COMPUTER PROGRAMS FOR OPTICAL DENDROMETER MEASUREMENTS OF STANDING TREE PROFILES

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Abstract--Tree profile equations are effective volume predictors. Diameter data for building these equations are collected from felled trees using diameter tapes and calipers or from standing trees using optical dendrometers. Developing and implementing a profile function from the collected data is a tedious and error prone task. This study created a computer program, Profile Data Calculator (www.timbercruise.com/Downloads/TProfile/TProfileSetup.exe) that calculates diameters and heights directly from dendrometer outputs, negating the necessity for intermediate calculations and allowing for improved functionality and immediate utility of the devices. Six different dendrometer models (calipers, calipers with Haglof Gator-Eyes® attachment, Wheeler Pentaprism, Spiegel Relaskop, Tele Relaskop, and Barr & Stroud FP15) were evaluated for incorporation into the computer program. The data processing program was written in Microsoft Visual Basic® Editor within Microsoft Excel®. TProfile© software reads the Microsoft Visual Basic® output and produces tree profile equations which are subsequently imported into TVolume© software to predict volume. Six program modules were created that allow for rapid deployment of profile equations for tree volume estimation.

INTRODUCTION

Tree profile equations are tools for quickly calculating tree volumes and heights to any top diameter limit using minimal input data, such as diameter at breast height (d.b.h.) and total or merchantable height. There are a variety of these equations that involve various methods of assessing stem shape. Max and Burkhart (1976) developed a profile function that is, perhaps, the best known. The utility of profile equations is their flexibility in determining tree taper, volume, and value for multiproduct inventories where merchantability specifications frequently change. However, the application of these functions is only valid for the specific tree grouping sampled during data collection (Grosenbaugh 1966). Adequate data must be available for each specific grouping (for example: species, species group, region, geographic area, physiographic provenance, stand density, or age) from which taper may be generalized to form an equation (Grosenbaugh 1966). The data collection process is tedious and requires height and diameter measurement at many points along the entire length of a standing or felled tree stem. Felled and standing tree data collection methods differ in regard to ease of measurement, accuracy, required time, and cost.

Felled Tree Data Collection

Felled tree data collection is destructive but allows for direct measurement of the stem. Measurements are generally acquired through the use of calipers, a bark gauge, and a logger's tape. Matérn (1990) discovered that when directly measuring diameter, tapes and calipers provided about the same bias, but use of diameter forks, such as the sector fork, resulted in a higher positive bias. Diameter tapes and calipers have been the preferred diameter measurement devices for the felled tree method, which has long been considered a standard and accurate procedure for developing profile equations. Once data are collected, additional calculations are not required other than organization into the proper format for analysis. The use of this method is limited to situations where a significant number of trees are available for destructive sampling, which may not be feasible if there are restrictions such as accessibility or cost.

Standing Tree Data Collection

Standing tree data collection may be achieved in several ways. If possible, the tree can be directly measured using climbing spikes and a harness. Climbing individual trees, however, is costly, time consuming, and requires additional safety procedures. Optical dendrometers are an alternative to tree climbing that allows visual measurement of diameter at any point along the stem (Avery and Burkhart 2002). Existing optical dendrometer models can be delineated into one of three classes (optical forks, optical calipers, and short base rangefinder dendrometer) according to the trigonometric functions from which their measurements are derived. Grosenbaugh (1963) details the history and theory of optical dendrometers and provides information on the geometry involved with each

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class and its associated benefits and disadvantages. The most notable disadvantage is that collected data are typically intermediate values for which post-processing requires a thorough understanding of the underlying principles of the instrument. Of the three classes of optical dendrometers, optical calipers are the simplest group to use because they do not require knowledge of height or vertical angle in order to calculate diameter (Grosenbaugh 1963). Optical forks and short base rangefinder dendrometers relate their respective diameter measurements back to recorded height to the point of diameter measurement.

OBJECTIVES

The focus of this study was to improve the usability of optical dendrometer data in developing standing tree profile functions by automating intermediate calculations and profile function construction within an easy to use computer interface. Because there will always be a need for accurate volume prediction from reliable profile functions, improving the usability of standing tree diameter measurements for this purpose would make them more widely applicable. Previous optical dendrometer programs were developed for single devices in non-Microsoft Windows® based applications (Arney and Paine 1972, Grosenbaugh 1967, Jager 1976, Parker 1997). The application resulting from this study included instruments from all dendrometer types and was delivered in a Web accessible Microsoft Excel® Visual Basic® Editor program.

METHODS

Dendrometers

Optical dendrometer devices from each of three categories (Grosenbaugh 1963) were evaluated for incorporation into a Microsoft Excel® Visual Basic® Editor program. The Wheeler Pentaprism® and calipers with a Haglof Gator-Eyes® attachment represented the optical calipers class while the Spiegel Relaskop® and Tele Relaskop® represented the optical fork category. The Barr & Stroud FP15® filled the short base rangefinder dendrometer category. In addition to these devices, calculations and input routines were constructed for felled tree caliper measurements.

Microsoft Excel® Visual Basic® Editor was used to code program modules to calculate tree profile diameters from each instrument’s field observations according to their underlying trigonometric functions. Respective manuals and research articles for the devices provided the appropriate mathematical equations to derive results from intermediate data. With the exception of the Tele Relaskop®, where Parker’s (1997) improved equations (through personal correspondence with Bitterlich) were used, each instruments manufacturer’s manual was referenced for program development. Development of the Spiegel and Tele Relaskop® programs were based on the manufacturer’s manuals, publication by Parker (1997), and Bitterlich’s (1984) conspectus on a suite of devices that he engineered. The Wheeler Pentaprism® and calipers with Haglof Gator-Eyes® attachment read diameter in inches directly from the devices and do not require calculations, but do require separate height measuring instruments. The Barr & Stroud FP15® and Spiegel Relaskop® require both diameter and height calculations and presented the most complicated programming routines of all the dendrometers. For this reason, close attention and verification were exercised during program development to ensure that appropriate functions were written that produced good variable estimates. A routine for constructing profile equations from felled tree data was added to those for the five optical dendrometers, and the application was named Profile Data Calculator.

Profile Data Calculator produces diameter and height data in a format acceptable for input to TProfile© (Matney 1996a). TProfile© software fits 16 commonly used tree profile functions and outputs parameter estimates, fit statistics, and residual analysis files. TProfile© reads the Microsoft Visual Basic® output and produces tree profile equations that can be imported by TVolume© (Matney 1996b) or TCruise© (Matney 1996c) software to predict volume.

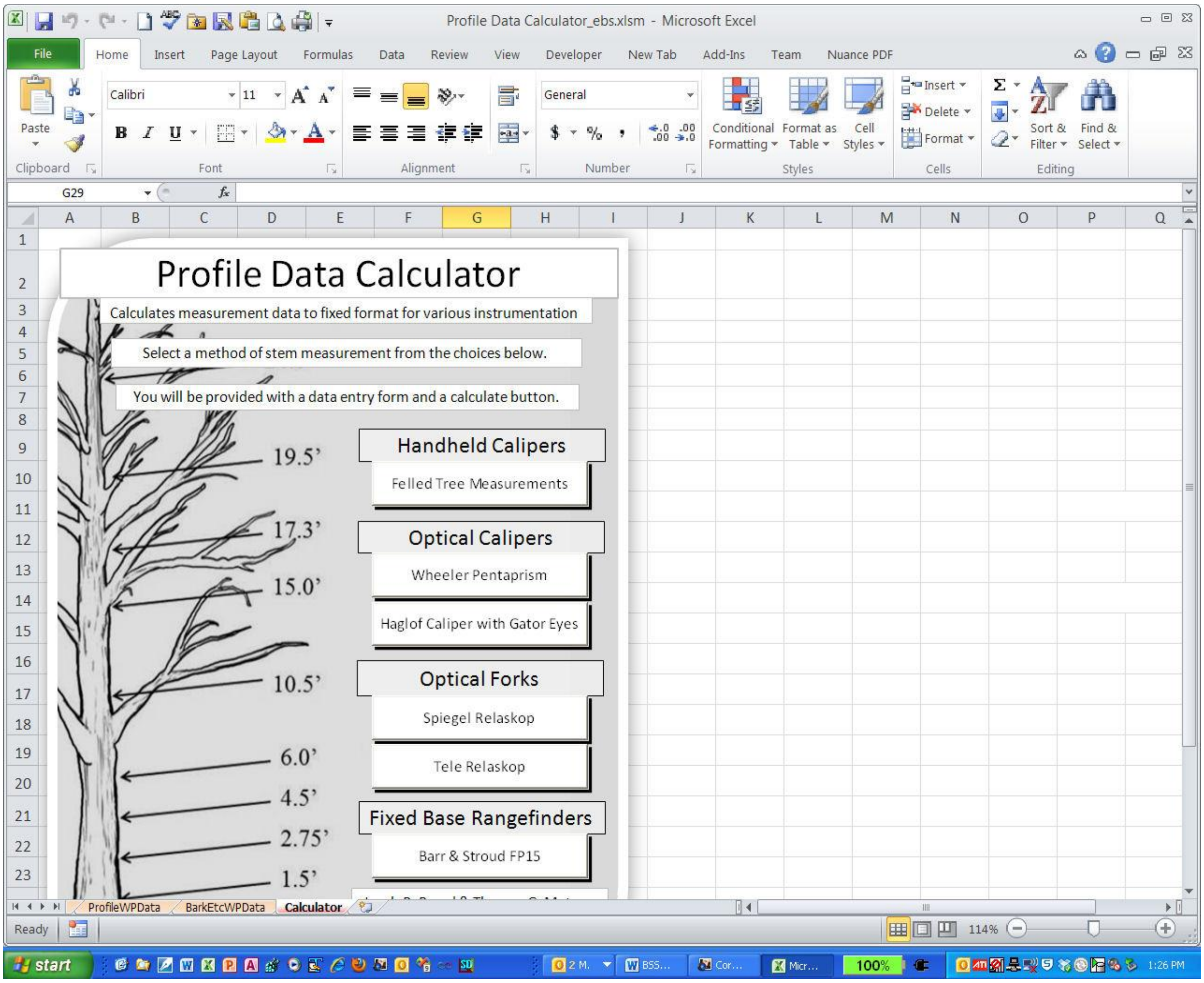

Figure 1--Welcome Microsoft Excel® worksheet for Profile Data Calculator software that calculates diameters and heights directly from outputs of five optical dendrometer instruments plus felled tree data.

Profile Data Calculator User Interface Construction

A standard user entry form was created for each optical dendrometer and for felled tree data collection. In the case of felled tree data collection, input fields were created for measurements along the felled bole at 0.5, 2.0, 3.5, 4.5, 6.0, and 8.0 feet and every 4.0 feet thereafter, including an additional measurement at form class height, 17.3 feet. For standing tree optical dendrometer data collection, input fields were created for measurements along the standing bole at groundline, 0.5, 1.5, 2.75, 4.5, and 6.0 feet, and every 4.5 feet thereafter, plus 17.3 feet for form class height. In both data collection methods, measurements were terminated at 3.0 inches diameter outside bark (DOB) top height. Total height was also an input field for both methods. Other data entry form elements pertain to specific units and data requirements for measuring diameters and heights that are associated with the underlying technology of the instrument.

A Microsoft Excel® application workbook was designed to open in a welcome worksheet (fig. 1), from which the user navigates to the appropriate data input form through the use of command buttons linked to separate instrument/data collection interface worksheets.

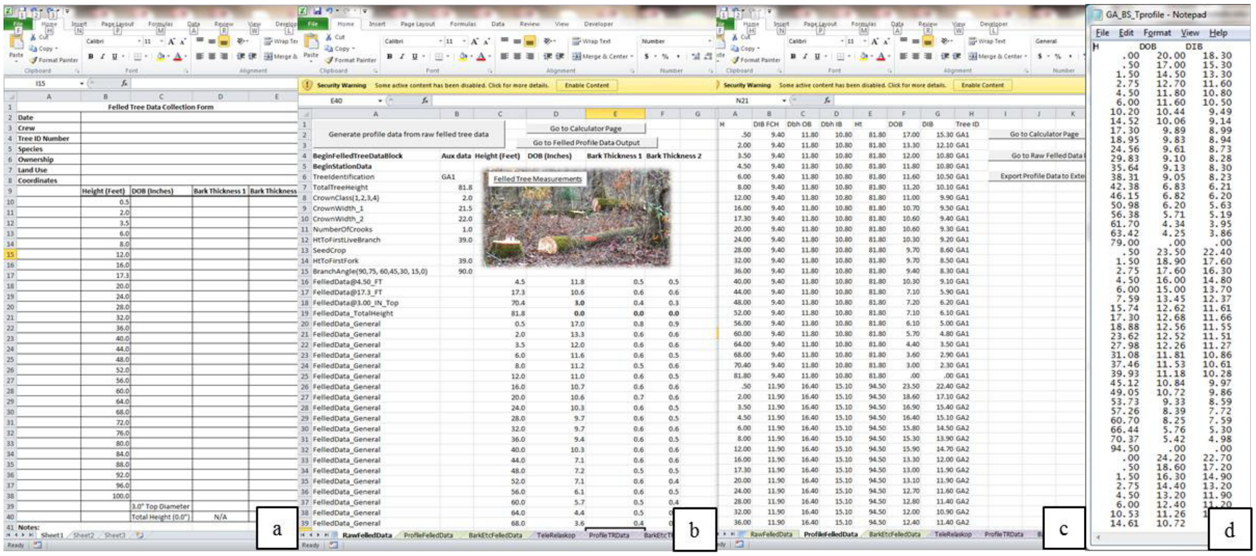

Figure 2--Profile Data Calculator screen shoots of the (a) field data collection form appropriate to the device, (b) spreadsheet data entry form appropriate to the device, (c) output form containing calculated tree profile data from entered field data, and (d) electronic output file in a format acceptable as input to TProfile©.

An output data worksheet is associated with each data collection form, and a simple return command button was implemented to link the user back to the main page. Error routines and messages were implemented to prevent calculations from easily discerned data entry (typographical) errors such as the misplacement of a decimal point or a missing digit. Detection of other errors requires visual inspection of graphical displays of individual tree profile data.

RESULTS

The Web accessible Microsoft Excel® Visual Basic® program (Profile Data Calculator) created in this study provided an automated process for producing formatted tree profile data from the field outputs of five optical dendrometer instruments plus felled tree data. Each instrument module within the program provided (1) a field data collection form appropriate to the device (fig. 2a); (2) a spreadsheet data entry form appropriate to the device (fig. 2b); (3) an output form containing calculated tree profile data from entered field data (fig. 2c); and (4) an electronic output file in a format acceptable as input to TProfile© (fig. 2d). Each program module incorporates the full functionality of its respective device to accommodate a range of user preferences. Instruments that record field data that are intermediate in form and require post-field calculations may now be considered as functional as instruments that provide direct measurements.

CONCLUSION

The Web assessable Profile Data Calculator, www.timbercruise.com/Downloads/TProfile/TProfileSetup.exe (case sensitive), software created in this study provides profile data outputs for five optical dendrometer instruments (calipers with Haglof Gator-Eyes® attachment, Wheeler Pentaprism®, Spiegel Relaskop®, Tele Relaskop®, and Barr & Stroud FP15®) representing three classes of dendrometers (optical forks, optical calipers, and short base rangefinder dendrometer) plus felled tree data. Many optical dendrometer instruments record intermediate data in the field that must undergo trigonometric computations to produce diameter and height measurements. This process is tedious, time consuming, and can hamper the instrument's use and functionality. In situations where tree species are too valuable to collect felled data or there are logistical obstacles to felling trees, optical dendrometers provide a means of collecting data for constructing tree profile equations. The application is executed from within an easy-to-use Microsoft Excel® Visual Basic® application and produces files formatted for subsequent input into TProfile©, TVolume©, or TCruise© software for profile equation construction and volume estimation.

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