A method enabling the reconstruction of internal features of logs from sawn lumber: The log end template

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Abstract

Knowledge of the internal characteristics of logs enables the optimization of sawn recoveries. This has led to the development of various nondestructive and destructive methods for characterizing interior log features. The objective of this study was to develop a method for tracking the origin of individual lumber boards through a commercial sawmill, allowing the reconstruction of logs from data gathered from the sawn lumber. Log end templates were designed that are glued to each log end. After sawing, a portion of the template remains glued to each end of every piece of lumber, from which polar coordinates and a unique log identifier can be read. This can then be incorporated into a database with grade data such as knot and feature locations, together with tree and stand data. The method provides an efficient, accurate, robust, and reliable way of tracking boards through a sawmill while the mill operates normally.

In silvicultural and wood products research it is desirable to identify individual boards after sawing in relation to origin with the log and tree. This allows the researcher to identify characteristics of the sawing process, log, tree, stand, or silvicultural practice that has impacted on individual board quality. It also allows reconstruction of internal features of the log. A variety of methods have been developed but these are often very labor or capital intensive.

Lemieux et al. (1997) and Harless et al. (1991) describe the development and application of various methods for evaluating interior characteristics of logs. While nondestructive methods remain very expensive and in development, significant application lies in simple and efficient methods of destructive evaluation (Zhu et al. 1996, Gronlund and Grundberg 1999). Destructive methods have utilized longitudinal (Peter and Bamping 1962, Steele et al. 1993), crosscut (Somerville 1985, Harless et al. 1991) or rotary dissection of logs (Lemieux et al. 1997). These are very labor intensive, more so when small section boards or disks are cut to increase the resolution of the internal detail measured.

Longitudinal methods cut logs into flitches and record grade data and features from each flitch. These methods can also be used to reconstruct the log and the recording of features can be made easier using digital cameras and software. Crosscut methods are good for characterizing log shape but result in larger numbers of pieces and the subsequent handling costs are high. With both the flitch method and crosscutting, knots (or other features and defects) can be contained within sawn sections if the sections are too thick and knots are parallel to the cuts. If logs are cant sawn,

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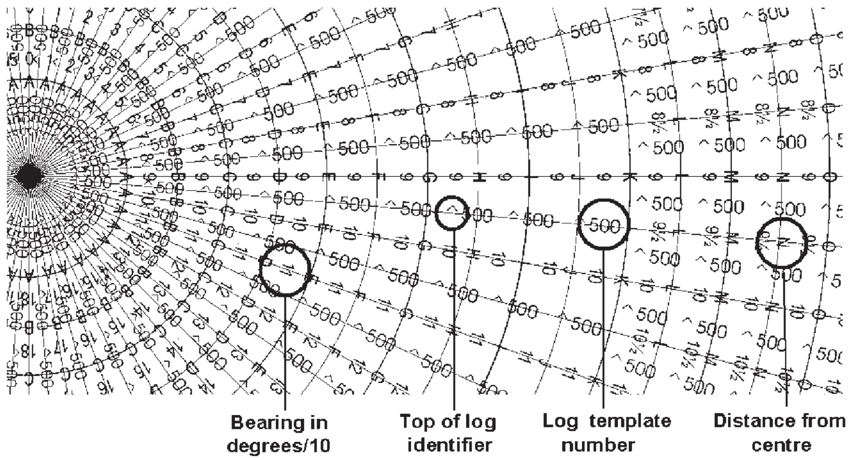

Figure 1. — Template design showing detail of radial and polar grid and coordinates, unique log template number and symbol for the top (^) or bottom (@) of the log.

this will ensure boards are backsawn from all sides of the log. Both longitudinal and crosscut methods result in losses to sawkerf. Peeling methods eliminate any losses and are most accurate for the description of knots and other features as the veneer is always tangential to the log center (Lemieux et al. 1997). To our knowledge, no method allows the normal processing of logs in the sawmill. The objective of this study was to develop a method for tracking the origin of individual boards through a sawmill that will enable “reconstruction” of the log from which the boards were sawn. In our case, this was to compare recoveries from logs from stands with different silvicultural histories.

In previous studies, boards were tracked by numbering each board as it is sawn in a predetermined sequence. This method means that the mill must operate slowly and inflexibly and often there must be people at many locations throughout the mill (Park and Leman 1983). For accuracy, the position the board came from must be measured after each board is cut. If there is any problem during sawing, boards are lost and identification becomes difficult or impossible. Also, any errors in numbering or allocation of boards to a log can be carried through to later boards or can result in boards being allocated to the wrong log, compounding errors. In many commercial mills, numbering individual boards is not possible for practical, economic, and safety reasons. Also, in many studies, the aim will be to perform operations by normal commercial methods or to assess normal operations.

As with many of the methods, Lemieux et al. (1997) present a method developed to tackle the problem of characterizing knots within a log; however, their method requires specialized lab equipment. The method presented in this paper was also developed for the characterization of knots (and other defects) in eucalypts grown for solid wood products. Because many eucalypts self-prune efficiently, there are no external characteristics on the log that make the location of knots known. Therefore, the best method for sampling within the log for knots is to saw longitudinally.

This paper presents a method of labeling log ends to allow tracking of individual boards through a sawmill. The method uses a grid template that gives the detailed location of a board within the log so that the log can be reconstructed later from the data. The method utilizes materials that are readily available from commercial suppliers.

Method

The method uses a PVA-based glue to fix a paper template to both ends of each log after the final breakdown of stems before milling. Details are given below of the template design, gluing to the log end, milling, data capture, and database design.

Field measurements

In order for the exact origin of individual boards to be ascertained after sawing, north and east must be marked on the standing tree, and then after felling, above and below the cut position where each log is to be bucked. This is most easily done using a shallow longitudinal chain saw cut into the log sides. North and east can then be color coded with spray paint so they are easily distinguishable when templates are being fixed later. The dimensions of each log should also be recorded, including end diameters and detailed sweep descriptions. The extent and detail of other external tree and log measurements will depend on the purpose of the study being undertaken; however, the precision of reconstruction of internal features will depend on the external measurement and sweep.

Template design

The objective of the template design was to ensure that information that identifies the origin of each piece of timber remains on the end of each piece after sawing. The density of the grid is constrained by the size of the timber pieces that will be cut from the log and the minimum size of the font that can be used so as to remain legible after use. The template design uses a radial grid containing polar coordinates (**Fig. 1**). The grid has circles that increase in radius in 15-mm intervals. The interval between radiating lines depends on the distance from the center of the log. Initially, the interval is 10 degrees from 0 to 350. The 0 degree line is oriented to the north. After a radius reaches approximately 180 mm, the interval is reduced to 5 degrees to maintain the required density of grid points. There is also a template number that uniquely identifies each log and a symbol that indicates whether it is the top (^) or bottom (@) of the log. This is necessary as it is not possible to tell the top or bottom of pieces of lumber. The log identifier and symbols must be repeated at a fine enough scale to occur on the smallest piece and every piece of lumber to be sawn and to be legible (**Fig. 2**). Before adhesive is applied to the log end, the template center (0 / 0) was aligned with the geometric center of the log and the coordinates of the pith were recorded.

Fixing templates to log ends

Several label materials and glue products were trialed for printing of the template and fixing to the log ends, in order to withstand the sawing process. The labels needed to be flexible, easily printed, and easily handled. Plastic films were too high strength. Once the saw con-

Figure 2. — Board ends after sawing with log template sections attached. Note some darkened templates from exposure to rain.

tacted these films, they were torn from the glued areas adjacent to the cut. This didn't occur with paper and fabric as these products were low strength. Permanent printing was also necessary and this proved more difficult with fabric. The fabric product could not be printed in normal commercial printers. Normal bond paper proved to be low strength so that a clean edge was achieved after cutting. The paper was successful in combination with Bondcrete™ (a PVA-based construction adhesive) because the adhesive soaked into the paper and a coat over the template could be used to protect the paper (it dried clear to allow reading of the template).

Prior to fixing, any irregularities on the log ends were smoothed using a chain saw and any details such as tree and log numbers on the log ends were recorded, along with the template number. The templates were carefully positioned over a generous coating of adhesive, avoiding any wrinkling or stretching. The paper was flexible enough to be carefully pushed into all minor irregularities on the surfaces of the log ends, ensuring a good bond. A final generous coating of adhesive was used to protect the paper template during sawing.

Bondcrete was sufficiently water resistant when subjected to the small amount of water in the sawmill. After sawing, the labels on the ends of some boards were wet by rainfall, and in the worst case, boards were very difficult to read as the clear coating of adhesive turned cloudy and then black when dry. This problem would not have occurred without exposure to rain (**Fig. 2**).

The printing was undertaken on inkjet and laser printers. It was necessary to print templates up to 70 cm diameter, therefore a commercial printer was used to produce A1 prints (dimensions). The water-soluble ink in inkjet-type printers proved less satisfactory as there was some bleeding of printed characters within the templates, therefore laser printing was preferred. It is critical that no docking of boards be undertaken after sawing. This ensures that labels and

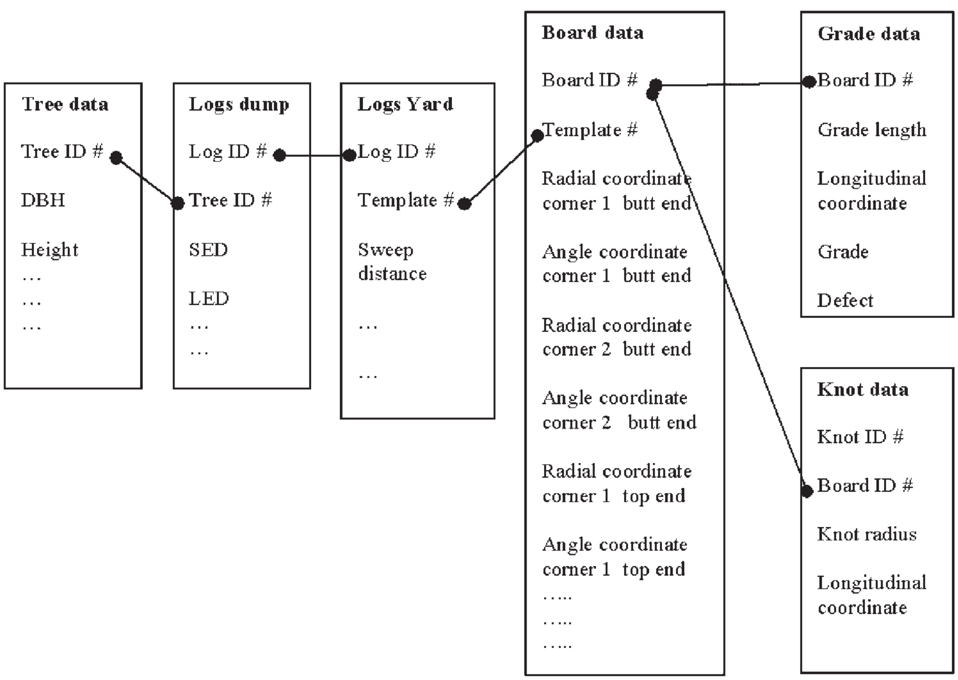

Figure 3. — The database designed in Microsoft Access. The template number provides the connection between individual board data and log, tree, and stand data.

boards are intact. If docking must take place, it would be possible by numbering both cut ends of the boards and retaining the offcuts.

Data capture and database design

Reading coordinates from the template requires some training. The coordinate pairs are labeled differently to avoid confusion: Bearings are numbers from 0 to 35 and radial distances are letters: A, B, C, etc (**Fig. 1**). The main difficulty was estimating the coordinates of the corner of a board by extrapolating the coordinates on the face. Once the coordinates from the template and the position (distance from the end of the board) of any features are recorded, the intra-log geometry can be fully described. Where less accuracy and greater speed is required, reading any coordinates from the end of the board may be sufficient. In this study, the coordinates were on a 15-mm grid; however, measurements were interpolated to half-grid measurements. We consider that it would be possible to increase the precision to within millimeters by interpolating between grid lines. It would also be possible to increase the density of the grid and reduce the size of the font if a smaller piece size was required for greater precision, although the limits have not been tested.

In the database, the unique log template number was used as a table key, linking data collected from boards (template coordinates, distortion, grade) to data collected from logs (dimensions, position in tree) and through to trees and stands (**Fig. 3**). This means that the actual number used on any particular template is arbitrary as long as the log identifier is recorded with the template number.

As with other methods, the data need to be reconstructed. This is a simple procedure as the data are in a three-dimensional grid format. In this study, the data were transformed to longitudinal, radial, and height coordinates within each tree. To allow accurate reconstruction of interior features of the log, data will need to be transformed according to the sweep of each log. The data from an initial trial have not yet been incorporated into specialized software.

Discussion

The method described allows the tracking of boards during sawing without intervention or observation. The system offers safe and fast material tracking and requires no specialized equipment. It is not necessary to batch logs when processing (although this can be used as a crosscheck of final results). It may even be possible to saw other logs not used in the study at the same time. At the current time, the system has been tested in a single mill designed to cut high-density hardwoods. The machinery was relatively aggressive in terms of piece handling, and therefore the method is regarded as robust. When sawing is complete, the study material may be recovered and assessed independently of the sawmill. Logs may be reassembled from individual boards by manipulating data.

A significant restriction of the system is that boards cannot be crosscut during processing, because it would lead to the loss of the template on the end of a board. Similarly, any pieces cut with wane on one end do not carry a section of the template. Another limitation is that boards were graded before drying. A sample of boards were kiln dried and the templates were darkened; however, the identity of the boards can be tracked through the kiln using a marker known to withstand kiln treatment applied to the board surface before drying. This would allow checking of the grading of a sub-sample of boards after drying. The boards in this study were not dipped in lyctid borer preventative solution.

There was some difficulty encountered where the interaction of glue with water caused darkening of the glue layer over the template, leading to difficulty reading markings. Where logs are prepared and processed relatively quickly, not exposed to any wet weather, and the condition of the template maintained, difficulties would not occur.

The successful application of the method depends on attaining sufficient density of template markings to allow identification of boards after sawing. This in turn depends on the detail that can be provided when designing and printing the templates, as well as the size of logs being sawn. A trial of some templates was conducted, before sawing the study material, to confirm that the desired quality of information could be retrieved. Other sawing patterns may require a customized design of the template. End splitting due to growth stresses was not a large problem when sawing *Euclayptus pilularis* logs in this study. When board ends did split, the template remained attached to both sides and the template tore.

During data collection, operators are required to place each sawn board on a bench such that the board is consistently oriented in relation to the location of the pith. In this situation, it was only necessary to record two diagonally opposite coordinate pairs. Operators are also required to interpolate between gridlines of the template to accurately locate two corners of each board end. The need for interpolation is reduced at higher grid densities; however, it is not completely avoidable.

The method requires no specialized equipment and provides an efficient, accurate, robust, and reliable way of tracking boards through a sawmill during normal operation. Further development of the method is possible utilizing higher density grids and development of specialized software or adaptation of an existing package.

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