# CONSTRUCTION OF A PRECISE GROWTH MODEL TO PREDICT THE INDIVIDUAL TREE STEM VOLUME OF *Tectona grandis* L.f. (TEAK) IN A 29 YEAR OLD PLANTATION IN MIHINTALE IN ANURADHAPURA DISTRICT

By

**W.P.K. Gunaratne (B.Sc. Biology, USJP)**

Dissertation submitted for the Degree of Master of Science of the Faculty of Graduate Studies, University of Sri Jayewardenepura, Nugegoda, Sri Lanka.

**NOVEMBER 2004**

# ABSTRACT

**Gunarathne W.P.K., 2004, Construction of a precise growth model to predict the individual tree stem volume of *Tectona grandis* L.f. (teak) in a 29 year old plantation in Mihintale in Anuradhapura District. MSc Dissertation, University of Sri Jayewardenepura.**

Stem volume is the most important variable in commercial forestry because all the management decisions are taken on the volume production of trees. However, it is also the most difficult variable to measure and therefore it is necessary to accurate volume prediction methods.

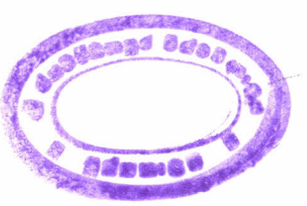
For the present study a growth model was constructed to predict the stem volume of individual *Tectona grandis* L.f. (TEAK) trees of the 29 year old plantation (ID No: Block 01, Sub-block 29) in Mihintale Beat of the Anuradhapura Forest Division. The age of this even-aged plantation was 29 year and the size was 34.0 ha.

In order to collect the data, ten 0.02 ha circular sample pots were randomly laid. Diameter at breast height (dbh), total height and crown height of the trees in all the sample plots were measured as the first step. Tree basal area, stand basal area and top height were calculated using these data. For the second step of data collection, each tree stem was divided into 3-5 m sections without felling them using the Blume-Leiss altimeter. Then the bottom, middle and top diameters of each section were measured using Spiegal relascope. The volume of each section was calculated separately using Newton's formula and the stem volume was determined by summing the section volumes together. For this reason, the final section of the tree was considered as a cone. The sample plot data were divided into two as construction (75%) and validation (25%) and the latter was not used for building the model.

A theoretical model was developed to predict the individual tree volume using the relationship of form factor with volume, basal area and total height. It was fitted to the collected data using multiple linear regression in MINITAB. Three site factors and four transformations which are biologically accepted were used to enhance the quality of the models.

After fitting 13 models were selected for further analysis due to their high $R^2$ values which were over 85% and good distribution of standard residuals. For these selected models, average model bias and modelling efficiency were tested to select the best model. The biases indicated by all the models were insignificant and the model with the highest modelling efficiency (0.982) was selected for the field use. When the final model was validated with independent data reserved at the beginning of the model construction, the results proved the ability of using the selected model in the field without producing errors.

The finally selected model for the field use is $\sqrt{v} = 0.0567\sqrt{ba * ht} + 0.00356 topht$.



# CONTENTS


| | | Page |
|---|---|---|
| CONTENTS | | i |
| LIST OF FIGURES | | iii |
| LIST OF TABLES | | iv |
| ABSTRACT | | v |
| CHAPTER 1: | INTRODUCTION | 1 |
| CHAPTER 2: | REVIEW OF LITERATURE | 4 |
| 2.1 | General introduction of teak | 4 |
| 2.2 | Plantation forestry in Sri Lanka | 5 |
| 2.3 | History of teak plantations in Sri Lanka | 6 |
| 2.4 | Tree improvement and vegetative propagation of teak | 7 |
| 2.5 | Yield prediction in forestry | 7 |
| 2.6 | Important growth parameters in forestry | 9 |
| 2.6.1 | Diameter | 9 |
| 2.6.2 | Height | 9 |
| 2.6.3 | Crown and canopy | 10 |
| 2.6.4 | Stand density | 10 |
| 2.7 | Competition between trees | 11 |
| 2.8 | Thinning | 11 |
| 2.9 | Tree volume | 12 |
| 2.10 | Sampling | 15 |
| 2.10.1 | Systematic sampling | 15 |
| 2.10.2 | Random sampling | 16 |
| 2.10.3 | Sample size | 16 |
| 2.10.4 | Sample shape | 16 |
| 2.11 | Regression analysis | 17 |
| 2.12 | Construction of growth and yield models | 19 |
| 2.13 | Parameter estimation | 20 |
| 2.14 | Model evaluation | 21 |
| 2.15 | Model validation | 22 |
| CHAPTER 3: | METHODOLOGY | 23 |
| 3.1 | Introduction | 23 |
| 3.1.1 | Construction or developing growth and yield models | 23 |
| 3.1.2 | Advantage of using a combination of tests | 23 |
| 3.2 | Method used for the construction of the current models | 24 |
| 3.3 | Selected species and plantation | 25 |
| 3.3.1 | Species selected | 25 |
| 3.3.2 | Selected plantation | 25 |

3.4 Sampling and measurements taken ..... 26
3.4.1 Sampling ..... 26
3.4.2 Parameters measured ..... 27
3.5 Calculations ..... 29
3.5.1 Determination of total stem volume ..... 29
3.5.2 Total basal area ..... 30
3.5.3 Top height ..... 30
3.5.4 Stand density ..... 30
3.6 Parameter estimation ..... 30
3.6.1 Data transformation ..... 31
3.6.2 Fitting the theoretical equations to data ..... 31
3.7 Model evaluation ..... 31
3.7.1 Theoretical valuation ..... 31
3.7.2 Qualitative tests ..... 32
3.7.3 Quantitative tests ..... 32
3.8 Model validation ..... 33

**CHAPTER 4: RESULTS** ..... 34
4.1 Relationship of tested variables with volume ..... 34
4.2 Selected models for further tests ..... 35
4.3 Evaluation of the selected models ..... 36
4.4 Selected final model ..... 38
4.5 Validation of the final model ..... 39

**CHAPTER 5: DISCUSSION** ..... 41
5.1 Relationship with tested variables with volume ..... 41
5.2 Construction of models ..... 41
5.3 Model testing ..... 42
5.4 Validation of the models ..... 42
5.5 Comparision of present study with similar studies in Sri Lanka ..... 43
5.6 Limitations of the constructed model ..... 44

**CHAPTER 6: CONCLUSIONS** ..... 45

**CHAPTER 7: RECOMMENDATIONS** ..... 46

**REFERENCES**
**APPENDICES**