



Field Document No. 3

ASSISTANCE TO THE FORESTRY SECTOR-PHASE-II

BANGLADESH

INVENTORY
OF
FOREST RESOURCES OF SOUTHERN
SYLHET FOREST DIVISION

By

R.Drigo
FAO Inventory Officer

Md.Shaheduzzaman
Assistant Conservator Of Forests
Working Plans Division

J.A.Chowdhury
Senior Research Officer
Inventory Division
Bangladesh Forest Research Institute

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PREFACE

The conclusions and recommendations given in the report are those considered appropriate at the time of its preparation. They may be modified in the light of further knowledge gained at subsequent stages of the project.

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ABSTRACT

In 1986-1987 an inventory was carried out of the forest resources (Plantations, High Forest and Bamboo) of the Southern Sylhet Forest Division (manageable part of the Division) with the purpose to provide data to feed a newly introduced Computerized Resource Management System. The total area amounts to some 40,200 ha that can be broadly divided :

- approx. 17,700 ha - timber producing (Plantation and natural forest)
- approx. 13,900 ha - bamboo producing
- approx. 3,400 ha - denuded (sungrass, brush)
- approx. 5,200 ha - agriculture or other destinations.

Productive area amounts to some 31,600 ha (79%) while manageable area amounts to some 35,000 ha or 87% of the total area.

Plantations, the main object of the inventory, cover some 11,500 ha (28.6%) of total area) and are divided into long rotation (78%) and short rotation (22%) working cycles.

Long rotation stands are mainly composed of pure or mixed Teak plantations with few exceptions that are dominated by Sal (*Shorea Robusta*), Garjan (*Dipterocarpus Spp.*) or others.

Productivity of long rotation plantation now ranges around 3.1 $m^3/ha/yr.$ of Mean Annual Increment (MAI). Improved management is likely to increase such value to some 5-6 $m^3/ha/year.$

Short rotation plantations are almost exclusively composed by *Moluccana* (*Paraserianthes Falcataria*) that shows an average MAI of 11 $m^3/ha/year.$ Improved management could increase the MAI value to some 15 $m^3/ha/year.$

Plantations were started in Sylhet Division in 1922, initially consisting only of few stands of limited extent. The planting programme gained momentum in the period 1955-1960 with the establishment of some 200 ha per year and increased further more in 1975-1980 to some 500 ha per year divided, almost equally into short and long rotation.

The natural forest covers a total of some 6,270 ha of which 3,340 ha (54%) made by closed-canopy high forest and 2,830 ha by an uneconomical open-canopy type (scattered trees). The gross volume productivity per ha of the high forest (closed-canopy) types ranges around 60 m^3 (type LF) and 90 m^3 (type HF) Pure Bamboo areas, mostly located in the Eastern side of the division, add to some 13,900 ha and are an important source of revenue. Harvested of the mature culms every four years, bamboo areas presently produce 4,000 to 7,000 culms per ha.

Inventory data show, however, a considerably higher quantity of exploitable culms (6,000 - 14,000/ha) that could be harvested if felling

operations are controlled and carried out evenly all over the assigned areas.

The total manageable tree growing stock amounts (in 1987) to some 870,000 m³ of gross volume, 74% coming from Plantations and 26% from closed-canopy natural forest.

An extra 50,000 m³ is estimated to be available in the open canopy natural forest.

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1. INTRODUCTION

The Forest Department of Bangladesh assisted by the FAO/UNDP/GOB project "Assistance to the Forestry Sector" Phases I and II have been involved in forest inventory activities since 1982.

The present report is in fact the last of a series of reports that describe the forest condition of Chittagong and Chittagong Hill Tracts Districts and of four Coastal Afforestation Divisions.

Under the objectives of the IDA assisted Second Forestry Project and in direct link with a recently introduced Resource Management System, Inventory activities have substantially modified their perspectives, from a conventional forest type description to a much more location specific description of manageable units.

The main purpose of the inventory was to determine the extent and describe the condition of Plantation, High Forest and Bamboo Forest (in that order of importance) for the part of Sylhet Division where conventional forest management could be applied/ This "productive" part is called "Southern Sylhet" but in fact it covers the largest part of the Division, excluding only small and mostly unproductive areas on the north-western side of the Division.

The inventory work in Sylhet Forest Division started in January 1986 immediately facing the constraints of an insufficient and poorly detailed aerial photo coverage.

The poor remote sensing information has represented the single most limiting factor for the inventory in Sylhet, the lack of aerial photographs being only partially solved by the supply, in April-May 1987, of SPOT Satellite imageries.

Continued throughout 1986, field work activities were largely completed by May 1987, with a short additional field programme in December 1987.

The total area has been divided into 483 sub-blocks each of them described in the sub-block list that will represent the input data to the Resource Management System.

The report is accompanied by the Map Series "Forest Cover Map of Southern Sylhet Forest Division" composed of 24 sheets at a scale of 1:15840.

2. DESCRIPTION OF THE AREA*

2.1 CLIMATE

Climate data is available in the two reports of Reconnaissance Soil Surveys (Sunamganj and Habiganj Sub-Division 1973 ; Sadar and Moulvi Bazar Sub-Division, 1965). Very large variations in rainfall are observed between different Reserved Forests. The general pattern is monsoonal, as in the whole region, but with a longer wet season in the north. The southwestern Reserved Forests (Raghunandan, Tarap Hill, Rajkandi) get 2200-2600 mm of rain annually, Haragaj and Patharia Hills some 2600-3800 mm, and the four Reserved Forests east and north of Sylhet get perhaps 5000-5800 mm.

2.2 GEOLOGY

Detailed geological information is also available in the soil survey reports. The five large Reserved Forests on the south and east border with India tend to occupy the higher ridges of the northermost extensions of Dupitila, Tipam and Skurma sedimentary rocks extending from the Chittagong Hill Tracts through Tripura State of India. The ridges are relatively low and topography subdued at these northern tips, although there are some very steep and highly dissected landscapes to the east of the Division.

The rocks are mostly sandstones, siltstones and mudstones, locally altered to slates and shales. The strikes are generally north, and dips can vary from zero to 90 degrees, tending to be steep on the higher more dissected land with resistant rocks. Sediments are generally well weathered, sometimes cemented with secondary ironstone. The geological map with the DP/UN/BGD 74-009/l Report (1982, The Hydrologic Conditions of Bangladesh) clearly shows the typical sequences :

- highest, steepest land in centre of the ridge : Ts (Surma)
- if Ts absent, highest land is Tf (Tipam)
- next lowest land surrounding Ts or Tf is Td (Dupitila)
- low altitude, rolling, slightly dissected deposits are Qp (Piedmont.)

* 2.1 to 2.4 From P.R. Stevens "Land Classification and site suitability for plantation in the Sylhet Division".

2.3 GEOMORPHOLOGY

Any west-east transect across the five large southern Reserved Forests therefore shows a simple and typical sequence :

Raghunandan RF : Very gently rolling Qp to gently undulating Td to Qp.

Tarap Hill RF : Qp tp Td to Qp.

Rajkandi RF : Qp to Td to steep and dissected Tf to Td

Hararganj RF : Qp to Td to Tf to Ts to Tf to Td.

Patharia Hills RF : Qp to Td to Tf to Td.

2.4 SOILS

Soil distribution is obviously closely related to geology and geomorphology as outlined above. Details are found in the Reconnaissance Survey reports.

Gently rolling Qp and some Td areas tend to have deep sandy soils, even on ridge crests, especially in Raghunandan and Tarap Hill. Locally clay-rich soils may be found. As slopes steepen soils become shallower and drier, often over weathering sandstone or ironstone cementation. Under remnant high forest organic matter contents can be moderate, but on sandy soils, and after clearing for plantations, levels decline. Soils are only moderately fertile in most forested areas, and are generally of low pH. Textures are mostly sandy loams over sandy clay loams.

The significant Soil Series (by area) in the hills of Sunamganj and Habiganj are Kalapani, Nalua, Ramgarh and Rangamati on Dupitila Formation, occupying some 155 square miles. In the other survey, covering the eastern half of the Division, Hill soils occupy some 25% of the area and the significant series are Barlekha and Khadimnagar, and Associations of these series.

Details can be found in the survey reports. The analytical data on these soils series generally supports the general description given above.

It is important to avoid excessive reliance upon the Reconnaissance Survey reports when planning new plantations. The surveys, quite properly at the time, tended to concentrate on agricultural land and so survey intensities were much lower on forested land which is less accessible and where soils are highly variable over short distances. The soil maps with the reports are of only indicative value. Analytical results for some Series are incomplete and again only of indicative value.

There is no substitute for on-site inspections and assessments when contemplating expensive afforestation over quite small areas such as 100-200 acres in any one locality.

2.5 THE FOREST

The natural forest can be classified as tropical mixed evergreen with bamboo species as gregarious undergrowth. The natural virgin forest has almost completely disappeared being replaced by plantations or leaving a secondary regrowth with various degrees of density. Considerable areas of sungrass, *Imperata cylindrica*, occur in the western side (Ragunandan R.F.) and, in patches, elsewhere. Sungrass is used by local people as thatching material. In large areas of the eastern side, namely Rajkandi R.F., Harargonj R.F. and Patharia R.F., the original forest have been completely destroyed (by fire or illicit felling, shifting cultivation etc.) leaving an almost pure natural bamboo regrowth (mostly *Melocanna Bambusoides*) that is managed with a 4 years felling cycle.

Man made forests are mainly composed of Teak(*Tectona grandis*) with various mixture of local species (*Dipterocarpus spp.*, *Shorea Robusta*, *Lagoestroemia Speciosa* *Artocarpus Chaplasha* etc.) for the long rotation working circle and by Moluccana (*Paraserianthes Falcataria*) for the Short Rotation working circle. Recently Acacia and Eucalyptus species have been introduced for fuel wood production.

The presence of bamboos and sungrass has implications for the ease and cost of plantation establishment and maintenance.

2.6 ADMINISTRATIVE UNITS

The area is divided into 7 Ranges composed of 32 Beats as per list given in following page.

SOUTHERN SYLHET FOREST DIVISION - AREA STATUS

RANGE	CODE	BEAT	CODE	AREA	REMARKS
JURI	1	Sagarnal	1	1359	
		Ragna	2	1966	
		Putichara	3	1423	
		Barlekha	4	2071	
		Samanbag	5	732	
		Lathitila	6	2291	
		Madhabchara	7	1189	
TOTAL AREA:				11031	
MOULAVIBAZAR	2	Lawachara	1	1271	Area as per proposed
		Chautali	2	433	Beat boundaries
		Kalachara	3	933	
		Borshijura	4	351	
		Satgaon	5	735	
TOTAL AREA:				3722	
RAJKANDI	3	Kurma	1	3289	Area as per proposed
		Adampur	2	2598	Beat boundaries
		Kamarchara	3	1423	
TOTAL AREA:				7310	
KULAURA	4	Muraichara	1	1525	
		Monchara	2	1019	
		Gazipur	3	350	- Area incomplete due to
		Baramchal	4	808	lack of information
		Bhattera	5	0	-All under rubber cult.
		Nalduri	6	1156	
TOTAL AREA:				4858	
HABIGANJ	5	Kalenga	1	3216	
		Rema	2	2182	
		Rashidpur	3	530	
		Putijuri	4	1118	
TOTAL AREA:				7046	
RAGHUNANDAN	6	Chatian	1	0	- Now under Shahapur Beat
		Shahapur	2	1402	
		Shaltila	3	1408	As per proposed
		Shahajeebazar	4	826	Beat boundaries
		Jagadishpur	5	767	
TOTAL AREA:				4403	
SATCHARI	7	Satchari	1	1027	As per proposed
		Telmachara	2	775	Beat boundaries
TOTAL AREA:				1802	
GRAND TOTAL:				40172	

3. METHODOLOGY - PLANTATION INVENTORY

3.1 PHOTO AND SATELLITE INTERPRETATION

The availability of remote sensing data has represented the single most limiting factor for the completion of the inventory work.

The available photo coverage (1 : 50000 1984, false colours) is very limited since security restrictions have prohibited aerial photography over the Indo-Bangladesh border area, where most of the Forest Reserves are located. Some of the photographs, available at SPARRSO have not been released for similar security reasons.

As a result only approximately 40% of the forests are covered by the 1 : 50000 false colour aerial photographs, as is shown in the table below and in the index map in appendix 5.

TABLE OF COVERAGE WITH 1:50000 TOPOGRAPHIC MAPS
AND AVAILABLE 1:50000 AERIAL PHOTOGRAPHS

Reserved Forest	Topo Maps	Aerial Photographs						Cover
		Line	Numbers					
RAGHUNANDAN	78 P/8	32	51	52	53	54	50%	
		31	9	10	11	12		
TARAP HILL	78 P/12	31	6	7			30%	
		33	57	58				
		32	50					
RAJKANDI	78 P/15 78 P/16	30	87	88			10%	
HARARGANJ	83 D/2 83 D/3		No coverage					
PATHARIA HILLS	83 D/2 83 D/3		No coverage					
WEST BHANUGACH	78 P/15	30	84	85	86		100%	
BORSHIJURA	78 P/15	28	6	7			100%	
		29	5	6				
SATGAON-DINERPUR	78 P/11	30	80	81	82		100%	
WEST (PUTIJURI)								
SATGAON-DINERPUR	78 P/11	30	80	81	82		100%	
EAST (SATGAON)								
BHATTERA HILL	78 P/14 (All in rubber now)	26	2	3	4		100%	
BARAMCHAL	78 P/14 (Mostly in rubber now)	27	46	47	48		100%	
		27	46	47	48			

Flight lines are on 1 : 250000 scale base maps at SPARRSO numbered 46-14 and 46-13.

To cover the balance area with the best possible remote sensing data, considering costs and time, an order was placed with SPOT IMAGE, agents for the new European Satellite SPOT, to acquire multispectral and stereo panchromatic data over Sylhet region.

Data were acquired in October 1986 (Panchromatic) and in November 1986 (Multispectral) and finally delivered in the form of Computer Compatible Tapes to FAO, Rome in April 1987. A study tour has been organized in this connection, with the purpose of producing, with the support of FAO Remote Sensing Centre, the best digital enhancement and final paper prints at a scale of 1 : 50000.

The "Report on the utilization of SPOT Satellite Imagery for the inventory of forest resources of Sylhet District Bangladesh", has been prepared by Messrs R. Drigo, Shaheduzzaman and M. Lorenzini, on the techniques, methodologies applied and findings on what can be considered the first application of second generation satellites to management oriented inventory of forest resources. Although the information provided by the aerial photographs and by the SPOT Data throw considerable light over an area that was never properly mapped, it has to be clearly stated that they both are far below standard compared to the information content usually required for plantation inventory with management purposes. A photo scale normally adopted for this purpose ranges around 1 : 15000 which means resolution 11X greater than the available 1 : 50000 aerial photographs and 100X greater than SPOT data.

The interpretation of the plantations has been carried out on the air-photos and satellite imageries (both at scale 1 : 50000) aiming to the delineation of unit homogeneous by species composition (and rotation period) and age, where a unique management approach could be applied. Considering the relatively poor information content of the air-photos and even more, of the SPOT data, the delineation of such units, hereafter called Sub-blocks* required the synthesis of the following various levels of informations :

- 1 - Differentiation on air-photos or satellite imageries
- 2 - Beat and Range sketch maps showing plantation areas
- 3 - Field staff information
- 4 - Sampling and survey work.

The merging of all these inputs is at the base of the delineation of each sub-block.

The over all result greatly depended on the following factors :

- 1 - The quality of the plantation.

* The term "sub-block" has been adopted because traditionally used although in Sylhet the parent unit "Block", doesn't exists. In most computer files the correspondent term is DLU (Descreet Land Unit).

A good, dense plantation is clearly visible also in the satellite imageries while a poor or bamboo invaded stand cannot be delineated even on the more detailed photographs.

2 - Beat maps quality.

Beat maps are on the average of very poor cartographic standard with somewhere no link whatsoever with the real topography. Such maps have been used mainly as broad guideline.

3 - Territorial knowledge.

Owing to regular staff transfer policies, the territorial officers often do not know or get confused about year of establishment of older plantations and in most cases only the village Headmen can say something about it.

As a result the bamboo-invaded and poorly stocked plantations are only approximately delineated and age classes of certain older sub-blocks cover wider periods, since individual year of establishment could not be consistently separated.

3.2 FIELD WORK

The Plantation Inventory field work have been carried out during the periods January 1986 - May 1986 and November 1986 - May 1987, a smaller amount of field work, mainly map verification, has been carried out during the period November - December 1987. Winter, between the two monsoons, is the only period of the year during which forest areas are accessible thanks to the drier and stable road conditions and to the possibility to cross unbridged rivers and charas.

During the first season in concomitance with the High Forest sampling a limited number of sample plots (11% of total) have been measured in the western part of the division mainly in the photo-covered plantation areas.

During the second period, all balance area have been sampled. Since satellite imageries were not yet available, the sampling had to be supported by considerable survey data, mainly in the form of road and path survey with detailed side information.

The sampling and surveying work have been done by 6 field teams, each team composed of 1 sub-professional officer (Forester, Deputy Ranger or Ranger) and 2 Forest Guards. Teams activity have been supervised by the Inventory Officer, 1 Assistant Conservator of Forests (ACF) and 1 Senior Research Officer, FRI.

3.3 SAMPLING DESIGN

Circular plots of varying size, from 0.01ha to 0.03ha, have been distributed in each sub-block.

Plot size have been adopted according to the year of establishment as follows :

<u>Plantation established</u>	<u>Plot size</u>	<u>Radius</u>
Prior 1940	0.03 ha	9.77 m
1940 - 1979	0.02 ha	7.98 m
1980 - 1982	0.01 ha	5.64 m

On slopes the plot radius have been adjusted in function of the steepest slope going through the plot centre. The factor used for the correction corresponding to 1/2 of the steepest slope.

Sample Plots have been taken along lines of regular intervals (100m or 200m). The distribution and orientation of the lines have been systematic in area poorly or not covered at all by remote sensing data. For areas that could be delineated in advance on aerial photographs, the lines have been run across the sub-block from a selected visible starting point.

An average of 7, 4 sample plots per sub-blocks have been measured, from a minimum of 2 plots in very small sub-blocks to over 15 for very large ones (maximum 26 plots in one sub-block).

3.4 FIELD FORMS

Two kind of field forms have been utilized for the field data collection :

- Plantation Inventory Form, used for sample plot measurements. Example of the form and detailed description is given in Appendix 1.
- Volume Table Form, used for stems measurements for volume calculation. Example of the form is given in Appendix 1. Detailed description of the form and methodology followed is given in Working Paper No. 6A by R. De Milde "Tree measurements for volume tables". Since the sample trees could not be felled, stem diameter measurements have been taken on standing trees by means of Bitterlich Relascope up to crown point.

3.5 SAMPLING SIZE

A total of 1833 sample plots, varying in size according to plantation age, were distributed over the planted area with the purpose of achieving the best possible information of each manageable unit (sub-block).

Out of 1833 plots, 93 have been excluded from later computation since such plots had fallen in totally failed plantation areas (usually invaded by bamboo).

A total of 1740 plots have therefore been used to compute DLU descriptions.

A total of 415 trees have been measured to provide function relating total and commercial volume to DBH and total Height for the minor plantation species for which local volume functions were not available.

<u>Local name</u>	<u>Scientific name</u>	<u>Approx. % of genl. composition</u>	<u>Trees measured</u>
Pinkado	<u>Xylia dolabriformis</u>	0.4%	94
Jarul	<u>Lagerstroemia speciosa</u>	2.9%	74
Sal	<u>Shorea Robusta</u>	2.5%	79
Kadam	<u>Anthocephalum sinensis</u>	0.7%	51
Chapalish	<u>Artocarpus Chaplasha</u>	1.7%	28
Garjan	<u>Dipterocarpus turbinatus</u>	2.6%	49
Gamar	<u>Gmelina Arborea</u>	0.6%	23
Dhakijam	<u>Syzygium grande</u>	0.9%	16

The above generally represent secondary species in the largely preponderant Teak plantations.

3.6 COMPIILATION OF RESULTS

Sample plot data have been recorded, checked and processed by Personal Computer ; in Dhaka Forest Department by an IBM PC AT and in Chittagong Inventory Unit by a "No Name" Clone PC XT.

The Data Processing Consultant's Report, given in Appendix 4 gives a description of the work carried out and a list of files, programmes, equipments, and softwares involved.

3.6.1 SUB-BLOCK PARAMETERS

The following parameters have been computed for each sub-block from the sample plot data :

- Range code
- Beat code
- Sub-block

- Species codes
- Species names or "TOTAL" for sub-blocks composed of more than 1 species
- Year or period of plantation establishment
- Average plantation age in 1987
- Area in Ha
- Land-Use code :"P" for all plantations
- Map sheet number as the last two digits of the sheet reference number
- Species composition as a percentage of each species represented.

For each species a separate set of data giving :

- number of stems per ha
- standard deviation of above
- standard error % of the mean
- average DBH (of tree of average BA)
- standard deviation of DBH
- average height (of tree of average BA)
standard deviation of height
- basal area (BA) per ha
- quality 1 volume per ha (vol. underbark at 10cm top diameter for tree classes* 1 and 2).
- quality 2 volume per ha (vol. underbark at 10cm top diameter for tree classes* 3 to 8).
- volume underbark at 10cm top diameter, all classes
- total gross volume overbark.
- For the whole sub-block (when more than 1 species is present) a separate set of data giving all values mentioned above as weighted average or summary of all species composing the stand.
- MAI : Mean Annual Increment as m /ha/year
- Total gross volume available in the sub-block

3.6.2 SITE CLASSIFICATION AND GROWTH FUNCTIONS

Individual tree measurements divided by species have been utilized to compute the following :

- Broad site classification of Teak (the only species evenly distributed throughout the Division). The height values of the 100 trees/ha with largest DBH have been plotted against age to produce growth curves for the dominant trees. Curves of many geographical locations have been compared and eventually grouped where no consistent difference could be found.

* See "tree class" in Appendix 1 : Description of Plantation Field Form.

Experience from Chittagong and Cox's Bazar Inventory have shown that a real site indexing is very difficult and unreliable due to the very high variability of site characteristics (four or five site classes can alternate in mere few meters). Instead of finding out micro specific differences, the data have been used to show growth tendencies of Teak in clearly divided geographical locations such as, in our case, the individual hill ranges on which the plantations are located.

- Growth functions for all species.

Tree measurements divided into "main crop"** and "thinning crop"** have been subjected to curve-fitting for growth functions using the statistical software package SPSS/PC+. Example of SPSS/PC + printout is given in Appendix 6.

Data of the two broad teak site classes have been analyzed separately to produce, for teak, independent growth functions.

3.6.3 VOLUME FUNCTIONS

Functions for the main Sylhet species (Teak and Moluccana and Eucalyptus) were available from F.R.I. literature both for total volume and for volume underbark at 10cm top diameter.

From collected sample trees stem measurements a set of functions have been prepared for the minor species with the main purpose of achieving a reasonably good volume estimate for the present inventory.

Computer printouts with the details of the multiple regression analysis for total volume (gross volume overbark) and for commercial volume (at 10 cm top diameter underbark) for each species are given in Appendix 10.

Being based on measurement taken from standing trees, these functions should be considered indicative only. If it will be considered important to develop formal volume tables for such species, more data from felled trees should be collected and analysed.

** "main crop" is represented by the best 300-400 trees/ha and the "thinning crop" is represented by the balance trees.

4. METHODOLOGY - HIGH FOREST INVENTORY

4.1 AERIAL PHOTOGRAPHS AND SATELLITE IMAGERY INTERPRETATION

Most of the remaining closed canopy natural forest is located on the central and eastern part of the Inventory area. Consequently, and fortunately, most part of it was covered by '84 1:50000 aerial photographs although some of them could only be briefly seen at SPARRSO and have not been later released due to tight security restrictions. A preliminary interpretation was carried out on SPARRSO's photograph on transparent overlays in December 1985.

The interpretation have finally been up-dated and completed on SPOT imageries taken in October-November 1986 and produced, under FAO Remote Sensing assistance, in May 1987.

As per Cox's Bazar and Chittagong High Forest inventory, the forest area have been stratified in three main classes :

Stratum 1 = HF(High Forest);	crown cover >/ 50% = large crown high forest.
Stratum 2 = LF(Low Forest);	crown cover >/ 50% = small crown high forest.
Stratum 3 = ST(Scattered Trees);	crown forest < 50% = degraded, heavily disturbed forest, usually mixed with Brush, Sun-grass or Bamboo

The last type (ST) have been considered non-economical and excluded from sampling.

The types have not been always clearly discernible on satellite imageries and have therefore been often grouped to cover a possibly higher variation, e.g. : HF-LF ; LF-ST etc..

4.2 FIELD WORK

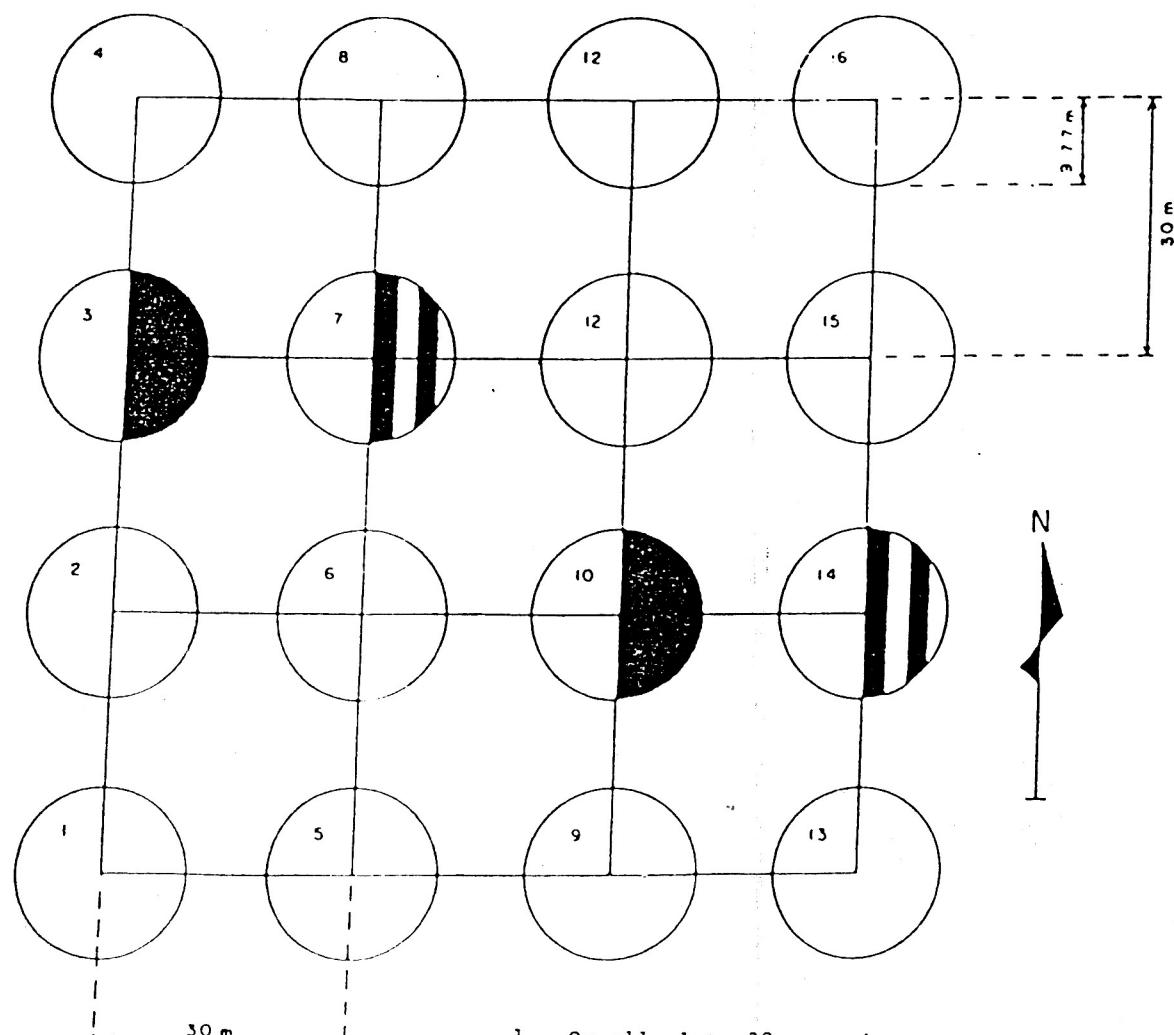
The high forest inventory field work has been carried out during the period January-May 1986. Fortunately most of the remaining High and Low forest patches were covered by aerial photographs. Enlargements of preliminary interpretation were used for the location of the sampling units.

The sampling and surveying work have been done by 3 field teams each composed of 1 sub-professional officer (Forester, Deputy Ranger or Ranger) 2 Forest Guards and 1 or 2 labourers according to the condition of the forest. Teams activities have been supervised by 1 ACF and the Inventory Officer.

4.3 SAMPLING DESIGN

From experience of Chittagong and Cox's Bazar High forest inventory and from preliminary field reconnaissance to obtain information on diversified conditions of Sylhet High Forests, it was decided to use cluster sampling with circular sample plots. the sampling unit consisting of 16 circular plots, (each of 0.03 hectare i.e., circle of radius 9.77m) is shown in the following figure.

Figure of sampling design - Sylhet high forest inventory



1. On all plots 30 cm and +
2. On half of plots 3 and 10
 - 10-29 cm
 - bamboo
3. On half of plots 7 and 14
 - 10-29 cm
 - 0-9.9 cm
 - bamboo.

The 16 circular plots are clustered in an area of dimension 90m x 90m. The sample unit was distributed systematically and sample plots are laid down 30m apart from each other as shown in the figure. The sample plots are always numbered from the south to the north irrespective of the direction of access of the field crews. In this way the sampled area per sample unit becomes 0.48 hectares. Data are recorded from the sample plots as follows :

- i. On all plots :
 - trees with diameter 30cm and +
- ii. On 1/2 of plots 3 and 10 : (additional measurement)
 - trees of diameter 10-29cm
 - estimate of the number of natured and immatured bamboo clums.
- iii. On 1/2 of plots 7 and 14 : (additional measurement)
 - trees of diameter 10-29cm
 - trees of diameter less than 10cm
 - estimate of the number of matured and immatured bamboo culms.

4.4 FIELD FORMS

Inventory data were collected in the field form given in Appendix 2. The column by column description of the form with an explanation of methodology used, the measurements taken, the observation made etc. is also given in Appendix 2.

4.5 SAMPLING SIZE

40 Sampling Units, for a total of 640 sample plots, have been systematically distributed over the major blocks of closed-canopy natural forest.

17 Sampling Units have been located in Stratum 1, HF (High Forest) and 23 in Stratum 2, LF (Low Forest).

The High Forest (total area = 796ha) have been sampled with an intensity of 1.0%.

The Low Forest (total area = 2541ha) have been sampled with an intensity of 0.4%.

4.6 COMPIRATION OF RESULTS

4.6.1 DESCRIPTION OF STRATUM 1 (HF) AND STRATUM 2 (LF)

High forest data have been entered in the IBM System 34 at BARC (Bangladesh Agricultural Research Council), and processed by use of FORTRAN

IV language. Complete list of programs and data files used is given in Appendix 4. Data have been entered separately for stratum 1 and stratum 2 in the files SHFSTR1 and SHFSTR2 respectively and checked with the help of check program SHFDAC. Listing program SHFSTR produces list of data.

Species-wise number of trees having diameter 30cm and + was calculated for each stratum separately with the help of programs SHFNT and for tree having diameter 10-29cm, number of trees/species was computed by use of program SHFNTS. The total number of trees (dia 30cm and +) for each species were then distributed over 9 dia-classes (30-39, 40-49, 100-109, 110 +) with the help of program SHFDT. The program SHFDTS gives distribution of trees having diameter 10-29cm over 4 dia-classes (10-14, 15-19, 20-24 & 25-29). Trees distributed in various diameter classes were then arranged by species name and dia-classes in tabular form according to species groups (dominant commercial, other commercial, potential and miscellaneous). Stand tables showing number of trees per hectare were prepared manually for each stratum separately. The stand tables for regeneration trees and bamboos were produced manually by use of computer data lists.

The individual tree volumes are the basis for the calculation of per hectare volume over species, species group and diameter classes. Due to limited time factor it was not possible to collect a sufficient number of data to calculate the volume equation for Sylhet high forest species. Considering the small extent of Sylhet high forests, it was decided to use as a basis, for the volume calculation, the taper series prepared for the Chittagong high forests species. The number of series has been reduced by grouping, discarding the series with the extreme values, to 5 only (see tables....& showing taper groups for Chittagong and Sylhet and figures 1 and 2 showing taper series for Chittagong and Sylhet) and they have been assigned to Sylhet high forests species, where possible by diameter classes (see table....).

The following volumes (inside bark) are calculated for each individual tree with the help of the program ITVCAL.

- Gross volume = vol. of section of quality 1 to 6.
 - Utilizable volume = vol. of sections of quality 1 to 3.
 - Quality 1 volume = vol. of sections of quality 1.
- The volume of any section is calculated as follows :

$$V_n = \frac{(\text{Do} \times \text{BF} \times \text{Fn})^2}{4} \times L_n$$

where, Do = reference diameter
BF = bark factor
Fn = taper factor for the corresponding section mid point
Ln = length of section

The gross, utilizable and quality 1 volume per sampling unit according to species group are calculated for trees with diameter 30cm and above with the help of program SHVSU.

Individual tree volumes (gross, utilizable and quality 1) were calculated by use of program ITVCAL. The program ITVCAL also created two separate output files ITVCAL1 and ITVCAL2 containing individual volume outputs for stratum 1 and stratum 2 respectively. The program SHVSU was then run over data files ITVCAL1 and ITVCAL2 to obtain gross, utilizable and quality 1 volumes per sampling unit according to species group and utilization group. Sampling Unit-wise volumes were then processed manually to produce stock tables showing 3-types of volumes (in m^3/ha) for each species group. Individual tree volumes were also processed manually to obtain species-wise volumes for stratum 1 and stratum 2 separately.

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Field Document No. 3

46

ASSISTANCE TO THE FORESTRY SECTOR-PHASE-II

BANGLADESH

INVENTORY
OF
FOREST RESOURCES OF SOUTHERN
SYLHET FOREST DIVISION

By

R.Drigo
FAO Inventory Officer

Md.Shaheduzzaman
Assistant Conservator Of Forests
Working Plans Division

J.A.Chowdhury
Senior Research Officer
Inventory Division
Bangladesh Forest Research Institute

Food and Agriculture Organization Of the United Nations
FAO/UNDP Project BGD/85/085
Assistance to the Forestry Sector - Phase II
January 1988

3.5 SAMPLING SIZE

A total of 1833 sample plots, varying in size according to plantation age, were distributed over the planted area with the purpose of achieving the best possible information of each manageable unit (sub-block).

Out of 1833 plots, 93 have been excluded from later computation since such plots had fallen in totally failed plantation areas (usually invaded by bamboo).

A total of 1740 plots have therefore been used to compute DLU descriptions.

A total of 415 trees have been measured to provide function relating total and commercial volume to DBH and total Height for the minor plantation species for which local volume functions were not available.

<u>Local name</u>	<u>Scientific name</u>	<u>Approx. % of genl. composition</u>	<u>Trees measured</u>
Pinkado	<u>Xylia dolabriformis</u>	0.4%	94
Jarul	<u>Lagerstroemia speciosa</u>	2.9%	74
Sal	<u>Shorea Robusta</u>	2.5%	79
Kadam	<u>Anthocephalum sinensis</u>	0.7%	51
Chapalish	<u>Artocarpus Chaplasha</u>	1.7%	28
Garjan	<u>Dipterocarpus turbinatus</u>	2.6%	49
Gamar	<u>Gmelina Arborea</u>	0.6%	23
Dhakijam	<u>Syzygium grande</u>	0.9%	16

The above generally represent secondary species in the largely preponderant Teak plantations.

3.6 COMPILATION OF RESULTS

Sample plot data have been recorded, checked and processed by Personal Computer ; in Dhaka Forest Department by an IBM PC AT and in Chittagong Inventory Unit by a "No Name" Clone PC XT.

The Data Processing Consultant's Report, given in Appendix 4 gives a description of the work carried out and a list of files, programmes, equipments, and softwares involved.

3.6.1 SUB-BLOCK PARAMETERS

The following parameters have been computed for each sub-block from the sample plot data :

- Range code
- Beat code
- Sub-block

In the list of "uneconomic" and "understocked" plantations given in Appendix 7 those sub-blocks presenting a high standard deviation of No. of stems/ha (where $SD > 1/2 ST-HA$) have been marked and underlined for individual inspection and consideration.

7.2.6 VOLUME FUNCTIONS

Double entry volume functions of the type : $\ln \text{Volume} = A + B * \ln (\text{DBH}) + (\text{Height})$ have been prepared or taken for available literature (Moluccana and Eucalyptus) to compute total volume over bark (list of species and correspondent coefficient is given below).

To compute volume under bark at 10 cm top diameter independent functions of the same kind (logarithmic) have been prepared with only exception for Moluccana and Eucalyptus for which the volume is computed by applying a factor of the kind : $F = A * (1-e^{-B * DBH})^C$ to the total volume over bark.

TOTAL VOLUME OVERBARK (all LOG. functions)			VOLUME UNDERBARK AT 10 CM TOP DIAM. (L=LOG. function) (F=factorial function)			
---	--	--	--	--	--	--

CODE	NAME	A	B	C	VOL10	A10	B10	C10
✓1	Moluccana	-8.9942	1.4963	1.1461	F	0.9781	-0.2838	84.5910 - Das et al. 1985
✓2	Eucalyptus	-9.4209	1.7480	0.9310	F	0.9151	-0.4043	72.1010 - I Auf et al 1988
✓3	Gammar	-10.0399	2.1532	0.7161	L	-11.0115	2.1689	0.9544
✓4	Kadam	-10.4647	2.3911	0.6373	L	-11.1096	2.5050	0.6575
✓5	Chapalish	-10.0581	1.9464	0.9376	L	-10.5583	1.9613	1.0222
✓6	Dhakijam	-10.7345	1.4842	1.7521	L	-11.4342	1.4043	2.0144
✓7	Garjan	-9.5258	2.1229	0.5993	L	-9.9731	2.1776	0.6094
✓8	Jarul	-9.6744	2.1065	0.6675	L	-10.5464	2.1618	0.8398
✓9	Pinkado	-9.4303	2.0988	0.6042	L	-10.1764	2.2303	0.6213
✓9	Sal	-10.0253	2.1163	0.7588	L	-10.8289	2.2561	0.7692
✓11	Teak	-9.4808	1.6212	1.1648	L	-9.9761	1.5800	1.6300 -
	- other -	-10.1064	1.9613	0.9664	L	-10.8759	1.9905	1.12

Xylia dolabriiformis
Roxb. Taub.
Fabaceae
→ I Auf et al 1985

APPENDIX 10

PRINTOUT OF MULTIPLE REGRESSION
ANALYSIS FOR PLANTATION SPECIES
VOLUME FUNCTIONS

Appendix 10

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number i Dependent Variable.. LOGTVOL

Beginning Block Number i. Method: Stepwise

Variable(s) Entered on Step Number

i.. LOGDBH

Multiple R .98620
 R Square .97159
 Adjusted R Square .97123
 Standard Error .17036

F = 745.04951 Signif F = .0000

(23) GAMAR TOT VOL

IMPORTANT:

all independent constants in the printout are given for DBH in DM and HT in M. Constant for DBH in CM is written below the printed one.

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.53882	.09301	.98620	27.296	.0000
(Constant)	-3.42768	.11333		-30.245	.0000

Variables Entered on Step Number

i.. LOGHT

Multiple R .99198
 R Square .98403
 Adjusted R Square .98243
 Standard Error .13364

F = 616.04433 Signif F = 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.15318	.12520	.83640	17.198	.0000
LOGHT	.71608	.18920	.18406	3.785	.0012
(Constant)	<u>(5.08200)</u>	.44600		-11.395	.0000
	<u>-10.0399</u>				

$y = A + B \log(DH)$
 $y = C \log(H)$

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

(23) GAMAR TOT VOL.

Equation Number 1 Dependent Variable LOGCVOL

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number

1.. LOGDBH

Multiple R	.98278
R Square	.96585
Adjusted R Square	.96422
Standard Error	.20222

F = 593.90329 Signif F = .0000

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.68282	.11009	.98278	24.370	.0000
(Constant)	-3.81268	.13414		-28.424	.0000

Variable(s) Entered on Step Number

2.. LOGHT

Multiple R	.99193
R Square	.98392
Adjusted R Square	.98231
Standard Error	.14218

F = 611.92304 Signif F = .0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.16885	.18320	.79450	16.282	.0000
LOGHT	.95439	.20129	.23135	4.741	.0001
(Constant)	-6.01755	.47451		-12.682	.0000
	-11.0115				

Listwise Deletion of Missing Data

(24) KADAM TOT VOL

Equation Number: 1 Dependent Variable: LOGTV01

Figure 1. The relationship between the number of species and the area of forest cover.

Multiple R	0.71
R Square	0.49
Adjusted R Square	0.46
Standard Error	13.3

2913 01259 signif. 6.1e-00000

Variables in the Equation ---

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.80137	.05185	.99171	54.030	.0000
(Constant)	-3.47690	.05489		-63.338	.0000

Variable(s) Entered on Step Number

2. LIGHT

Multiple R	0.99531
R Square	0.99063
Adjusted R Square	0.99026
Standard Error	165.28

F = 2542.29740 Signif F = 0.0

Variables in the Equation ---

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.39109	.07834	.84647	30.521	.0000
LOGHT	.63727	.10515	.16808	6.061	.0000
(Constant)	-4.95905	.24809		-19.989	.0000
	-10.46434				

*** MULTIPLE REGRESSION ***

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOGVOL

(24) KADAM COMM VOL

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number

1.. LOGDBH

Multiple R	.99086
R Square	.98179
Adjusted R Square	.98142
Standard Error	.15208

F = 2642.45191 Signif F = .0000

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.92832	.05697	.99086	51.405	.0000
(Constant)	-3.81240	.06031		-63.211	.0000

Variable(s) Entered on Step Number

2.. LOGHT

Multiple R	.99430
R Square	.98275
Adjusted R Square	.98228
Standard Error	12077

F = 2109.88631 Signif F = 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	1.50504	.08985	.84782	17.887	.0000
LOGHT	.66746	.12064	.16575	5.450	.0000
(Constant)	-5.34150	.28463		-18.765	.0000
	-11.1096.				

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOGTVOL

(58) CHAPALISH TOT VOL

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number

1.. LOGDBH

Multiple R .99265

R Square .98535

Adjusted R Square .98478

Standard Error .14887

F = 1748.42688 Signif F = 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.47396	.05917	.99265	41.814	0.0
(Constant)	-3.29217	.07945		-41.438	.0000

Variable(s) Entered on Step Number

2.. LOGHT

Multiple R .99437

R Square .98980 ✓

Adjusted R Square .98895

Standard Error .12659

F = 1212.64189 Signif F = 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	1.94645	.16750	.78099	11.621	.0000
LOGHT	.93757	.28394	.22192	3.302	.0029
(Constant)	-5.57527	.69503		-8.023	.0000

*** MULTIPLE REGRESSION ***

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOGCVOL

(58) CHAPALISH COMM VOL

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number

1.. LOGDBH

Multiple R	.99124
R Square	.98256
Adjusted R Square	.98189
Standard Error	.16673

F = 1465.18671 Signif F = 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.53641	.06626	.99124	38.278	0.0
(Constant)	-3.55200	.08898		-39.919	.0000

Variable(s) Entered on Step Number

2.. LOGHT

Multiple R	.99377
R Square	.98758
Adjusted R Square	.98659
Standard Error	.14350

F = 994.09669 Signif F = 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	Sig T
LOGDBH	1.96130	.18972	.76649	10.338 .0000
LOGHT	1.02219	.32162	.27566	3.178 .0039
(Constant)	-6.04225	.78725		-7.675 .0000
	-10.5583			

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

(61) DHAKIJAM TOT VOL

Equation Number 1 Dependent Variable.. LOGTVOL

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number

1.. LOGD8H

Multiple R .98554

R Square .97129

Adjusted R Square .95924

Standard Error .17953

F = 473.59071 Signif F = .0000

----- Variables in the Equation -----

Variable	B	SE B	Beta	t	Sig t
LOGD8H	2.62801	.12076	.98554	21.762	.0000
(Constant)	-3.46240	.09867		-35.817	.0000

Variable(s) Entered on Step Number

2.. LOGHT

Multiple R .99714

R Square .99428

Adjusted R Square .99340

Standard Error .08315

F = 1129.97227 Signif F = .0000

----- Variables in the Equation -----

Variable	B	SE B	Beta	t	Sig t
LOGD8H	1.48418	.16782	.55659	8.844	.0000
LOGHT	1.75213	.24237	.45497	7.229	.0000
(Constant)	-7.31702	.53507		-13.675	.0000

-10.7345

*** MULTIPLE REGRESSION ***

Listwise Deletion of Missing Data

(61) DHAKIJAM COMM VOL

Equation Number 1 Dependent Variable.. LOGCVOI

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number

1.. LOGDBH

Multiple R	.98124
R Square	.96284
Adjusted R Square	.96018
Standard Error	.21228

F = 362.70409 Signif F = .0000

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.71940	.14279	.98124	19.045	.0000
(Constant)	-3.76900	.11430		-32.973	.0000

Variable(s) Entered on Step Number

2.. LOGHT

Multiple R	.99548
R Square	.99097
Adjusted R Square	.98958
Standard Error	.10857

F = 713.51164 Signif F = 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	.146434	.11912	.50673	6.409	.0000
LOGHT	2.01441	.31646	.50329	6.365	.0000
(Constant)	-8.20063	.69856		-11.738	.0000
	-11.4342				

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOGCVOL

(62) GARJAN COMM VOL

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number
1.. LOGDBH

Multiple R	.97812
R Square	.95672
Adjusted R Square	.95580
Standard Error	.17202

F = 1038.97930 Signif F = .0000

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.34404	.07272	.97812	32.233	.0000
(Constant)	-3.22918	.09345		-34.556	.0000

Variable(s) Entered on Step Number
2.. LOGHT

Multiple R	.98319
R Square	.96667
Adjusted R Square	.96522
Standard Error	.15259

F = 667.06966 Signif F = 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.17763	.07860	.90868	27.705	.0000
LOGHT	.60940	.16446	.12154	3.700	.0000
(Constant)	-4.95890	.47410		-10.460	.0000
	-9.9731				

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOGTVOL

(62) GARJAN TOT VOL

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number

1.. LOGDBH

Multiple R	.97961
R Square	.95964
Adjusted R Square	.95878
Standard Error	.16180

F = 1117.41305 Signif F = .0000

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.28655	.06840	.97961	33.428	.0000
(Constant)	-2.93667	.08790		-33.410	.0000

- R.2016

Variable(s) Entered on Step Number

2.. LOGHT

Multiple R	.98477
R Square	.96978
Adjusted R Square	.96849
Standard Error	.14152

F = 738.03124 Signif F = 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.12291	.07290	.90950	29.121	.0000
LOGHT	.59926	.15253	.12271	3.929	.0003
(Constant)	-4.63763	.43971		-10.547	.0000
	-9.5258				

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOGTIVOL

(64) JARUL TOT VOL

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number

1.. LOGDBM

Multiple R	.98388
R Square	.96802
Adjusted R Square	.96758
Standard Error	.16659

F : 2179.64636 Signif F : .0000

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBM	2.50915	.05374	.98388	46.687	.0000
(Constant)	-3.38424	.05646		-59.942	.0000

Variables Entered on Step Number

2.. LOGHT

Multiple R	.99312
R Square	.98628
Adjusted R Square	.98587
Standard Error	.10989

F : 2551.69844 Signif F : 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBM	2.10650	.05453	.82600	38.632	.0000
LOGHT	.66752	.06868	.20780	9.719	.0000
(Constant)	-4.82401	.15275		-31.581	.0000
	-9.6744				

*** MULTIPLE REGRESSION ***

Listwise Deletion of Missing Data

(64) JARUL COMM VOL

Equation Number 1 Dependent Variable.. LOGCOMVOL

Beginning Block Number 1. Method Stepwise

Variable(s) Entered on Step Number
1.. LOGDBH

Multiple R	.97895
R Square	.95834
Adjusted R Square	.95776
Standard Error	.20322

F = 1656.40088 Signif F = .000

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.66829	.06556	.97895	40.699	.0000
(Constant)	-3.75746	.06887		-54.557	.0000

Variable(s) Entered on Step Number
2.. LOGHT

Multiple R	.99178
R Square	.98363
Adjusted R Square	.98317
Standard Error	.12827

F = 2133.74516 Signif F = .00

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.16176	.06364	.93111	33.968	.0000
LOGHT	.83975	.08010	.14260	10.475	.0000
(Constant)	-5.56872	.17829		-31.234	.0000

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOGTIVOL

(71) PINKADO TOT VOL

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number

1.. LOGDBH

Multiple R	.98984
R Square	.97978
Adjusted R Square	.97956
Standard Error	.15304

F = 4458.49381 Signif F = .0000

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.39507	.03587	.98984	66.772	.0000
(Constant)	-3.08937	.04867		-63.474	.0000

Variable(s) Entered on Step Number

2.. LOGHT

Multiple R	.99359
R Square	.98723
Adjusted R Square	.98095
Standard Error	.12231

F = 3516.73128 Signif F = 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.09881	.04977	.85740	42.174	.0000
LOGHT	.60423	.08297	.14979	7.283	.0000
(Constant)	-4.59766	.21072		-21.818	.0000
	-9.4303				

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOGTIVOL

(71) PINKADO TOT VOL

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number

1.. LOGDBH

Multiple R .98984

R Square .77978

Adjusted R Square .97956

Standard Error .15304

F = 4458.49381 Signif F = .0000

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.39507	.03587	.98984	66.772	.0000
(Constant)	-3.08937	.04867		-63.474	.0000

Variable(s) Entered on Step Number

2.. LOGHT

Multiple R .99359

R Square .98723

Adjusted R Square .98595

Standard Error .12231

F = 3516.73128 Signif F = 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.09881	.04977	.85740	42.174	.0000
LOGHT	.60423	.08297	.14979	7.283	.0000
(Constant)	-4.59766	.21072		-21.818	.0000
	-9.4303				

*** MULTIPLE REGRESSION ***

Lastwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOGVOL

(71) PINKADO COMM VOL

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number
1.. LOGDBH

Multiple R .98832
R Square .97677
Adjusted R Square .97652
Standard Error .17389

F = 3863.88883 Signif F = .0000

----- variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.53495	.04075	.98832	62.200	.0000
(Constant)	-3.43990	.05530		-63.109	.0000

Variable(s) Entered on Step Number
2.. LOGHT

Multiple R .99186
R Square .98378
Adjusted R Square .98342
Standard Error .14611

F = 2759.47692 Signif F = 0.0

----- variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	1.03030	.05948	.86964	17.514	.0000
LOGHT	.11124	.02511	.14501	.44267	.6557
(Constant)	-5.00091	.25170		-20.018	.0000
	-10.1764				

***** MULTIPLE REGRESSION ANALYSIS *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOGCVOL

(72) SAL COMM VOL.

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number

1.. LOGDBH

Multiple R	.98696
R Square	.97409
Adjusted R Square	.97375
Standard Error	.17795

F = 2894.88687 Signif F = .0000

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.70056	.05019	.98696	53.804	.0000
(Constant)	-3.84129	.05815		-66.053	.0000

Variable(s) Entered on Step Number

2.. LOGHT

Multiple R	.99391
R Square	.98787
Adjusted R Square	.98755
Standard Error	.12258

F = 3693.47800 Signif F = 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.05603	.05904	.82451	35.111	.0000
LOGHT	.76920	.08281	.20041	9.288	.0000
(Constant)	-3.63411	.19714		-18.580	.0000
	-10.8289				

***** MULTIPLE REGRESSION *****

Listwise Deletion of Missing Data

Equation Number 1 Dependent Variable.. LOGTVOL

(72) SAL TOT VOL

Beginning Block Number 1. Method: Stepwise

Variable(s) Entered on Step Number

1.. LOGDBH

Multiple R .98696

R Square .97410

Adjusted R Square .97376

Standard Error .10832

F = 2895.68930 Signif F = .0000

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.55479	.04748	.98696	53.312	.0000
(Constant)	-3.38381	.05501		-61.515	.0000

Variable(s) Entered on Step Number

2.. LOGHT

Multiple R .99452

R Square .98908

Adjusted R Square .98879

Standard Error .11003

F = 3440.39883 Signif F = 0.0

----- Variables in the Equation -----

Variable	B	SE B	Beta	T	Sig T
LOGDBH	2.11529	.05300	.81756	39.933	.0000
LOGHT	.75879	.07433	.20898	10.208	.0000
(Constant)	-5.15238	.17695		-29.118	.0000
	-10.0253				