Bergstrom Xylodensimeter
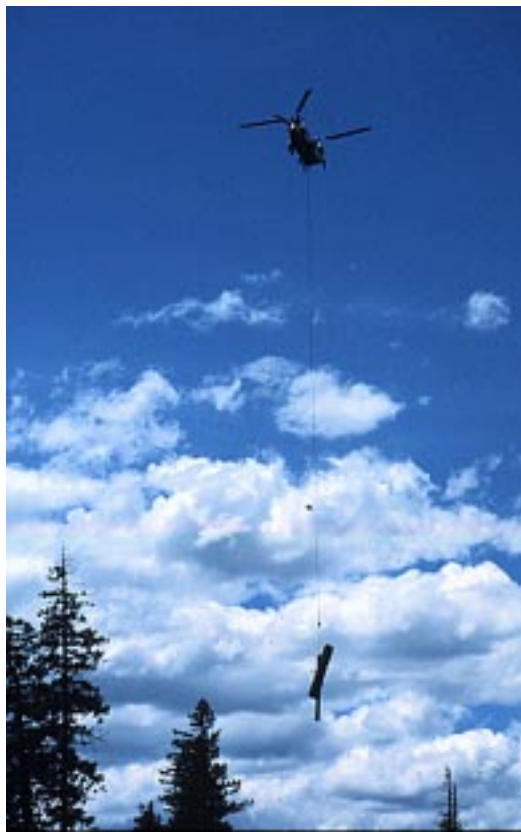## A Tool Useful for Estimating Log Weights

by Skip Garrett, P.E. Mechanical Engineer, Senior Project Leader

INTRODUCTION

In the recent past, there has been a large emphasis on reducing the over all impact on the environment caused by timber harvesting on our National Forests. This has led to the extensive use of logging systems that depend on air lifting of the logs from the cutting area. These aerial systems rely primarily on helicopters, which provide the advantages of improving access to remote timber and reducing costs for road construction and log hauling, while lessening the environmental impacts of harvesting.

Accurately estimating the weight of logs is important in making any harvesting operation more efficient, but it is critical for helicopter logging. While estimating the volume in a log is relatively simple, a good estimate of the density is required to determine the weight of the log. Densities can vary greatly due to the species, location, season, and the length of time between falling and yarding. Precise, on-the-spot, just-in-time measurements of log density can make planning more accurate and logging more efficient. With expensive helicopter logging, maximum efficiency and proper harvesting planning are required to make a timber sale viable. In addition, overloading a helicopter can be a serious safety issue. A device that can be used in the field to easily and accurately determine the density of logs is required.

BACKGROUND

"The Bergstrom xylodensimeter is useful for measuring wood densities, which can be applied to the estimation of log and bole weights. This new approach to estimating log weights promises to be useful for planning and conducting logging operations, especially with logging systems that have weight limits." This quote is from the conclusion of research paper PNW-322, Pacific Northwest Forest and Range Experiment Station.

The xylodensimeter ("xylo" refers to wood) is an instrument that is used to measure the density of green wood. It was developed by Gary Bergstrom while he was working as a logging specialist

on the Rogue River National Forest in Region 6. A patent of the method and instrument was assigned to the United States of America as represented by the Secretary of Agriculture.

In some cases log weights have been determined using a "best guess" approach. Often, handbook tables, local experience, and possibly some data from weighing wood on log trucks during previous harvesting in the area was used. These unscientific methods have led to poor planning, inefficient harvesting, and lost revenue. Accurate estimates of log weights can provide Forest Service personnel with the information needed to select a particular type of equipment, plan the timber sale to closely match the particular project requirements, use the most efficient logging and airlifting systems, and produce an accurate economic appraisal of the timber sale.

BERGSTROM XYLODENSIMETER

The Bergstrom xylodensimeter is a device invented for measuring the density of green wood. Since it is designed to be used in the woods, its construction is rugged. The xylodensimeter provides a simple means of determining the density of trees that are still alive or freshly cut, in the field, on site, in real time and in a non-destructive way. It uses the well-proven hydrometer principle, only in reverse, to measure wood density. In normal use, hydrometers determine the specific gravity of a liquid by measuring how a cylinder of known density floats in the liquid. The xylodensimeter uses a liquid of known specific gravity, water, and by floating a chamber that holds an increment core of specific volume, green density is read directly from the graduated scale on the floating chamber at the water surface.

Figure 1. The Bergstrom xylodensimeter.

The Bergstrom xylodensimeter as illustrated in figure 1 has two main parts: the floatation chamber, a clear plastic cylinder that is sealed at the bottom with an end cap, and the sample chamber and quill assembly. The sample chamber is designed and calibrated to hold a sample core of a specific diameter and length. Density is read directly from the waterline on the graduated scale on the quill. In addition, there is a core cutter guide, an L-shaped, aluminum device with a scale for percentage of sapwood inscribed on its surface.

Bergstrom xylodensimeters are generally calibrated to work in conjunction with an increment borer that produces cores that are 0.200 inches (5.15 mm) in diameter. Cores should be checked periodically to make sure they are within 0.002 inches (0.05 mm) of the desired 0.200 inches. If they are not, a correction factor can be used. Another standard increment borer size is 0.169

inches (4.29 mm) and if this is used the readings from the xylodensimeter should be multiplied by 1.4. Another option would be to recalibrate the xylodensimeter relative to the size core produced by your increment borer.

Step-by-step procedures for using the xylodensimeter are on the final pages of this Tech Tip.

COMMENTS AND CAUTIONS

The Technology and Development Center at San Dimas, California had a few Bergstrom xylodensimeters built for evaluation by logging engineers and specialists in several regions. Comments received from these individuals indicate that this instrument is a handy tool and it works well. Most use it to determine log weights for planning, appraising, and laying out timber sales that will be harvested using helicopters. One unique benefit of using the xylodensimeter that was noted was that it was an excellent training aid in that it showed timber staff the wide variation in log weights that are typical and that guess-estimates are often far off, thus providing the opportunity to focus on this important factor for helicopter sales. Another benefit was that the instrument is very helpful in planning for helicopter harvesting of hardwoods due to the high densities and high values of some of these species.

Several cautions were also noted. Experience has shown that the density of trees often varies greatly with height, so sampling only the butt logs can lead to erroneous assumptions on middle and crown logs. However, the butt log is often the most critical since it has the largest weight and value. Rot in the butt log can cause problems because it can make it difficult to get a good core and large amounts of moisture are usually associated with extensive rot which can cause large variations in density. The problem of not being able to get a good core can be overcome by taking several cores and using the pieces to makeup one good one or using a core that is half the size needed (while still maintaining the proper heartwood/sapwood ratio) and then doubling the density reading. Log densities are site and specie specific with large differences noted between trees on north and south aspects or ridge line versus low on the slope. It may be desireable to collect a large number of samples. One field suggestion was to develop a powered increment borer to speed up the data-taking process. Finally, most users recognized that experience and good judgement are crucial when using the Bergstrom xylodensimeter and that this device is a useful scientific and professional tool for estimating log weights.

PURCHASING A XYLODENSIMETER

Gary Bergstrom continues to build xylodensimeter units in his shop at home. However, his production capacity is limited. The Technology and Development Center at San Dimas, CA has a set of drawings that can be used by a skilled machinist to produce these devices. The 1997 price is between $300 and $400 per unit, depending on the quantity ordered. For information on obtaining Bergstrom xylodensimeters contact San Dimas.

USING THE XYLODENSIMETER TO DETERMINE WOOD DENSITY

The following materials are required:

- Bergstrom xylodensimeter
- Xylodensimeter floating chamber filled with clean distilled water
- Percent-sapwood core cutter guide
- Percent sapwood chart
- Diameter tape
- Increment borer
- Scale (in inches and tenths)
- Sharp pocket knife

Gary Bergstrom's instructions for wood density sampling with the xylodensimeter:

1. Determine the inside bark diameter of the tree or log at the sample point.

2. Bore the tree or log so as to extract the longest core possible.

3. Measure the sapwood thickness of the sample core with the scale. Push the sample back into the borer barrel to avoid drying of the sample.

4. Look up the percentage of sapwood the sample should contain on the Percent Sapwood Graph (see figure 2). Use the diameter inside bark and inches of sapwood measurements made in steps 1 and 3.

Another way to complete this step is to use the data and the equation that was used to generate the Percent Sapwood Graph. To calculate percentage of sapwood (%S) use:

$$\%S = \frac{(DIB)^2 - (DIB) - 2(IOS)^2 \, (100)}{(DIB)^2}$$

Figure 2. Percent Sapwood Graph.

which can be simplified as:

$$\%S = \frac{4(IOS) \, (DIB - IOS)}{(DIB)^2} \, (100)$$

DIB = diameter inside bark (in inches); IOS = inches of sapwood

5. Cut the sample core to the proper length and sapwood ratio by placing the sample on the cutter guide with the heartwood/sapwood transition on the percentage mark determined in step 4. Use a sharp knife to cut off both ends of the sample flush with the ends of the cutter guide. The sample now contains the proper percentages of heartwood and sapwood and the total volume needed to match the calibration of the xylodensimeter.

6. Remove the plug from the bottom of the xylodensimeter by twisting and pulling. Do not grasp the instrument by the quill or top collar.
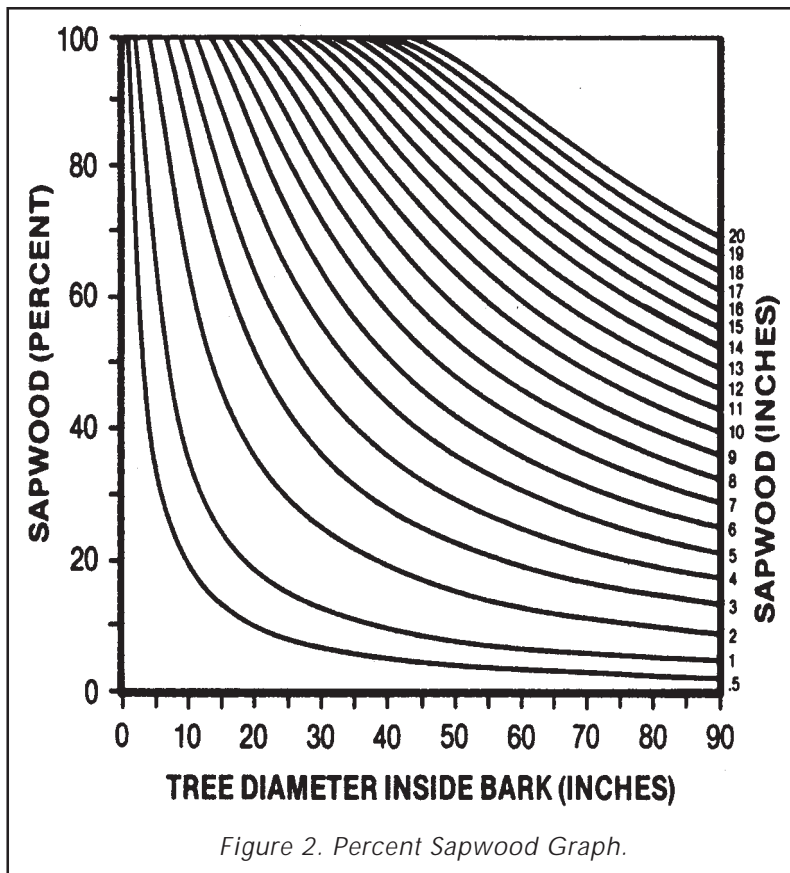
7. Place the sample quickly in the sample chamber and replace the plug.

8. Float the xylodensimeter in the floating chamber. Spin the instrument in the water to get rid of any air bubbles which may adhere to the outside.

9. Read the density of the sample (in pounds per cubic foot) from the quill at the water line.

Figure 3 is a graphic representation of the process described above.

Calculating Log Weights

To estimate bole or log weights, the density is multiplied by the gross cubic volume, which can be obtained via standard scaling methods.

Different formulas are used due to the fact that the taper of a tree often varies over its height.

Judgement must be used to choose the best equation for the crown, middle, and butt sections of the tree to get the most accurate volume. volume calculations.

Density is multiplied by the volume to get weight. Note: This means the bark is included as part of the gross wood volume and is multiplied by the average density value equal to that of the wood. Since most bark is less dense than wood, the calculated weight may be slightly higher than actual and on smaller-diameter logs this may be a significant factor. Another approach would be to use inside-bark diameters to calculate the weight of the wood and adding the weight of the bark, which can be estimated by multiplying the bark volume by the bark density obtained from handbook values for the particular species.
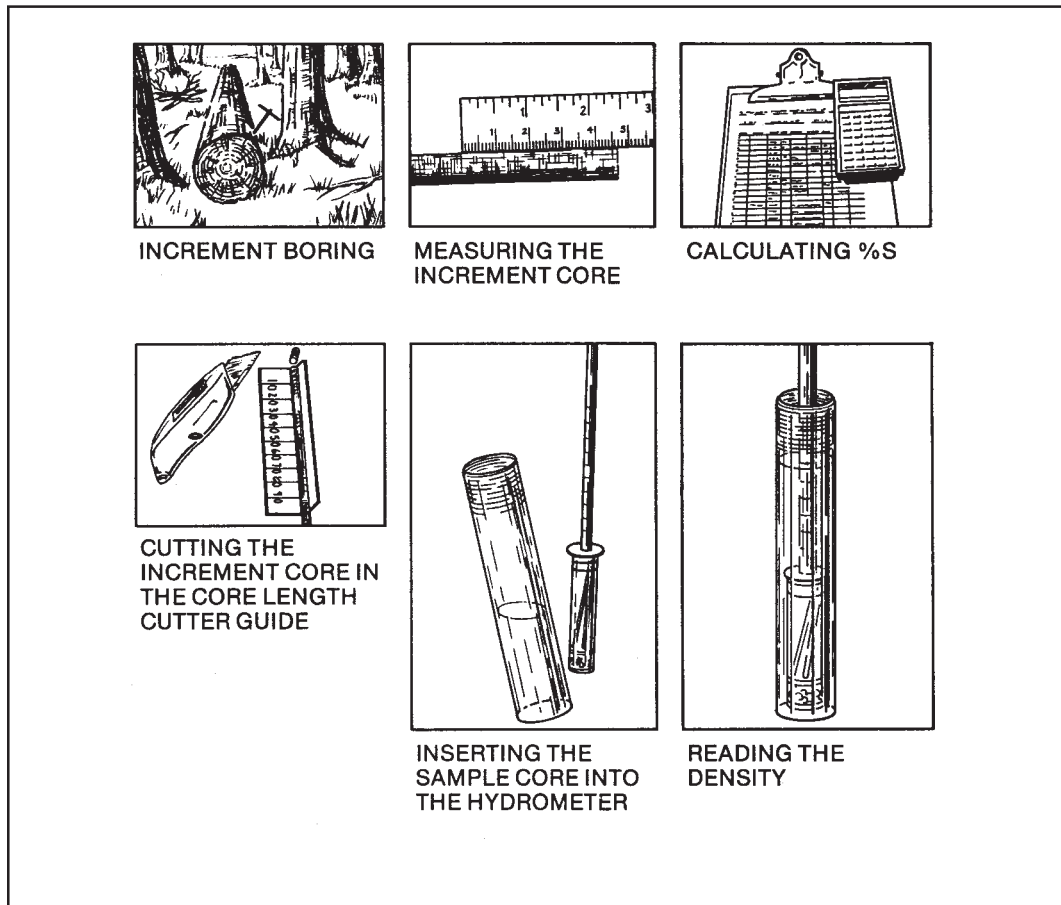

INCREMENT BORING

MEASURING THE INCREMENT CORE

CALCULATING %S

CUTTING THE INCREMENT CORE IN THE CORE LENGTH CUTTER GUIDE

INSERTING THE SAMPLE CORE INTO THE HYDROMETER

READING THE DENSITY

Figure 3. Measuring wood density with the Bergstrom xylodensimeter.

PROJECT PROPOSAL
USDA Forest Service
Technology and Development Program

SDTDC solicits input from the field for suggestions for future projects. Your suggestions are important to us, so please take a few moments to complete this form and return to the address provided.

Project Originator: _____ Name _____ Date

Title _____

Unit _____

Mailing address _____

DG address _____ Telephone _____

Project Title: _____

Current Problem/Need
Describe how work is currently being done; current problem/need, location; why improvement is needed.
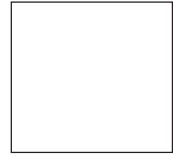
Proposed Solution
Describe your concept of the end product, i.e., new equipment design, video production,
handbook, etc.

Potential Benefits
Describe how this product will improve safety, resource management; increase efficiency,
customer satisfaction, productivity; reduce cost, time.

- affix here -

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User Feedback Survey

User Name (optional) _____

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Bergstrom Xylodensimeter
9824 1304

Benefits	Yes	No	Amount
Saves money	_____	_____	_____
Saves time	_____	_____	_____
Increases efficiency	_____	_____	_____
Other	_____	_____	_____

How effective or relevant is this information?

What would you change?

General comments: