	37.39	7.6
	Medium density ^y	18	14.3	33.98	16.9
	Stem crook ^x	18	14.3	38.68	5.4

^zHole = a space considerably out of proportion with the uniform branch characteristics of the balance of the tree.

^yMedium density = whorls being reasonably close together with spaces between filled with branches and needles so that 50% to 70% of the main stem was not visible.

^xStem crook = a visible main stem curve of 5 to 10 cm from vertical.

Table 5. Mean retail value (dollars) and ranges (in parentheses) for U.S. Dept. of Agriculture (USDA) grade-height class categories for Fraser fir Christmas trees in 1991.^z

Ht class	USDA grade			
	Premium	No. 1	No. 2	Cull
5-6	23.50 a ^y (15.00-30.60)	22.10 a (13.80-27.80)	15.71 b (9.30-26.80)	7.40 c (0.00-23.90)
6-7	33.08 a (25.20-38.60)	29.83 ab (20.00-35.40)	27.72 b (13.60-37.20)	20.00 c (0.00-28.80)
7-8	40.90 a (34.00-46.20)	37.68 b (29.40-44.20)	33.24 c (9.00-43.20)	20.74 d (0.00-20.74)
8-9	47.95 a (42.40-54.60)	43.56 ab (32.40-51.00)	39.26 b (18.00-46.40)	---
9-10	54.76 a (49.00-59.00)	52.67 a (41.40-56.80)	---	---
Combined	42.36 a (15.00-59.00)	36.09 b (13.80-56.80)	28.39 c (9.00-46.40)	15.86 d (0.00-28.80)

^zAbsence of data for three cells is due to lack of trees graded into these categories.

^yMean separation in rows by Duncan's multiple range test at $P \leq 0.05$.

quent value if it reduces branch strength relative to ornament supporting ability. At the other extreme, large branch diameter can be a problem in the Christmas tree mail-order business.

In conjunction with the retail price differentials associated with specific traits, the correlations obtained reveal a serious shortcoming of the current USDA grading system. Grades are assessed subjectively with a limited number of grade categories. The effects of many diverse defects on grade, and consequently wholesale value, tend to be equal and of a threshold nature. However, their impact on retail value vary substantially, both between and within different defect types. Retail value, unlike grade and wholesale value, is infinitely variable and can be responsive to the continuously variable nature of any trait.

With the current USDA grade $\times$ height class wholesale categorization, an impediment to obtaining good differentiation of retail quality is the 30.5-cm width of the height classes. Adopting narrower height class categories might reduce some of the overlap of retail values between grades within the one height class. However, a quality description system that accurately relates to the retail market's quality and price should result in little or no overlap between the retail values of different quality ratings within a height class. As an analogy, 1 kg of USDA premium-grade potatoes typically has a higher average retail value than 1 kg of USDA grade no. 1 potatoes. Such clear distinction is not achieved by current USDA Christmas-tree grades. For trees of identical height, some inferior USDA grade trees have higher retail value than superior grade ones.

This study also reveals serious deficiencies in the cull-grade category, which is intended to identify only unmerchantable trees. Current standards do not just assign truly unmerchantable trees to the cull category. In this

study, $\approx 63\%$ of the trees graded as culls were considered to be marketable on retail lots. Retail price of cull trees varied greatly within each height class and overlapped widely into the retail price ranges of higher quality grades (Table 5). Some cull trees had greater value than some premiums in the 5 to 6 and 6 to 7 height classes. In addition, existence of wholesale market values for cull trees indicates some market demand for these supposedly unmerchantable trees (Table 1).

Proposed method for quality classification. Generally, Christmas trees are unique among USDA-graded produce. They have high unit value, and retail prices generally are assigned by size and individual merit, irrespective of grade. Consumers typically take great care and time to evaluate all relative merits of many trees before making a choice. Consequently, the industry clearly needs a more accurate system for quality description of Fraser fir.

A good tree-quality rating system must be sensitive to the infinitely variable nature of quality traits and the differential effects of traits on retail value. This goal might best be achieved using multiple linear regression to combine scores and measurements of important traits into a CTQI.

The data of this study, analyzed using stepwise linear regression, yielded the following equation for obtaining CTQI: $CTQI = 5.166 \times HT + 4.393 \times CDM - 2.659 \times DN - 0.445 \times ST$, where HT = tree height (in feet) measured to 0.1 ft; CDM = maximum crown diameter (in feet); DN = crown density scored on a scale of 1 (heavy) to 3 (light) in accordance with USDA grading standards for Fraser fir; and ST = straightness of the visible stem scored on a scale of 1 (straight) to 3 (crooked), also in accordance with USDA grading standards. Traits and defects omitted from the equation (including holes, gaps, uneven density, and incorrect taper) had no significant influence

Table 6. Correlations of Fraser fir growth and quality traits with Christmas tree wholesale and average retail values.

Ht class	Trait	Wholesale value	Avg retail value
All			
combined	Height class	0.90**	0.78**
7-8	Holes	-0.56**	-0.21**
	Uneven density	-0.35**	-0.15*
	Form	0.04 ^{NS}	0.27**
	Branch diameter	0.07 ^{NS}	0.11*
	Straightness	-0.20**	-0.05 ^{NS}
	Density	-0.40**	-0.42**
	Height variation within class	0.11 ^{NS}	0.50**

^{NS}, *, **Nonsignificant or significant at $P \leq 0.05$ or 0.01, respectively.

Table 7. Correlations of Fraser fir average retail value with U.S. Dept. of Agriculture (USDA) grade and with Christmas tree quality index (CTQI).

Ht class	USDA grade	CTQI
All combined	-0.53	0.89
6-7	-0.46	0.72
7-8	-0.44	0.68
8-9	-0.46	0.64

^aAll correlations significant at $P \leq 0.05$.

on overall value. For this study, the CTQI values represent the estimated average retail value of individual trees. In general application though, CTQI is unitless, representing relative retail quality; it does not equate to actual value in any given retail market.

The superiority of CTQI over USDA grades for quality classification is revealed in Table 7. CTQI more strongly correlates with quality, as measured by average retail value, within overall height classes and within any one specific 30.5-cm height class. The index clearly accounts for more of the quality variation. However, this particular equation must be considered as preliminary and warrants refinement based on a more extensive range of tree-quality data covering a more even distribution of tree qualities.

We propose that CTQI could replace the current grade categories. Quality for an individual tree could be specified by a CTQI value; for groups or lots of trees, mean CTQI or the mean and percent distribution of CTQIs would be appropriate. Height class also could be specified. New USDA standards could be formulated specifying the CTQI equation and measurement of the appropriate input variables. Official grading and certification by USDA inspectors still could be achieved rapidly in the field or market place by using handheld programmable calculators.

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Fig. 2. Normalized frequency distributions of retail values by U.S. Dept. of Agriculture Christmas-tree grade for trees in the 7 to 8 height class (i.e., 2.13 to 2.41 m; 7.0 to 7.9 ft).

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