

**Eberswalde University for Sustainable Development**

Faculty of Forest and Environment

Final Project

For

Course: Programming 1

On

Calculation of stem volume of trees

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**Introduction**

Trees are important ingredients of the nature. Ingredients of trees contribute in different aspects of human civilization; wood products for instance. This inspired the wood industry to valuation of timber as well as in allocation of forest areas for wood harvest. Measuring the biomass and tree volume has turned to an integral task in the field of sustainable forest resource management, nutrient and energy flows in ecosystem. [1]

For production of wood, the estimation of increasing stock is expressed as wood volume, which is estimated from measurable dimensions of tree. This measurements can be performed in either destructive (clear-cut) or non-destructive (allometric equation) methods [2,3]

Allometric equations based on relationships variables such as diameter and height are the most powerful and widely used volume measurement tools. [4] In order to ensure the accuracy of the forest resource assessment and composing effective forest policies and management interventions, choosing the perfect volume equation is required. [5] Being influenced by this, researchers and from various academic and professional background have developed numerous equations for biomass and tree volume estimation based on different criterions. [6] Although the equations differ for different species, country of origin, geometric shape etc., but the primary objective of these is to generate accurate estimates with acceptable range of bias values. The diversity of volume equations can be realized from [1], [4], [6], [7] and many more literatures where equations for different countries, species or shape. The diversification of equations have constructed a puzzling situation for the amateurs and new comers in the field, who become puzzled to pick the accurate equation for their area of interest. So, the necessity of the simplification of volume estimation process is beyond discussion.

The simplification could be done by collecting all the volume equations in one place. In this regard, while few of the developed countries have developed their own database for allometric equations, developing countries, such as of south Asian countries, are still struggling to construct their databases. [6] The second step in simplification process could be the automation of the estimation process. This work aims to contribute in this aspect of the task.

For that purpose, the literature [1] has been considered as a reference, where authors have accumulated more than hundreds of tree volume equations for different species and countries of Europe.

**Objectives**

This project aims to achieve the following outcomes-

1. To automate and simplify the stem volume calculation process
2. To help the newcomers measure stem volume easily and accurately.

**Methodology**

The outcome of this project is a software program based on Python programming language.

The program takes different dimensions of trees and generates the estimated tree volume after processing the data with its algorithms. The algorithms were developed based on the equations reviewed in [1].

The mentioned literature presented the mathematical forms of the empirical models, their associated statistical parameters and information about the size of the trees and the country of origin, which were collected from various scientific sources.

**Area of interest:** A total of 230 stem volume equations were presented in the paper for several European countries. Including all the equations of this large area was beyond the scope of this project. So, 5 of the stem volume equations for 2 species from 3 countries Germany (*Pinus sylvestris*, *Fagus sylvatica*), Romania (*Pinus sylvestris*) and Netherlands (*Pinus sylvestris*, *Fagus sylvatica*) were chosen. Because these equations were considered to be representative of larger geographical regions and major tree species in Europe.

**Background:** For all the empirical models (equations) presented in this project the key variables are Diameter at Breast Height (DBH) (D) and the Tree Height (H).

Flow Chart

Testing

**References**

1. [Biomass and Stem Volume Equations for Tree Species in Europe]
2. Golley B F, et al. 1975 Mineral Cycling in a Tropical Moist Forest Ecosystem University of Georgia Press. Athens
3. Ketterings Q M, et al. 2001 Reducing uncertainty in the use of allometric biomass equations for predicting above-ground tree biomass in mixed secondary forest For. Ecol. Magt. 146 199
4. S.O. Akindele; V.M. LeMay (2006). *Development of tree volume equations for common timber species in the tropical rain forest area of Nigeria. , 226(1-3), 0 48.*doi:10.1016/j.foreco.2006.01.022
5. Morgan W B and Moss P A 1985 Biomass energy and urbanisation: commercial factors in the  
   production and use of biomass fuels in tropical Africa Biomass 6 285
6. A critical review and database of biomass and volumeallometric equation for trees and shrubs of Bangladesh
7. <https://doi.org/10.1016/j.foreco.2012.01.004>
8. Bruce, D. & Schumacher, F.X. 1950. Forest mensuration. McGraw-Hill Book company, Inc. New York. 483 p.
9. Köhl, M., Päivinen, R., Traub, B. & Miina, S. 1997. Comparative study. In: Study on European forestry information and communication system. Reports on forest inventory and survey systems . European commission. p. 165–13.

[http://dx.doi.org/10.1080/00049158.1998.10674752]

Equations that provide accurate predictions of total stem volume from ground to tip without local bias, that is bias within any specified diameter class, over the entire range of diameter are one of the basic building blocks of a forest growth and yield simulation system. They also form the basis for calculating carbon storage and sequestration rates for forest stands when volume predictions are converted to biomass. [http://dx.doi.org/10.1080/00049158.1998.10674752]

the objective of any volume equation is to provide accurate estimates with acceptable levels of local bias over the entire diameter range in the data.

Often stem volume equations are applied to individual trees at stand level for the estimation of stand volume and yield, yet the accuracy of such estimations has been seldom evaluated. In addition, many native forests consist of mixed species stands, therefore the accuracy of stand volume prediction can not be easily extrapolated from validation statistics for individual trees.

[doi:10.1016/j.foreco.2006.03.013  ]

For national-scale applications, the choice of two-way equations is unusual: hundreds of papers using biomass– diameter power functions were reviewed by Zianis and Mencuccini (2004) and Zianis et al. (2005).

The present analysis revealed species-specific behaviours, as far as tree form variations are concerned. Three groups of species were discriminated: in Sessile Oak and Common Beech, form factor evolves only slightly with diameter (in opposite directions), but markedly with hardiness; Pines behave similarly to hardwoods, although with a lower form factor; in dark-crowned conifers (Norway Spruce, Silver Fir and Douglas Fir), form factor decreases markedly with diameter and exhibits weak or no trends with hardiness (Fig. 5a and b and Table 4). Within each group, there are interspecific differences for the level of form factors and the strength of effects: this prevents from fitting global volume equations.

Measurement errors play an important role in the assessment of uncertainties in forest inventory estimates, but they are not the only source of error. Cunia (1965) distinguishes among sampling variability, model error, and measurement error.

Objectives