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RESEARCH REPORT

A METHOD FOR SURFACING LARGE LOG CROSS-SECTIONS FOR SCANNING AND CROSSDATING

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ABSTRACT

We present a method for obtaining a true flat surface on cross-sections of large logs that exceed the width of many belt sanders, to aid in digital scanning and computer-aided ring width measurement. The method uses a vertical mill that is available in most university machine shops, gradually removing thin layers of wood to achieve a surface that is planar within *ca.* 0.3-mm precision. We have tested the method on several sizes, shapes, and decay states of log samples and found that it performs well across these variations. Samples can then be directly sanded with medium- to fine-grit sandpaper to achieve a finished surface that lies flat on a scanner plate and shows rings and cell structure with high clarity.

RÉSUMÉ

Nous présentons une méthode pour obtenir une surface plane sur des sections transversales de gros troncs d'arbres morts qui excèdent la largeur de la plupart des ponceuses à bandes, afin d'aider à la numérisation des échantillons sur scanner à plat pour la mesure des cernes de croissance par ordinateur. La méthode utilise une fraiseuse verticale, un appareil disponible dans la plupart des ateliers de travail des universités, pour enlever graduellement de fines couches de bois afin d'obtenir une surface qui est plane avec une précision d'environ 0,3 mm. Cette méthode s'est avérée être très efficace sur des échantillons de troncs d'arbres morts de différentes tailles, formes et degrés de décomposition. Les échantillons peuvent par la suite être poncés directement avec du papier de grain moyen à fin pour parvenir à une surface qui repose parfaitement à plat sur la plaque d'un scanner et montre les structures cellulaires des cernes de croissance avec une grande clarté.

Keywords: coarse woody debris, crossdating, cross-section, dead wood, digital archiving, flat surface, log, mill, tree-ring measurement, scanning, surface preparation.

INTRODUCTION

Obtaining accurate tree-ring series from dead, down logs is a key component of many dendrochronological studies, aiding in extending master chronologies as well as inferring forest dynamics and disturbance histories (*e.g.* Zalatan and Gajewski 2006; Aldrich *et al.* 2010; Speer 2010; Simard *et al.* 2011). Frequently, samples may come from large-diameter logs because of the nature of dominant tree species and a need for the longest time series.

One of the primary challenges of large-diameter cross-sections (cookies) is that the field cut is often non-planar (irregular on a coarse-scale) because of necessary variations in chainsaw bar angle, multiple cut entries, and/or breakage. Lack of planarity creates a blurred image for portions of the sample that do not lie flush on a computer scanner plate, creating difficulty for computer-aided ring measurement and subsequent crossdating (using, *e.g.* the program COFECHA [Holmes 1983; Grissino-Mayer 2001]). Because

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scanning and digital processing are becoming preferred methods to facilitate crossdating and data archiving, an array of methods is needed so that all types of samples can be analyzed similarly.

Most tree-ring samples, including small- to medium-diameter log cross-sections, can be processed to a flat surface using a belt sander, but this standard tool has limitations for larger log samples. Often large-diameter pieces far exceed the width of the sanding belt, such that the sander will impart a smooth surface at a fine scale, but with coarse-scale undulations resulting from manual movement of the piece across the belt. There are several options for processing large samples, to which we add in this paper. One option has been to plane the surface (Olson *et al.* 1978), a method that can be effective in many cases but is not preferred by some users because most planers are not made to remove material across end-grain. Another alternative is to trim the irregular surface with a bandsaw, which can work for some samples. Finally, the sample could be split into smaller pieces; this may be acceptable for some objectives, but for others it is often desirable to leave a complete sample intact.

To add to the options available for processing large log cross-sections, we developed a different method to obtain a flat surface prior to sanding. The method is similar in general concept to cost-intensive, specialized tree-ring equipment (*e.g.* Lignostation™; http://www.rinntech.com) but uses a vertical mill that is available in most university machine shops, achieving a surface that is planar within *ca.* 0.3-mm precision and taking approximately 10 minutes per sample. We have tested the technique on several types and sizes of sample, including irregular shapes and those in advance stages of decay with appropriate pretreatment. In the following sections we describe the equipment and technique we use, in order to thoroughly illustrate the method for others to use, including tree-ring researchers and machinists; however the method should be adaptable to other similar equipment and technique modifications.

MATERIALS AND SET-UP

In essence, the milling method involves rotating the sample on a turntable attached to a vertical mill, making passes with a cutting tool that removes a thin layer of material from high spots, then repeating for subsequent layers to the necessary depth to achieve planarity. We use a Bridgeport three-axis vertical mill with digital readouts on all three axes (Figure 1). The mill is set up using a 30.5 cm (12 in) rotary table and a 25.4 cm (10 in) four-jaw lathe chuck (larger turntables would work as well). The cutting tool is a CNC spoilboard up shear, 10.1 cm (4 in) diameter by 3 wings (Whiteside Machine Co., part #SBU40-3), fit with inserts that are each 14 × 14 × 2 mm (0.55 × 0.55 × 0.08 in) four-sided carbide spurs (Whiteside Machine Co., part #SB-insert). The steps to the set-up are as follows:

1. Secure the rotary table to the mill.
2. Center and secure the four-jaw lathe chuck to the rotary table.
3. Center the chuck to the mill and zero the X and Y axes.
4. Secure the cutting tool in the collet.
5. Move the X axis 2 inches in the positive direction to put the leading edge of the cutting tool in line with the Y center line of the work piece.

For safety, the operator should be trained on best safety practices for using a vertical mill (as are most university machinists), because the equipment requires a high level of skill and training to properly operate. We recommend wearing ANSI Z87 or higher rated safety glasses along with a full face shield. Be mindful of broken or cracked samples, as large wood chips may be thrown at a high velocity from the sample. Hearing protection and a dust mask are also recommended. Attaching a vacuum or dust collection hose to the mill reduces dust and wood chips. Keep the cutting blade inserts clean of sap using an organic solvent, and ensure that the sample is securely fastened to the turntable. Of course, because of the variation in machine shop equipment and institutional occupational health and safety policies, the operator should always consult with his or her institutional occupational health and safety office regarding appropriate personal protective equipment and machine shop safety practices before utilizing the method described in this paper.

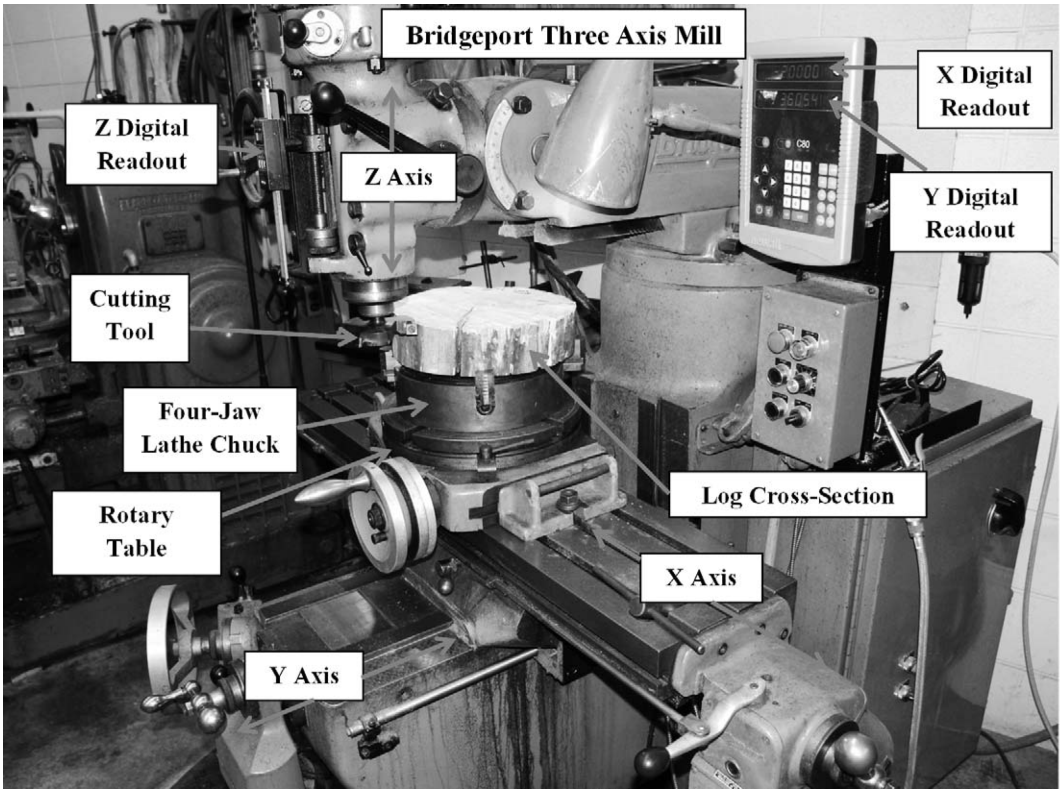

Figure 1. Example of the vertical mill equipment and set-up. The log cross-section sample has been rough-cut in the field with a chainsaw, and is chucked into a rotary turntable attached to the mill. A rotating cutting tool is lowered to the sample to progressively remove high spots as the sample is turned on the turntable.

SAMPLE PROCESSING

The key concept to obtain the best results with minimal tear-out (*i.e.* creation of pits through pulling out of material as the blade cuts across the surface) is to ensure that the leading edge of the cutting tool cuts at 90 degrees into the tree rings (Figure 2). The processing steps are as follows:

1. The work piece (log cross-section) is centered by eye in the four-jaw chuck, often using the pith of the tree as the effective center of the work piece.
2. Zero the Z-axis on the highest point of the work piece. Do this by rotating the turntable and adjusting the Y-axis as necessary.
3. The Y-axis is then moved in the negative direction so that the cutting tool is off of the work piece.
4. Set cut depth by moving and locking the Z-axis. Depth should be no more than 5 mm (*ca.* 0.200 in).
5. Start the mill and set rotations per minute (RPM): 4,200 RPM is maximum on the Bridgeport we use; if possible, however, 7,000 RPM to 10,000 RPM should produce a better surface finish.
6. Move the Y-axis in the positive direction until 50% of tool is engaged in work piece. This will create a 90° cutting angle as the leading edge of the tool cuts into the surface, once the turntable is rotating.
7. Start rotating the turntable counterclockwise. Watch the surface finish to determine feed rate.
8. Move the Y-axis to maintain tool engagement of 50% at all times until the cut spirals to the center.
9. Repeat steps 2 through 8 until a flat surface is obtained.

We have found that a maximum cut depth of 5 mm (*ca.* 0.200 in) provides a good balance of

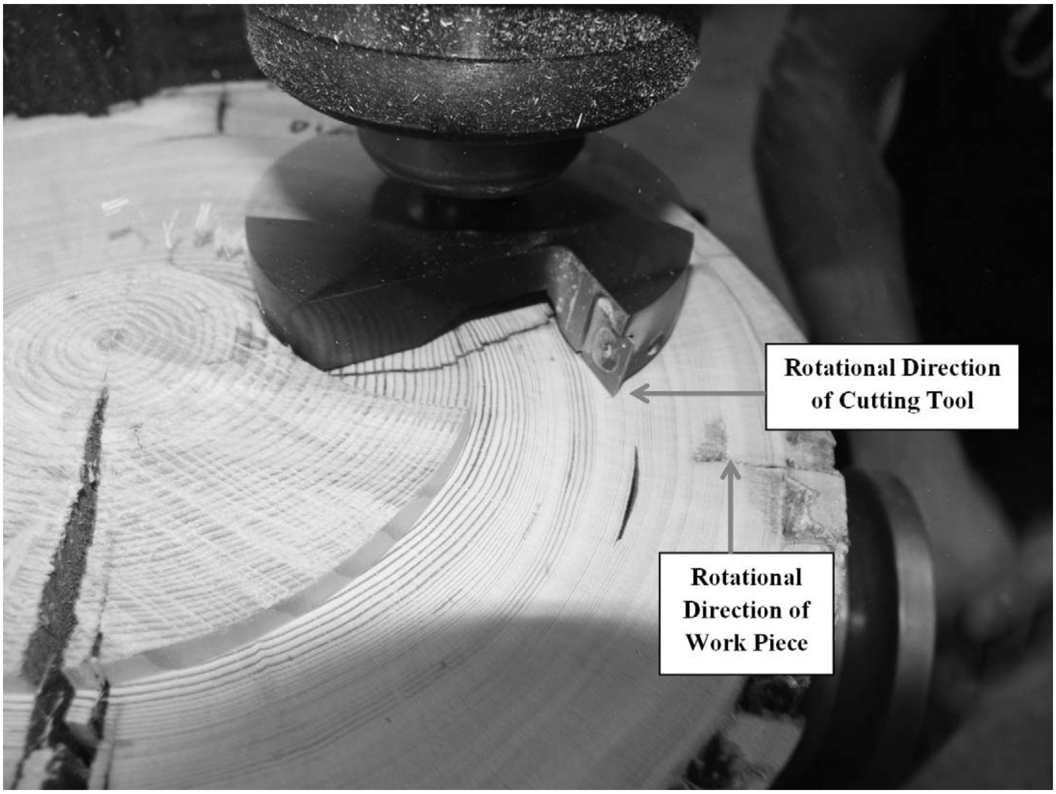

Figure 2. High-speed photo freezing the rotary cutting tool during processing. The sample is being slowly turned counterclockwise (from top perspective) on a turntable beneath. The cutting tool is spinning at 4,200 RPM clockwise (from top perspective) and is set to remove material to a depth of no more than 5.0 mm (*ca.* 0.200 in). In this example the cutting tool is moving across a natural crack in the sample log.

material removal while providing a satisfactory surface finish. This maximum may vary depending on wood type, equipment, cutting tool, RPM, and feed rate (turntable rotation). In some cases, for example when the wood is dense and hard, a finishing pass at a depth of 0.1 mm (*ca.* 0.004 in) produces a better finish. Some minor tear-out is normal for the process, but this is generally on the order of a few cell layers and can be sanded out quickly (see below). Tear-out should be still less for species with denser wood (*e.g.* many broadleaf hardwoods). We have also found that having two people run the mill makes the process easier, although this is not absolutely necessary.

For samples in various stages of decay, we tested and found that the method works well for fragmented pieces once they are glued or epoxied together. When decay is very advanced (approaching cube rot, or decay class 4 [*e.g.* Cline *et al.* 1980]), we found that the method works fine on such samples once they are pretreated using the dilute-glue impregnation technique (Krusic and Hornbeck 1989).

The maximum piece diameter we have processed with this method is *ca.* 50 cm; however the limit could be increased by using a larger turntable, or by attaching a sample to a fixed-dimension wooden template via screws, with the template then secured to the four-jaw chuck as described above. We have also successfully used the method for partial x-sections (*e.g.* half-cookies), simply chucking the piece in position as if the other half were present.

Once the milling process is complete, the sample can be sanded as usual using an orbital sander or similar tool. The sandpaper passes can start with 120 or 180 grit (depending on degree of tear-out) and proceed up to desired fineness. We have found that the wide majority of processed samples could start with 180 grit with a pass of 3–5 minutes to remove all tear-out and prepare for the next sandpaper grit. After completing sanding with 600 grit and a pulse of compressed air, the log cross-section should show reflection, and lie perfectly flat on a scanner plate.

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REFERENCES CITED

Aldrich, S. R., C. W. Lafon, H. D. Grissino-Mayer, G. G. DeWeese, and J. A. Hoss, 2010. Three centuries of fire in montane pine-oak stands on a temperate forest landscape. *Applied Vegetation Science* 13:36–46.

Cline, S. P., A. B. Berg, and H. M. Wight, 1980. Snag characteristics and dynamics in Douglas-fir forests, western Oregon. *Journal of Wildlife Management* 44:773–786.

Grissino-Mayer, H. D., 2001. Evaluating crossdating accuracy: A manual and tutorial for the computer program COFECHA. *Tree-Ring Research* 57:205–221.

Holmes, R. L., 1983. Computer-assisted quality control in tree-ring dating and measurement. *Tree-Ring Bulletin* 44:69–75.

Krusic, P. J., and J. W. Hornbeck, 1989. Preserving decayed wood samples for tree-ring measurement. *Tree-Ring Bulletin* 49:23–27.

Olson, J. R., D. G. Arganbright, and P. T. Rygiewicz, 1978. Increment core planer for x-ray densitometric sample preparation. *Wood Science* 11:33–36.

Simard, M., W. H. Romme, J. M. Griffin, and M. G. Turner, 2011. Do mountain pine beetle outbreaks change the probability of active crown fire in lodgepole pine forests? *Ecological Monographs* 81:3–24.

Speer, J. H., 2010. *Fundamentals of Tree-Ring Research*. University of Arizona Press, Tucson.

Zalatan, R., and K. Gajewski, 2006. Dendrochronological potential of *Salix alaxensis* from the Kuujjua River area, western Canadian Arctic. *Tree-Ring Research* 62:75–82.

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