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Forest Product Measurement Systems in the World—Measurement of Wood and Fuelwood Products Measurement Systems around the World a Social, Economic, Environmental and Cultural Approach

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Abstract

The measurement of forest products has an impact on the economic-social and environmental areas of a region, that is, on the economic and sustainable development of a country. Measurement systems at the global level have not been homogenized because there are technical deficiencies in the measurement process allowing the plundering of forest resources and causing the impoverishment of workers, due to unfair piecework, leaving the inhabitants with negative externalities. The measurement of forest products is complex due to the factors involved in quantifying the volume of a piece. There are countless methods, many very local. In the United States and Canada there are more than 95 rules or formulas in current use out of about 185 in existence. There are systems such as the JAS (Japanese Agricultural Standard) Rule or formula, which is currently being adopted in Japan, Chile, East Asia, and Oceania. Artificial Intelligence is also used for measurement. The company Timbeter™ has been venturing into almost all countries using various formulas and calculating the volume with the use of a Tablet or a Smartphone, taking a photo of the wood to be cubed. This method is too expensive. Only countries with a lot of forests are acquiring it. Artificial Intelligence technology will displace most of the methods currently used, without erroneous factors in the payment of piecework. Although traditionalism in some regions of the world considers it difficult to train the workforce. This article presents the most commonly used methods, rules and formulas today, the methods of cubic volume measurement or table foot prediction, and finally the measurement of firewood that has its own cubing methods. The foregoing takes the economic and social

aspects of the inhabitants of the forests as a context. The conditions for empirical study are not yet present. The objective of this study is to show the methods and formulas of measurement, clarifying that it does not intend to compare with the Japanese Agriculture System JAS which is the most used in the world, nor with the Timbeter method, which is venturing into the world market, it is only a historical tour of the ways of measuring the volume of forest products.

Keywords

Poor Forest Measurement, Social Effects of Measurement, Deforestation, Timber and Cubing Rules, A Technical, Social, Economic and Environmental Approach

1. Introduction

A famous phrase from the physicist and mathematician Lord Kelvin, reads: "*When you can measure what you are talking about and you can express it in numbers, you know something about the subject; but when it cannot be measured, when it cannot be expressed in numbers, knowledge is poor and unsatisfactory...*" metaphorically defines the measurement of cut-offs. In addition, there are numerous local variations in the application of a given rule.

There are several purposes for measuring wood: 1) to quantify forest production for purchase and sale, or 2) to control forest resources. In the near future, the ecological and cultural aspects will be taken into account.

The complicated thing in measurement has other axes. Forests produce various types of benefits for both forest landowners and society. The social benefit of private forestry is equal to private profit plus positive externalities minus negative externalities. In addition, there are numerous local variations in the application of a given rule. [1]

There are a number of measures of the value of forests, of which economics is only one. Forests have a social dimension: human-dimensional people interact with them in complex ways, ways that affect the character and well-being of the nation and the way forests are used.

One of the ancestral uses of wood, in its many presentations, was housing. Wood has been part, totally or partially, of buildings built by man. From the Neolithic itself, it is very likely that they already used wood as the building material for their first shelters. They manufacture devices to hunt or defend themselves from predators, and most importantly, use them as fuel, to protect themselves from the cold in winter and to cook their food. [2]

Rulers are the most popular measuring instruments. A measuring instrument is a device used to compare physical quantities through a measurement process. Previously established objects and events are used as units of measurement as standards or patterns, and the measurement results in a number that is the relationship be-

tween the object of study and the unit of reference. Measuring instruments are the means by which this logical conversion is made.

Measurement errors

The following types of errors are mentioned:

a) Systematic errors: they occur due to a defect in the devices or to the detriment of the reader. It is repeated with some frequency, always in the same sense.

b) Compensating errors: these are errors independent of the instrument and the operator. They occur when rounding or approximating values.

c) Estimation errors: they exist when the desired diameter is not directly measured; they are always presented when there are variations and are the basis for statistical calculation.

d) Accidental errors: It can be an error in the decimal part of annotations, reading, etc. These jump out at you.

Poor countries and regions, as suppliers of raw materials, are the most affected, because they have to deforest their forests with reduced payments for forest measurement reasons.

Measurement, the reason for deforestation and poverty, raises the question: How is a rule or formula designed? What role does measurement play? How does a country deforest by measuring forest products?

The irrational exploitation of rich countries is carried out by the colonizers, or the clients who impose the measurement systems in the face of the ignorance of the owners of the forests.

An example is that local timber entrepreneurs in Durango have been adopting forest value chains as a result of deforestation, the basis of climate change. Many of these interactions cannot be measured or at least are not currently measured. This chapter examines forest-community interactions that are conducive to a level of quantification such as: the number of forest-dependent communities, health and safety in forest industries, forestry research, and education in the forestry sector. At the center of all externalities is forest measurement. [3]

For Freese (1973) [4], when the initiative is taken to design a measurement rule for forest products, he has two variables to take into account to develop it.

The first variable for cubing the wood from the piece is to take the margin for saw cut and shrinkage, the thickness and minimum width and length of the boards, taper assumptions, etc., and then to draw diagrams in circles of various sizes, representing the sawing pattern at the small end of a log.

The second variable starts with the design of the formula for some assumed geometric solids and then makes adjustments to account for losses in the saw.

The purpose of standardizing units of measurement and calculation of wood volumes is related to the proper use and handling of roundwood transport. In extraction, in transport in the logging yard, in all stations there are different types of measurement, the most critical is in the forestry industry, where the payment of workers is made for the volume of chopped processed work. [5] [6]

The exchange of wood for other goods led each locality to drive in its own way. Trade was the driving force behind the implementation of wood measurement

methods, first within the locality and later between them. Within countries and between countries. [7]

The concept of a rule or formula can be defined as a table showing the estimated net yield for a log of diameter and length, as well as other rules and formulas that estimate the cubic volume of the log, or those that express the result in sawn board feet.

In the case of stacked firewood, in a way, it is the estimated volume discounting the way it is stacked considering the spaces between forest products. [4] [8]

The result of this chaos in the quantity of wood is that in the United States and Canada there are more than 95 rules or formulas in recognized current use out of about 185 existing. In addition, there are numerous local ways of measuring or variations in the application of a given standard. [4] [5] [9]-[12]

In Mexico, especially in Durango, the use of units of the decimal metric system is legally established, and it is recognized that the basic unit is the meter with multiples and submultiples. However, in commercial timber transactions, units of the English system are in daily use, and other units of specific use in timber measurement are based on that system.

2. Methods

Bibliographic research was carried out on the qualitative variables that affect the measurement of logging, wood and firewood, in addition to the social, environmental, ecological, economic and cultural implications.

The rules and/or formulas for cubic volume, net volume, and biofuel volume were shown. Taking into account production and marketing, in addition to an Artificial Intelligence algorithm.

With the globalization of trade, countries and blocs of countries were faced with various methods of measurement in all commodities; forest products were no exception. The measurement of forest trees is the function of Dasometry, or dendrometry for the Anglo-Saxons. [8]

Population centers, especially in Latin America, to date, have continued to use the formulas and methods that were inherited from their buyers, and will continue to use conversion factors to comply with the law. [13] (Instructions for wood cubing for forest controls on land roads (S/F).

The use of technology derived from Artificial Intelligence is still unfeasible given the circumstances already mentioned

3. Results

There are two rules or groups of formulas that are exposed in this article:

1. Cubic volume rules or formulas
2. Rules or formulas for standing at a table

The rules or formulas of cubic volume are those that estimate the volume of wood contained in the log. Some examples are:

1. Cubic volume log rules

a) Beretron log ruler: Metric measurements.
b) Burt's quarter-circumference method
c) Chinese national standard
d) Cubic meter rule
e) Francon's measurements.
f) Hoppus Ruler
g) Formula Huber
h) Huber Formula- Metric
i) Ireland: Measuring log volume
j) Japanese Agricultural Standard (JAS)
k) Manitoba- cubic method
l) Newton's formula
m) Nova Scotia cubic meter log scale.
n) Pressler's Cubic Foot Formula
o) Metric Smalian Formula
p) Imperial Smalian formula.
q) Solid volume of a log
r) Spike's rule
s) Calculating the volume of Swedish logs

2. Rules for standing logs board

Beretron Rule: Imperial Measurements
a) Blodgett Foot Rule
b) Doyle Rule
c) 1/4-inch International Ruler
d) 1/8-inch International Ruler
e) Roy's rule
f) Ontario Rule
g) Scribner Rule
h) Scribner Decimal C Rule
i) Beretron Ruler; Imperial Measurements
j) Blodgett Foot Rule
k) Early log rule
l) Scribner Rule
m) Scribner Decimal C

Graves (1951) [11], states that the logs were scaled according to Doyle's rule and the total number of board feet was divided by 300 to determine the number of standards. This standard is also called the New York twenty-four-inch standard.

The New Hampshire Rule is based on a rather unusual standard: 16 inches in diameter and 1 foot long. This is considered to be equivalent to 1 cubic foot (although it is actually approximately 1,396 cubic feet), which is called a "Blodgett foot."

The term "standard" has also been applied as a measure of timber, such as in

the Gothenburg Standard, the Quebec Standard and the Petrograd (St. Petersburg) Standard.

There are many different log calculation formulas around the world and one of the most widely used is the JAS (Japanese Agricultural Standard). This formula is currently being adopted in Japan, Chile, East Asia and Oceania.

The JAS method was developed in Japan to measure roundwood in the late 1940s. Use the narrow end of the diameter to calculate the volume.

Throughout the United States, the volume of the plank foot is used to express the volume of the logs. The basic unit of measurement is one (1) board foot which is equivalent to a 12-inch by 12-inch board that is one (1) inch thick.

Two measurements are needed to determine the volume of the footboard of a trunk: length and diameter. The length of a log is measured in feet, and the diameter of the small end of the log is measured in inches.

Professional cubers are also required to estimate how much volume of a log is lost due to defects (such as kinks, sweeps, decay, and breaks), but the training and experience required for a net board foot volume estimate is beyond the scope of the forestry competition. You are expected to know how to measure only the gross volume of the table foot. [14]

Socially, communities may also depend on forests in non-timber areas for food, raw materials and cultural ties. Information of this type is not available at the state, territorial or national level and cannot be reported here. [3]

Sloman (2010) [15] argues that current data on the viability of forest-dependent communities is not sufficient to support the debate on this issue at the national level. Through the process of regional forest agreements, social assessment methods and consultative processes are being developed.

Forest-dependent communities have been defined as communities that depend on survival logging because they do not work it but live solely on land rent (Forest Right or Lordship). Such communities include indigenous communities and technical groups.

In the U.S., they identified the emergence of "social forestry," a form of networked governance, as a predominant institutional regime on national forest lands in the Pacific Northwest.

Forestry workers are exposed to a degree of occupational risk: they work with noisy and potentially dangerous machines, often in steep terrain, logging and extraction create large and unwieldy issues. They may also be involved in fire prevention and extinguishing activities. The wood processing industry is less dangerous. [16]

At first glance, it would seem to be a simple matter; this would be thought by those who are not familiar with the large variations in the dimensions of the wood that can be produced from a log of several operators, and finally, with the variations in the logs.

Over the past three decades, occupational health and safety standards, along with more advanced equipment and methods, have made forestry, sawmills, paper

mills, and other industries remain one of the riskiest of all professions, even riskier than the highland mining industry. [17]

Chapman H.H. (1921) [10] classified forest "values" into four dimensions: (1) climatic-regulatory, (2) environmental, (3) commercial, and (4) social. They concluded that the climate-regulating function is by far the most important globally. Baskent (2020) [18] classified ecosystem services as (1) provisioning, (2) regulation, (3) support, and (4) cultural services. [19] Mikkilä *et al.* (2005) developed a hierarchy for the acceptability analysis of forest industries where the main criteria (called dimensions) were (1) economic/financial/technical, (2) environmental, (3) social, and (4) cultural/political.

For now, let's continue with current and accessible technology. The only conversion factor is one cubic meter equivalent to 212 board feet, although that refers to 50% of the yield from cutting to boards. It was designed using circular sawmills, which, at each step of the saw over the piece, turned 1/4 inch into sawdust. The new sawmills belt is only 1/8 inch and the conversion factor is still considered to date. [1]

Sustainable forest management means that forestry must be sustainable in all these respects, not only in the environmental, economic and social aspects. Cultural sustainability is mentioned as the fourth aspect. [20]

Economic sustainability usually refers to the production of wood and the income obtained from the sale of wood, but with appropriate measurement systems. It requires sustainable production, and the forest's capacity to generate economic benefits is maintained. On the other hand, environmental sustainability implies a non-diminishing flow of environmental, regulative and protective benefits, and ecological sustainability means that forestry should not jeopardize the viability of the populations of species they inhabit.

The forestry companies of Mexico are dispersed and it is difficult for the forestry bureaucracy to pay the 30 thousand forest producers of Mexico, which makes the provision of Timbeter technology unviable; production is very precarious.

In addition, Timbeter's monopoly causes prices to be relatively high. Technology has not been tested because it is difficult to transfer technology, and it would have to be convened by the corresponding instances of the three levels of Government.

4. The Timbeter Method

Socially, artificial intelligence is for large producers, not for small producers. However, there is a need to reduce cubing errors.

All errors can be corrected with Artificial Intelligence (AI) measurement, as shown in **Figure 1**.

The story behind Timbeter: In 2013, Vallo Visnapuu, the organizer of a local tech hackathon called Garage48, asked the event organizers to present a problem he was facing in his sawmill and how utilizing new technology could solve it.

Visnapuu had the idea that if smartphones could recognize human faces, they

Figure 1. Measurement with Artificial Intelligence (AI) by the company Timbeter.

couldn't recognize records from a photograph. Visnapuu met Anna-Greta Tsahkna and Martin Kambla, technology and forestry enthusiasts, at the event, and together they launched a prototype that won the competition.
(https://timbeter.com/es/about/, accessed April 2025)

On April 9, 2025, Timbeter had the privilege of participating in the industry seminar "Digital Methods for Measuring Wood Material", held at the Forest Promotion Center in Goraj-Zamek, organized under the patronage of the Director General of State Forests (Lasy Państwowe) in Poland.

The event focused on photo-optical and harvester head-based measurement systems, as well as techniques used in wood processing plants, Timbeter presented its state-of-the-art photo-optical measurement solution, demonstrating how digital tools can ensure accuracy, transparency and efficiency in roundwood measurement,
(https://timbeter.com/es/blog/timbeter-presenta-su-innovadora-tecnología-de-medición-de-madera-en-seminario-forestal-en-polonia/)

The company Timbeter has developed cubing models with a cell phone or a tablet, which take photos and eliminate errors using an artificial intelligence algorithm. However, poor countries and regions find it difficult to acquire and even more difficult to train because Timbeter is cost-effective with abundant woody material, for an individual piece in procurement requires a monthly payment.

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gether they launched a prototype that won the competition. (https://timbeter.com/es/about/, accessed April 2025)

5. Discussion

In Mexico, and in Durango, the country's leading forest producer, to date the Doyle Toras Rule is used, it is also used in the eastern and central parts of North America, being originated in 1825. The use of this rule puts environmental and ecological sustainability at risk.

As mentioned by the same company, Timbeter is not for poor countries with scattered forestry industries. We will wait for more developers so that the price makes the technology accessible to underdeveloped countries, with abundant forest wealth.

In Mexico, there is only one customer of Timbeter PROTSUR https://www.protsur.com.mx, Timbeter celebrates its first customer in Mexico: Protsur.

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A comparison video posted on youtube: Introduction to Timbeter and how to start using digital measurements, how sample that use Timbeter.

It is possible that in the medium term, the use of Artificial Intelligence will emerge from local research centers, in such a way that its use is profitable. At this time, it is unfeasible for Mexico, and Latin American countries, to acquire the technology.

Wood measurement has long been a time-consuming and manual task, demanding precise calculations and adherence to strict technical standards. However, with advances in digital tools, new solutions like Timbeter are transforming the way foresters measure and manage wood. A recent study conducted at the Krakow University of Agriculture highlights the significant benefits of Timbeter's photo-optical measurement technology, demonstrating its potential to revolutionize the industry.

6. The Comparative Study

The Featured Study: Comparing Traditional and Digital Measurement Methods

The research, carried out in one of Poland's forest districts, compared the accuracy and efficiency of Timbeter's digital measurement with traditional methods using the ruler. With the conventional approach, 810.71 m^3 of wood was measured, while Timbeter recorded 823.55 m^3, a difference of 1.5%. The biggest advantage was seen in time savings, as Timbeter reduced measurement time by 83% on average. Measuring large logs (diameter) was 89% faster, while medium-sized products (contour measurement) improved by 62%. For small piles of less than 10 m^3, the discrepancies were minimal (0.5%), while in piles of more than 20 m^3,

the maximum variation was 3.5%.

This difference in methods explains why manual diameter measurements and Timbeter results can vary. Timbeter detects more than 2000 points per log for accurate diameter measurement, whereas in manual measurement, the common practice is to measure the log at its widest and narrowest points and then calculate the average.

7. Final Recommendations

The measurement of forest products is as old as forest harvesting; there are measurement methods as there are forest regions. If the volume processed is relatively small, in the short term you will have to continue using traditional methods

There is a method such as the Japanese (JAS), which demonstrates accuracy and is the most used in the world; in any case, you can be trained in the use of this method.

It is easy to say that switching to the JAS Method is easy, but training and traditionalism are the factors to overcome. In addition, if the production volume is insignificant, then the traditional method is the best option.

In the comparative study carried out in one of the Districts of Poland, a difference of 1.5% was obtained, considering a non-significant amount, for a sample of more than 800 m3, which indicates that only time savings are the factor to be considered.

Finally, consider simple Timbeter training versus traditional training. In the short term, it is not advisable to change the current methods.

It is recommended to wait for developers at local Universities and Research Centers to develop their local methods.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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