A Review of the Use of Acoustic Speed to Assess Standing Timber Quality

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Objective:

The objective of this short note is to share, from a technical perspective, background information on the use of both Director HM200 and Director ST300 tools. A complete, thorough technical publication on the topic is being prepared and will be presented at the 14th International Symposium on Nondestructive Testing of Wood, May 2005, in Hannover, Germany.

Basic Science:

The use of speed of sound (variously referred to as acoustic speed, ultrasonic speed, stress wave speed) for assessing the quality (mechanical and physical properties) of wood and wood-based materials is known and well documented. For an overview of the underlying physics and a summary of research and development efforts aimed at using it to assess wood properties, please examine the book by Pellerin and Ross (2002) entitled "Nondestructive Evaluation of Wood". It is published by the Forest Products Society (www.forestprod.org). Over 400 technical reports are listed in this book, many of which refer to this topic area.

Our (FPL) work on the use of acoustic speed to assess standing timber quality began in earnest in 1998. Since that time, we (FPL and our cooperators) have tested over 1000 trees from various sites in the United States (Alaska, Michigan, Missouri, Oregon, Washington, Wisconsin), Australia and New Zealand. Because of the well known relationship between acoustic speed and wood product quality, we focused our research efforts on examining the fundamental relationship between standing tree assessment and log quality. Figure 1 illustrates our results. As is shown, a strong positive relationship exits, with standing tree acoustic speeds being slightly larger (faster velocities) than those measured on logs cut from the trees. We are constantly asking, and investigating, as to why this occurs. Irregardless, the relationship is based on solid physics and is reproducible across a broad spectrum of wood species and stands or ecosystems.

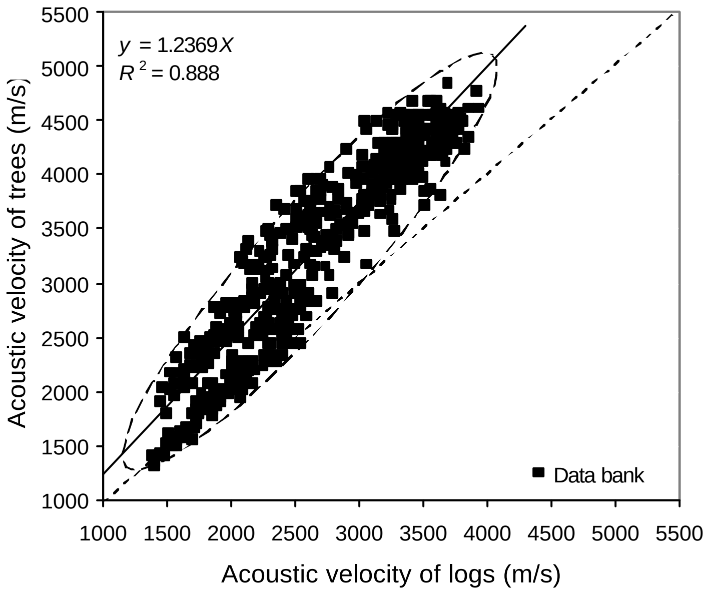

Figure 1.

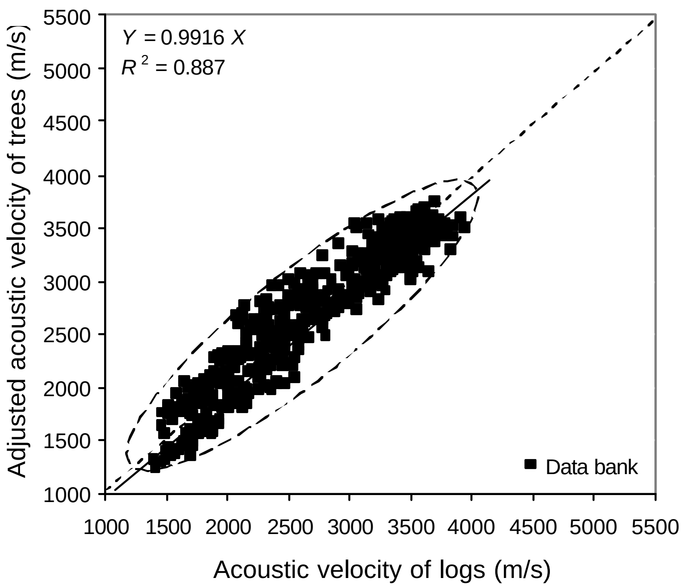

Figure 2.

Figure 2 illustrates the same data set, only the standing tree values are corrected and plotted against corresponding log values. An excellent relationship exists.

Technology

Fibre gen (www.fibre-gen.com) has developed two excellent tools that are based on the use of acoustic speed to evaluate wood quality. The Director HM200 uses a pulse-echo measurement to assess logs. We have used this tool extensively, comparing readings obtained from it with laboratory equipment. Figure 3 shows a typical plot observed when comparing HM200 readings with those obtained from an oscilloscope. An outstanding relationship is observed. The Director ST300 utilizes several technologies (ultrasound, lasers, and impact induced stress waves) to assess standing timber. In our research comparing ST readings taken on standing trees with those obtained from corresponding logs, the ST readings compare very well (Figure 4). This is an extremely important point because, as a consequence, we are able use the extensive fundamental data bank we have established to interpret the relationship between ST300 and HM200 values.

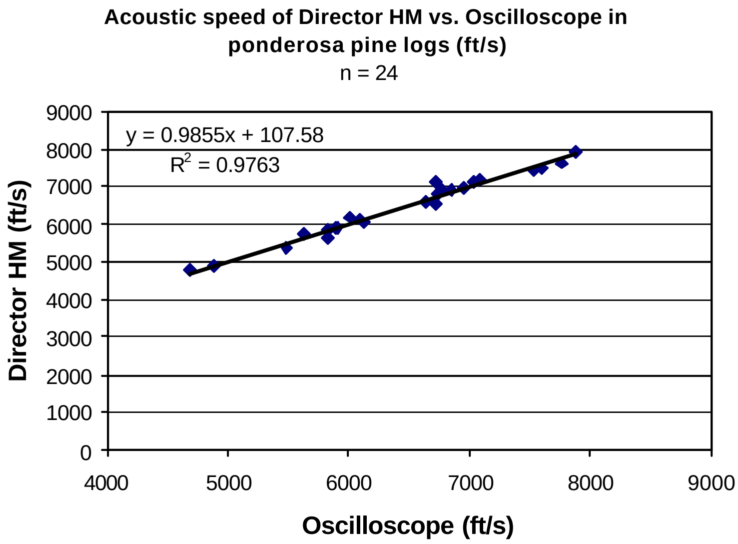

Figure 3.

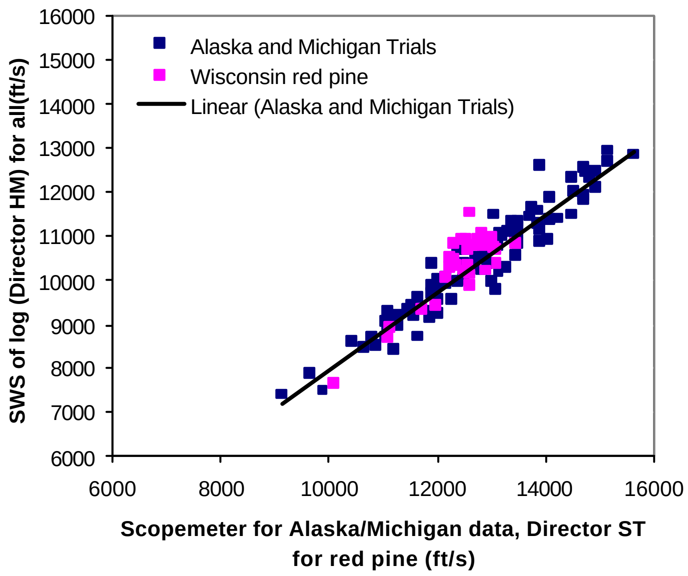

Figure 4.

Analysis

To begin our efforts, we used the fundamental relationship we discovered to begin to adjust standing tree measurements to corresponding log measurements. While conducting this analysis, we noted that while the fundamental relationship holds for a broad range of species, when looking at a particular species, the best results are obtained with a correction established for that particular species. Tables 1 and 2 show the correlative relationships that we developed for several of the species evaluated. Note that with these equations it is possible to correct ST300 measurements to correspond very closely with HM200 values.

Conclusions

Based on our efforts we conclude the following:

1. A strong, fundamental relationship exists between acoustic speed measurements made on standing trees and on logs obtained form the trees.

2. The Director HM200 and Director ST300 are two reliable tools that can measure acoustic speed in logs and trees, respectively.

3. The Director HM200 and Director ST300 are in close calibration with our field and laboratory measurements.

4. Adjustments, based on either the fundamental relationship or a species specific empirical model, can be made so that values obtained from the ST300 correspond closely to HM200 values.

Table 1. Relationship between tree velocity and log velocity (Vtree = a + bVlog)

Species	**a**	**b**	**R^2**
Sitka spruce -US	282.96	1.1285	0.93
Western hemlock-US	730.15	0.9959	0.84
Jack pine -US	1894.3	0.6557	0.54
Ponderosa pine -US	-332.4	1.5301	0.83
Southern pine -US	1633.9	0.7531	0.42
Radiata pine -New Zealand	-469.22	1.2952	0.90
Radiata pine -Australia	1709.2	0.7539	0.75
Overall	**0**	**1.2369**	**0.89**

Table 2. Relationship between log velocity and tree velocity (Vlog = a + bVtree)

Species	**a**	**b**	**R^2**
Sikta spruce	-18.71	0.8265	0.93
Western hemlock	-152.74	0.8482	0.84
Jack pine	-34.26	0.8309	0.54
Ponderosa pine	516.88	0.5426	0.83
Southern pine	1019.2	0.5596	0.42
Radiata pine -New Zealand	537.58	0.6951	0.90
Radiata pine -Australia	-903.59	0.9972	0.75