HaLT2—an enhanced lumber grading trainer

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Abstract

This paper reports on HaLT2, an improved version of HaLT (Hardwood Lumber Training Program)—a computer program that provides training in lumber grading. The newly added enhancements in HaLT2 will provide training for both novice and experienced hardwood lumber graders in accordance with National Hardwood Lumber Association (NHLA) rules. HaLT2 is more accurate, easier to use, and can be used to create boards that emphasize particular points of study. It can also be used to grade actual boards for evaluative use by industry, academia, and the NHLA. The feedback from these evaluations indicates HaLT2 to be accurate.

The complexity of National Hardwood Lumber Association (NHLA) grading rules[1] makes grading skills difficult to acquire. The primary source of training is a 14-week course offered by the NHLA in Memphis, Tenn. Short courses (3 or 4 days) are also offered, but these are not aimed at producing lumber graders. HaLT[2,3] was developed to assist in training lumber graders. An advanced version of HaLT called HaLT2 was developed in response to comments from users, including industry, academia, and the NHLA.

The features of HaLT2 include:

1. High resolution color graphics allowing color encoding of nine types of defects: stain, checks, sound knots, unsound knots, wane, pith, splits, holes, and decay.

2. The ability to zoom into 4-foot sections of the board to see greater detail. Because most boards are much longer than they are wide, it is not possible to fit a scaled version of the board on a PC screen and show sufficient detail.

3. On-screen rulers are available to measure the defects and board dimensions. These rulers are provided in both the normal and expanded views of a board.

4. Consideration of both faces while grading a board, which is a significant advantage over other grading programs. Grading of both sides is essential if the grading process is to be properly performed.

5. Mouse support, which greatly facilitates its use.

6. A board editor allows the user to create a board using either the keyboard or the mouse. The mouse is recommended because of its ease of use.

7. Boards are called up by the user in one of four ways: sequentially; in random order (so that solution

[1] National Hardwood Lumber Association. 1990. Rules for the measurement and inspection of hardwood and cypress lumber. Memphis, Tenn.

[2] Klinkhachorn, P., C. J. Schwehm, C.W. McMillin, and H.A. Huber. 1989. HaLT: a hardwood lumber training program for graders. Forest Prod. J. (39)2:38-40.

[3] Franklin, J.P., C.W. McMillin, R.W. Conners, and H.A. Huber. 1988. Automated computer grading for hardwood lumber. Forest Prod. J. 38(3):67-69.

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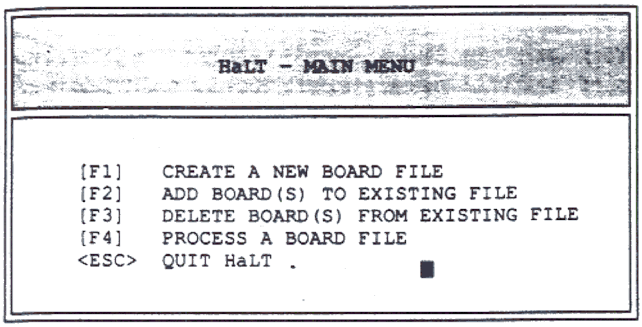

Figure 1. — The HaLT main menu.

sequences are not memorized); by serial position in the file (1st, 10th, 16th, etc.); and by board identification number or name.

8. Does not require prior knowledge of the grade of a board. Boards can be created by the editor (feature 6) or entered from data measured directly from real, perfectly rectangular boards. HaLT2 will compute the grade.

9. Interactively shows the user how the grade of the board was computed. The user is asked to estimate the grade. HaLT2 indicates the actual grade if the user's estimate is incorrect and provides an option to view the sequential manner with which the correct grade was computed.

10. Species specific exceptions to the standard rules may be entered.

HaLT2—program operation

HaLT2 requires an IBM-PC or IBM-compatible computer with 640K of random access memory (RAM) and an enhanced graphics adapter (EGA). The performance of the program can be enhanced with an AT class or better machine, a hard disk, mouse, and a math coprocessor, although they are not essential to program operation.

Initially, HaLT2 gives the user a choice of three editing functions, one board processing function, and a program exit (Fig. 1). The three editing functions allow the creation of new boards in a file or the addition or deletion of boards from an existing file. The processing function prompts the user to estimate the board grade, then confirms or corrects the estimated grade, and offers the option to see a detailed explanation of the steps leading to the correct grade. These options are discussed in the following sections.

Creating a board file

A board file can be created with data encoded from real boards provided the boards are perfect rectangles. However, the user may also wish to create a sequence of boards that emphasizes specific defects such as knots, end splits, or wane. Without a mouse, the data to create the boards are entered in response to a series of prompts. With a mouse, board creation is much faster as the board is simply drawn on the PC screen and the coordinates of the defects created are provided to the user.

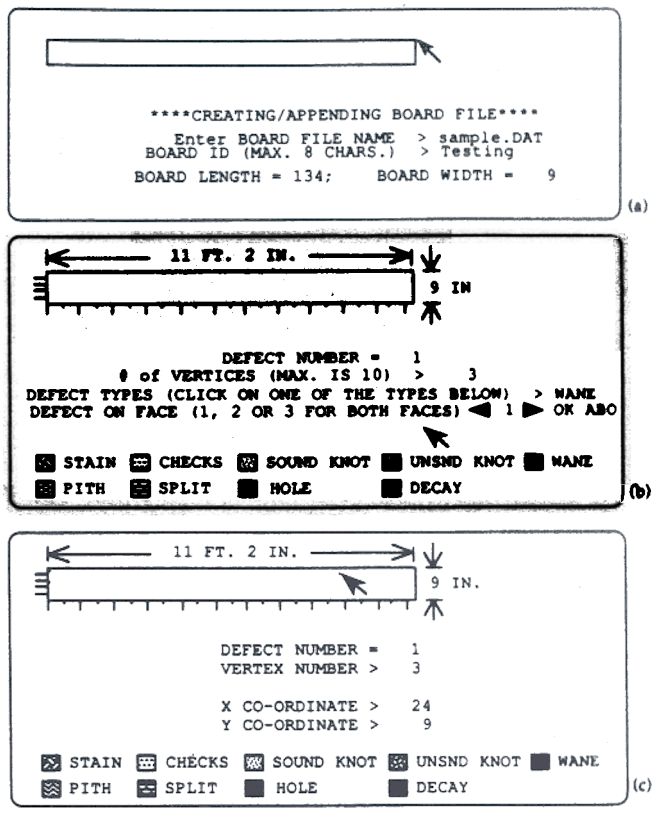

Figure 2. — Sequence of steps in creating a board file.

Figure 2 shows a sequence of operations leading to the creation of a sample board with a mouse. In Figure 2a, the lower left corner of the board is fixed and the remainder of the rectangle is generated automatically according to the position of the cursor. The dimensions of the board are shown at the bottom of the screen. The user can click the mouse button when the board dimensions are acceptable. The number of vertices of a polygon enclosing a defect, the type of defect, and the face on which it lies are then selected as shown in Figure 2b. The location and expanse of a defect require the location of each of the vertices, which is reduced to a point-and-click operation, allowing for easy defect creation (Fig. 2c). For long boards, the minimum dimension of a defect is 1/3 inch when entered with a mouse. When constructing a board containing defects that are 1/4-inch or smaller, the keyboard must be used.

Processing a board file

The "Process a Board File" option is the HaLT2 training procedure. The user must first decide how a board is to be selected from the board data file. The choices are: sequentially, randomly, by serial position (i.e., the 10th board in the disk file), or by board identification tag or number.

The training procedure begins by showing the user a view of the entire board (Fig. 3). The defects on each side are shown one face at a time and as many defects

as can be listed in the space available are shown. The user is then asked to calculate the surface measure (SM) of the board and is given three options that can be viewed before specifying the board feet of SM: examine the other face, examine an expanded view, or exit the program. The user can examine opposite faces and expanded views as many times as desired. The expanded view is illustrated in Figure 4. In the expanded mode, the user may scan back and forth along the length of the board or flip the board to obtain any additional information. When the expanded viewing is terminated, the user may again choose from the three options or answer the prompted question on board SM. If the answer is correct, a message to that effect appears. If the answer is incorrect, the correct answer and how the correct answer was calculated are given.

For boards whose SM does not compute to a whole number (e.g., 10.5), HaLT2 follows a policy of truncating if the fractional part is less than 0.5 (i.e., an SM of 10.2 is treated as 10.0) and rounding up if the fractional part is greater than 0.5 (i.e., an SM of 10.6 is treated as 11.0). HaLT2 will use the lower value in the special case where the SM is exactly halfway between two integers. Thus, 10.5 is treated as 10.0. This procedure generally assures that the highest grade possible is determined.

The user is next asked for the correct grade. Possible choices for grades are: FAS, Selects, No. 1 Common, No. 2A Common, No. 3A Common, and Below Grade. If the chosen answer is incorrect, the correct answer is given. Whether the choice is correct or incorrect, the user has the option of either seeing how the correct grading decision was made or continuing on to the next board (Fig. 5).

How HaLT2 works

Within limitations, HaLT2 grades a board as a human would. It looks for the highest possible grade one grade at a time. If a board isn't FAS, the program considers Selects. If it is not Selects, HaLT2 considers No. 1 Common, and so on. As called for in paragraph six of the NHLA rules[1], HaLT2 looks for the minimum requirements for each grade.

The program first examines the length and width of the board. If these meet the requirements of FAS, then each face is evaluated. First, pith is considered. Then, the edges are examined for wane. Next, the ends are examined for splits (length and slope) and the amount of clear-face material in one or two pieces. Then, the face is examined for knots or holes that exceed in inches one-third the SM of the board. If a defect is found that exceeds acceptable limits, the analysis for FAS is terminated. If no such defect is found, the poorest face is then evaluated to determine if it contains enough clear-face area cuttings of the specified sizes of no more than the allowable number of grading cuttings.

If, for any reason, the board cannot meet the FAS requirements, Selects will be considered. Selects allow narrower and shorter boards but are otherwise generally graded the same with respect to knot and hole size, pith, and the condition of the end of the board. The reader is referred to the NHLA Rule Book for exceptions

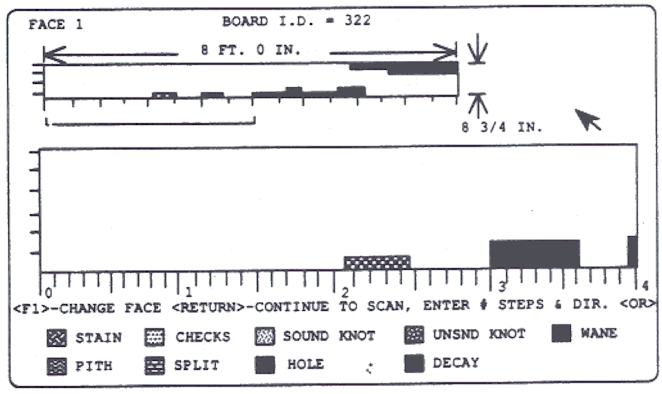

Figure 4. — Expanded view of the board.

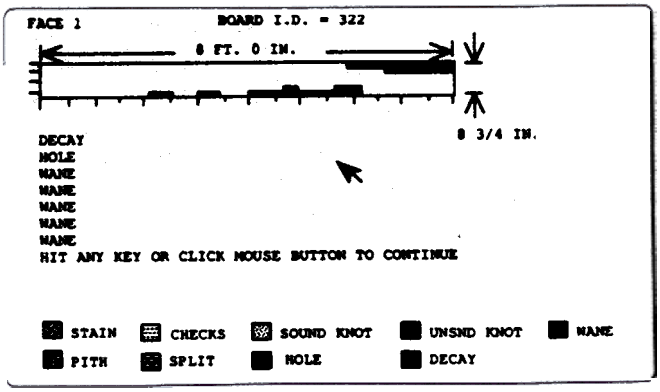

Figure 3. — Introductory view of the board.

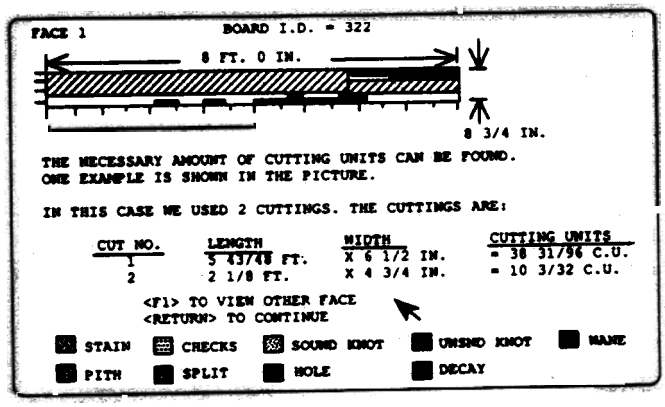

Figure 5. — Example of cuts found to meet a grade.

concerning wane. HaLT2 contains all wane rules and their exceptions. If no excluding defects are found, the program evaluates the board in the following order: Selects with sound back, two clear-face cuttings of any length that are the full width of the board and contain 97 percent of the surface area of boards that are 6 feet through 12 feet in SM; and Selects with No. 1 Common back. If not a Selects, then the analysis is begun again with the minimum requirements for No. 1 Common becoming the standard of comparison. The process is repeated through 2A Common and 3A Common. If the board will not make the 3A Common grade, it is classified as Below Grade.

The HaLT2 program determines the grading cuttings surface area by looking for the longest (first) and widest cuttings available that meet the minimum required surface area for the grade. Sometimes the program's cutting solution is not one that a human would produce. Humans will usually grade width first and then length, particularly when full-width cuttings are available. This should be of no concern to the user. HaLT2 simply illustrates one solution that works. There may be several others that include more total surface area. But the user should recall that each grade defines only the poorest piece in the grade. HaLT2 looks for the minimum surface area in the fewest number of pieces possible.

When grading FAS, 1 foot at each end in the standard length must contain at least 50 percent clear face wood in no more than two pieces of any shape and an additional 25 percent in any number of pieces of sound wood. While the human eye can easily see whether the board conforms, a computer-derived solution would be too time consuming. HaLT2 determines the area of the defects in the first foot and calculates whether the remainder meets the specifications. HaLT2 computes the rule without consideration of the number of pieces but only on the amount of clear area.

In actual grading, it is possible to put any overlength (hardwood lumber is always graded based on standard or whole foot lengths) on either end of the board or to divide any overlength in any ratio between the ends. This can be useful if large grade-limiting defects occur on the ends. If they can be placed in any overlength, they may be ignored. HaLT2 simply places any overlength on the end with the greatest amount of defective area.

How accurate are the grades of actual boards as determined by HaLT2? For the most part, the NHLA rules are straightforward. Once all objectionable defects have been identified and entered into the data, they will be accounted for in evaluating each face (side) of a board. The poor face of the board will be identified and used to determine the amount of surface area in the grading cuttings. The back (best) face of the board will be re-evaluated and allowable defects will be eliminated from consideration. It is at this point that two problems can occur having to do with 1) choosing the grading face; and 2) determining what is allowable on the back face.

In choosing the grading face, HaLT2 first grades each face without regard to the other. The program stops grading when the first solution is found that meets the grade requirements for size and number of cuttings. HaLT2 then compares the amount of surface area from each solution and uses that face with the smallest grading cutting(s) area as the poor or grading face. This is similar to human grading except that humans will maximize grading cutting areas before comparing, whereas HaLT2 compares minimum or first solution values. This could cause the wrong face to be chosen as the grading face. Of course, this can only occur when both faces grade the same.

Determining what is allowable on the back or sound side of the grading cuttings is a different matter. The basis of the standard hardwood lumber grades is clear-face cuttings. The 1990 NHLA Rule Book on clear-face and sound cuttings contains the following definitions:

> Clear-face cutting: A cutting having one clear face (ordinary season checks are admitted) and the reverse side sound as defined in Sound Cutting. The clear face of the cutting shall be on the poor side of the board except when otherwise specified.
>
> Sound cutting: A cutting free from rot, pith, shake and wane. Texture is not considered. It will admit sound knots, bird pecks, stain, streaks or their equivalent, season checks not materially impairing the strength of a cutting, pin, shot and spot worm holes. Other holes 1/4 inch or larger are admitted but shall be limited as follows: one 1/4 inch in average diameter in each cutting of less than 12 units; two 1/4 inch or one 1/2 inch to each 12 units and on one side only of a cutting. (A unit is 12 square inches.)

Thus, a 1/4- or 1/2-inch hole (or unsound knot or bark pocket) can be allowed if it is on the back face and if the size of a cutting in which it can be placed is sufficiently large. Further, two or more of each in close proximity to each other on the back face could also be allowed if they could be placed in separate cuttings according to the rule. Consideration to this degree of subjectivity was beyond the scope of HaLT2.

In a test using the new USDA Forest Service databanks[4], it was decided to ignore all the back face 1/4-inch defects and to include all back face 1/2-inch defects. To be able to calculate all possible cuttings and then try the 1/4-inch defects for best fit would require an excessive amount of time and computational resources. The 1/4-inch defect decision was made, in part, because the databank is accurate only to the nearest 1/4 inch. Smaller defects such as shot and pin worm holes are shown as 1/4 inch although their size is coded within the data. The 1/2-inch defect decision was made with the observation that, often, such a defect comes through to the other face and therefore is accounted for. Also recall that the board is usually graded from the poor side and it is on this side where one would expect to find one-face-only 1/2-inch defects.

[4] Gatchell, C.J., J.K. Wiedenbeck, and E.S. Walker. Forest Service 1992 red oak lumber data banks. USDA Forest Serv., Northeastern Forest Expt. Sta., Princeton, W. Va. (In preparation for publication.)

A total of 384 FAS and Selects boards were examined. In no case was a board placed in these high grades because the 1/4-inch defects were ignored. The FAS boards, of course, were not affected by including all 1/2-inch defects on the back face. If they were, they would not be FAS. Of the 185 Selects boards, there were 43 with 1/2-inch defects but none were adversely affected. This was not surprising because Selects are graded from the best face and there are three ways to get a Selects board: sound back, 97 percent rule, and 1 Common back. In the last case, each face is graded independently and the locations of the defects on the 1 Common face are irrelevant. Of three hundred sixty-one 1/2-inch defects in No. 1 Common samples, 209 occurred on the grading face. Of eight hundred eighteen 1/2-inch defects in No. 2A Common samples, 488 occurred on the grading or poor face.

To-scale plots of 481 No. 1 Common and 584 No. 2A Common red oak boards were compared with the HaLT2 grading procedures. Thirty percent of the No. 1 Common and 20 percent of the No. 2A Common having 1/2-inch defects on the back (or best) face (152 No.1 Common and 330 No. 2A Common boards) had the grading surface area reduced but not sufficiently to lower the grade. This reduction had no effect as the lumber grades are designed to identify only the poorest piece in the grade. The remaining 1/2-inch defects were either covered by defects on the grading side or were in areas that were too small to be considered for grading cutting purposes.

In no case was a board misgraded because 1/4-inch defects on the back side were ignored. Considering all 1/2-inch defects on the back side caused seven of the No. 1 Common (1.5%) and four No. 2 Common (0.7%) boards to be misgraded. Thus, we feel confident in stating that HaLT2 grades boards with a 98 percent rate of accuracy with respect to defects.

One word of caution is needed when grading actual boards from encoded data. HaLT2 was designed primarily as a training program using a small number of defects. An increased number of defects results in a non-linear increase in the number of cutting permutations, which drastically increases the time required to determine a solution.

Conclusion

This paper reports on the continued development of a program (HaLT2) that provides training in the area of hardwood lumber grading. Our tests have shown HaLT2 to be accurate and reasonably fast when the number of defects on the board is relatively small. An increased number of defects, as expected, results in an exponential growth of processing time. In its current form, HaLT2 can be used as a valuable tool by novice and experienced graders. The ability of a user to conjure up a board without knowing its grade is an important asset of the program. This facility can be used to try out an infinite number of boards because HaLT2 does not require a priori knowledge of the board's grade.

For copies of the HaLT2 program, contact Charles W. McMillin, c/o National Hardwood Lumber Association, P.O. Box 34518, Memphis, TN 38184-0518.