WOODLAND STRUCTURE, BASIC DENSITY AND ABOVE GROUND CARBON STOCK ESTIMATIONS OF WET MIOMBO WOODLANDS IN MBOZI DISTRICT TANZANIA

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ABSTRACT

Species diversity, stocking, carbon stock and wood basic density for wet miombo woodlands of Iwuma forest reserve in Mbozi District were assessed. Biophysical data were collected through common methodology in forest inventory. Systematic sampling design technique was used to collect information in 37 rectangular plots measuring 20m x 40m each. Trees with DBH $\geq$ 5 cm were identified and measured for DBH, height, crown diameter and crown height. A total of 820 wood cores were extracted from different tree species identified and recorded in the forest. Data were analysed for species composition, diversity,stocking, carbon stocks and basic density. Carbon was estimated through multiplying tree volume by basic density. The most dominant tree species were *Brachystegia boehemii, Brachystegia spiciformis* and *Parinari excelsa*. The Shannon-Wiener Index of Diversity was 1.3 and Simpson's Index was 0.4 which show a low diversity of tree species in the site. Mean stem density, basal area and volume were 553 (SPH), 9.60 m^2ha^{-1} and 60.29 m^3ha^{-1} respectively. About 87% (34.54 t ha^{-1}) of the total carbon stocks (39.46 t ha^{-1}) was contributed by the three most dominant species; *Brachystegia boehemii*, *Brachystegia spiciformis* and *Parinari excelsa.* There was a large variation in basic density between tree species whereby, *Combretum zeyherii* had the highest basic density of 0.59gcm^{-3}, followed by *Julbernadia globiflora (*0.49gcm^{-3}), *Parinari excelsa* (0.47gcm^{-3}), *Brachystegia spiciformis* (0.46gcm^{-3}) and *Brachystegia boehemii* (0.44gcm^{-3}) and the minimum basic density was 0.41gcm^{-3} for *Despems abysinica.* Based on the above findings, the study recommends; sustainable management practices, especially for the three dominant tree species to enhance their management and conservation for climate change mitigation and provide information for REDD+ projects of Tanzania and the global at large.

DECLARATION

I, YOHANE PIASON MWAMPASHI do hereby declare to the Senate of Sokoine University of Agriculture, that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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Yohane Piason Mwampashi Date

The above declaration is confirmed

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Prof. P.K.T. MUNISHI Date

(Supervisor)

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DEDICATION

This work is dedicated to my parents, the late father Piason Nyapin Mwampashi and my lovely mother Mynurse Mwayila. These two laid the foundation for my education with a lot of sacrifices, May almighty God rest my father’s soul in Eternal Peace! Amen. This is also dedicated to my lovely wife Renatha for her valuable advice and assistance, our daughters; Herieth, Dayana and Jackline without forgetting my brother Taska Piason Mwampashi for his tireless encouragement.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

ANOVA	Analysis of Variance
Avg	Average
BD	Basic density
°C	Celsius degree
C	Carbon
cc	Cubic Centimeter
CCIAM	Climate Change Impacts, Adaptation and Mitigation
CDM	Clean Development Mechanism
CO_2	Carbon dioxide
Crn.D	Crown Diameter
Crn.H	Crown Height
DBH	Diameter at Breast Height
DNRO	District Natural Resources Officer
DRC	Democratic Republic of Congo
et al	And others
FAO	Food and Agricultural Organization
FBD	Forest and Beekeeping Division
G	Gram
G	Basal area per hectare
g_i	Basal area of a single tree (m^2)
GPS	Global Positioning System
G.v	Green volume
Ht	Height

H’	Shannon-Wiener Index of Diversity
ha	Hectare
i.e	That is
ID	Index of Dominance
IPCC	Intergovernmental Panel on Climate Change
K: TGAL	Kyoto: Think Global Act Local project
Ln	Natural Logarithm
M	Meter
Mg	Megagram
MgC	Mega tonne of Carbon
MNRSA	Management of Natural Resources for Sustainable Agriculture.
MNRT	Ministry of Natural Resources and Tourism
O.d	Oven dry
REDD	Reduce Emission from Deforestation and forest Degradation
RSE	Residual Standard Error
SPH	Stems per hectare
SUA	Sokoine University of Agriculture
t	Tone
TFS	Tanzania Forest Service
UNFCCC	United Nations Framework Convention on Climate Change
V	Volume
VEO	Village Executive Officer
VFR	Village Forest Reserve
WEO	Ward Executive Officer
Yr	Year

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Tropical forests store more than 320 billion tons of carbon, (Gibbs *et al*., 2007). Clearing these forests result in large emission of carbon dioxide (CO_2) to the atmosphere, the emission from current tropical deforestation have been estimated at 20% of total global CO_2 emissions (IPCC, 2007). There is a historical controversy as to whether terrestrial ecosystems are releasing carbon to the atmosphere or withdrawing it and accumulating it in vegetation biomass and soils (Kauppi *et al.*, 1992; Wisniewski *et al.*, 1993). It is however, widely known that terrestrial ecosystems in general play a major role in the global carbon budget and fluxes (Dixon, 1996; Munishi and Shear, 2004). Reducing forest loss is therefore of most importance for climate change mitigation and this is reflected in the commitment to include emission from deforestation and degradation (REDD) in the post- 2012 agreements of the UNFCCC (United Nations Framework Convention on Climate Change). Human induced changes can have a strong impact on natural resources. Possible negative consequences at the regional level are soil erosion and desertification, but land- use changes are also related to global climate change. Desertification processes might be reversed and climate change mitigated by withdrawing CO_2 from the atmospheres.

Miombo woodlands are the most extensive tropical seasonal woodland and dry forest formation in Africa perhaps even globally covering an estimated 2.7 million km² in regions receiving more than 700mm mean annual rainfall on nutrient- poor soils (Frost, 1996). However, the name miombo is widely used to describe the savanna woodlands of Southern Africa that are dominated by the trees of the subfamily Caesalpinioideae of the leguminosae, mainly of the genera *Brachystegia, Julbernadia* and *Isoberlinia.* Rough estimates a decade ago suggested that 40 million people inhabited areas covered, or formerly covered by miombo woodland with an additional 15 million urban dwellers relying on miombo wood or charcoal as a source of energy, (Campbell *et al*., 1996).

Dry forests are the most widely distributed habitat types in the tropics, (Jaramillo *et al.,* 2003), covering 42% of all tropical vegetation (Murphy and Lugo, 1995). While dry forests typically have lower biomass densities than wetter forests, their extensive coverage makes them a significant terrestrial carbon store. Conversion of African dry forest to agricultural usage dramatically reduces ecosystem carbon stocks (Woomer, 1993). As carbon emissions from land cover change have been linked with increasing global concentrations of greenhouse gases (Brown, 1997; Houghton, 1997; Clark and Clark, 1999), the importance of monitoring terrestrial carbon storage has grown. An estimated 13 million ha of tropical forest is lost each year to deforestation (FAO, 1999) emitting 5.6 – 8.6 Gt of heat-trapping carbon into the atmosphere. On the other hand, the role of tropical secondary forests as a carbon sink, either by natural or man-induced regeneration, is receiving increasing attention in the debate on the global carbon cycle. Indeed, over 40% of the carbon stored in terrestrial biomass is stored in tropical forests, (Dixon *et al.,* 1994*)* of which 40% are secondary and in some stage of regeneration (Brown and Lugo, 1990).

Brown *et al.,* (1996), gave an overview of global estimates for the potential quantity of carbon that might be sequestered and conserved by forest management between 1995 and 2050. To set up a successful carbon sequestration project in a region, one must first estimate its carbon sequestration potential during the time of the project, considering biological, physical, social, economic and political constraints. Estimation of this carbon can also be done using allometric equations (models), however single species and mixture of species differ in allometry, wood density and architecture, (Chave *et al*., 2003).

Forest woodlands in Tanzania cover about 33.5 million hectares which is around 38% of the total land area (MNRT, 1998) and about two third of this is occupied by the miombo woodlands. Miombo woodlands in Tanzania contribute significantly to mitigating carbon emission through the process of sequestration (Mnangwone, 1999), (Appendix 3). Large quantity of carbon stored in this ecosystem is not known and this hinders the establishment of clear arguments for building up a carbon baseline for this ecosystem. Tanzania contain both, dry miombo woodlands which cover extensive areas like Tabora, Shinyanga, Morogoro etc., and wet miombo woodlands that occupy most of the southern eastern regions of Tanzania like Mbeya, Iringa, Ruvuma, Lindi and Mtwara.

1.2 Problem Statement and Justification of the study

Various studies have revealed that, different species have different ability to sequester and store carbon (FAO, 2003). Carbon stock estimation requires reliable estimation which can be obtained from allometric equations resulting from destructive sampling of selected tree species, (Joosten *et al*., 2004). Most of the studies on carbon estimation, basic density and stocking in miombo woodlands have been concentrated in the dry miombo (receiving less than 1000mm rainfall per year) part of Tanzania but less in the wet miombo (receiving more than 1000mm rainfall per year) of the southern eastern Tanzania.

This study was conducted in Mbozi District of the southern highlands of Tanzania so as to determine; wet miombo basic density, stocking and carbon storage. Due to the fact that, different species differ in carbon sequestration and storage capability, this study aimed at quantification of carbon storage for the tree species found in the miombo ecosystem of Mbozi to enhance their management and conservation for climate change mitigation and provide information for REDD+ projects of Tanzania and the global at large.

1.3 General Objective

The overall objective of this study was to assess forest stand structure, basic density and estimate above ground carbon stock of wet miombo woodlands of Mbozi District, Tanzania.

1.3.1 Specific Objectives

The specific objectives were to:

i. Assess species composition, diversity and stocking of miombo woodlands of Mbozi district
ii. Determine inter and intra species variation in basic density in the wet miombo woodlands
iii. Quantify above ground carbon storage potential of the miombo woodlands in Mbozi

1.3.2 Research questions

This study was guided by the following research questions:

i. What were the forest species composition and richness?
ii. What factors were responsible for the variation of basic density within and between tree species?
iii. What were the dominant tree species of the study area?
iv. How much above ground carbon was stored in the forest?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Global Miombo woodlands with carbon storage

Miombo is among the worlds' vegetations characterized by *Brachystegia* and an understory of grasses normally growing on nutrient poor soils derived from acid crystalline bedrock. Grasses found in miombo are normally C_4 grasses and grow alongside sedges and shrubs (Frost, 1996). They grow in area with climate characterized by mean temperatures of 18.0 – 23.1°C and precipitation of 710 - 1365mm (Frost, 1996). Generally, miombo vegetations cover 20% of the total world surface while 65% of this biome are situated in Africa continent covering about 2.7 million km^2 of Tanzania, Congo, Angola, Zimbabwe, Zambia, Malawi, and Mozambique (Campbell, Thomas and Packham, 2007). They are also characterized by frequent fires especially in the dry seasons (Ryan and Williams, 2010). This biome provides various ecosystem goods and services ranging from food, fuel, medicine and construction materials to large scale carbon and water management services.

Large scale carbon stored by miombo vegetations have called for its quantification/estimation and preservation, again the development of payment systems under REDD have necessitated the knowledge of carbon stock in miombo vegetations, (Angelsen *et al*., 2009). According to the literature, the above ground carbon storage in the whole tropical woodlands is between one to 12 Mg C $year^{-1}$, (Grace *et al*., 2006).

2.1.1 Miombo woodlands in Tanzania with carbon storage

Miombo woodlands in Tanzania are very important vegetations for being sources of rainfall and for supporting agriculture, for instance tobacco growers use energy from these vegetations for processing tobacco, they are also sources of wood fuels, construction poles, food (meat, fruits, honey, mushrooms etc.) and traditional medicine. Major problem facing this vegetation is deforestation mainly for charcoal production and timber, shifting cultivation, overgrazing and wildfires. This means that, miombo woodlands in Tanzania are more regarded as a source of livelihoods especially to the adjacent communities. Based on their extensive coverage (93.2%), miombo woodlands play a great role on carbon storage; reports from different areas of the country have shown different figures of miombo woodlands capacities in carbon storage. Lewis *et al*., (2009) reported 23.3 Mg C ha^{-1} as the capacity of carbon storage for Tanzanian miombo woodlands, 23.3 Mg C ha^{-1} was again reported by Shirima *et al*., (2011), 19.12 t ha^{-1} by Munishi *et al*., (2010) and 22.5 Mg C ha^{-1} (Zahabu, 2008). Based on these figures and an area covered by these vegetations in Tanzania, more knowledge of both, above ground and below ground carbon stocks in miombo woodlands which will provide useful input into REDD initiatives in Tanzania and the world at large is required.

2.2 Wood Density or Basic density

Wood is a biological tissue made of cells, or tracheides, and of walls composed of lignin. The tracheides are like pipes, that transport the sap along the stem and they are filled with water. The density of tree wood is an interesting variable because it tells how much carbon the plant allocates into construction costs, (Chave *et al*., 2005).

Wood density also known as Basic density (BD) is the ratio between the oven dry mass and its green volume;

$$BD = \frac{Oven\,dry\,mass}{Green\,volume} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(1)$$

Basic density is among the very important tree parameters in both carbon accounting programs and general wood strength properties of both secondary and old-growth tropical forests. It is usually considered as the best single descriptor of wood due to its correlation with numerous morphological, mechanical, physiological and ecological properties of wood, (Chave *et al*., 2006). Volumes of literature have shown a big variation of basic density within and between different tree species (Wilkes, 1988; Karki, 2001 and Zziwa *et al*., 2006) to mention few.

Wood density varies significantly within the plant, during the life of the plant, and between individuals of the same species. The study done by Karki, (2001), reported that, there was variation in basic density within a European aspen, basic density was observed higher in the living crown and it was decreasing as going lower heights up to 12m, the study also found that, basic density was higher beneath the bark rather than the pith. Ishengoma and Gillah, (1992), reported that, juvenile wood is significantly lower in basic density than mature wood and hence the reduction in density as you move away from the butt end. This implies that, higher density wood from butt end logs should be used for structural purposes where high strength is required. However enforcement might be difficult because timber sawyers are usually after profit maximization, again the separation of timber on the basis of location in a tree, may have cost implications.

Basic density variation between tree species has been attributed to different factors; some of them have been environment of the individual tree species, location in its range, site, climate and genetic factors. As pointed before, Basic density is an important predictor for wood strength properties, Hygreen and Bowyer, (1996), found that, the strength of the wood is usually closely correlated to density and it is possible to estimate wood strength based only on density without detailed knowledge of the species. Ishengoma *et al*., (1997), noted that, basic density was the main criterion for prediction of clear wood strength properties. This therefore means that, the knowledge of the basic density of any tree species is vital in the preliminary selection and utilization of wood especially for structural purposes. Global climate simulation studies have predicted high droughts and high temperatures in summer especially to trees in Europe (IPCC, 2001). These changes expected will not only cause the effect to tree growth but also wood density and other wood properties, especially for those species which have a large diversion of densities between their early and late woods. Basic density is highly sensitive to climate variation and the strength correlation between basic density and climate has made basic density of the wood be an important parameter for climate reconstruction, (Briffa *et al*., 1998). Basic density and other fibre characteristics have also been used as a criterion for improving the quality of some species especially Eucalyptus, among all other characteristics, basic density has normally been the first wood property assessed in a tree improvement program, (Lima *et al*., 2000).

2.3 Species Diversity

Diversity can be defined as the structural variety of plants and animals at genetic, species, population, community and at the system level. It comprises of two categories: Species richness, which is the actual number of species contained within a community and evenness of the community or the spread of individuals between the species within the community (Kent and Coker, 1992). In miombo woodlands, woody plants comprise 95-98% of the above ground biomass of undisturbed stands, grass and herbs make up the rest (Chidumayo, 1993a). Factors which are associated with disturbances are the most important to determine species composition in miombo woodlands especially when the edaphic factors are similar (Luoga, 2000).

The genera *Brachystegia*, *Julbernardia* and *Osoberlinia* dominating miombo woodlands make them floristically distinct from most other African woodlands because these genera are hardly found in other ecosystems. The composition and structure of miombo woodland appear superficially to be relatively uniform over large regions, suggesting a broad similarity in key environmental conditions. Species diversity and composition in miombo woodlands have been shaped in many ways by human beings and it is believed no part of it remains absent of human influence (WWF-SARPO, 2001). The knowledge of species diversity is equally important especially when one wishes to understand the influence of biotic disturbances, state of succession and stability in the environment (Misra, 1989), species diversity is also a useful parameter for comparison of communities. High species diversity is regarded by most ecologists as a desirable property of any community or ecosystem and this criteria has dominated most methods for ecological and conservation evaluation techniques (Kent and Coker, 1992).

2.4 Tree stocking (N), Basal area (G) and Standing volume (V)

Number of stems, basal area and volume of standing trees are the important parameters as far as stocking is concerned. Stem density for example varies widely in miombo woodlands but generally it ranges from 380 to 1400 SPH (Nduwamungu and Malimbwi, 1997; Mohamed, 2006). Stand basal area (G) is the total basal area of all trees or of specified classes of trees per hectare (Philip and Gentry, 1993). It is a good measure of the potential of a site, mostly ranges between 7 and 25m^2 per hectare in miombo woodlands (Mohamed, 2006; Zahabu, 2001). The harvestable mean volume in miombo woodlands ranges between 14m^{3}ha^{-1} in dry miombo woodlands of Malawi (Lowere *et al.*, 1994) and 117m^{3}ha^{-1} in Zambian wet miombo woodlands (Chidumayo and Siwela, 1988).

2.5 Species Importance Value Index (IVI)

Species Importance value index is a composite index made up of sum of Relative Frequency (RF), Relative Density (RD) and Relative Dominance (RDo) of species. This index is useful in evaluating the dominance of a given species in a given plant community and does not exceed 300 (Kent and Coker, 1992). It is computed as follows (Ambasht, 1990):

$$\text{Re}\,lative\ Frequency\ (RF) = \frac{Frequency\ of\ occurence\ of\ a\ species}{Frequency\ of\ occurence\ of\ all\ species}\,x\,100$$

$$\text{Re}\,lative\ Density\ (RD) = \frac{Number\ of\ individuals\ of\ a\ species}{Number\ of\ individuals\ of\ all\ species}\,x\,100$$

$$\text{Re}\,lative\ Do\min ance\ (RDo) = \frac{Total\ basal\ area\ of\ a\ species}{Total\ basal\ area\ of\ all\ species}\,x\,100$$

$$IVI = RF + RD + RDo \qquad \text{……………………………………………………..(2)}$$

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location

The study was done in Iwuma village Forest Reserve (owned by Nyimbili village and ward) found in Mbozi District (Figure 1, Appendix 1). The District lies between latitudes 8° and 9° 12" South and longitudes 32° 7' 30" and 33° 2' 0" East. To the South, Mbozi district is bordered by Ileje district, to the East by Mbeya rural district, to the North, the district extends to Lake Rukwa where it is bordered by Chunya district, while in the West it shares the borders with Rukwa region and the republic of Zambia. Mbozi district is composed of six divisions namely, Vwawa, Igamba, Iyula, Kamsamba, Msangano and Ndalambo. The District has a total area of 9 679 km^2 (967 900 ha) and lies between 900 – 2750 meters above sea level, (URT, 2002).

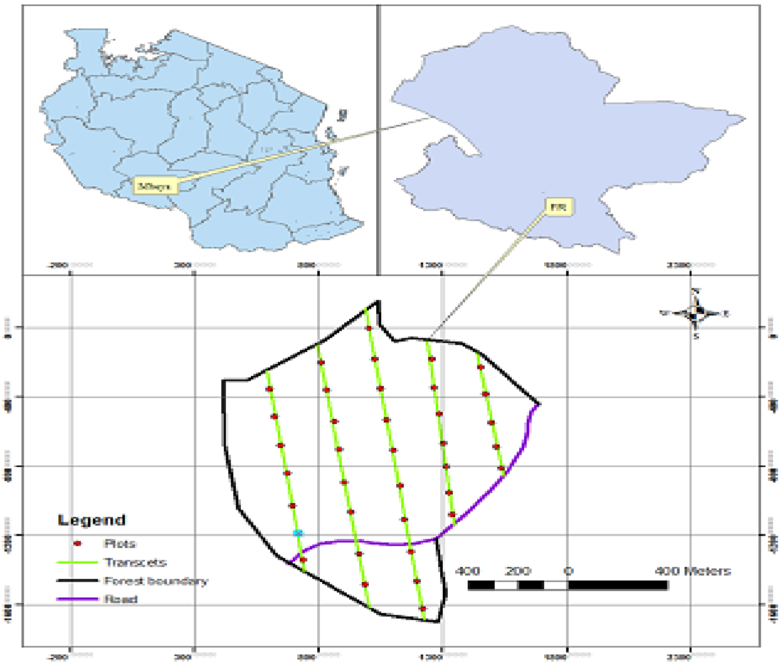

Figure 1: Map of Mbeya region showing the study area.

3.1.2 Climate

The climate of Mbozi is characterized by a binomial rainfall pattern. The short rains are usually between October and December while heavy rains occur in February to May. This is followed by a dry season between June and September. However, the amount of rainfall is unevenly distributed. The district receives rainfall ranging from 1350 to 1550 mm per annum, and the mean daily temperature ranges between 20°C to 28°C.

3.1.3 Ethnic groups

The major ethnic groups in terms of their numbers are Wanyiha and Wanyamwanga. Wanyiha is the dominant ethnic group in the highland areas which cover Igamba, Iyula and Vwawa divisions, they account for about 50% of the total population of Mbozi district. Wanyamwanga are the main ethnic group in the lowland areas which include; Kamsamba, Msangano and Ndalambo divisions, they account for about 30% of the district total population. Other ethnic groups found in Mbozi are; Wawanga, Wanyakyusa, Wandali, Walambya, Wamalila and Wasafwa. Currently, Wamasai and Wasukuma have been found in Mbozi due to pastoralist's immigration.

3.1.4 Socio- Economic activities

Two main economic activities of the communities found in Mbozi district are agriculture and livestock keeping. In the case of agriculture, the communities grow both, food and cash crops. Most of the food crops which are extensively grown by these communities are maize, beans, rice and bananas, and cash crops produced are like groundnuts and coffee. Other crops grown as cash crops are potatoes, wheat, cabbage and sugar cane. Livestock kept are cows (both dairy and beef), goats, sheep, pigs, chicken and rabbits.

3.1.5 Vegetation

Large area in this district is covered by miombo woodlands especially the hilly areas. Some of the common miombo species found in Mbozi District are; *Julbernardia globiflora, Brachystegia spiciformis, Uapaca kirkiana, Brachystegia boehemii* and *Parinari excelsa. Uapaca* and *Parinari* sometimes form unique associations in these ecosystems with *Uapaca* forming pure stands on well drained areas thus their high contribution to carbon storage in this Miombo ecosystem (Munishi *et al*., 2010). The plains areas are mainly covered by savannah grasslands and it is in these plains where agricultural and livestock keeping activities take place.

3.2 Methods

3.2.1 Sampling design

A systematic sampling design was employed where plots were established systematically along transects at a fixed distance between plots and transects. The main reason for applying this design was to make sure that there was an even distribution of the sample plots throughout the forest area and therefore increase the chance of covering the whole area for inventory (Philip, 1994). The first sample plot was established randomly on one of the forest adge, 25m into the forest so as to avoid the edging effects. Other sample plots were laid systematically along the transect at a distance of 150m between plots and 250m between transects.

3.2.1.1 Sampling intensity, plot size and shape

In order to carry an accurate forest inventory, a sampling intensity ranging from 0.5% to 0.7% is recommended (Synnot, 1979). This would mean a total of 1275 sample plots for Iwuma Forest Reserve with 204Ha. However, Malimbwi *et al*., (2005), recommended that, due to financial and time constraints and also the purpose of carrying out an inventory practice, sampling intensity can be as low as 0.01%. So the sampling intensity adopted in this study was 0.0145% which gives a total of 37 sample plots. The forest was then divided into five transects at 250m apart and interplot distance of 150m. Rectangular plots measuring 40m x 20m (0.08ha) were used.

3.2.2 Data collection

In each sample plot the following parameters were measured; diameter at breast height (DBH) for all trees ≥ 5 cm and heights (of 3 trees; small, medium and large) were measured using a caliper and sunto hypsometer respectively. Wood cores were extracted at DBH and at ½ the tree height using a wood corer while crown size estimation was done by using the average of the maximum and minimum diameter method (Malimbwi *et al.*, 1994). Each tree was identified by both local and scientific names (Appendix 2). In each sample plot, GPS (Global Positioning System) coordinates were taken by use of handheld GPS receiver (Gamin CSx) for future monitoring. Data collected were recorded in plot field forms (Appendices 4 and 5).

3.3 Data Analysis

3.3.1 Determination of inter and intra species variation in basic wood density

Wood cores obtained from the field were soaked in water for 72 hours (three days) to saturation and weighed for green weight. Each saturated wood core was totally emerged in a known volume of distilled water in a measuring cylinder. The water displaced from the cylinder was measured in order to obtain volume of the specimens which is equal to the volume of water displaced (Archmedes Principle). Then the samples (wood cores) were oven dried at 103±2 to a constant dry weight which was as well recorded. After this laboratory work, the basic density of each wood core was computed as the ratio of oven-dry mass to green volume as follows:

$$Basic\ density = \frac{Oven\,dry\,mass}{Green\,volume} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

This procedure was applied to all specimens extracted at 1.3m (DBH) and at 0.5 total heights of trees of the same tree and from different tree species. This was done to facilitate comparison of wood density within and between tree species (Appendix 7).

3.3.2 Quantification of above ground carbon storage

Biomass estimation was done by multiplying basic density calculated above (formula 1 and 3) with volume which was estimated by using volume equation developed by Malimbwi *et al.*, (1994) (formulae 7);

Biomass = Basic density x Volume………………………………………………….. (4)

Biomass of each individual tree calculated was converted into carbon in tons per hectare by multiplying biomass by 0.49 (percentage forest default value of aboveground carbon dry mass (IPCC, 2006; Fagan and Defries, 2009; Brown, 2002; Munishi and Shear, 2004) (Appendix 6).

3.3.3 Species Diversity, Stocking and Dominance in Miombo woodlands

Species Diversity

Species diversity was examined by the following indices:

a). Shannon-Wiener index of diversity (H')

This is the most frequently used index of diversity; usually combining both, species richness and evenness. It is also not affected by the sample size of a given study. The knowledge of species diversity is useful for establishing the influence of biotic disturbance and the state of succession and stability in the environment (Misra, 1989). The species diversity index increases with the number of species in the community but in practice, for biological community, H' does not exceed 5.0 (Krebs, 1989). The index was calculated as follows:

$$H' = -\sum_{i=1}^{S} P_i \ln P_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

Where;

H' = the Shannon index of diversity

Σ = the summation symbol

S = the number of species

Pi = the proportion of individuals or the abundance of species I in the sample

ln = the logarithm to base e

\- = the negative sign multiplied with the rest of variables in order to make H' Positive

b) Index of dominance (Simpson Index)

The index of dominance (ID) is a measure of the distribution of individuals among the species in a community. It is also called "*Simpson index*" and is always equal to the probability of picking two organisms at random of different species (Krebs, 1989). The logic behind this index is "the greater the value of dominance index, the lower the species diversity in that community and vice versa". The index was calculated using the formulae below:

$$ID = \sum \left[\frac{n_i}{N} \right]^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(6)$$

Where;

ID = the index of dominance

ni = the number of individuals of species i in the sample

N = the total number of individuals (all species) in the sample

Σ = the summation symbol

c) Forest Stocking Parameters

Number of stems per hectare (N), basal area (G) and volume of standing crop (V) were computed as follows:

(i) Number of stems (N)

Number of stems per hectare (N) was calculated using the following formulae:

$$N = \frac{i}{A} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(7)$$

Where;

N = Stem density (stem count/ha)

i = Stem count

A = Plot area (ha)

(ii) Basal area (G)

Basal area (m^2/ha) of an individual tree and then per hectare basis were calculated as shown below:

$$g_i = \frac{\pi dbh^2}{4}$$

$$G = \sum\left(\frac{g_i}{A \times n}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(8)$$

Where;

π = Pie

dbh = Diameter at Breast Height (cm)

A = Plot area (ha)

n = Number of plots

g_i = Basal area of a single tree (m^2)

G = Basal area (m^2/ha)

(iii)Volume

The mean volume of the forest was calculated by using a volume equation developed by Malimbwi *et al*., (1994):

$$V = 0.0001d_i^{\,2.032}\,h_i^{\,0.66} \quad (9)$$

Where;

V= Mean total volume (m^3)

d_i = Diameter at Breast Height of the i^{th} tree (m)

h_i = Total height of the i^{th} tree (m)

CHAPTER FOUR

4.0 RESULTS AND DISSCUSSION

4.1 Species Composition, Diversity and Stocking

4.1.1 Species Richness

A total of 11 tree species were identified and recorded (Table 1). Based on both, frequency of occurence and Species Importance Value Index (IVI) the most dominant tree species were found to be; *Brachystegia boehemii* (61%), *Brachystegia spiciformis* (14%) and *Parinari excelsa* (12%). The IVI of Iwuma village forest reserve miombo woodland was 300 (Table 2).

Table 1: A list of tree species identified in the Iwuma Forest Reserve, Mbozi District

S/n	**Species name**	**Number of occurence**	**% age of dominance**
1	*Brachystegia boehemii*	994	61
2	*Brachystegia spiciformis*	237	14
3	*Parinari excelsa*	192	12
4	*Julbernadia globiflora*	79	5
5	*Protea rupense*	50	3
6	*Uapaka kirkiana*	22	1
7	*Combretum molle*	21	1
8	*Despems abysinica*	18	1
9	*Protea gagued*	12	1
10	*Combretum zeyherii*	10	1
11	*Bosia salisfolia*	1	0
	TOTAL	**1636**	**100**

Table 2: A list of species and dominance based on Species Importance Value Index (IVI)

Spp	**Relative Frequency**(RF)	**Relative density**(RD)	**Relative Domince**(RDo)	RF+RD+RDo
Brachystegia boehemii	60.7579	60.7579	61.598	183.1138
Brachystegia spiciformis	14.4866	14.4866	15.2763	44.2495
Paripari excelsa	11.7359	11.7359	11.0172	34.489
Julbernadia globiflora	4.8289	4.8289	4.9982	14.656
Protea rupense	3.0562	3.0562	2.3231	8.4355
Uapaka kirkiana	1.3447	1.3447	1.3024	3.9918
Combretum molle	1.2836	1.2836	0.704	3.2712
Despems abysinica	1.1002	1.1002	0.9504	3.1508
Protea gagued	0.7335	0.7335	0.7744	2.2414
Combretum zeyherii	0.6112	0.6112	1.056	2.2784
Bosia salisfolia	0.0611	0.0611	0.0106	0.1328
TOTAL	**99.9998**	**99.9998**	**100.0106**	**300.0102**

Same tree species were also reported as common species of miombo woodlands of the Southern Highlands of Tanzania, (Munishi *et al*., 2010). This species composition and dominance has an important message to sustainable management and conservation of the Iwuma forest reserve. Species like *Brachystegia boehemii*, *Brachystegia spiciformis* and *Parinari excelsa* would be given a special consideration in terms of conservation in order to ensure persistence in carbon storage for that forest.

4.1.2 Species Diversity

Based on values of the indices of diversity, the diversity of the forest looks low compared to other studies in the miombo woodlands. The Shannon-Wiener index obtained with regard to this study had a value of 1.3 (Table 3). This index is all about the number of species (species richness) and species distribution (species evenness). Any ecosystem with a Shannon Wiener index value which is greater than 2.0 is regarded as medium to highly diverse in terms of species, (Barbour *et al*., 1999). Generally, the greater the value of H’, the higher the species diversity. The result therefore suggests that, there is relatively low species diversity in Iwuma forest reserve. Comparative studies of other scholars in other areas; miombo woodlands have higher values compared to these results indicating high species diversity in those forests compared to Iwuma forest reserve and this might be due to differences in geographical locations, environmental and genetic factors. A study by Zahabu, (2001) at Kitulangalo forest reserve, Morogoro, Tanzania, reported an H' value of 3.13, Giliba *et al.*, (2011), reported 4.27 as H' value of Bereku forest reserve, a miombo woodland in Babati District, Manyara region, Tanzania while Mohamed, (2006) reported a value of 3.1 for Handeni Hill forest reserve, Tanga, Tanzania.

The Simpsom index of Dominance value calculated was 0.4 (Table 3). This value is high suggesting that, there is high dominance of few species in the Iwuma village forest reserve and therefore low diversity because the higher the index of Dominance value the lower the diversity and vice versa (Ingram *et al*., 2005). The index of dominance in this study is relatively higher when compared to other studies with similar ecological conditions, for instance; Giliba *et al*., (2011) reported an index of Dominance of 0.043, Malimbwi and Mugasha (2002) reported an ID value of 0.073 while Mohamed (2006) found an ID of 0.063 for the same miombo woodland forests in Handeni Hill Forest reserve, Tanga, Tanzania.

Table 3: Tree species composition and Diversity in Iwuma forest reserve, Mbozi District

Parameter	**Values**
Richness (Total number of species)	11
Shannon-Wiener index of diversity	1.3
Simpson's index	0.4

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4.1.3 Tree stocking (N), Basal area (G) and Standing volume (V)

a) Tree stocking (N)

The average number of stems in Iwuma forest reserve (for trees ≥ 5cm) was 553 SPH (Table 4). Diameter class distribution of Iwuma forest reserve showed a reversed J-distribution with number of stems decreasing with an increase in diameter at breast height (Figure 2). This confirms that, the ecosystem is regenerating. It has been shown that stocking in miombo woodlands of Handen Hill was 355 SPH (Malimbwi and Mugasha, 2001) and 817 SPH (Mohamed, 2006), Malaisse, (1978) observed a stocking of 520 – 645 ha^{-1} in miombo woodlands of Katanga.

Table 4: Forest stocking parameters from Iwuma forest reserve, Mbozi District

Species name	V (m^3/ha)	G (m^2/ha)	N (SPH)
Brachystegia boehemii	110.63	17.50	994
Brachystegia spiciformis	27.49	4.34	237
Parinari excelsa	19.55	3.13	192
Julbernadia globiflora	8.69	1.42	79
Protea rupense	3.78	0.66	50
Uapaka kirkiana	2.25	0.37	22
Combretum molle	1.04	0.20	21
Protea gagued	1.32	0.22	12
Despems abysinica	1.52	0.27	18
Combretum zeyherii	2.20	0.30	10
Bosia salisfolia	0.01	0.003	1
MEAN	**60.29**	**9.60**	**553**

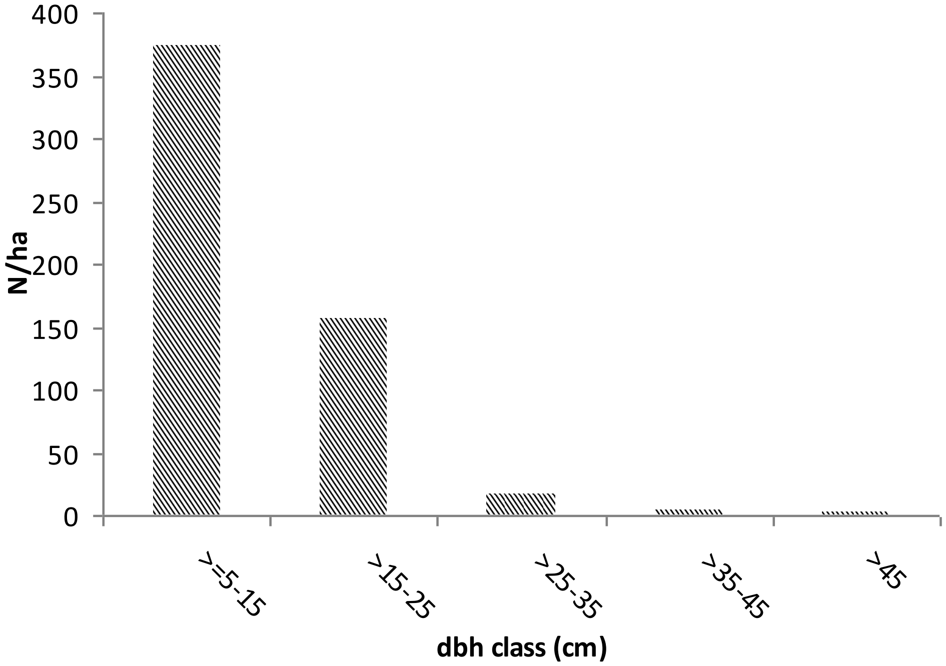

Figure 2: The Diameter class distribution in Iwuma forest reserve, Mbozi District

b) Basal Area (G) and Standing Volume (V)

The mean basal area and standing volume was 9.6 m^2ha^{-1} and 60.29 m^3ha^{-1} for Iwuma forest reserve respectively. Basal area ranging from 7 to 25 m^2 per hectare is the most reported for miombo woodlands (Lowore *et al*., 1994; Zahabu, 2001; Mohamed, 2006). Based on these findings, both, basal area and standing volume of Iwuma forest reserve are within the ranges of normal stocking of the regional miombo woodlands (Figures 3 & 4). A study done at the Kitulangalo government forest reserve by Chamshama *et al*., (2004) reported basal area and standing volume of 9 m^2 per hectare and 76 m^3 per hectare respectively. Zahabu, (2001) reported basal area and standing volume of 10.1 m^2 per hectare and 78 m^3 per hectare in Kilungalo forest reserve respectively. Small differences noticed when comparing the stocking parameters may be due to site differences and species composition factors.

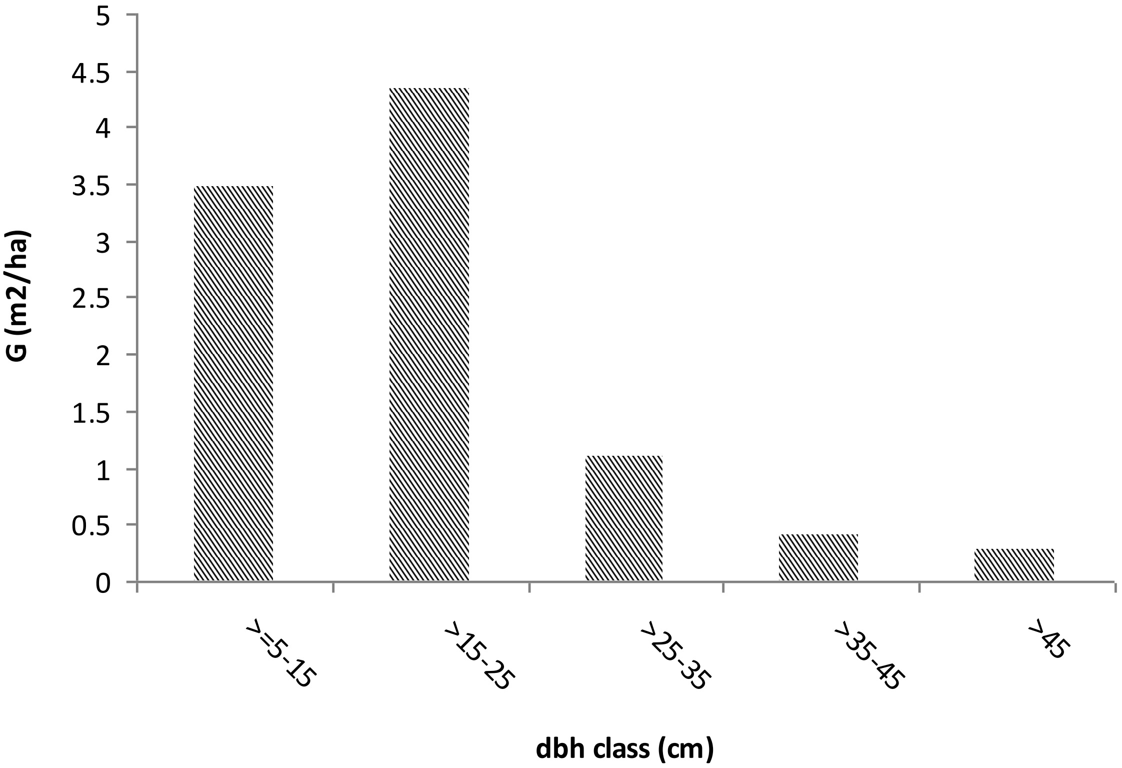

Figure 3: Distribution of basal area by diameter classes in Iwuma forest reserve, Mbozi District, Tanzania

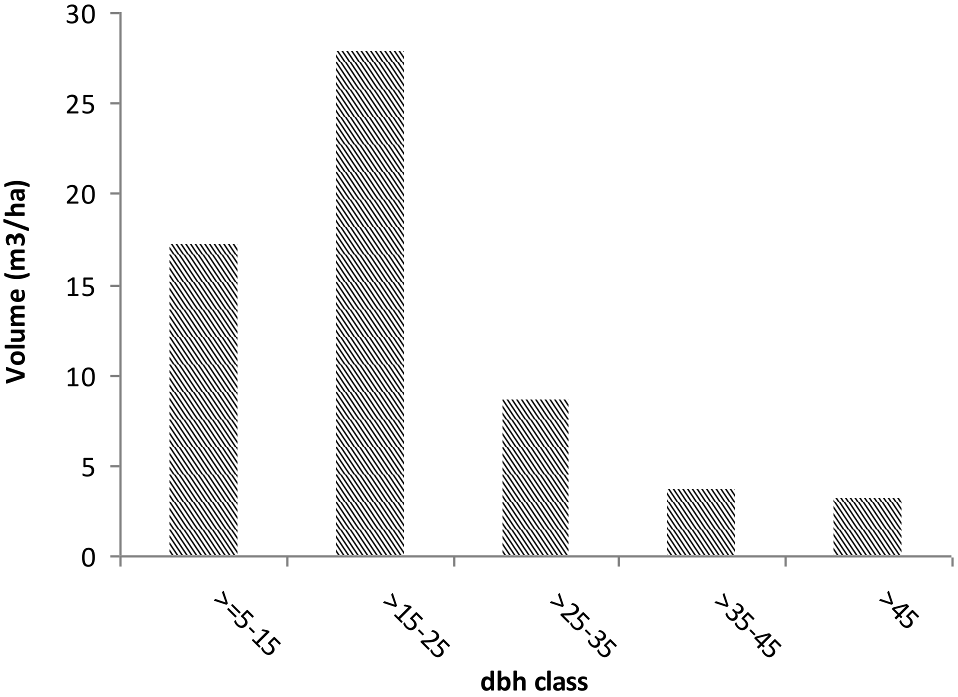

Figure 4: Distribution of volume of standing crop by diameter classes in Iwuma forest reserve, Mbozi District, Tanzania

4.2 Comparison of Basic Wood Density Between and Within Tree Species

A total of 820 wood cores were extracted from different tree species of the Iwuma forest reserve and brought to the laboratory for processing and analysis (Table 5).

Table 5: Wood cores extracted from different tree species of the Iwuma forest reserve, Mbozi District

Name of species	Total number of wood cores per species
Brachystegia boehemii	340
Brachystegia spiciformis	166
Combretum molle	28
Combretum zeyherii	6
Despems abysinica	12
Julbernadia globiflora	36
Parinari excelsa	144
Protea gagued	8
Protea rupense	64
Uapaka kirkiana	14
Bosia salisfolia	2
TOTAL WOOD CORES	**820**

Plate 1: Wood core extracted at ½ a tree height using a wood corer in Iwuma forest reserve, Mbozi District (Photo: Yohane Mwampashi)

4.2.1 Basic density

The basic density of the trees at DBH and at ½ a tree height are shown in (Table 6, Appendix 7).

Table 6: Average basic density between tree species of Iwuma Forest Mbozi District

S/n	Species name	Average density (gcm^{-3})	Number of individuals	Average DBH(cm)
1	*Brachystegia boehemii*	0.44	170	15.4
2	*Brachystegia spiciformis*	0.46	83	13.5
3	*Combretum molle*	0.44	14	10.2
4	*Combretum zeyherii*	0.59	3	16.2
5	*Despems abysinica*	0.41	6	6.0
6	*Julbernadia globiflora*	0.49	18	16.5
7	*Parinari excelsa*	0.47	72	14.7
8	*Protea gagued*	0.46	4	20.2
9	*Protea rupense*	0.48	32	12.8
10	*Uapaka kirkiana*	0.43	7	13.4
11	*Bosia salisfolia*	0.46	1	7.0

Combretum zeyherii has the highest basic density compared to the other tree species of Iwuma village forest reserve with the average basic density of $0.59gcm^{-3}$, *Julbernadia globiflora* ($0.49gcm^{-3}$) ranked the second, followed by *Protea rupense* ($0.48gcm^{-3}$), *Parinari excelsa* ($0.47gcm^{-3}$), *Brachystergia spiciformis, Bosia salisfolia* and *Protea gagued* ($0.46gcm^{-3}$), *Brachystergia boehemii* and *Combretum molle* had $0.44gcm^{-3}$ each, and the last two species were *Uapaka kirkiana* and *Despems abysinica* with density of $0.43gcm^{-3}$ and $0.41gcm^{-3}$ respectively.

Variation in basic density could be due to the age of the tree in which wood cores were extracted. Species like *Brachystergia boehemii* with 170 individuals might be affected by the fact that, many individuals were at juvenile stage which have a great effect on basic density variation while *Combretum zeyherii* with only three individuals is likely to have all matured individuals and hence high basic density.

Basic density variation between tree species may also be attributed to different factors, such as; location/environment of the individual tree species, location in its range, site conditions and genetic factors. These reasons among others might have been responsible for the differences in basic density in this study for species like *Brachystergia boehemii, Brachystergia spiciformis* and *Combretum* species when compared with the study of Malimbwi *et al*., (1994). In their study at Kitulangalo forest reserve they reported average basic density for *Brachystergia boehemii* to be 0.74gcm^{-3}, *Brachystergia spiciformis* as 0.61gcm^{-3} and 0.78gcm^{-3} for *Combretum* species. The values of all basic densities of species named above were higher than the values for the same species from the Iwuma village forest reserve. This may be due to genetic and age factors, Kitulangalo, an old forest being conserved for a long time and hence having trees with larger DBH compared to Iwuma forest reserve which is a new forest gazetted in 2004. The findings of this study are in agreement with Shirima *et al.,* (2011), who reported wood density of individual species ranging from 0.22gcm^{-3} to 0.56gcm^{-3} except for the *Combretum zeyherii* which has a slightly higher basic density of 0.59gcm^{-3}. Together with the above factors leading to differences in basic density of some species, Williams *et al*., (2008) mentions other factor like, site specific, growth condition and position on the tree.

4.2.2 Basic density within the same tree species

Average basic density of *Brachystergia boehemii* species was a little bit higher at ½ a tree ($0.45gcm^{-3}$) than that at DBH ($0.44gcm^{-3}$), basic density of *Brachystergia spiciformis* was the same at both ½ a tree and at DBH while it was higher at DBH than at ½ a tree with *Combretum molle* and with *Combretum zeyherii* species, unlike the above two species, basic density was observed to be less at DBH and higher at ½ a tree with *Despems abysinica* and *Bosia salisfolia,* while *Julbernadia globiflora* species showed higher basic density at DBH than that of ½ tree but basic density was constant with *Parinari excelsa* species, *Protea gagued* and *Protea rupense* species showed an increase of basic density with height while there were no changes in basic density in *Uapaka kirkiana* species (Table 7).

Table 7: Basic density differences at DBH and at ½ a tree from Iwuma forest tree species, Mbozi District

Species name	Average Basic density (gcm^{-3}) at DBH	Average Basic density (gcm^{-3}) at ½ tree	Average DBH (cm)
Brachystegia boehemii	0.44	0.45	15.4
Brachystegia spiciformis	0.46	0.46	13.5
Combretum molle	0.46	0.43	10.2
Combretum zeyherii	0.59	0.54	16.2
Despems abysinica	0.38	0.45	6.0
Julbernadia globiflora	0.51	0.49	16.5
Parinari excelsa	0.47	0.47	14.7
Protea gagued	0.45	0.49	20.2
Protea rupense	0.47	0.50	12.8
Uapaka kirkiana	0.43	0.43	13.4
Bosia salisfolia	0.46	0.47	7.0

Mean basic densities at DBH ($0.46gcm^{-3}$) and that of ½ a tree ($0.47gcm^{-3}$) showing that it was increased with height. This might have been caused by extracting wood cores only at DBH and at ½ a tree.

The observed variation might be attributed to age and genetic differences. The age of the cambium and the stimuli to which it is subjected during growth influence horizontal and vertical variation of density in a tree, (Zziwa *et al.,* 2006). Few studies have been done especially in hardwoods to find a variation of the basic density of the stem within the same species but a study of some species like *Meosopsis eminii* and *Antiaris toxicaria* by (Desch, 1981) show a slight decreasing of basic density and strength properties with increasing height. A study done in *Eucalyptus grandis* by Hans, (1976), as cited by Wilkins and Horne, (1991) reported that, major density differences within trees have been attributed to age of trees and to a lesser extent, height in the stem. Those findings are supported by the fact that juvenile wood is usually known to have lower density than mature wood (Zobel and Buijtenen, 1989).

Wood density and tree- ring growth have been used extensively as indicators of climate change, where growth is generally related to rainfall in the growing season and wood density is a predictor for summer temperatures. While these relations have been established for conifers, (Briffa *et al*., 2004), deciduous species have not been studied in detail, especially with respect to wood density because of the more complicated structure and variability in their annual tree-ring growth, (Bouriaud *et al*., 2004). Another argument on variation of basic density within a tree was reported by Skomarkova *et al.,* (2006), where lower values of wood density of *Fagus sylvatica* found in Germany and Italy were observed at the beginning of the growing season, this was followed by a period with more less constant wood density, which then increased later in the season to reach a maximum at the end of the growing season. The same author also argues that, change in the density profile as well as the seasonal trends was mainly caused by seasonal changes in the frequency of vessels in the wood matrix. The facts that there is seasonal changes in the frequency of vessels in the wood matrix (hence seasonal variation), the issues of juvenile and mature wood, height in the stem itself, age and genetic differences are probably the main factors that cause density variation within tree species.

4.3 Carbon Stock

4.3.1 Total carbon

Average Carbon stock estimated for all 11 tree species found in the Iwuma forest reserve was 39.45t ha^{-1} (Table 8). This value is higher when compared with average carbon of 19.12t ha^{-1} by Munishi *et al*., (2010) from similar Miombo woodlands at Zelezeta and Longisonte forest reserves. The main reason for this difference might be differences in methods, human disturbances compared to Iwuma village forest which has been properly managed hence minimum human disturbances.

Table 8: Carbon contributed by different species in Miombo woodlands at the Iwuma forest reserve, Mbozi District

S/n	Species name	Carbon, t ha^{-1}	Basal area (m^2/ha)	% carbon by species
1	*Brachystegia boehemii*	23.85	17.50	60.45
2	*Brachystegia spiciformis*	6.19	4.34	15.69
3	*Parinari excelsa*	4.50	3.13	11.41
4	*Julbernadia globiflora*	2.08	1.42	5.27
5	*Protea rupense*	0.89	0.66	2.26
6	*Uapaka kirkiana*	0.47	0.37	1.19
7	*Combretum molle*	0.22	0.20	0.56
8	*Despems abysinica*	0.31	0.27	0.79
9	*Protea gagued*	0.30	0.22	0.76
10	*Combretum zeyherii*	0.64	0.30	1.62
11	*Bosia salisfolia*	0.003	0.003	0.01
	TOTAL	**39.45**	**28.4**	**100**

Plate 2: Intact Iwuma Village Forest Reserve potential for Carbon storage, Mbozi District (Photo: Yohane Mwampashi)

It should be noted that, carbon resulting from several allometric equations/methods and these equations/methods originate from different sites can lead to different outputs. Brown, (2003), put it very clear that, different equations which are used in carbon estimation can lead to diversity in the output depending on geographical location from which the equation was developed, vegetation type and input variables.

Differences in carbon storage capacity among Miombo woodland species is inevitable. These species have been exposed to different climatic and environmental conditions, different approaches for carbon quantification and genetic factors among others. Munishi *et al.*, (2010), responded to these variations in carbon storage that, differences in carbon densities might be due to varying degrees of exposure to human degradation, the difference in the age of the tree species and the type of the Miombo woodlands involved. These reasons might be the main causes of the difference in carbon stored by the miombo woodlands in Iwuma forest reserve when compared with the other areas. Carbon stock for the Iwuma forest reserve was found to be higher than those reported by Chamshama *et al*., (2004), zahabu, (2008) and Shirima *et al*., (2011) which were 19.04MgC ha^{-1}, 22.5MgC ha^{-1} and 23.3MgC ha^{-1} respectively. However, higher carbon stocks have been reported by K: TGAL. (2008), (Kyoto: Think Global Act Local project) research project from Duru-Haitemba (old growth miombo forest) as 75.4t ha^{-1}. Again, the potential of forests to sequester carbon depends on the forest type, age of the forest and size class of trees, (Terakunpisut *et al*., 2007). On the other hand volumes of literature reveal that, miombo woodland vegetations are the most extensive area in Tanzania covering about 45% of the total land surface while only about 2% is covered by closed-canopy forests. This information must have big implications on carbon storage potential of the ecosystem in Tanzania compared to other vegetation and therefore needs a close attention on their management and conservation.

Plate 3: *Brachystegia* woodland “miombo” as it was observed in the Iwuma forest reserve, Mbozi District (Photo: Yohane Mwampashi)

4.3.2 Carbon stock for the dominant tree species

About 34.54t ha^{-1} carbon was found to be stored by three species dominating Iwuma forest reserve which were identified as *Brachystegia boehemii*, *Brachystegia spiciformis* and *Parinari excelsa*. This study has also proved that, the dominating species in both occurrence or frequency, Importance Value Index and basal area content are the ones which have high contribution to carbon storage of the forest. This is in agreement that, *Brachystegia boehemii* with its total individuals of 994, IVI (61) and basal area of 17.5m^2/ha, stored the highest amount of carbon per unit area in Iwuma forest reserve of 23.85t ha^{-1} (60.45%), followed by *Brachystegia spiciformis* with 237 individuals, IVI (14) and basal area of 4.34m^2/ha storing 6.19t ha^{-1} (15.69%) and *Parinari excelsa* with 192 individuals, IVI (12) and basal area of 3.13 storing 4.5t ha^{-1} (11.41%) of carbon (Table 9 and Figure 5).

Therefore carbon stock stored by only three dominant tree species (*Brachystegia boehemii, Brachystegia spiciformis* and *Parinari excelsa)* accounts for about 87.55% of the total carbon in the forest, meaning that, only 12.45% of carbon is the only portion stored by the other remaining eight tree species. This means more conservation measures to these species because if anything bad happens like eruption diseases to these species, it would be a disas trous to the whole ecosystem.

Table 9: Carbon storage by three dominant tree species in Iwuma forest reserve in Mbozi District

S/n	Species name	Carbon, t ha^{-1}	Basal area (m^2/ha)	% carbon per species
1	*Brachystegia boehemii*	23.85	17.5	60.45
2	*Brachystegia spiciformis*	6.19	4.34	15.69
3	*Parinari excelsa*	4.5	3.13	11.41
	TOTAL	**34.54**	**24.97**	**87.55**

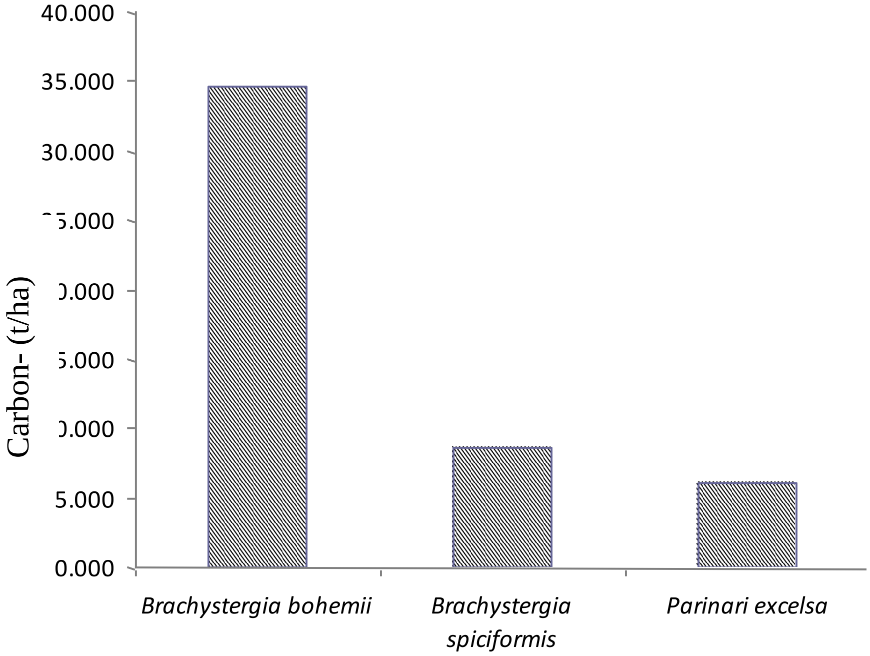

Figure 5: Carbon stored by three dominant tree species in the Iwuma forest reserve, Mbozi District

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMANDATIONS

The intention of this study was to estimate above ground carbon stock of the forest and of the most dominating tree species of wet miombo woodlands, assess forest stand structure and identify the variation in basic density between and within tree species of Iwuma forest reserve in Mbozi District. Species diversity of the forest was relatively low (H' = 1.3) with only 11 tree species and a stocking of 553 SPH (trees ≥ 5cm). The study revealed an amount of 39.45t ha^{-1} as carbon stored by the forest and dominant tree species (*Brachystegia boehemii, Brachystegia spiciformis* and *Parinari excelsa*) contributing to about 87.55% of the total carbon stock of the ecosystem. *Brachystegia boehemii* species alone accounted for about 61%. Proper management of the forests for carbon storage would therefore focus on managing *Brachystegia boehemii, Brachystegia spiciformis* and *Parinari excelsa* with implications on management of the associated species in the miombo woodlands of Southern Highlands of Tanzania.

Proper management practices to this miombo woodland will lead to high contribution of the ecosystem as carbon sinks hence reduce emission of CO_2 to the atmosphere and therefore have a positive effect on the REDD+ process in Tanzania and the global at large. The Iwuma forest reserve can be a good example of participatory forest management for carbon emission mitigation. The study has shown low basic density for most of tree species of the forest, this has been contributed mainly by age of the forest, genetic and environmental factors. However, the basic density parameter should not be overlooked in studies mainly for carbon stock estimation and with the fact that many strength properties of wood for many tree species have a positive correlation with basic density.

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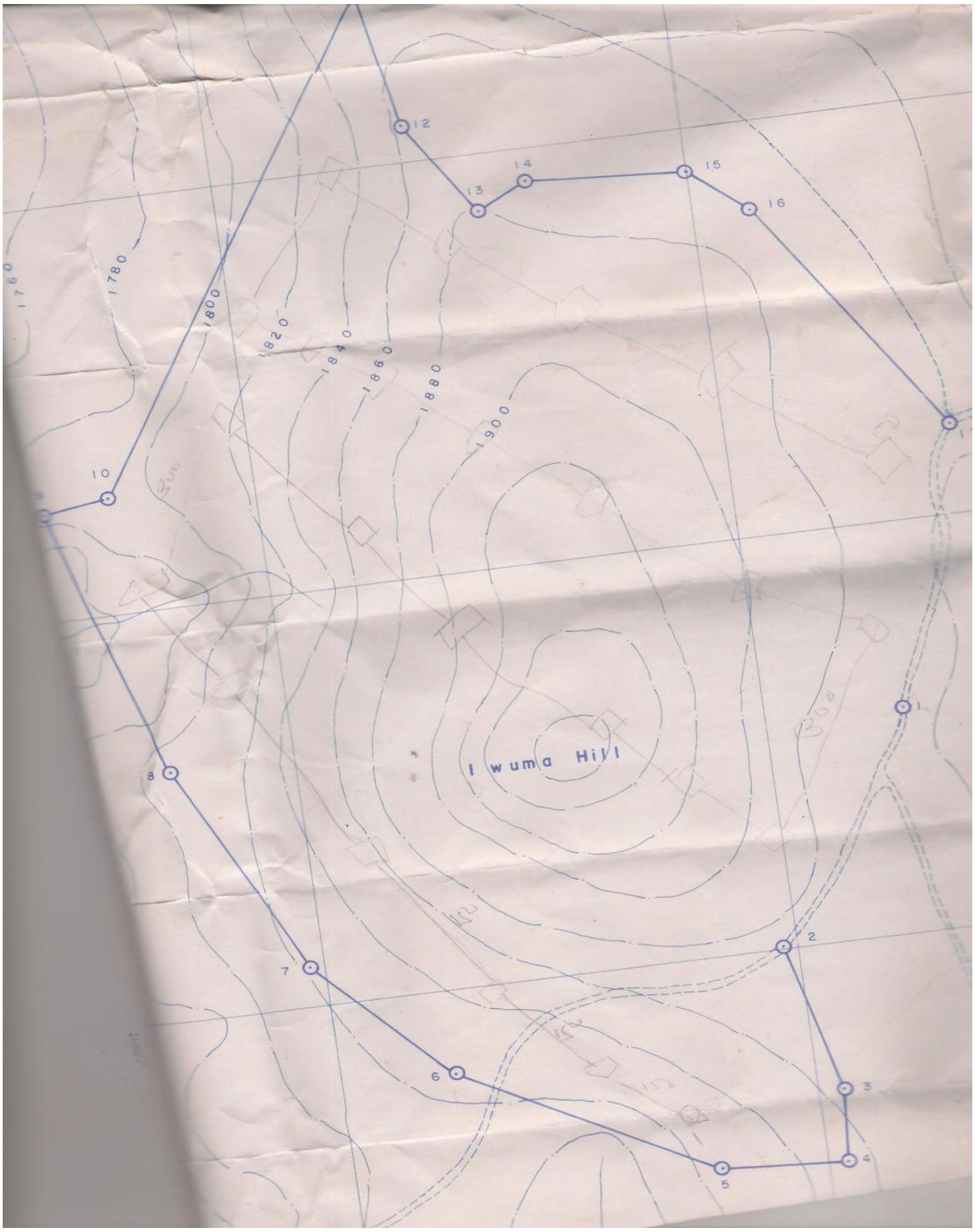
APPENDICES

Appendix 1: A map of Iwuma village forest reserve (The study area)

AREA 204 HECTARES OR 2.04SQ KILOMETRES



SCALE 1:15000

Appendix 2: Checklist of the tree species of Iwuma forest reserve

S/N	Spp Code	Botanical Name	Local Name(nyiha)
1	11	*Bosia salisfolia*	Isahala
2	2	*Brachystergia boehemii*	Ing'anzo
3	1	*Brachystergia spiciformis*	Iyombo
4	10	*Combretum molle*	Ilama
5	5	*Combretum zeyherii*	Ihahatu
6	3	*Despems abysinica*	Isisibhizi
7	9	*Julbernadia globiflora*	Iyombo
8	8	*Parinari excels*	Ibhula
9	4	*Protea gagued*	Isense
10	6	*Protea rupense*	Ivundavunda
11	7	*Uapaka kirkiana*	Ikusu

Appendix 3: Forested area on Tanzania mainland.

Forest type	Area Km^2	Percent %
Closed Forests	24 313	6.1
Miombo woodlands	374 356	93.2
Mangroves	1 569	0.4
Plantations	1 349	0.3
Total	**401 587**	**100.0**

Appendix 4: Plot form used for recording information in the field

	PLOT FORM			
	Plot No…………., Date………/……………/………………..			
	Transect No……………,Plot area…………………			
	GPS X (Eastings)………………………………………., District Name………………………….			
	GPS Y (Northings)……………………………………., Ward Name……………………………			
	Forest Name&area……..…………………………….. , Village Name…………………………….			
T/No	**Local Name**	**Botanical Name**	**DBH(cm)**	**HT(m)**

Appendix 5: Dominant tree form used to record information of all dominant trees

DOMINANT TREE FORM									
T/No	Species name	Tree Parameters				At DBH		1/2 a tree	
		HT(m)	DBH(cm)	Crn.D	Crn.h	G.v	O.d	G.v	O.d

Appendix 6: Carbon calculation by multiplying volume and basic density

Plot No	vol(m^3)	G(m^2/ha)	N/ha	BD(g/cm^3)	Biomasst/ha	Carbont/ha
1	3.017539864	0.66195145	72	0.46	1.370087362	0.671342807
2	4.963800802	0.83041514	47	0.46	2.259391704	1.107101935
3	6.572858966	1.075657	57	0.47	3.087342095	1.512797627
4	4.529208996	0.83329636	77	0.46	2.163430165	1.060080781
5	3.329492248	0.60781914	55	0.46	1.570871557	0.769727063
6	6.275506854	0.95345486	42	0.44	2.768081491	1.35635993
7	6.715013993	0.99407943	42	0.44	2.956784647	1.448824477
8	7.009958187	0.95473007	41	0.44	3.084381602	1.511346985
9	7.904931877	1.19660043	70	0.45	3.589221795	1.75871868
10	7.450252005	1.18680964	66	0.44	3.314190168	1.623953182
11	5.076058809	0.93044521	72	0.44	2.233352753	1.094342849
12	11.39605012	1.20316036	20	0.45	5.052751181	2.475848079
13	2.886686433	0.3839715	10	0.46	1.335942942	0.654612041
14	5.917120947	0.90916886	39	0.46	2.786504703	1.365387304
15	5.932889067	0.92238547	40	0.44	2.62285257	1.285197759
16	4.249543179	0.778404	66	0.45	1.909243142	0.93552914
17	5.340262099	0.93523886	64	0.45	2.412838059	1.182290649
18	4.750261853	0.73890771	35	0.45	2.102608302	1.030278068
19	6.310051283	0.92270279	38	0.45	2.817399174	1.380525595
20	5.453824843	0.86007193	40	0.45	2.45863318	1.204730258
21	4.574209691	0.72400979	40	0.45	2.056446078	1.007658578
22	2.715930512	0.45591621	22	0.46	1.250571752	0.612780158
23	4.592584864	0.79650764	50	0.44	2.027039075	0.993249147
24	5.954694791	1.00731007	58	0.45	2.661322482	1.304048016
25	2.366121229	0.43334421	34	0.47	1.101392088	0.539682123
26	1.850359656	0.33283879	24	0.45	0.843349184	0.4132411
27	4.318117978	0.73883229	48	0.44	1.913864502	0.937793606
28	5.261859919	0.83614457	40	0.45	2.404958101	1.17842947
29	2.869982664	0.38307971	11	0.46	1.346058928	0.659568875
30	4.249589219	0.70833164	41	0.44	1.865588369	0.914138301
31	3.830464335	0.66065293	44	0.45	1.708619766	0.837223685
32	4.896468955	0.78214086	40	0.46	2.312209415	1.132982613
33	4.891149421	0.76050071	32	0.44	2.16415526	1.060436077
34	4.700383084	0.78638686	47	0.44	2.095972214	1.027026385
35	2.146568375	0.41018843	40	0.44	0.944614131	0.462860924
36	3.306412738	0.56094814	38	0.46	1.538599655	0.753913831
37	0.86389636	0.19831664	34	0.47	0.406031289	0.198955332
TOTAL	**178.4701062**	**28.4547197**	**1636**		**80.53670088**	**39.46298343**
MEAN	**60.2939548**	**9.59874387**	**553**		**27.20834489**	**13.332089**

Appendix 7: Basic density calculated from wood cores from the Iwuma forest reserve, Mbozi District

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
22	20	½	0.51	0.25	0.49	
22	20	1.3	0.5	0.29	0.58	0.54
22	6	1.3	0.6	0.31	0.52	
22	6	½	0.65	0.3	0.46	0.49
22	8	½	0.48	0.25	0.52	
22	8	1.3	0.5	0.22	0.44	0.48
22	4	½	0.45	0.21	0.47	
22	4	1.3	0.48	0.19	0.40	0.43
22	16	½	0.5	0.26	0.52	
22	16	1.3	0.35	0.23	0.66	0.59
22	17	½	0.5	0.33	0.66	
22	17	1.3	0.51	0.25	0.49	0.58
22	18	½	0.52	0.29	0.56	
22	18	1.3	0.6	0.36	0.60	0.58
22	5	1.3	0.6	0.24	0.40	
22	5	½	0.5	0.23	0.46	0.43
22	15	1.3	0.5	0.25	0.50	
22	15	½	0.53	0.33	0.62	0.56
22	22	1.3	0.85	0.46	0.54	
22	22	½	0.5	0.34	0.68	0.61
22	2	½	0.95	0.32	0.34	
22	2	1.3	0.65	0.28	0.43	0.38
22	1	½	0.45	0.22	0.49	
22	1	1.3	0.49	0.23	0.47	0.48
31	32	1.3	0.65	0.38	0.58	
31	32	½	0.49	0.28	0.57	0.58
31	37	1.3	0.5	0.23	0.46	
31	37	½	0.66	0.31	0.47	0.46
31	6	1.3	0.5	0.29	0.58	
31	6	½	0.49	0.2	0.41	0.49
31	40	½	0.49	0.28	0.57	
31	40	1.3	0.49	0.22	0.45	0.51
31	13	½	0.49	0.22	0.45	
31	13	1.3	0.47	0.2	0.43	0.44
31	8	1.3	0.51	0.26	0.51	
31	8	½	0.7	0.39	0.56	0.53
31	42	1.3	0.63	0.39	0.62	
31	42	½	0.52	0.26	0.50	0.56
31	9	1.3	0.51	0.28	0.55	
31	9	½	0.48	0.2	0.42	0.48

Plot no	**Tree no**	**Wood Core at**	**V (cm³)**	**Oven dry (gm)**	**BD**	**Avg BD**
31	27	1.3	0.62	0.39	0.63	
31	27	½	0.51	0.26	0.51	0.57
31	44	½	0.5	0.27	0.54	
31	44	1.3	0.75	0.27	0.36	0.45
31	39	1.3	0.85	0.24	0.28	
31	39	½	0.5	0.22	0.44	0.36
31	30	1.3	0.51	0.26	0.51	
31	30	½	0.49	0.23	0.47	0.49
31	41	½	0.5	0.24	0.48	
31	41	1.3	0.9	0.24	0.27	0.37
36	31	½	0.65	0.31	0.48	
36	31	1.3	0.61	0.29	0.48	0.48
36	2	½	0.5	0.29	0.58	
36	2	1.3	0.64	0.3	0.47	0.52
36	11	1.3	1	0.38	0.38	
36	11	½	0.51	0.28	0.55	0.46
36	30	½	0.52	0.22	0.42	
36	30	1.3	0.75	0.37	0.49	0.46
36	5	½	0.5	0.2	0.40	
36	5	1.3	0.89	0.19	0.21	0.31
36	28	1.3	0.75	0.25	0.33	
36	28	½	0.81	0.28	0.35	0.34
36	6	1.3	0.61	0.29	0.48	
36	6	½	0.86	0.32	0.37	0.42
36	7	½	0.95	0.28	0.29	
36	7	1.3	0.5	0.22	0.44	0.37
36	23	½	0.3	0.18	0.60	
36	23	1.3	0.49	0.17	0.35	0.47
36	1	½	0.65	0.27	0.42	
36	1	1.3	0.52	0.33	0.63	0.53
36	14	1.3	0.75	0.34	0.45	
36	14	½	0.25	0.23	0.92	0.69
36	37	½	0.49	0.27	0.55	
36	37	1.3	0.61	0.29	0.48	0.51
36	36	1.3	0.51	0.26	0.51	
36	36	½	0.98	0.39	0.40	0.45
36	29	½	0.41	0.14	0.34	
36	29	1.3	0.51	0.3	0.59	0.46
36	25	1.3	0.61	0.29	0.48	
36	25	½	0.55	0.29	0.53	0.5
25	26	1.3	0.5	0.28	0.56	
25	26	½	0.6	0.29	0.48	0.52
25	28	1.3	0.48	0.26	0.54	
25	28	½	0.8	0.29	0.36	0.45

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
25	34	1.3	0.9	0.34	0.38	
25	34	½	0.6	0.27	0.45	0.41
25	22	½	0.65	0.31	0.48	
25	22	1.3	0.7	0.25	0.36	0.42
25	31	1.3	0.6	0.33	0.55	
25	31	½	0.45	0.27	0.60	0.58
25	15	½	0.5	0.2	0.40	
25	15	1.3	0.4	0.29	0.73	0.56
25	29	1.3	0.5	0.26	0.52	
25	29	½	0.8	0.27	0.34	0.43
25	27	½	0.7	0.26	0.37	
25	27	1.3	0.7	0.32	0.46	0.41
25	18	1.3	0.4	0.19	0.48	
25	18	½	0.6	0.25	0.42	0.45
21	38	½	0.81	0.29	0.36	
21	38	1.3	0.75	0.29	0.39	0.37
21	24	½	0.54	0.26	0.48	
21	24	1.3	0.82	0.29	0.35	0.42
21	5	½	0.5	0.22	0.44	
21	5	1.3	0.5	0.26	0.52	0.48
21	22	½	0.62	0.27	0.44	
21	22	1.3	0.49	0.22	0.45	0.44
21	10	½	0.52	0.22	0.42	
21	10	1.3	1	0.37	0.37	0.4
21	9	½	0.5	0.2	0.40	
21	9	1.3	0.52	0.25	0.48	0.44
21	20	½	0.5	0.23	0.46	
21	20	1.3	0.45	0.17	0.38	0.42
21	28	½	0.5	0.2	0.40	
21	28	1.3	0.5	0.28	0.56	0.48
21	32	1.3	0.45	0.2	0.44	
21	32	½	0.51	0.24	0.47	0.46
21	18	1.3	0.5	0.3	0.60	
21	18	½	0.55	0.24	0.44	0.52
21	21	1.3	0.49	0.25	0.51	
21	21	½	0.55	0.34	0.62	0.56
30	9	1.3	0.75	0.27	0.36	
30	9	½	0.5	0.27	0.54	0.45
30	41	1.3	0.8	0.25	0.31	
30	41	½	0.65	0.26	0.40	0.36
30	40	½	0.65	0.23	0.35	
30	40	1.3	0.75	0.24	0.32	0.34
30	39	½	0.75	0.23	0.31	
30	39	1.3	0.95	0.25	0.26	0.28

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
30	2	1.3	0.48	0.2	0.42	
30	2	½	0.6	0.28	0.47	0.44
30	26	½	0.55	0.34	0.62	
30	26	1.3	0.75	0.3	0.40	0.51
30	19	1.3	0.45	0.22	0.49	
30	19	½	0.25	0.1	0.40	0.44
30	22	½	0.75	0.37	0.49	
30	22	1.3	0.75	0.32	0.43	0.46
30	33	½	0.6	0.31	0.52	
30	33	1.3	0.75	0.35	0.47	0.49
30	7	½	0.65	0.27	0.42	
30	7	1.3	0.9	0.43	0.48	0.45
28	25	½	0.85	0.27	0.32	
28	25	1.3	0.5	0.22	0.44	0.38
28	40	1.3	0.49	0.18	0.37	
28	40	½	0.65	0.25	0.38	0.38
28	18	1.3	0.45	0.22	0.49	
28	18	½	0.5	0.27	0.54	0.51
28	19	½	0.75	0.3	0.40	
28	19	1.3	0.65	0.31	0.48	0.44
28	35	½	0.75	0.35	0.47	
28	35	1.3	0.5	0.26	0.52	0.49
28	23	1.3	0.5	0.28	0.56	
28	23	½	0.5	0.28	0.56	0.56
28	14	1.3	0.5	0.23	0.46	
28	14	½	0.28	0.18	0.64	0.55
28	3	½	0.28	0.23	0.82	
28	3	1.3	0.75	0.28	0.37	0.6
28	1	½	0.75	0.25	0.33	
28	1	1.3	0.75	0.25	0.33	0.33
28	20	1.3	0.82	0.28	0.34	
28	20	½	0.76	0.26	0.34	0.34
28	27	1.3	0.85	0.37	0.44	
28	27	½	0.75	0.38	0.51	0.47
28	36	1.3	0.6	0.29	0.48	
28	36	½	0.75	0.29	0.39	0.44
28	12	½	0.65	0.24	0.37	
28	12	1.3	0.65	0.29	0.45	0.41
28	39	1.3	0.8	0.27	0.34	
28	39	½	0.75	0.25	0.33	0.34
28	8	½	0.75	0.28	0.37	
28	8	1.3	0.6	0.33	0.55	0.46
6	2	½	0.9	0.47	0.52	
6	2	1.3	1	0.51	0.51	0.52

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
6	4	1.3	0.75	0.24	0.32	
6	4	½	0.75	0.3	0.40	0.36
6	40	1.3	0.8	0.39	0.49	
6	40	½	0.75	0.42	0.56	0.52
6	22	½	0.5	0.27	0.54	
6	22	1.3	0.49	0.25	0.51	0.53
6	24	½	0.65	0.3	0.46	
6	24	1.3	0.65	0.29	0.45	0.45
6	43	1.3	0.49	0.17	0.35	
6	43	½	0.37	0.14	0.38	0.36
6	12	½	0.85	0.36	0.42	
6	12	1.3	0.98	0.42	0.43	0.43
6	19	½	0.95	0.38	0.40	
6	19	1.3	0.9	0.39	0.43	0.42
7	27	1.3	0.6	0.32	0.53	
7	27	½	0.5	0.23	0.46	0.5
7	20	½	0.85	0.32	0.38	
7	20	1.3	0.75	0.25	0.33	0.35
7	32	1.3	0.5	0.19	0.38	
7	32	½	0.55	0.21	0.38	0.38
7	3	1.3	0.6	0.24	0.40	
7	3	½	0.5	0.18	0.36	0.38
7	33	1.3	0.45	0.19	0.42	
7	33	½	0.25	0.13	0.52	0.47
7	15	½	0.9	0.45	0.50	
7	15	1.3	0.55	0.32	0.58	0.54
7	23	½	0.75	0.34	0.45	
7	23	1.3	0.75	0.4	0.53	0.49
7	21	1.3	0.5	0.2	0.40	
7	21	½	0.65	0.22	0.34	0.37
7	7	½	0.9	0.43	0.48	
7	7	1.3	0.9	0.48	0.53	0.51
26	20	½	0.75	0.24	0.32	
26	20	1.3	0.6	0.27	0.45	0.39
26	19	1.3	0.6	0.18	0.30	
26	19	½	0.55	0.23	0.42	0.36
26	10	1.3	0.55	0.26	0.47	
26	10	½	0.6	0.33	0.55	0.51
26	6	1.3	0.75	0.35	0.47	
26	6	½	0.25	0.27	1.08	0.77
26	17	½	0.48	0.19	0.40	
26	17	1.3	0.5	0.2	0.40	0.4
26	11	1.3	0.75	0.24	0.32	
26	11	½	0.75	0.32	0.43	0.37

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
26	23	1.3	0.5	0.22	0.44	
26	23	½	0.55	0.33	0.60	0.52
26	24	1.3	0.75	0.31	0.41	
26	24	½	0.75	0.28	0.37	0.39
26	4	½	0.8	0.32	0.40	
26	4	1.3	0.75	0.31	0.41	0.41
26	14	½	0.9	0.4	0.44	
26	14	1.3	0.75	0.3	0.40	0.42
26	9	½	0.5	0.17	0.34	
26	9	1.3	0.9	0.21	0.23	0.29
26	2	1.3	0.49	0.21	0.43	
26	2	½	0.27	0.19	0.70	0.57
10	12	1.3	0.65	0.26	0.40	
10	12	½	0.65	0.27	0.42	0.41
10	32	1.3	0.5	0.26	0.52	
10	32	½	0.8	0.36	0.45	0.49
10	13	½	0.8	0.32	0.40	
10	13	1.3	0.55	0.27	0.49	0.45
10	8	1.3	0.8	0.27	0.34	
10	8	½	0.9	0.36	0.40	0.37
10	41	½	0.5	0.25	0.50	
10	41	1.3	0.65	0.29	0.45	0.47
10	39	1.3	0.8	0.24	0.30	
10	39	½	0.75	0.28	0.37	0.34
10	2	½	0.75	0.32	0.43	
10	2	1.3	0.8	0.28	0.35	0.39
10	62	½	0.45	0.26	0.58	
10	62	1.3	0.77	0.22	0.29	0.43
10	53	½	0.9	0.31	0.34	
10	53	1.3	0.4	0.23	0.58	0.46
10	60	½	0.75	0.24	0.32	
10	60	1.3	0.65	0.25	0.38	0.35
10	37	1.3	0.55	0.33	0.60	
10	37	½	0.6	0.24	0.40	0.5
10	61	1.3	0.55	0.19	0.35	
10	61	½	0.45	0.17	0.38	0.36
10	59	1.3	0.25	0.16	0.64	
10	59	½	0.23	0.15	0.65	0.65
23	40	½	0.5	0.27	0.54	
23	40	1.3	0.75	0.28	0.37	0.46
23	24	1.3	0.6	0.17	0.28	
23	24	½	0.5	0.24	0.48	0.38
23	41	½	0.28	0.16	0.57	
23	41	1.3	0.55	0.26	0.47	0.52

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
23	42	1.3	0.75	0.29	0.39	
23	42	½	0.85	0.34	0.40	0.39
23	50	½	0.5	0.24	0.48	
23	50	1.3	0.62	0.33	0.53	0.51
23	12	1.3	0.45	0.17	0.38	
23	12	½	0.5	0.26	0.52	0.45
23	1	1.3	0.65	0.38	0.58	
23	1	½	0.5	0.26	0.52	0.55
23	44	1.3	0.65	0.25	0.38	
23	44	½	0.55	0.25	0.45	0.42
23	10	½	0.65	0.24	0.37	
23	10	1.3	0.55	0.21	0.38	0.38
23	32	1.3	0.55	0.2	0.36	
23	32	½	0.85	0.25	0.29	0.33
9	69	1.3	0.75	0.3	0.40	
9	69	½	0.8	0.25	0.31	0.36
9	37	1.3	0.9	0.33	0.37	
9	37	½	0.85	0.37	0.44	0.4
9	46	1.3	0.75	0.34	0.45	
9	46	½	0.55	0.23	0.42	0.44
9	28	1.3	0.8	0.31	0.39	
9	28	½	0.6	0.24	0.40	0.39
9	3	½	0.6	0.21	0.35	
9	3	1.3	0.5	0.21	0.42	0.39
9	18	½	0.8	0.36	0.45	
9	18	1.3	0.5	0.32	0.64	0.55
9	63	½	0.7	0.25	0.36	
9	63	1.3	0.8	0.32	0.40	0.38
9	55	½	0.49	0.24	0.49	
9	55	1.3	0.8	0.27	0.34	0.41
9	48	1.3	0.25	0.19	0.76	
9	48	½	0.9	0.34	0.38	0.57
9	70	1.3	0.9	0.37	0.41	
9	70	½	0.65	0.27	0.42	0.41
9	38	1.3	0.85	0.33	0.39	
9	38	½	0.6	0.22	0.37	0.38
37	1	1.3	0.75	0.23	0.31	
37	1	½	0.49	0.18	0.37	0.34
37	16	1.3	0.85	0.34	0.40	
37	16	½	0.45	0.13	0.29	0.34
37	26	1.3	0.75	0.3	0.40	
37	26	½	0.7	0.29	0.41	0.41
37	4	½	0.5	0.26	0.52	
37	4	1.3	0.65	0.35	0.54	0.53

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
37	34	½	0.75	0.39	0.52	
37	34	1.3	0.65	0.31	0.48	0.5
34	5	1.3	0.75	0.33	0.44	
34	5	½	1	0.46	0.46	0.45
34	30	1.3	0.5	0.25	0.50	
34	30	½	0.75	0.29	0.39	0.44
34	7	1.3	0.65	0.21	0.32	
34	7	½	0.75	0.26	0.35	0.33
34	34	½	0.55	0.24	0.44	
34	34	1.3	0.65	0.23	0.35	0.4
34	45	1.3	0.67	0.23	0.34	
34	45	½	0.56	0.23	0.41	0.38
34	43	1.3	0.82	0.32	0.39	
34	43	½	0.9	0.31	0.34	0.37
34	46	1.3	0.74	0.3	0.41	
34	46	½	0.72	0.33	0.46	0.43
34	16	½	0.75	0.28	0.37	
34	16	1.3	0.8	0.26	0.33	0.35
34	6	½	0.75	0.35	0.47	
34	6	1.3	0.75	0.31	0.41	0.44
34	42	½	0.55	0.18	0.33	
34	42	1.3	0.65	0.22	0.34	0.33
34	8	½	0.9	0.31	0.34	
34	8	1.3	0.8	0.31	0.39	0.37
8	17	1.3	0.9	0.33	0.37	
8	17	½	0.75	0.34	0.45	0.41
8	2	½	0.75	0.31	0.41	
8	2	1.3	0.55	0.37	0.67	0.54
8	18	½	0.49	0.24	0.49	
8	18	1.3	0.75	0.26	0.35	0.42
8	38	½	0.55	0.23	0.42	
8	38	1.3	0.45	0.17	0.38	0.4
8	1	½	0.4	0.23	0.58	
8	1	1.3	0.52	0.31	0.60	0.59
8	13	½	0.2	0.18	0.90	
8	13	1.3	0.75	0.3	0.40	0.65
8	30	½	0.76	0.25	0.33	
8	30	1.3	0.53	0.28	0.53	0.43
8	40	½	0.75	0.3	0.40	
8	40	1.3	0.54	0.33	0.61	0.51
11	64	½	0.65	0.24	0.37	
11	64	1.3	0.75	0.23	0.31	0.34
11	16	½	0.95	0.35	0.37	
11	16	1.3	0.65	0.23	0.35	0.36

Plot no	**Tree no**	**Wood Core at**	**V (cm³)**	**Oven dry (gm)**	**BD**	**Avg BD**
11	12	½	0.65	0.23	0.35	
11	12	1.3	0.75	0.25	0.33	0.34
11	70	½	0.52	0.18	0.35	
11	70	1.3	0.75	0.25	0.33	0.34
11	11	1.3	0.8	0.27	0.34	
11	11	½	0.5	0.23	0.46	0.4
11	63	1.3	1.15	0.4	0.35	
11	63	½	0.8	0.3	0.38	0.36
11	62	1.3	0.75	0.33	0.44	
11	62	½	1	0.4	0.40	0.42
12	15	1.3	0.8	0.39	0.49	
12	15	½	0.54	0.29	0.54	0.51
12	7	½	0.9	0.32	0.36	
12	7	1.3	0.78	0.34	0.44	0.4
12	8	1.3	0.74	0.33	0.45	
12	8	½	0.53	0.27	0.51	0.48
12	2	½	0.5	0.2	0.40	
12	2	1.3	0.75	0.3	0.40	0.4
12	10	1.3	0.75	0.18	0.24	
12	10	½	0.82	0.34	0.41	0.33
12	4	½	0.8	0.37	0.46	
12	4	1.3	0.49	0.32	0.65	0.56
12	12	½	0.75	0.31	0.41	
12	12	1.3	0.5	0.26	0.52	0.47
12	5	1.3	0.75	0.31	0.41	
12	5	½	0.76	0.26	0.34	0.38
12	1	½	0.5	0.18	0.36	
12	1	1.3	0.8	0.31	0.39	0.37
12	11	½	0.66	0.3	0.45	
12	11	1.3	0.74	0.3	0.41	0.43
5	38	½	0.45	0.14	0.31	
5	38	1.3	0.45	0.17	0.38	0.34
5	12	½	0.5	0.18	0.36	
5	12	1.3	0.8	0.4	0.50	0.43
5	15	1.3	0.52	0.23	0.44	
5	15	½	0.5	0.2	0.40	0.42
5	37	1.3	0.46	0.17	0.37	
5	37	½	0.45	0.15	0.33	0.35
5	1	½	0.45	0.2	0.44	
5	1	1.3	0.5	0.25	0.50	0.47
5	47	½	0.55	0.21	0.38	
5	47	1.3	0.5	0.23	0.46	0.42
5	48	½	0.75	0.25	0.33	
5	48	1.3	0.6	0.24	0.40	0.37

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
5	16	½	0.8	0.4	0.50	
5	16	1.3	0.7	0.42	0.60	0.55
5	26	1.3	0.7	0.26	0.37	
5	26	½	0.4	0.12	0.30	0.34
5	29	½	0.48	0.16	0.33	
5	29	1.3	0.48	0.16	0.33	0.33
5	2	1.3	0.52	0.23	0.44	
5	2	½	0.48	0.21	0.44	0.44
5	39	½	0.5	0.24	0.48	
5	39	1.3	0.45	0.3	0.67	0.57
5	8	½	0.5	0.3	0.60	
5	8	1.3	0.5	0.27	0.54	0.57
5	20	1.3	0.92	0.45	0.49	
5	20	½	0.49	0.23	0.47	0.48
5	28	1.3	0.54	0.21	0.39	
5	28	½	0.49	0.18	0.37	0.38
14	36	1.3	0.75	0.25	0.33	
14	36	½	0.75	0.33	0.44	0.39
14	26	1.3	0.75	0.34	0.45	
14	26	½	0.9	0.38	0.42	0.44
14	37	1.3	0.7	0.23	0.33	
14	37	½	0.6	0.28	0.47	0.4
14	19	½	0.5	0.3	0.60	
14	19	1.3	0.8	0.35	0.44	0.52
14	29	½	0.49	0.3	0.61	
14	29	1.3	1.1	0.57	0.52	0.57
14	10	½	0.5	0.28	0.56	
14	10	1.3	0.78	0.41	0.53	0.54
14	3	½	0.6	0.39	0.65	
14	3	1.3	0.65	0.32	0.49	0.57
14	32	½	0.5	0.28	0.56	
14	32	1.3	0.5	0.3	0.60	0.58
14	2	½	0.49	0.19	0.39	
14	2	1.3	0.5	0.19	0.38	0.38
14	24	1.3	0.48	0.11	0.23	
14	24	½	0.21	0.1	0.48	0.35
14	13	½	0.39	0.17	0.44	
14	13	1.3	0.47	0.2	0.43	0.43
16	43	½	0.55	0.23	0.42	
16	43	1.3	0.7	0.32	0.46	0.44
16	61	½	0.75	0.27	0.36	
16	61	1.3	0.56	0.28	0.50	0.43
16	17	1.3	0.85	0.31	0.36	
16	17	½	0.6	0.25	0.42	0.39

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
16	39	1.3	0.6	0.23	0.38	
16	39	½	0.75	0.24	0.32	0.35
16	53	½	0.48	0.2	0.42	
16	53	1.3	0.85	0.35	0.41	0.41
16	37	1.3	0.75	0.34	0.45	
16	37	½	0.74	0.31	0.42	0.44
16	21	1.3	0.48	0.25	0.52	
16	21	½	0.55	0.27	0.49	0.51
16	31	1.3	0.81	0.38	0.47	
16	31	½	0.8	0.34	0.43	0.45
16	26	1.3	0.64	0.26	0.41	
16	26	½	0.65	0.21	0.32	0.36
16	19	½	0.9	0.34	0.38	
16	19	1.3	0.94	0.31	0.33	0.35
16	2	½	0.75	0.32	0.43	
16	2	1.3	0.9	0.34	0.38	0.4
16	10	½	0.65	0.31	0.48	
16	10	1.3	0.84	0.27	0.32	0.4
16	20	½	0.65	0.37	0.57	
16	20	1.3	0.71	0.43	0.61	0.59
16	4	1.3	0.92	0.45	0.49	
16	4	½	0.75	0.41	0.55	0.52
16	9	½	0.55	0.25	0.45	
16	9	1.3	0.65	0.34	0.52	0.49
15	23	1.3	0.75	0.33	0.44	
15	23	½	0.25	0.1	0.40	0.42
15	11	½	0.75	0.4	0.53	
15	11	1.3	0.6	0.29	0.48	0.51
15	5	1.3	0.59	0.28	0.47	
15	5	½	0.63	0.31	0.49	0.48
15	20	1.3	0.55	0.25	0.45	
15	20	½	0.65	0.35	0.54	0.5
15	37	1.3	0.76	0.36	0.47	
15	37	½	0.68	0.32	0.47	0.47
15	19	1.3	0.62	0.34	0.55	
15	19	½	0.38	0.21	0.55	0.55
15	6	½	0.55	0.2	0.36	
15	6	1.3	0.58	0.3	0.52	0.44
15	21	1.3	0.9	0.45	0.50	
15	21	½	0.6	0.33	0.55	0.53
15	38	½	0.4	0.27	0.68	
15	38	1.3	0.52	0.3	0.58	0.63
15	25	1.3	0.44	0.19	0.43	
15	25	½	0.85	0.25	0.29	0.36

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
15	28	1.3	0.68	0.4	0.59	
15	28	½	0.5	0.24	0.48	0.53
32	1	1.3	0.65	0.25	0.38	
32	1	½	0.45	0.25	0.56	0.47
32	37	½	0.52	0.27	0.52	
32	37	1.3	0.52	0.31	0.60	0.56
32	35	1.3	0.52	0.26	0.50	
32	35	½	0.45	0.21	0.47	0.48
32	26	½	0.5	0.3	0.60	
32	26	1.3	0.5	0.39	0.78	0.69
32	11	½	0.6	0.32	0.53	
32	11	1.3	0.72	0.36	0.50	0.52
32	16	1.3	0.8	0.37	0.46	
32	16	½	0.4	0.26	0.65	0.56
32	20	1.3	0.49	0.29	0.59	
32	20	½	0.5	0.22	0.44	0.52
32	21	1.3	0.55	0.37	0.67	
32	21	½	0.75	0.38	0.51	0.59
32	27	1.3	0.51	0.31	0.61	
32	27	½	0.59	0.32	0.54	0.58
32	3	½	0.51	0.24	0.47	
32	3	1.3	0.64	0.36	0.56	0.52
32	36	1.3	0.5	0.29	0.58	
32	36	½	0.35	0.25	0.71	0.65
32	28	1.3	0.55	0.24	0.44	
32	28	½	0.22	0.15	0.68	0.56
32	10	½	0.51	0.3	0.59	
32	10	1.3	0.57	0.36	0.63	0.61
32	34	½	0.35	0.26	0.74	
32	34	1.3	0.58	0.28	0.48	0.61
32	38	1.3	0.58	0.26	0.45	
32	38	½	0.7	0.29	0.41	0.43
13	8	1.3	0.5	0.27	0.54	
13	8	½	0.58	0.29	0.50	0.52
13	2	½	0.48	0.29	0.60	
13	2	1.3	0.9	0.39	0.43	0.52
13	10	1.3	0.56	0.3	0.54	
13	10	½	0.53	0.27	0.51	0.52
13	1	1.3	0.9	0.4	0.44	
13	1	½	0.5	0.3	0.60	0.52
13	4	1.3	0.52	0.25	0.48	
13	4	½	0.48	0.19	0.40	0.44
13	7	½	0.52	0.26	0.50	
13	7	1.3	0.55	0.27	0.49	0.5

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
13	9	1.3	0.65	0.26	0.40	
13	9	½	0.64	0.22	0.34	0.37
33	32	1.3	0.75	0.38	0.51	
33	32	½	0.85	0.35	0.41	0.46
33	31	½	0.62	0.28	0.45	
33	31	1.3	0.75	0.34	0.45	0.45
33	23	1.3	0.78	0.33	0.42	
33	23	½	0.51	0.3	0.59	0.51
33	5	1.3	0.7	0.31	0.44	
33	5	½	0.49	0.28	0.57	0.51
33	29	1.3	0.79	0.35	0.44	
33	29	½	0.52	0.31	0.60	0.52
33	28	1.3	0.6	0.28	0.47	
33	28	½	0.52	0.35	0.67	0.57
33	30	1.3	0.8	0.27	0.34	
33	30	½	0.51	0.25	0.49	0.41
33	10	½	0.5	0.28	0.56	
33	10	1.3	0.5	0.28	0.56	0.56
33	11	1.3	0.5	0.27	0.54	
33	11	½	0.9	0.28	0.31	0.43
19	5	½	0.75	0.28	0.37	
19	5	1.3	0.55	0.18	0.33	0.35
19	33	½	0.48	0.12	0.25	
19	33	1.3	0.5	0.21	0.42	0.34
19	19	½	0.25	0.12	0.48	
19	19	1.3	0.65	0.18	0.28	0.38
19	30	½	0.76	0.25	0.33	
19	30	1.3	0.56	0.37	0.66	0.49
19	7	½	0.51	0.26	0.51	
19	7	1.3	0.51	0.21	0.41	0.46
19	20	½	0.5	0.23	0.46	
19	20	1.3	0.48	0.17	0.35	0.41
19	31	1.3	0.74	0.31	0.42	
19	31	½	0.5	0.21	0.42	0.42
19	22	1.3	0.5	0.22	0.44	
19	22	½	0.75	0.25	0.33	0.39
19	36	½	0.55	0.25	0.45	
19	36	1.3	0.45	0.18	0.40	0.43
19	23	½	0.75	0.28	0.37	
19	23	1.3	0.55	0.18	0.33	0.35
19	17	½	0.59	0.26	0.44	
19	17	1.3	0.39	0.19	0.49	0.46
19	6	½	0.59	0.21	0.36	
19	6	1.3	0.41	0.27	0.66	0.51

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
1	66	1.3	0.3	0.15	0.50	
1	66	½	0.5	0.16	0.32	0.41
1	62	½	0.49	0.17	0.35	
1	62	1.3	0.48	0.21	0.44	0.39
1	58	1.3	0.51	0.18	0.35	
1	58	½	0.26	0.13	0.50	0.43
1	1	1.3	0.47	0.2	0.43	
1	1	½	0.48	0.16	0.33	0.38
1	59	1.3	0.98	0.22	0.22	
1	59	½	0.93	0.2	0.22	0.22
1	17	1.3	1	0.34	0.34	
1	17	½	0.97	0.23	0.24	0.29
1	38	1.3	0.87	0.25	0.29	
1	38	½	0.67	0.2	0.30	0.29
1	61	1.3	0.5	0.19	0.38	
1	61	½	0.27	0.14	0.52	0.45
1	16	1.3	0.55	0.24	0.44	
1	16	½	0.48	0.09	0.19	0.31
1	52	½	0.95	0.21	0.22	
1	52	1.3	1	0.22	0.22	0.22
1	6	½	0.48	0.17	0.35	
1	6	1.3	0.5	0.18	0.36	0.36
1	19	½	0.4	0.14	0.35	
1	19	1.3	0.35	0.13	0.37	0.36
1	55	½	0.3	0.15	0.50	
1	55	1.3	0.44	0.16	0.36	0.43
1	56	1.3	0.5	0.17	0.34	
1	56	½	0.25	0.14	0.56	0.45
35	39	½	0.6	0.3	0.50	
35	39	1.3	0.95	0.39	0.41	0.46
35	36	1.3	0.95	0.3	0.32	
35	36	½	0.68	0.28	0.41	0.36
35	40	1.3	0.75	0.3	0.40	
35	40	½	0.65	0.35	0.54	0.47
35	4	1.3	0.51	0.27	0.53	
35	4	½	0.8	0.32	0.40	0.46
35	7	½	0.65	0.29	0.45	
35	7	1.3	0.52	0.32	0.62	0.53
35	31	1.3	0.45	0.24	0.53	
35	31	½	0.4	0.2	0.50	0.52
35	16	1.3	0.7	0.28	0.40	
35	16	½	0.45	0.25	0.56	0.48
35	11	1.3	0.52	0.26	0.50	
35	11	½	0.6	0.27	0.45	0.48

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
35	34	½	0.65	0.24	0.37	
35	34	1.3	0.62	0.31	0.50	0.43
29	4	½	0.6	0.28	0.47	
29	4	1.3	0.48	0.25	0.52	0.49
29	9	1.3	0.55	0.26	0.47	
29	9	½	0.49	0.29	0.59	0.53
29	1	1.3	0.6	0.39	0.65	
29	1	½	0.6	0.33	0.55	0.6
29	7	1.3	0.65	0.29	0.45	
29	7	½	0.8	0.29	0.36	0.4
29	10	½	0.41	0.17	0.41	
29	10	1.3	0.61	0.18	0.30	0.35
29	11	½	0.68	0.24	0.35	
29	11	1.3	0.48	0.22	0.46	0.41
29	2	1.3	0.24	0.1	0.42	
29	2	½	0.29	0.13	0.45	0.43
29	3	1.3	0.6	0.24	0.40	
29	3	½	0.6	0.24	0.40	0.4
3	16	1.3	0.38	0.16	0.42	
3	16	½	0.8	0.3	0.38	0.4
3	46	1.3	0.45	0.23	0.51	
3	46	½	0.22	0.14	0.64	0.57
3	2	½	0.38	0.2	0.53	
3	2	1.3	0.32	0.18	0.56	0.54
3	5	½	0.25	0.16	0.64	
3	5	1.3	0.38	0.12	0.32	0.48
3	38	½	0.42	0.19	0.45	
3	38	1.3	0.32	0.16	0.50	0.48
3	13	1.3	0.25	0.11	0.44	
3	13	½	0.39	0.15	0.38	0.41
3	10	1.3	0.45	0.23	0.51	
	10	½	0.22	0.14	0.64	0.57
3	1	½	0.52	0.14	0.27	
3	1	1.3	0.4	0.18	0.45	0.36
3	52	1.3	0.23	0.14	0.61	
3	52	½	0.36	0.14	0.39	0.5
3	53	1.3	0.59	0.21	0.36	
3	53	½	0.2	0.1	0.50	0.43
3	54	½	0.59	0.26	0.44	
3	54	1.3	0.36	0.13	0.36	0.4
3	19	½	0.58	0.26	0.45	
3	19	1.3	0.4	0.22	0.55	0.5
3	8	½	0.4	0.18	0.45	
3	8	1.3	0.39	0.21	0.54	0.49

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
3	15	½	0.3	0.16	0.53	
3	15	1.3	0.3	0.19	0.63	0.58
3	28	1.3	0.38	0.21	0.55	
3	28	½	0.58	0.28	0.48	0.52
3	57	½	0.4	0.15	0.38	
3	57	1.3	0.4	0.15	0.38	0.38
20	9	½	0.5	0.21	0.42	
20	9	1.3	0.76	0.32	0.42	0.42
20	10	½	0.65	0.32	0.49	
20	10	1.3	0.7	0.31	0.44	0.47
20	13	½	0.38	0.2	0.53	
20	13	1.3	0.42	0.21	0.50	0.51
20	37	½	0.58	0.2	0.34	
20	37	1.3	0.38	0.19	0.50	0.42
20	14	1.3	0.42	0.23	0.55	
20	14	½	0.6	0.33	0.55	0.55
20	23	½	0.58	0.26	0.45	
20	23	1.3	0.58	0.29	0.50	0.47
20	2	½	0.4	0.21	0.53	
20	2	1.3	0.59	0.29	0.49	0.51
20	24	½	0.7	0.28	0.40	
20	24	1.3	0.6	0.23	0.38	0.39
20	19	½	0.5	0.3	0.60	
20	19	1.3	0.68	0.31	0.46	0.53
20	20	1.3	0.6	0.25	0.42	
20	20	½	0.62	0.21	0.34	0.38
4	12	1.3	0.18	0.09	0.50	
4	12	½	0.2	0.11	0.55	0.53
4	51	½	0.42	0.2	0.48	
4	51	1.3	0.4	0.16	0.40	0.44
4	72	1.3	0.19	0.09	0.47	
4	72	½	0.55	0.23	0.42	0.45
4	37	½	0.8	0.31	0.39	
4	37	1.3	0.7	0.32	0.46	0.42
4	57	1.3	0.53	0.19	0.36	
4	57	½	0.49	0.16	0.33	0.34
4	31	1.3	0.61	0.4	0.66	
4	31	½	0.46	0.26	0.57	0.61
4	9	1.3	0.38	0.21	0.55	
4	9	½	0.41	0.26	0.63	0.59
4	18	½	0.39	0.25	0.64	
4	18	1.3	0.44	0.21	0.48	0.56
4	56	1.3	0.78	0.37	0.47	
4	56	½	0.6	0.32	0.53	0.5

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
4	53	1.3	0.58	0.27	0.47	
4	53	½	0.4	0.18	0.45	0.46
4	20	½	0.77	0.41	0.53	
4	20	1.3	0.76	0.38	0.50	0.52
4	68	1.3	1	0.52	0.52	
4	68	½	0.45	0.25	0.56	0.54
4	24	½	0.42	0.25	0.60	
4	24	1.3	0.59	0.29	0.49	0.54
4	61	1.3	0.6	0.39	0.65	
4	61	½	0.45	0.25	0.56	0.6
17	50	1.3	0.6	0.32	0.53	
17	50	½	0.52	0.2	0.38	0.46
17	26	½	0.75	0.3	0.40	
17	26	1.3	0.6	0.26	0.43	0.42
17	12	½	0.62	0.29	0.47	
17	12	1.3	0.72	0.38	0.53	0.5
17	62	½	0.61	0.26	0.43	
17	62	1.3	0.77	0.33	0.43	0.43
17	47	½	0.5	0.26	0.52	
17	47	1.3	0.6	0.33	0.55	0.54
17	5	1.3	0.42	0.22	0.52	
17	5	½	0.6	0.24	0.40	0.46
17	54	½	0.62	0.24	0.39	
17	54	1.3	0.62	0.29	0.47	0.43
17	4	1.3	0.61	0.28	0.46	
17	4	½	0.42	0.25	0.60	0.53
17	23	1.3	0.81	0.4	0.49	
17	23	½	0.6	0.33	0.55	0.52
17	60	½	0.39	0.2	0.51	
17	60	1.3	0.4	0.19	0.48	0.49
17	48	½	0.61	0.32	0.52	
17	48	1.3	0.5	0.22	0.44	0.48
18	32	½	0.39	0.19	0.49	
18	32	1.3	0.41	0.19	0.46	0.48
18	2	1.3	0.58	0.27	0.47	
18	2	½	0.52	0.23	0.44	0.45
18	22	1.3	0.54	0.24	0.44	
18	22	½	0.75	0.28	0.37	0.41
18	15	1.3	0.6	0.3	0.50	
18	15	½	0.59	0.28	0.47	0.49
18	33	1.3	0.62	0.35	0.56	
18	33	½	0.42	0.17	0.40	0.48
18	34	½	0.78	0.37	0.47	
18	34	1.3	0.7	0.31	0.44	0.46

Plot no	Tree no	Wood Core at	V (cm³)	Oven dry (gm)	BD	Avg BD
18	26	½	0.8	0.38	0.48	
18	26	1.3	0.98	0.5	0.51	0.49
18	13	1.3	0.59	0.24	0.41	
18	13	½	0.57	0.23	0.40	0.41
18	30	½	0.56	0.24	0.43	
18	30	1.3	0.75	0.36	0.48	0.45
18	28	½	0.5	0.28	0.56	
18	28	1.3	0.59	0.21	0.36	0.46
18	16	½	0.38	0.14	0.37	
18	16	1.3	0.57	0.31	0.54	0.46
2	1	½	0.4	0.18	0.45	
2	1	1.3	0.58	0.27	0.47	0.46
2	31	1.3	0.59	0.25	0.42	
2	31	½	0.2	0.11	0.55	0.49
2	17	½	0.45	0.2	0.44	
2	17	1.3	0.6	0.31	0.52	0.48
2	6	½	0.22	0.19	0.86	
2	6	1.3	0.3	0.13	0.43	0.65
2	25	½	0.38	0.18	0.47	
2	25	1.3	0.38	0.14	0.37	0.42
2	10	½	0.59	0.18	0.31	
2	10	1.3	0.55	0.2	0.36	0.33
2	36	½	0.25	0.13	0.52	
2	36	1.3	0.4	0.18	0.45	0.49
2	9	1.3	0.41	0.18	0.44	
2	9	½	0.24	0.13	0.54	0.49
2	47	½	0.23	0.12	0.52	
2	47	1.3	0.38	0.17	0.45	0.48
2	7	½	0.42	0.16	0.38	
2	7	1.3	0.36	0.2	0.56	0.47
2	12	1.3	0.58	0.21	0.36	
2	12	½	0.38	0.21	0.55	0.46
2	41	½	0.46	0.16	0.35	
2	41	1.3	0.4	0.23	0.58	0.46
24	19	½	0.75	0.33	0.44	
24	19	1.3	0.75	0.34	0.45	0.45
24	27	½	0.6	0.3	0.50	
24	27	1.3	0.95	0.44	0.46	0.48
24	23	1.3	0.57	0.24	0.42	
24	23	½	0.55	0.21	0.38	0.4
24	17	1.3	0.78	0.32	0.41	
24	17	½	0.75	0.21	0.28	0.35
24	32	1.3	0.25	0.3	1.20	
24	32	½	0.63	0.2	0.32	0.76

Plot no	Tree no	Wood Core at	V (cm^3)	Oven dry (gm)	BD	Avg BD
24	11	½	0.6	0.2	0.33	
24	11	1.3	0.75	0.24	0.32	0.33
24	10	1.3	0.65	0.24	0.37	
24	10	½	0.5	0.23	0.46	0.41
24	53	1.3	0.9	0.31	0.34	
24	53	½	0.95	0.29	0.31	0.32
24	37	½	0.55	0.24	0.44	
24	37	1.3	0.5	0.23	0.46	0.45
24	54	½	0.6	0.26	0.43	
24	54	1.3	0.5	0.23	0.46	0.45
24	44	½	0.65	0.3	0.46	
24	44	1.3	0.85	0.27	0.32	0.39
24	2	½	0.75	0.4	0.53	
24	2	1.3	0.75	0.33	0.44	0.49
27	3	½	0.8	0.35	0.44	
27	3	1.3	0.75	0.33	0.44	0.44
27	5	½	0.75	0.34	0.45	
27	5	1.3	0.95	0.45	0.47	0.46
27	26	½	0.52	0.26	0.50	
27	26	1.3	0.5	0.23	0.46	0.48
27	14	½	0.5	0.32	0.64	
27	14	1.3	0.45	0.19	0.42	0.53
27	41	½	0.6	0.34	0.57	
27	41	1.3	0.45	0.24	0.53	0.55
27	10	½	0.5	0.2	0.40	
27	10	1.3	0.5	0.27	0.54	0.47
27	39	1.3	0.75	0.33	0.44	
27	39	½	0.6	0.33	0.55	0.5
27	19	1.3	0.9	0.39	0.43	
27	19	½	0.5	0.3	0.60	0.52
27	46	½	0.45	0.16	0.36	
27	46	1.3	0.62	0.23	0.37	0.36