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A STUDY OF THE SHARE OF FUELWOOD IN TOTAL WOOD PRODUCTION IN PRIVATE TREE PLANTATIONS IN LAO PDR

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FOREWORD

Millions of people throughout the world depend on woodfuels for cooking, heating, food processing, for small-scale industries, as well as other applications. Lao PDR is no exception. In fact woodfuels form by far the largest source of energy in the country, accounting for over 85% of all energy used.

In most developing countries, more people depend on woodfuels for their daily energy needs than on any other single energy source and woodfuels can therefore be considered one of the most important fuels in these countries. Unfortunately, it is often also considered to be in short supply. Although forests are an important source of woodfuels, evidence gathered has shown that non-forest land such as agricultural land, common land, homesteads, strips of land along roads, railways, etc., in many countries, are becoming important (if not the most important) source of woodfuels.

Besides these sources of woodfuels, more and more attention is being given to other sources of supply such as agro-forestry and community forestry schemes, forest plantations, etc. In particular, countries like China, India and Vietnam are examples where such practices are common. Most of the wood derived from these sources, even though it may initially have been planted to serve as a source of fuelwood, is often used for other purposes such as timber, pulpwood, etc. This is due to the fact that the competing users are willing to pay a higher price for the wood compared to its price as fuelwood. These competing users often are only interested in the tree-trunks and consequently a lot of waste is generated in the form of branches, twigs, leaves and tops that can be used as a source of energy.

The present study, which was initiated by Mr. Tara Bhattarai from RWEDP and carried out in Lao PDR by Mr. Thongthanh Southitham of Burapha Agro-Forestry Co. Ltd., tries to shed some light on the productivity of such fast growing tree plantation systems. Besides the total productivity, the relative importance of the various components, i.e. timber/pulpwood versus woodfuels, was studied through the development of "simple" relationships between diameter/height and yield. It is hoped that the results of the study will help to provide a better understanding of the interaction of labor and capital intensive tree plantations with woodfuel supply systems not only in Lao PDR but possibly also in other countries.

Auke Koopmans
Officer-in-Charge
FAO/RWEDP

PREFACE

Fuel wood plays a dominant role in the energy supply of Lao PDR as other sources of energy are still too expensive for the majority of the Lao people whose incomes are among the lowest in the region. Undoubtedly, large quantities of fuel wood will need to be readily available for the foreseeable future.

Much of the country's natural forests have been destroyed for agricultural purposes, for supplying wood processing industries and for household use, and the area under natural forest has steadily declined. Subsequently, fuel wood sources are becoming more and more scarce and located farther and farther from the communities that depend on them.

Plantations of fast growing tree species should be vigorously promoted for supplying wood for construction purposes and for some fuel wood. These plantations can play a vital role in supplying fuel wood and can do so in a much shorter time frame than natural forests.

Given the importance of plantations as a source of fuel wood, the study of the share of fuel wood in the total wood production of private plantations in Lao PDR should make an important contribution to the management of the fuel wood supply in the country.

I would like to express my gratitude to the Regional Wood Energy Development Programme of the Food and Agriculture Organization of the United Nations, Bangkok, Thailand for the financial support for this study. I would like to thank Mr. Tara N. Bhattarai, Wood Energy Resources Specialist, Regional Wood Energy Development Programme, for his important contributions in the design of the study methodology and for technical guidance during the field study. Mr. Bhattarai also offered many valuable comments on the draft report which allowed us to improve the presentation of the research findings. I would also like to thank Dr. C.T.S Nair, Senior Programme Advisor, Forestry Research Support Programme for Asia and the Pacific, for the technical guidance he provided during a visit to Vientiane.

Finally, I would also like to thank Mr. Bounlieng Singvichit and Mr. Bouaket Sayasouk, Wood Industry Technicians of the Department of Forestry, and my research assistant, Mr. Sangthong Luangsengphet, who ably assisted me in measuring the trees at the different sample plots in the field. Their suggestions and comments were also invaluable.

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TABLE OF CONTENTS

FOREWORD	i
PREFACE	ii
1. Background	1
2. Objectives	1
3. Methodology	1
3.1 Sampling Intensity	1
3.2 Approach to Sampling	1
3.3 Limitations and Explanations	3
4. Plantation Sites Studied	3
4.1 Introduction	3
4.2 Site 1: Private Tree Plantation	3
4.3 Site 2: Private Tree plantation	4
4.4 Site 3: Company Tree Plantation	4
5. Drying Procedure/Method and Results of the Weighing	4
5.1 Drying Procedure/Method	4
5.2 Result of the Weighing	5
6. Summary and Conclusions	6
6.1 Site 1: Private Tree Plantation	6
6.2 Site 2: Private Tree Plantation	6
6.3 Site 3: Company Tree Plantation	6
7. Recommendations	8

PART I. TABLES

Table 1: Standing tree measurement record sheet: Plantation site 1	9
Table 2: Summary of number of standing trees by diameter classes: Plantation site 1	9
Table 3: Results of the dried weight test: Plantation site 1	10
Table 4: Standing tree measurement record sheet: Plantation site 2	11
Table 5: Summary of number of standing trees by diameter classes: Plantation site 2	11
Table 6: Result of the dried weight test: Plantation site 2	12
Table 7: Standing tree measurement record sheet: Plantation site 3	13
Table 8: Summary of number of standing trees by diameter classes: Plantation site 3	13
Table 9: Results of the dried weight test: Plantation site 3	14
Table 10: A summary of green weight/volume for parts of trees in plantation site 1	15

Table 11: A summary of oven dried weights for parts of trees at moisture content zero in plantation site 1	15
Table 12: A summary of green weight/volume for parts of trees in plantation site 2	16
Table 13: A summary of oven dried weights for parts of trees at moisture content zero in plantation site 2	16
Table 14: A summary of green weight/volume for parts of trees in plantation site 3	17
Table 15: A summary of oven dried weights for parts of trees at moisture content zero in plantation site 3	17

PART II. ANNEXES

Annex 1: Terms of Reference for Assessing the Share of Fuelwood in Total Wood Production in Private Plantations in Lao PDR	19
Annex 2: Definition of Terms Used in the Study	22
Annex 3: Information on Plantation Sites	23
Annex 4: Explanation of the Oven and Kiln Drying Procedures	24
Annex 5: Explanation of Tables.....	25
Annex 6: Biomass Production Measurement Sheet by Diameter Class Type	26
Annex 7: Investment Record.....	58

1. BACKGROUND

The Regional Wood Energy Development Programme (RWEDP) was requested by the Burapha Agro-forestry Co. Ltd., to assist it in assessing the proportions of wood and fuel wood obtained from fast-growing exotic tree plantations of eucalyptus in Lao PDR. The proposal submitted by Burapha Agro-forestry Co. Ltd., suggested that the study include an assessment of the production of stem wood, fuelwood, twigs and leaves (or the total biomass production above ground) from the trees planted in the entire 2.52 hectares of three plantations scattered in three separate blocks. The three plantations, two of which were raised by individual farmers and one by the company itself over the last 4-7 years, were established as private or joint venture undertakings between the investors and the Forest Development Department. RWEDP agreed to provide financial support and technical expertise to the study and requested Dr. C.T.S. Nair of FORSPA, to recommend a reliable and cost-effective study methodology to Burapha Agro-forestry Co. (through Mr. Thongthanh Southitham, Operations Manager). The terms of reference for the study can be found in Annex 1.

2. OBJECTIVES

The primary objective of the study was to assess the total biomass production and determine the share of saw-logs, poles, branch-wood, twigs and leaves (please refer to Annex 2 for definitions of these terms) in the total production from the fast-growing high-yielding trees planted by private individuals and business undertakings in Lao PDR. Of particular interest was the establishment of a relationship between the diameter (DBH) and height of a tree and its total above-ground biomass production, including wood and non-woody biomass, at a rotation age of five years.

3. METHODOLOGY

3.1 Sampling Intensity

In order to assess the total volume/quantity of above-ground biomass production -or the woody and non-wood biomass in different utilization categories - harvested from these fast-growing short rotation tree plantations, a 10% sample of the entire area was considered sufficient for detailed measurement. Such a sample size would reduce the cost and the time required for the study in the field without compromising the validity of the results.

3.2 Approach to Sampling

Since fuelwood and other biomass availability will depend on the tree diameter and tree height, from the point of view of the wider application of the study yield was assessed on a per tree basis. Hence trees not sample plots within the plantation blocks were the sampling unit. The approach was very similar to that used when preparing conventional volume tables and included all the biomass including fuelwood (branches, twigs, leaves etc.).

Before felling, the diameter of all standing trees in each of the three plantation blocks was measured at 1.3 meters above ground. Then they were grouped into 5 cm diameter classes (i.e. 0-5 cm or class I; 5.1-10 cm or class II; 10.1-15 cm or class III, 15.1-20 cm or class IV, 20.1 – 25 cm or class V and 25.1 – 30 cm or class VI).

A 10% sample of the total number of trees in each diameter class was measured for detailed assessment. The number of trees that had the same size of diameter was recorded regardless of their heights. A color spray was used to mark the trees once they had been measured and recorded. The marking was conducted as follows: those trees, which were in diameter class I (0.0 cm -5.0 cm), were marked using the color spray with one big dot on the bark of the tree (.). Those trees, which were in diameter class II (5.1 cm – 10 cm), were marked by two big dots (..). The trees in diameter class III, IV, V and VI were marked by three big dots, four big dots, five big dots and six big dots, respectively. After this step, 10% of the trees measured from the total population in each diameter class was selected randomly after felling; however, the upper part of those trees was observed as well. It was observed that trees in the same diameter class could differ considerably in terms of the number of branches and leaves they had produced at the time of the study. The portion of wood at the stump after cutting was ignored. The height of every stump left in the plantations after cutting was approximately 5 to 10 centimetres. The reason for this is that the stump will produce more coppices for wood production in the second rotation.

Apart from measuring the diameter of the 10% sample from each diameter class, total height (total length) was also measured immediately after felling.

Yield from each of the felled trees was measured and classified as saw-logs (in m³), poles (in m³), branch wood (in kg), twigs (in kg), and leaves (in kg). The weights (green weight basis) of branch wood, twigs and leaves were measured immediately after felling at the site itself. The aim here was to ensure that they would not lose their moisture content before measurement. Respective air dry-weight or bone-dry weight conversion factors, were determined for all three-product categories after laboratory test measurements of sub-samples.

For each diameter class, a separate table was provided to show the detailed information in separate columns. This included the following items: number of trees in the 10% sample; diameter in centimeter to one decimal point; total height of the measured tree (or total length of the tree); volume and number of saw-logs produced from each tree (volume in m³ and number of logs, length and mid- diameter); volume and number of poles (volume in m³, length and mid-diameter); weight of branch-wood (in kg, green); weight of twigs (kg, green); and weight of leaves (kg). Based on the volume / weight conversion factors derived from field and laboratory measurements, the entire above-ground biomass output from a tree can be calculated in terms of its green-wet, or dry-weight basis. And applying these conversion factors, the share of saw-logs, poles, branch-wood, twigs and leaves in total production was estimated, including the share of fuelwood, pulpwood and the amount of wood used for other end-uses according to the prevailing market demand for these products in Lao PDR.

3.3 Limitations and Explanations

The main limitation of the study is that the ratios derived are related to the specific market situation prevailing at the time of felling. This is particularly the case with products that can be used for alternative end uses as in the case of pulpwood and fuelwood. The market supply/demand of wood, particularly for pulp wood will greatly affect the availability of wood for energy purposes when the price of fuel wood is not able to compete in the open market. In the past the market price for pulpwood was higher than at present, and this part of the output plus the twigs and leaves are currently available from such plantations for fuel purposes. Since a larger proportion from the plantation output is available as firewood it may be converted into charcoal for use in urban centers. Therefore, the figures derived in terms of the share of the firewood and other wood from a plantation area at a given time may not be relevant to another location and another time on account of the differences in the local market demand/supply of wood products. This is bound to affect the actual patterns of end uses of available wood. This problem can be addressed partly by clearly defining the terms used in the study - i.e. "saw-logs", "poles", "branch wood", "twigs" and "leaves" (see Annex 2 for definitions of these terms) - and specifying their output in number, length, mid-diameter, and/ or weight (in dry-weight basis). Stating the types of products that will be available exclusively for fuels, other specific uses, or both will also help.

4. PLANTATION SITES STUDIED

4.1 Introduction

Three plantation sites were chosen to assess the share of fuel wood in total wood production in fast-growing private eucalyptus (*Eucalyptus camaldulensis*) plantations in Lao PDR on the basis of different tree spacing regimes. These plantations were established using only seedlings as planting materials. There are 2m x 2m, 3m x 2m and 3m x 3m spacing regimes. These spacing regimes give different fuelwood outcomes. All the trees in the study were classified into one of six diameter classes. Information on the three sites can be found in Annex 3.

4.2 Site 1: Private Tree Plantation

In 1993, Burapha Agro-Forestry Co. Ltd., provided a tree plantation loan to a group of 14 farmers at Ban Boleck village, Pak-Ngum district, Vientiane Municipality. The village tree plantations are located about 36km south of Vientiane. Mr. Lung Vi, one of the members of the group, received the loan in the form of seedlings and barbed wire with a repayment period of 5 to 7 years. Two hectares were planted with *Eucalyptus camaldulensis* trees planted in June of the rainy season of 1993, using a spacing regime of 2m x 2m which gave 2,500 trees per hectare.

There was no soil preparation before planting and no fertilizer application after planting, therefore the conditions were not as good as they could have been and perhaps growth was restricted as a result. There were 1,277 trees measured at the stand, equivalent to 0.52 ha of land. The mortality of the stand was very low (about 1%) compared to other plantations in the study. The stand was maintained regularly with the maintenance work done by hand twice a year in the first two years and once a year thereafter.

The percentage of trees distributed according to different diameter classes was as follows: Class I, 33%; class II, 58.5%; class III, 8% and class IV, 0.5%. There were no trees in diameter classes V and VI at the time of the study (see tables 1 and 2).

4.3 Site 2: Private Tree plantation

Mr. Thongbai, age 54, received a loan from Burapha Agro-Forestry Co. LTD in 1991 to establish a *Eucalyptus camaldulensis* plantation. The company provided seedlings, fertilizer and barbed wire to Mr. Thongbai as well as other farmers in Ban Lingsane, Thoulakhom district, Vientiane province. His plantation is approximately 54 km from the centre of Vientiane and located in the north of Vientiane municipality. The land is partly waterlogged in the rainy season. Mr. Thongbai planted the trees in an area of one hectare and with a spacing regime of 3m x 2m on fallow land, which used to be planted with cash crops. The number of trees per hectare is 1,667. There was a mortality rate of 27 percent because of fire or because cattle destroyed the trees in the first three months. Before planting the trees the soil on the site was prepared by a farm tractor. The plantation was maintained regularly by hand in the first two years, but only once a year in years 3 and 4, and thereafter there was no maintenance at all.

The percentage of trees distributed according to different diameter classes is as follows: Class I, 22%; class II, 30%; class III, 33.2%; class IV, 11.6%; class V, 3%; and class VI, 0.2% (see tables 4 and 5).

4.4 Site 3: Company Tree Plantation

Burapha Agro-Forestry Co. LTD obtained a concession area for planting *Eucalyptus camaldulensis* at Ban Hatkieng, Saythany district, Vientiane prefecture. The actual site is about 48 km from Vientiane City. The company planted the trees in area of 23 hectares in June 1993 with a spacing regime of 3m x 3m, which gave 1,111 trees per hectare. Before planting, the site was cleared by hand and a farm tractor prepared the soil. The trees were fertilized twice in the first two months after planting. The plantation was maintained regularly in the first two years. In later years, little or no maintenance work was done. The area chosen for the study was one hectare.

The percentage of trees distributed according to different diameter classes is as follows: Class I, 7.7%; class II, 41.1%; class III, 43.2%; and class IV, 8%. No trees in this plantation were in classes V and VI at the time of the study (see tables 7 and 8).

5. DRYING PROCEDURE/METHOD AND RESULTS OF THE WEIGHING

5.1 Drying Procedure/Method

Study samples consisted of leaves, twigs, branches and trunks from the same tree (one tree from each diameter class), after felling. The tree parts were first air-dried in the sun and then the samples from plantation sites 2 and 3 were oven-dried in the laboratories either at Dong Dok Forest College or at the Soil Survey Center of the Ministry of Agriculture and Forestry. Twigs, branches and trunks from plantation site 1, the plantation of Mr. Lung Vi, were kiln-dried at Ban Non Khileck wood processing plant, which is located in the north of Vientiane Municipality about 8 km from Vientiane City Center.

The drying procedure in both laboratories was the same, i.e., an oven dryer was used. The machine can reach a maximum temperature of 200°C. The temperature for the drying was set at 100°C (plus or minus 5°C). Every 5 to 6 hours the tree parts were checked and weighed until they reached a constant weight, i.e., when the moisture content of the parts

was zero. At this point the specimens were removed and the weight was recorded. See Annex 4 for an explanation of the kiln drying procedure.

5.2 Result of the Weighing

(a) Site 1: Private Tree Plantation

Table 3 shows the result of the weighing of tree parts from site 1, a private tree plantation. The green weights ranged from 0.35 kg to 9.95 kg. The moisture content of the air-dried leaves ranged from 8.52% to 11.88%. Twigs, branches and trunks which were dried in a kiln had moisture contents (MC) (column 8) ranging from 4.88% to 9.75%. Column 11 shows conversion coefficients for each tree part, green weight (column 4) to oven dry weight (column 9), at moisture content zero (column 10).

The conversion coefficients vary slightly and range from 0.387611 to 0.522857. These conversion coefficients can be used to estimate the dried biomass obtained from each plantation in this study.

(b) Site 2: Private Tree Plantation

Table 6 shows the results of the weighing of tree parts from site 2, the second of the private tree plantations. Green weights are mostly 1 kg but ranged from 0.5 kg to 2 kg (column 4). The moisture content (column 6) of air-dried leaves ranged from 7.09% to 11.54%, twigs from 6.13% to 8.72%, branches from 6.97% to 11.35% and trunks from 8.14% to 12.80%. Column 11 shows conversion coefficients for each tree part, green weight (column 4) to oven dry weight (column 9), at moisture content zero (column 10). The coefficients vary slightly and range from 0.3458 to 0.4926.

(c) Site 3: Company Tree Plantation

Table 9 shows the result of the weighing of tree parts from site 3, the company tree plantation. Green weights are 1 kg for all samples (column 4). The moisture content (column 6) of air-dried leaves ranged from 8.32% to 9.38%, twigs from 9.68 % to 10.24%, branches from 9.11% to 10.92% and trunks from 9.36% to 11.23%. Column 11 shows conversion coefficients for each tree part, green weight (column 4) to oven dry weight (column 9), at moisture content zero (column 10). The coefficients vary slightly and range from 0.3174 to 0.56.

Record sheets for all the sites giving all measurements and weights can be found in Annex 6.

6. SUMMARY AND CONCLUSIONS

6.1 Site 1: Private Tree Plantation

The *Eucalyptus camaldulensis* plantation of Mr. Lung Vi is located at Ban Boleck. The trees in the plantation were planted in June 1993 with a spacing regime of 2m x 2m, which gave 2,500 trees per hectare. The plantation comprised four diameter classes at the time of study. Conversion coefficients for the leaves of this plantation ranged from 0.3881 to 0.4102, twigs from 0.4135 to 0.522857, branches from 0.4093 to 0.502 and trunks from 0.387611 to 0.457085 (see table 3).

These conversion coefficients can be used to calculate oven-dried weights on the basis of green weights of all parts of the trees. An example of this can be seen in tables 10 and 11. A one-hectare area of plantation gave 7 t (oven-dried weight) of fuelwood, 2.1 t of leaves, 1.6 t of twigs and 1.9 t of branch wood. These are shown in table 11. Construction poles and saw-logs can be accurately measured by volume in cubic meters whether they are in a green or dried condition. This plantation provides 38.468 m³ of construction poles and 0.2885 m³ of saw-logs. It should be noted that construction poles can be used for pulpwood. The conversion coefficients for trunks can be used for calculating how much oven dried weight of pulp wood can be obtained from one hectare of the plantation (see table 3 column 11, sample nos. 16 to 19).

6.2 Site 2: Private Tree Plantation

The *Eucalyptus camaldulensis* plantation of Mr. Thongbai is located at Ban Lingsane. The trees in the plantation were planted in 1991 with a spacing regime of 3m x 2m, which gave 1,667 trees per hectare. The plantation comprised six diameter classes. Conversion coefficients for the leaves of this plantation ranged from 0.3784 to 0.4423, for twigs from 0.3458 to 0.4641, for branches from 0.4219 to 0.4701 and for trunks from 0.4371 to 0.4926 (see table 6).

These conversion coefficients can be used to calculate oven-dried weights on the basis of green weights for all parts of the trees. An example of this can be seen in tables 12 and 13. A one-hectare area of plantation gave 8.5 t (oven dried weight) of fuelwood, 2.5 t of leaves, 2.1 t of twigs and 5.3 t of branch wood. These are shown in table 13. Construction poles and saw logs can be accurately measured by volume in cubic meters whether they are in a green or dried condition. This plantation provides 27.436 m³ of construction poles and 27.552 m³ of saw-logs. Construction poles, it should be noted, can be used for pulpwood. The conversion coefficients for trunks can be used to calculate how much oven dried weight of pulp wood can be obtained from one hectare of the plantation (see table 6 column 11, sample nos. 19 to 24).

6.3 Site 3: Company Tree Plantation

The *Eucalyptus camaldulensis* plantation of Burapha Agro-Forestry Co., Ltd is located at Ban Hatkieng. The trees in the plantation were planted in 1993 with a spacing regime of 3m x 3m, which gave 1,111 trees per hectare. The plantation comprised four diameter classes. Conversion coefficients for the leaves of this plantation ranged from 0.3174 to 0.4355, for twigs from 0.4129 to 0.56, for branches from 0.4061 to 0.493 and for trunks from 0.4402 to 0.4676 (see table 9).

These conversion coefficients can be used to calculate oven-dried weights on the basis of green weights for all parts of the trees. An example of this can be seen in tables 14 and 15. A one-hectare plantation area gave 4.3 t (oven-dried weight) of fuelwood, 1.3 t of leaves, 1.6 t of twigs and 2.8 t of branch wood. These are shown in table 15. Construction poles and saw logs can be accurately measured by volume in cubic meters whether they are in green or dried conditions. This plantation provides 45.452 m³ of construction poles and 4.083 m³ of saw-logs. Construction poles, it should be noted, can be used for pulpwood. The conversion coefficients for trunks can be used to calculate how much oven-dried weight of pulpwood can be obtained from one hectare of the plantation (see table 9 column 11, sample nos. 16 to 19).

It is very difficult to conclude that there is a systematic relationship between the diameter (DBH) and the height of a tree and its total above-ground biomass production. For example, the detailed record of every tree shows that a large diameter at breast height does not imply a tall or long tree. Large diameter trees could be short or long, and small diameter trees could be taller than trees that had larger diameters. However, diameter class seems to play an important role in determining biomass production above the ground. One point that was apparent was that plantation site 2 had the largest number of trees in diameter classes III and IV and hence produced the highest amount of poles and saw-logs on a per hectare basis. It also produced the highest amount of oven-dried "other biomass".

As mentioned in section 4.1, there was no soil preparation before planting and no fertilizer application after planting. This greatly affected the growth of the trees in private plantation site 1. Nevertheless, the yield of the first rotation could already cover the investment cost. While Mr. Lung Vi has to pay back to Burapha Agro-Forestry Co., Ltd 50.01 tons, the total yield obtained was 66.6 tons. Thus the first rotation already proved profitable.

The yield of the second rotation of this plantation will be only considered in terms of net profits. Because of the narrow spacing regime in this kind of plantation the number of trees is much higher, and the yield per hectare can be much greater than other plantations which use wider spacing regimes. Production of fuel wood and construction poles in short rotation using this spacing regime is highly recommended.

Plantation sites 2 and 3 were more intensively cared for than plantation site 1 in terms of soil preparation before planting and fertilizer application after the trees had been planted. The trees of these two sites reached the necessary dimensions for saw logs, which give higher value wood.

The trees in private plantation site 2 had a 27 percent mortality rate but under fertile soil condition. The yield of saw-logs and construction poles was 7.855 m³/ha/yr compared to 8.25 m³/ha/yr for the company plantation and 7.75 m³/ha/yr for plantation site 1. The yield of saw-logs and construction poles of the plantation site 2 would have been 11.22 m³/ha/yr if the mortality rate was more normal, e.g. 10%.

For a combination of saw-logs and construction poles/or pulp wood production a spacing regime of 3m x 2m is recommended; a spacing regime of 3m x 3m is recommended for saw-log production and 2m x 2m for fuelwood production. However, besides saw-logs,

construction poles and pulp wood, a larger amount of fuel wood could be obtained from plantation site 2.

7. RECOMMENDATIONS

It is recommended to continue private tree planting in available wastelands as well as in other types of available land, but this must be under the close supervision of tree planting experts and there must be a strong incentive for individual planter. Expecting a high return on this kind of investment is the most important incentive for any individual. Therefore, an improved seed supply for good seedling production and improved cutting technology, and high quality planting materials are the most important prerequisites for establishing such plantations. The capability of individuals to plant trees and to maintain the plantation in a good condition is the second most important factor and how much land area at a time they can take care. Of course, a market for this kind of plantation wood must be assured.

- In order to better understand the social, economic and environmental impacts of such short-rotation tree planting by the private sector research should focus on answering the following questions:
- To what extent can small-scale eucalyptus tree plantations help save natural forests from being destroyed or cut down for fuel wood, construction wood and so on?
- How do the small-scale eucalyptus tree plantations planted throughout the country by individual farmers affect water catchment areas or ground water resources?
- To what extent can short-rotation eucalyptus tree plantations planted by farmers or other individuals help improve the national economy?
- Assuming good plantation establishment management and the same soil, climate and landscape conditions, what is the best spacing regime in relation to fuelwood supply after the primary end-use is produced (e.g. saw logs, construction pole, and pulpwood)?

It can be noted that since market forces, particularly the price of competitive end-uses, will dictate the ultimate application of the wood produced in these short-rotation private tree plantations, industrial raw material is the most likely use of this wood.

PART I. TABLES

Table 1: Standing tree measurement record sheet: Plantation site 1

Owner's Name: Mr. Lung Vi Location: Boleck Village
 Year of Planting: June, 1993 Area: 0.52 ha
 Spacing: 2m X 2m
 Year and Month Trees Harvested: 24 - 25 October 1998

Diameter (cm)	Number of trees	Diameter (cm)	Number of trees
1.6	9	9.5	44
2.2	19	9.9	15
2.5	13	10.2	18
2.8	20	10.5	13
3.2	39	10.8	15
3.5	32	11.2	13
3.8	60	11.5	9
4.1	57	11.8	9
4.5	84	12.1	6
4.8	89	12.4	2
5.1	90	12.7	1
5.4	71	13.1	5
5.7	59	13.4	2
6.0	59	13.7	2
6.4	66	14.0	3
6.7	51	14.3	2
7.0	48	14.7	1
7.3	36	14.8	1
7.6	41	15.6	2
8.0	45	16.2	1
8.3	37	17.2	1
8.6	34	18.1	1
8.9	27	19.4	1
9.2	24		
Sub-totals	1110		167
Grand Total			1277

Table 2: Summary of number of standing trees by diameter classes: Plantation site 1

Diameter class	Diameter class in cm	Total number of trees in each diameter class	Percentage diameter class distributed	Number of trees required for 10% sample in each diameter class
I	0.0 - 5.0	422	33.0	42
II	5.1 - 10.0	747	58.5	74
III	10.1 - 15.0	102	8.0	10
IV	15.1 - 20.0	6	0.5	1
V	20.1 - 25.0			
VI	25.1 - 30.0			
Total		1277	100.0	127

Table 3: Results of the dried weight test: Plantation site 1

Sample No	Diameter classes	Part of tree	Green weight kg	Air dried		Kiln dried		Oven dried		Conversion coefficient
				Weight kg	*MC %	weight kg	MC %	weight kg	MC %	
1	2	3	4	5	6	7	8	9	10	11
1	I	Leaves	0.5	0.2281	11.88			0.201	0	0.402
2	II	Leaves	1	0.433	10.37			0.3881	0	0.3881
3	III	Leaves	1	0.4484	8.52			0.4102	0	0.4102
4	IV	Leaves	1	0.4527	11.77			0.3994	0	0.3994
5	V	Leaves								
6	I	Twigs	0.35			0.1754	9.75	0.1583	0	0.452286
7	II	Twigs	0.35			0.1948	6.06	0.183	0	0.522857
8	III	Twigs	1.05			0.5	6.82	0.4659	0	0.443714
9	IV	Twigs	1			0.4439	6.85	0.4135	0	0.4135
10	V	Twigs								
11	I	Branches	0.9			0.4207	6.77	0.3922	0	0.435778
12	II	Branches	0.7			0.3834	8.35	0.3514	0	0.502
13	III	Branches	1			0.5	5.30	0.4735	0	0.4735
14	IV	Branches	1			0.4303	4.88	0.4093	0	0.4093
15	V	Branches								
16	I	Trunks	2.5			1.25	8.72	1.141	0	0.4564
17	II	Trunks	7.35			3.45	8.93	3.142	0	0.427483
18	III	Trunks	9.95			4.95	8.12	4.548	0	0.457085
19	IV	Trunks	9.5			3.95	6.78	3.6823	0	0.387611
20	V	Trunks								

*MC: Moisture Content

Note: Four samples of specific products (i.e. leaves, twigs, branches, and trunks) were collected from any sample tree that was felled in each diameter class existing in each of the blocks chosen for the study. Total sample 4 x 4 = 16

Table 4: Standing tree measurement record sheet: Plantation site 2

Owner's Name: Mr. Thongbai Location: Lingsane Village
 Year of Planting: July, 1991 Area: 1 ha
 Spacing: 3m X 2m
 Year and Month of Harvest: 23 - 24 May 1998

Diameter in cm	Number of trees	Diameter in cm	Number of trees	Diameter in cm	Number of trees
1.6	5	9.5	27	17.5	6
1.9	10	10	19	17.8	12
2.2	15	10.2	18	18.2	3
2.5	25	10.5	22	18.5	10
2.9	29	11	20	18.8	6
3.2	24	11.2	12	19.1	8
3.5	33	11.5	21	19.4	6
3.8	37	11.8	37	19.8	6
4.1	29	12.1	21	20.1	4
4.5	30	12.4	18	20.4	5
4.8	28	12.7	21	20.7	2
5.1	20	13.1	13	21	5
5.4	25	13.4	20	21.3	3
5.7	24	13.7	17	21.7	4
6.1	20	14	114	22	4
6.4	28	14.3	12	22.3	1
6.7	17	14.7	11	22.6	1
7	23	15	23	22.9	2
7.3	26	15.3	11	23.3	3
7.6	23	15.6	12	24.2	1
8	27	15.9	11	24.5	1
8.3	30	16.2	11	25.5	1
8.6	13	16.6	14	25.8	1
8.9	20	17	14	26.1	1
9.2	20	17.2	10		
Sub-totals	581		529		96
Grand Total					1206

Table 5: Summary of number of standing trees by diameter classes: Plantation site 2

Diameter class	Diameter class in cm	Total number of trees in each diameter class	Percentage diameter class distributed	Number of trees required for 10% sample in diameter class
I	0.0 - 5.0	265	22.0	27
II	5.1 - 10.0	362	30.0	36
III	10.1 - 15.0	400	33.2	40
IV	15.1 - 20.0	140	11.6	14
V	20.1 - 25.0	36	3.0	4
VI	25.1 - 30.0	3	0.2	1
	Grand Total	1206	100.0	121

Table 6: Result of the dried weight test: Plantation site 2

Sample No	Diameter classes	Part of tree	Green weight kg	Air dried		Kiln dried		Oven dried		Conversion coefficient
				weight kg	*MC %	weight kg	MC %	weight kg	MC %	
1	2	3	4	5	6	7	8	9	10	11
1	I	Leaves	1	0.5	11.54			0.4423	0	0.4423
2	II	Leaves	1	0.45	8.11			0.4135	0	0.4135
3	III	Leaves	1	0.4562	9.60			0.4124	0	0.4124
4	IV	Leaves	1	0.4108	7.55			0.3798	0	0.3798
5	V	Leaves	1	0.4208	10.08			0.3784	0	0.3784
6	VI	Leaves	1	0.4368	7.09			0.4058	0	0.4058
7	I	Twigs	1	0.4944	6.13			0.4641	0	0.4641
8	II	Twigs	1	0.3729	7.27			0.3458	0	0.3458
9	III	Twigs	1	0.4568	7.14			0.4242	0	0.4242
10	IV	Twigs	1	0.4116	6.22			0.386	0	0.386
11	V	Twigs	1	0.46	8.29			0.419	0	0.419
12	VI	Twigs	1	0.453	8.72			0.4135	0	0.4135
13	I	Branches	1	0.4626	8.80			0.4219	0	0.4219
14	II	Branches	1	0.5045	9.45			0.4568	0	0.4568
15	III	Branches	1.4	0.7074	6.97			0.6581	0	0.470071
16	IV	Branches	1.9	0.96	9.53			0.8926	0	0.469789
17	V	Branches	1	0.5249	11.35			0.4653	0	0.4653
18	VI	Branches	1	0.4789	10.40			0.4243	0	0.4243
19	I	Trunks	1	0.4942	11.55			0.4371	0	0.4371
20	II	Trunks	0.5	0.2607	11.89			0.2297	0	0.4594
21	III	Trunks	1	0.4927	11.61			0.4355	0	0.4355
22	IV	Trunks	2	1.0725	8.14			0.9852	0	0.4926
23	V	Trunks	2	1.10169	12.80			0.9607	0	0.48035
24	VI	Trunks	1.5	0.7734	11.15			0.6872	0	0.458133

*MC: Moisture Content

Note : 6 samples from each diameter class tree to assess the green/dry weight of different products in the block. Total sample 6 x 4 = 24.

Table 7: Standing tree measurement record sheet: Plantation site 3

Owner's Name: Burapha Agro-Forestry Co., LTD. **Location:** Hatkieng Village
Year of Planting: June, 1993 **Area:** 1 ha
Spacing 3m X 3m
Year and Month of Harvested: 18 - 19 July 1998

Diameter in cm	Number of trees	Diameter in cm	Number of trees
3.8	14	11.8	36
4.1	13	12.1	37
4.5	20	12.4	35
4.8	21	12.7	28
5.1	18	13.1	14
5.4	14	13.4	18
5.7	26	13.7	21
6.1	25	14	23
6.4	32	14.3	21
6.7	17	14.7	18
7	24	15	15
7.3	30	15.3	14
7.6	15	15.6	12
8	23	15.9	16
8.3	32	16.2	5
8.6	24	16.6	8
8.9	23	16.9	5
9.2	22	17.2	5
9.6	24	17.5	3
9.9	16	17.8	2
10.2	19	18.5	1
10.5	24		
10.8	23		
11.2	24		
11.5	28		
Sub-totals	551		337
Grand Total			888

Table 8: Summary of number of standing trees by diameter classes: Plantation site 3

Diameter class	Diameter class in cm	Total number of trees in diameter class	Percentage diameter-class distributed	Number of trees required for 10% sample in each diameter class
I	0.0 - 5.0	68	7.7	7
II	5.1 - 10.0	365	41.1	37
III	10.1 - 15.0	384	43.2	38
IV	15.1 - 20.0	71	8.0	7
V	20.1 - 25.0			
VI	25.1 - 30.0			
Grand Total		888	100.0	89

Table 9: Results of the dried weight test: Plantation site 3

Sample No	Diameter classes	Part of tree	Green weight kg	Air dried		Kiln dried		Oven dried		Conversion coefficient
				weight kg	*MC %	weight kg	MC %	weight kg	MC %	
1	2	3	4	5	6	7	8	9	10	11
1	I	Leaves	1	0.45	8.89			0.41	0	0.41
2	II	Leaves	1	0.4	9.38			0.3625	0	0.3625
3	III	Leaves	1	0.35	9.31			0.3174	0	0.3174
4	IV	Leaves	1	0.475	8.32			0.4355	0	0.4355
5	V	Leaves								
6	I	Twigs	1	0.5	10.00			0.45	0	0.45
7	II	Twigs	1	0.62	9.68			0.56	0	0.56
8	III	Twigs	1	0.46	10.24			0.4129	0	0.4129
9	IV	Twigs	1	0.475	9.68			0.429	0	0.429
10	V	Twigs								
11	I	Branches	1	0.45	9.11			0.409	0	0.409
12	II	Branches	1	0.478	10.92			0.4258	0	0.4258
13	III	Branches	1	0.463	12.29			0.4061	0	0.4061
14	IV	Branches	1	0.55	10.36			0.493	0	0.493
15	V	Branches								
16	I	Trunks	1	0.5	10.32			0.4484	0	0.4484
17	II	Trunks	1	0.5	9.36			0.4532	0	0.4532
18	III	Trunks	1	0.4959	11.23			0.4402	0	0.4402
19	IV	Trunks	1	0.523	10.59			0.4676	0	0.4676
20	V	Trunks								

*MC: Moisture Content

Note: Total sample 4 x 4 = 16; No trees in diameter class V.

Table 10: A summary of green weight/volume for parts of trees in plantation site 1

No	Diameter class	Vol. of saw logs	Vol. of constr. poles	Total branch wood green	Total twigs green	Total leaves green	Tops and lops green
		m ³ /ha	m ³ /ha	kg/ha	kg/ha	kg/ha	kg/ha
1	I			296.791	286.09	2453.6	3509.9
2	II		23.158	1772	1622	1616	10595
3	III		14.69	1717.33	1336.9	1152.2	1426
4	IV	0.2885	0.623	177.692	107.08	131.75	621.35
5	V						
6	VI						
Total		0.2885	38.468	3963.81	3352	5353.5	16152
				ton/ha	ton/ha	ton/ha	ton/ha
				4.0	3.4	5.4	16.2

Table 11: A summary of oven dried weights for parts of trees at moisture content zero in plantation site 1

Total branch wood	Total twigs	Total leaves	Tops and lops
Oven dried coefficients			
0.43578	0.4523	0.402	0.4564
0.502	0.5229	0.3881	0.4275
0.4735	0.4437	0.4102	0.4571
0.4093	0.4135	0.3994	0.3876
Oven dried weights			
kg/ha	kg/ha	kg/ha	kg/ha
129.335	129.39	986.33	1601.9
889.544	848.07	627.17	4529.2
813.154	593.19	472.63	651.82
72.7295	44.276	52.619	240.84
1904.76	1614.9	2138.7	7023.8
ton/ha	ton/ha	ton/ha	ton/ha
1.9	1.6	2.1	7.0

Table 12: A summary of green weight/volume for parts of trees in plantation site 2

No	Diameter class	Vol. of saw log	Vol. of constr. poles	Total branch wood green	Total twigs green	Total leaves green	Tops and left over wood green
		m ³	m ³	kg	kg	kg	kg
1	I			125.83	124.65	152.91	1118.1
2	II		3.7748	1020	797.31	1178.1	3955.9
3	III	6.9517	12.21	4267	2301.4	2370.9	8143.9
4	IV	14.108	9.9054	3709.1	1341.4	1647.4	4122.4
5	V	5.4243	1.4447	2075.4	591.5	713.1	1223.1
6	VI	1.0677	0.1011	72.0	84.6	117.9	95.7
Total		27.552	27.436	11269	5241	6180	18659
				tons	tons	tons	tons
				11.3	5.2	6.2	18.7

Table 13: A summary of oven dried weights for parts of trees at moisture content zero in plantation site 2

Total branch wood	Total twigs	Total leaves	Tops and left over wood
Oven dried coefficients			
0.4219	0.4641	0.4423	0.4371
0.4568	0.3458	0.4135	0.4594
0.4701	0.4242	0.4124	0.4355
0.4698	0.386	0.3798	0.4926
0.4653	0.419	0.3784	0.4804
0.4243	0.4135	0.4058	0.4581
Oven dried weights			
kg/ha	kg/ha	kg/ha	kg/ha
53.086	57.849	67.634	488.72
465.95	275.71	487.15	1817.3
2005.8	976.25	977.76	3546.7
1742.5	517.78	625.68	2030.7
965.68	247.83	269.83	587.52
30.55	34.982	47.844	43.843
5263.6	2110.4	2475.9	8514.8
ton/ha	ton/ha	ton/ha	ton/ha
5.3	2.1	2.5	8.5

Table 14: A summary of green weight/volume for parts of trees in plantation site 3

No.	Diameter class	Vol. of saw log	Vol. of constr. poles	Total branch wood green	Total twigs green	Total leaves green	Tops and left over wood green
		m ³ /ha	m ³ /ha	kg/ha	kg/ha	kg/ha	kg/ha
1	I			39.3	34.3	18.2	337.6
2	II		5.4	959.7	493.8	504.7	2217.6
3	III		29.2531	4117.9	2261.7	2371.1	5358.2
4	IV	4.1	10.8	1392.7	764.5	913.8	1703.0
5	V			0	0	0	0
6	VI			0	0	0	0
Total		4.083	45.4523	6509.6	3554.3	3807.7	9616.4
				ton/ha	ton/ha	ton/ha	ton/ha
				6.5	3.6	3.8	9.6

Table 15: A summary of oven dried weights for parts of trees at moisture content zero in plantation site 3

Total branch wood	Total twigs	Total leaves	Tops and left over wood
Oven dried coefficients			
0.409	0.45	0.41	0.4484
0.4258	0.56	0.3625	0.4532
0.4061	0.4129	0.3174	0.4402
0.493	0.429	0.4355	0.4676
Oven dried weights			
kg/ha	kg/ha	kg/ha	kg/ha
16.0912	15.431	7.4479	151.367
408.621	276.55	182.95	1005.03
1672.28	933.84	752.59	2358.69
686.609	327.96	397.95	796.316
2783.6	1553.8	1340.9	4311.4
ton/ha	ton/ha	ton/ha	ton/ha
2.8	1.6	1.3	4.3

PART II. ANNEXES

Annex 1: Terms of Reference for Assessing the Share of Fuelwood in Total Wood Production in Private Plantations in Lao PDR

1. BACKGROUND

The Regional Wood Energy Development Programme (RWEDP) was requested by the Burapha Agro-forestry Co. Ltd., to assist it in assessing the proportions of wood and fuel wood obtained from fast-growing exotic tree plantations of eucalyptus in Lao PDR. The proposal submitted by Burapha Agro-forestry Co. Ltd., suggested that the study include an assessment of the production of stem wood, fuelwood, twigs and leaves (or the total biomass production above ground) from the trees planted in the entire 2.52 hectares of three plantations scattered in three separate blocks. The three plantations, two of which were raised by individual farmers and one by the company itself over the last 4-7 years, were established as private or joint venture undertakings between the investors and the Forest Development. RWEDP agreed to provide financial support and technical expertise to the study and requested Dr. C.T.S. Nair of FORSPA, to recommend a reliable and cost-effective study methodology to Burapha Agro-forestry Co. (through Mr. Thongthanh Southitham, Operations Manager).

2. OBJECTIVES

The primary objective of the study shall be to assess the total biomass production and determine the share of saw-logs, poles, branch-wood, twig and leaves (please refer to Annex 2 for definitions of these terms) in the total production from the fast-growing high-yielding trees planted by private individuals and business undertakings in Lao PDR. Of particular interest will be the establishment of a relationship between the diameter (DBH) and height of a tree and its total above-ground biomass production, including wood and non-woody biomass, at a rotation age of five years.

3. METHODOLOGY

3.1 Sampling Intensity

In order to assess the total volume/quantity of above-ground biomass production -or the woody and non-wood biomass in different utilization categories - harvested from these fast-growing short rotation tree plantations, a 10% sample of the entire area will be considered sufficient for detailed measurement. Such a sample size will reduce the cost and the time required for the study in the field without compromising the validity of the results.

3.2 Approach to Sampling

(a) Since fuelwood and other biomass availability will depend on the tree diameter and tree height, from the point of view of the wider application of the study yield will be assessed on a per tree basis. Hence trees not sample plots within the plantation blocks will be the sampling unit. The approach will be very similar to that used when preparing conventional volume tables and included all the biomass including fuelwood (branches, twigs, leaves etc.).

Before felling, the diameter of all standing trees in each of the three plantation blocks will be measured at 1.3 meters above ground. Then they will be grouped into 5 cm diameter

classes (i.e. 0-5 cm or class I; 5.1-10 cm or class II; 10.1-15 cm or class III, 15.1-20 cm or class IV, 20.1 – 25 cm or class V and 25.1 – 30 cm or class VI.

A 10% sample of the total number of trees in each diameter class will be measured for detailed assessment of main categories of products above ground, (e.g. saw-logs, poles, branch-wood, twigs, leaves) immediately after tree felling. Ideally, a random sample consisting of 10% of all trees in the entire plantation in each block should be selected. But in view of the practical difficulties associated with this, one would select the trees for detailed measurement after they are harvested, and the measurement of additional trees should continue until the required number of trees is reached and constitutes a 10% representative sample for each diameter class.

Apart from measuring the diameter of the 10% sample from each diameter class, total height (total length) will also be measured immediately after felling.

Yield from each of the felled trees was measured and classified as saw-logs (in m³), poles (in m³), branch wood (in kg), twigs (in kg), and leaves (in kg). The weights (green weight basis) of branch wood, twigs and leaves shall be measured immediately after felling at the site itself. The aim here will be to ensure that they do not lose their moisture content before measurement. Respective air dry-weight or bone-dry weight conversion factors, shall be determined for all three-product categories after laboratory test measurements of sub-samples.

For each diameter class, a separate table shall be provided to show the detailed information in separate columns. This includes the following items: serial number of trees measured in each diameter class (1,2,3 etc. up to the last number that makes up the 10% sample size); diameter in centimeters to one decimal point; total height of the measured tree (or total length of the tree); volume and number of saw-logs produced from each tree (volume in m³ and number of logs, length and mid- diameter); volume and number of poles (volume in m³, length and mid-diameter); weight of branch-wood (in kg, green); weight of twigs (kg, green); and weight of leaves (kg) other residues from tree harvest (i.e. wood chips, sawdust), if any (in kg, green).. Based on the volume / weight conversion factors derived from field and laboratory measurements, the entire above-ground biomass output from a tree can be calculated in terms of its green-wet, or dry-weight basis. And applying these conversion factors, the share of saw-logs, poles, branch-wood, twigs and leaves in total production was estimated, including the share of fuelwood, pulpwood and the amount of wood used for other end-uses according to the prevailing market demand for these products in Lao PDR.

The above information could be used to develop tables that indicate the proportion (share) of fuelwood and other biomass as a function of diameter and height. The advantage of this approach is that it could be used to estimate the proportion of fuelwood and biomass obtainable from a wide range of conditions – like spacing regime, site quality, age etc. Once a sample measurement of diameter class distribution is obtained, the table could be used to derive yield from unit area.

3.3 Limitations and Explanations

The main limitation of the study is that the ratios derived will be related to the specific market situation prevailing at the time of felling. This will particularly be the case with products that can be used for alternative end uses as in the case of pulpwood and fuelwood. The market supply/demand of wood, particularly for pulp wood, will greatly affect the availability of wood for energy purposes when the price of fuel wood is not be able to compete in the open market. In the past the market price for pulpwood was higher than at present, and this part of the output plus the twigs and leaves is currently available from such plantations for fuel purposes. Since a larger proportion from the plantation output is available as firewood it may be converted into charcoal for use in urban centers. Therefore, the figures derived in terms of the share of the firewood and other wood from a plantation area at a given time may not be relevant to another location and another time on account of the differences in the local market demand/supply of wood products. This is bound to affect the actual patterns of end uses of available wood. This problem can be addressed partly by clearly defining the terms used in the study - i.e. "saw-logs", "poles", "branch wood", "twigs" and "leaves" - and specifying their output in number, length, mid-diameter, and/ or weight (in dry-weight basis). Stating the types of products that will be available exclusively for fuels, other specific uses, or both will also help.

Annex 2: Definition of Terms Used in the Study

Saw Logs:

Saw logs mean the logs shall have average diameter of 15 cm under bark and shall be straight, the length of the log can be from one meter to 6 m. Furthermore, the logs must be free from rotten parts, metals (trees, which grow along, the roads close to communities). The logs should have a curve of less than 5%. The saw logs are measured in cubic meters.

Construction Poles:

Construction poles mean those parts of a plantation tree, that have a particular length determined by a user, are used for supporting buildings/houses frames when being constructed. There are particular lengths such as 3 m, 3.5 m, 4 m, 4.5 m, 5 m, 5.5 m, 6 m and 8 m. Each size has its own top end diameter. The logs, which are 3 m, 3.5 m, 4 m and 4.5 m long, have a minimum top diameter of 5 cm, the logs of 5 m, 5.5 m and 6 m log have a minimum top diameter of 6 cm and the top diameter long of 8 m long is 11 cm.

Branch Wood:

Branch wood is the wood obtained from only the side branch of a tree and without leaves and twigs.

Twigs:

Twigs are those parts of a tree that connect the branches and the leaves.

Tops and Lops:

Top wood (or tops) is the wood obtained from the top part of a stem or a trunk. When saw logs on construction poles are cut from a tree, the rest of the upper part of the tree is considered tops. Tops are mostly used for charcoal and fuel wood.

Lops (or left over wood) is the wood obtained from a stem or a trunk. This part of the wood is not suitable for using for saw logs or construction poles because of its bending characteristics and its unusual fatness at the bottom part of a tree. Lops are generally used for pulp wood, charcoal or fuel wood.

Both of tops and lops can be representative specimens for weighing saw logs and construction poles, because these parts were picked up from the same tree where saw-logs and construction poles were obtained.

Note: **Burapha Agro-Forestry Co., LTD** has its own standard sizes of eucalyptus logs for sawmilling and eucalyptus poles for construction, both of which are sold in the Vientiane market, Laos. Burapha Agro-Forestry Co., LTD will continue to invest in the wood processing industry, using raw material (wood) from the country's tree plantations, especially eucalyptus plantations.

Annex 3: Information on Plantation Sites

Site 1 Private Tree Plantation

Farmer's Name: Mr. Lung Vi
Location: Ban Boleck, Saythani District, Vientiane Municipality
36 km from Vientiane City
Plantation Tree Species: *Eucalyptus camaldulensis*
Plantation year: 1993
Area: 2 ha
Spacing: 2m X 2m
Number of trees/ha: 2500
Measured area: 0.52 ha
Area description (before planting): Fallow land, formerly planted with dry rice, maize and other cash crops in the rainy season; well-drained area

Site 2 Private Tree Plantation

Farmer's Name: Mr. Thongbai, Age 54 years
Location: Ban Lingsane, Thoulakhom District, Vientiane Municipality
53 km from Vientiane City
Plantation Tree Species: *Eucalyptus camaldulensis*
Plantation year: 1991
Area: 1 ha
Spacing: 3m X 2m
Number of trees/ha: 1667
Measured area: 1 ha
Area description (before planting): Fallow land, formerly planted with cash crops in the rainy season; partly water-logged area

Site 3 Company Tree Plantation

Owner's Name: Burapha Agro-Forestry Co., LTD
Location: Ban Hatkieng, Saythany District, Vientiane Municipality
48 km from Vientiane City
Plantation Tree Species: *Eucalyptus camaldulensis*
Plantation year: 1993
Area: 25 ha
Spacing: 3m X 3m
Number of trees/ha: 1111
Measured area: 1 ha
Area description (before planting): Fallow land, formerly planted with dry rice during the rainy season; well-drained area

Annex 4: Explanation of the Oven and Kiln Drying Procedures

A: Oven Drying Procedure

An electrical oven drying machine was used in the study. The model used is the “TUNIOR FISCHER ISOTEMP”. It can reach a maximum temperature of 200°C.

Each specimen was dried at an average temperature of 65°C. Every 5 hours the moisture content of the specimen was checked by weighting it. If the weight of this specimen stayed constant, then it was considered as having zero percent moisture content. The weight of the specimen was recorded when the moisture content reached Zero.

B: Kiln Drying Procedure

The kiln drying procedure for drying eucalyptus wood was conducted using a kiln dryer, which uses hot water steam. The kiln dryer contains: 1) a big chamber in which sawn wood or parts of trees can be dried; 2) 8 fans used for circulating hot air inside the chamber (it should be noted that the temperature inside the chamber can be adjusted automatically); 3) a hot water steel palette inside the chamber.

The procedure starts by putting eucalyptus parts like wood stem, branches, and twigs, in the kiln-drying chamber. The initial temperature is 25°C, and this is increased overtime up to 80°C. Air circulation direction in the chamber is changed every three hours. Moisture contents in the tree parts are checked regularly until the moisture contents are less than 10 percent. This procedure takes approximately 14 days.

Annex 5: Explanation of Tables

Table 1, 4 and 7 show the range of tree diameters and the number of trees having a particular diameter in the range.

Tables 2, 5, and 8 show the different diameter classes, the number of trees in each diameter class, the percentage distribution of trees in each diameter class and the number of trees chosen for measurement (10 percent of the total number of each diameter class)

Tables 3, 6 and 9 display the results of the dried weight measurements of leaves, twigs, branches and trunks. Column 4 shows the green weight in kilograms; column 5 the air-dried weight. All samples were dried in the sun until the researchers felt they were sufficiently dry.

The moisture content of each sample is shown in column 6. Moisture content was measured when the samples were taken for oven drying in the laboratories. Column 7 gives a kiln-dried weight for each sample. The purpose of kiln drying is to accelerate the drying process.

Oven-dried weights shown in column 9 were derived from the dried weight when the moisture content of each sample was at zero (column 10). Column 11 shows conversion coefficients for each sample and is derived from dividing column 9 by column 4. These coefficients can be used to convert green weight to an oven-dried weight or vice versa.

Annex 6: Biomass Production Measurement Sheet by Diameter Class Type

Table A1. Plantation site 1: Diameter class 0 - 5 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)				Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)	
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.					Volume
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
1	4	5											0.5	0.44	0.04	4
2	3.5	6.2											0.4	0.136	0.264	4.4
3	4.1	7.9											0.95	0.67	0.627	7.6
4	4.1	6											1.2	1.31	0.99	13
5	3.2	6											0	0.83	1.32	8.4
6	2.2	4											0.08	0.03	0.033	1.3
7	2.2	3.5											0.05	0.07	0.033	0.95
8	3.5	6											0.35	0.45	0.495	3.5
9	2.9	5.8											0.1	0.33	0.066	4
10	3	5.4											0.05	0.17	0.132	2.8
11	3.2	6.5											0.05	0.17	0.231	3.4
12	4.5	8											0.1	0.94	0.858	7.95
13	3.8	7											0.65	0.55	0.462	6
													dried			
													0.5			
14	3.8	6.5											0.2	0.5	0.198	5.1
15	2.8	5											0.05	0.12	0.132	2.2
16	2.5	4.6											0.25	0.06	0.026	1.9
17	2.8	9											0.05	0.18	0.264	2.9
													dried			
													0.5			
18	2.5	4.4											0.1	0.25	0.198	1.5
19	3.5	7											0.2	0.34	0.264	4.5
													dried			
													0.1			
20	3.18	7.2											0.05	0.24	0.264	3.6
21	2.5	4.4											0.1	0.17	0.132	1.6

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)				Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)	
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.					Volume
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m³	m	cm	cm	cm	m³	kg	kg	kg	kg
													dried			
													0.1			
22	2.8	4.8											0.2	0.07	0.033	2.3
23	4.1	7.5											0.6	0.58	0.462	8.05
24	1.59	4											0	0.08	0.066	0.8
25	1.9	4											0.1	0.15	0.099	1.05
													dried			
													0.5			
26	2.5	4.3											0.1	0.15	0.198	1.6
27	1.9	2.3											0.1	0.05	0.099	0.6
													dried			
													0.05			
28	2.2	3.4											0.05	0.02	0.003	0.85
													dried			
													0.005			
29	1.9	3.3											0.05	0.07	0.033	0.7
30	2.5	5.9											0.1	0.07	0.132	2
													dried			
													0.05			
31	4.7	8											0.25	0.6	0.396	5.5
													dried			
													0.02			
32	4.1	7											0.5	0.82	0.528	6.4
33	4.1	10.5											0.6	0.25	0.297	6.1
													dried			
													0.15			
34	4.1	9.4											0.1	0.24	0.264	7
													dried			
													1.15			
35	3.5	5											0.65	0.52	0.528	4.05
													dried			
													0.005			

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
36	4.4	7.3											0.8	0.74	0.66	7.1
37	4.4	7.6											0.6	0.32	0.33	8.25
													dried			
													0.25			
38	3.5	7											0.3	0.45	0.495	5
39	3.1	6.2											0.2	0.43	0.297	3.6
40	4.4	8.8											0.55	0.67	0.528	9.4
41	4.2	9.5											0.3	0.37	0.528	9.5
42	3.18	4.5											0.35	0.2	0.6	1.2
								10% green weight:					15.36	14.81	13.61	181.65
								Total green weight of 0.52 ha:					154.33	148.8	1276	1825.15
								Total green weight of one hectare:					296.79	286.1	2454	3509.904

Table A2. Plantation site 1: Diameter class 5.1 - 10 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)				Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)	
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.					Volume
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m³	m	cm	cm	cm	m³	kg	kg	kg	kg
1	5.7	10						3			7	0.01154	0.5	0.874	0.726	13.85
2	5.1	10.2						3			6.5	0.00995	0.7	1.144	1.056	5.25
3	6.4	11.3						4			7.5	0.01766	0.3	0.574	0.726	6.5
4	5.4	10.8						3			6.5	0.00995	1.5	0.542	0.858	8.6
												0	dried	dried		
												0	0.1	0.05		
5	5.1	10.3						3			6	0.00848	0.15	0.555	0.495	6.05
												0	dried			
												0	0.1			
6	5.7	11.5						3			7	0.01154	0.4	0.456	0.594	8.9
7	6.05	10						3.5			7.5	0.01545	1.7	0.94	0.66	8.1
												0	dried			
												0	0.05			
8	6.36	11						3.5			7	0.01346	0.6	0.336	0.264	8.9
												0	dried			
												0	0.1			
9	5.73	10.6						3.5			6.5	0.01161	1.05	1.178	1.122	5.45
10	7	12.2						4			8	0.0201	1.6	1.046	1.254	10.7
11	6.05	12						3.5			6.5	0.01161	0.8	0.572	0.528	9.5
12	7	13						4			7.5	0.01766	0.9	0.772	0.528	2
13	7.64	12						4			8	0.0201	1	1.106	0.594	5.5
								4			5.5	0.0095	dried			
												0	0.1			
14	6.4	11.4						3			5	0.00589	0.5	1.114	1.386	6.3
												0	dried			
												0	0.2			
15	6.05	10.1						3			6.5	0.00995	1	0.84	0.66	7.5
												0	dried			
												0	0.1			

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
16	6.4	10.4						3			7	0.01154	0.6	1.144	1.056	9
17	5.1	9						3			6	0.00848	0.4	0.602	0.198	4.5
												0	dried			
												0	0.2			
18	5.4	8.6						3			6.5	0.0099	0.5	0.542	0.858	4
19	6.05	10.6						3.5			7	0.01346	0.7	0.978	1.122	8.4
												0	dried			
												0	0.3			
20	5.7	10						3			6.5	0.00995	0.8	0.608	0.792	6.75
												0	dried			
												0	0.05			
21	5.1	10						3			5.5	0.00712	0.4	0.672	0.528	6.8
22	6.4	11.1						3.5			7	0.01346	0.4	1.16	0.99	10
												0	dried			
												0	0.2			
23	5.4	11.1						3			6.5	0.00995	0.3	0.74	0.66	7.5
24	6.7	11.6						3.5			7.5	0.01545	0.6	0.842	0.858	8.8
												0	dried			
												0	0.1			
25	8.3	14.2						4			9.5	0.02834	3.3	2.292	2.508	12.75
								3			6	0.00848	dried			
												0	0.1			
26	7.6	12.1						4			7	0.01539	2	1.816	1.584	10.4
												0	dried			
												0	0.3			
27	6.4	10.3						3.5			7.5	0.01545	1	0.94	0.66	6.8
28	6.7	9.5						3.5			7	0.01346	1	1.248	1.452	9.2
29	5.6	10.5						3			6.25	0.0092	1	1.246	1.254	6
30	6.7	11						4			9	0.02543	1.3	0.978	1.122	10.2
31	5.4	10						3			6	0.00848	0.4	1.044	1.056	7.2
32	8	10.3						3			7	0.01154	0.8	0.742	0.858	3.2

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)				Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)	
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.					Volume
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
								3			4.5	0.00477				
33	6.7	10						4			7.5	0.01766	1.4	1.697	1.353	7.65
												0	dried			
												0	2.5			
34	5.3	8.5						3			6.5	0.00995	0.85	0.758	0.792	6.1
35	9.9	14						4			10	0.0314	2.8	2.634	3.366	3.05
								4			7.5	0.01766				
								3			5.75	0.00779				
36	9.2	14.5						4			10	0.0314	1.7	2.298	3.102	11.5
								4			6.85	0.01473				
37	8.6	11.5						3			7.5	0.01325	1	1.588	2.112	11.8
38	5.4	11						3			6	0.00848	1.6	0.842	0.858	8.3
												0	dried	dried	dried	
												0	0.1	0.15	0.15	
39	4.7	8.6						3			6	0.00848	0.3	0.268	0.132	10.5
40	6.05	12.8						3			6.5	0.00995	0.4	0.372	0.528	13.4
41	9.2	15.6						4			10.5	0.03462	1.65	1.868	1.782	4.25
								4			7	0.01539				
42	6.4	10.7						3.5			7	0.01346	1.1	1.01	0.99	7.7
												0	dried			
												0	0.1			
43	8.6	10.2						3			6	0.00848	0.2	1.01	0.99	6.5
												0	dried			
												0	0.1			
44	7.3	10.3						3.5			7.75	0.0165	3.1	1.548	1.452	10.1
												0	dried			
												0	0.4			
45	6.4	10.3						3			7	0.01154	1.2	1.244	1.056	7.6
46	8	12						3			9	0.01908	1	1.75	1.65	9
								3			3.5	0.00288	dried	dried		
												0	0.2	0.1		

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)				Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)	
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.					Volume
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m³	m	cm	cm	cm	m³	kg	kg	kg	kg
47	5.7	9.5						3			6.25	0.0092	1.1	0.706	0.594	6.1
48	6.05	10.5						3			7	0.01154	0.9	0.67	0.33	9
												0	dried			
												0	0.9			
49	6.05	11.2						3.5			7	0.01346	0.9	1.108	0.792	7.7
50	6.7	12						3			8	0.01507	0.4	0.874	0.726	9.9
51	8	12.2						3			8	0.01507	0.9	1.79	2.31	8.2
								3			5.5	0.00712				
52	6.4	11.5						3			8	0.01507	0.6	0.944	1.056	9.3
53	7	12.5						3.5			8	0.01758	0.9	1.25	1.65	7.5
								3			5.5	0.00712				
54	7	11.5						3.5			8	0.01758	1.2	1.18	1.32	11.4
												0	dried			
												0	0.1			
55	5.7	8						3			5.5	0.00712	1.1	0.472	0.528	3.7
												0	dried			
												0	0.1			
56	6.05	10						3.5			7	0.01346	0.6	0.874	0.726	7
57	5.1	10						3			4	0.00377	1.1	0.84	0.66	5.6
												0	dried			
												0	0.1			
58	5.6	9.5						3.5			6	0.00989	0.8	0.808	0.792	7.4
59	6.4	11						3			5	0.00589	0.6	0.842	0.858	8.6
60	5.1	9						3			6	0.00848	0.3	0.64	0.66	6
61	5.1	8.5						3			5.75	0.00779	0.6	0.91	0.99	4
												0	dried			
												0	0.4			
62	5.4	9						3			6	0.00848	0.6	1.044	1.056	4.6
63	5.4	8						3			5.5	0.00712	0.6	0.438	0.462	3.5
64	6.4	10.5						3			7	0.01154	0.4	0.706	0.594	4.7
65	5.1	10						3			5.5	0.00712	0.3	0.74	0.66	6.5

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
66	5.4	10						3			6.5	0.00995	1	0.89	0.66	7.3
67	5.1	8.5						3			5.75	0.00779	0.9	0.486	1.056	3.7
68	8.3	11.2						3			8.5	0.01701	2.8	1.786	1.914	6.2
								3			6	0.00848				
69	7.6	11.5						3			8.5	0.01701	1.1	1.682	1.518	5.05
								3			6	0.00848				
70	5.4	8						3			6	0.00848	1.4	0.646	0.704	4.6
71	9.5	13						4			10.5	0.03462	4.7	3.974	3.828	7.8
								4			7	0.01539	dried	dried		
												0	0.5	0.3		
72	7.6	10						3			9	0.01908	2.3	1.712	1.188	3.5
								3			5.25	0.00649				
73	9	12.5						3.5			10.5	0.03029	4.7	2.526	2.574	7.9
								3.5			7	0.01346				
74	9.4	12						4			10	0.0314	4.5	3.863	3.717	7
								3			6	0.00848				
												1.19295	91.3	83.53	83.24	545.8
							10% green weight:				Kg:		91.3	83.53	83.24	545.8
							Total green weight at 0.52 ha:				Kg:		921.64	843.2	840.3	5509.6
							Total green weight at one ha:				Kg:		1772	1622	1616	10595
							Total Volume at 0.52 ha				12.042 m ³		for construction poles			
							Total Volume at one ha				23.158 m ³		for construction poles			

Table A3. Plantation site 1: Diameter class 10.1 - 15 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)				Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)	
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.					Volume
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
1	10.5	14.5						4			11	0.03799	9	4.259	4.191	7.7
												0	dried			
													0.5			
								4			7	0.01539				
2	11.5	15.8						4			12	0.04522	4.5	11.636	6.864	10.9
								4			8.5	0.02269				
3	12.7	14.2						4			12	0.04522	9.2	4.654	5.346	8.55
								4			9	0.02543	dried			
								3.5			6.5	0.01161	0.35			
4	11.5	16.5						2			14.5	0.03301	7	13.85	5.94	4.45
								4			14.5	0.06602	dried			
								4			8	0.0201	1.15			
								3			6	0.00848				
5	14.6	15						2			16.25	0.04146	22.8	13.59	11.814	13.8
								2			12.75	0.02552				
								2			11	0.019				
								2			9.5	0.01417				
								3			6.5	0.00995				
6	12.1	14.7						2			13	0.02653	7.3	5.668	6.732	7
								4			9	0.02543				
								4			7	0.01539				
7	10.8	15.5						2			12	0.02261	5.5	4.346	4.554	3.6
								4			8.5	0.02269				
								4			7.5	0.01766				
								3			6	0.00848				
8	10.2	14						4			10.5	0.03462	7.8	3.214	4.686	3.5
								4			8	0.0201				
								3			6	0.00848				
9	10.2	13.5						2			12	0.02261	7.75	2.94	3.96	4.7
								4			8	0.0201				

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
								4			6	0.0113				
10	11.5	16						2			11.5	0.02076	4.7	3.997	4.653	8.5
								4			7	0.01539				
								4			7	0.01539				
												0.74876	87.55	68.154	58.74	72.7
									10% green weight:				87.55	68.154	58.74	72.7
									Total green weight of 0.52 ha				893.01	695.17	599.15	741.54
									Total green weight of one ha				1717.3	1336.9	1152.2	1426.04
									Total volume of construction poles of 0.52 ha in m ³ :							7.6373769
									Total volume of construction poles of one ha in m ³							14.687263

Table A4. Plantation site 1: Diameter class 15.1 - 20 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
1	17.2	15	2			17.5	0.04808						15	9.08	11.418	26.75
								4			9.5	0.02834	dried	dried		27.1
								3.5			10	0.02748	0.4	0.2		
				Total:			0.04808					0.10389	15.4	9.28	11.418	53.85
								10% green weight:					15.4	9.28	11.418	53.85
								Total green weight of 0.52 ha					92.4	55.68	68.51	323.1
								Total green weight of one ha:					177.69	107.08	131.75	621.34615
								Total volume of construction poles in m ³ :								0.6233685
								Total volume of saw-logs in m ³ :								0.2884875

Table A1. Plantation site 2: Diameter class 0 - 5 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)				Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)	
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.					Volume
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m³	m	cm	cm	cm	m³	kg	kg	kg	kg
1	1.6	5.1											0.25	0.5	0.35	3.5
2	3.5	5.3											0.24	0.3	0.54	4.5
3	3.25	5.1											0.26	0.25	0.35	2.6
4	4.14	3.5											1.1	0.74	0.36	3.6
5	4.78	6.22											0.85	0.53	0.62	5.1
6	4.78	6											0.7	0.88	1.72	7
7	3.82	5.3												0.42	0.52	3.75
8	3.82	4											0.4	0.41	0.39	3.6
9	4.46	5.5											0.55	0.3	0.49	6.15
													dried	dried		
													0.2	0.2		
10	4.46	3.8											0.4	0.27	0.53	0.52
													dried	dried		
													0.5	0.5		
11	4.14	4.8											0.35	0.42	0.73	3.8
12	4.46	5.8											1.05	0.7	1.06	6.35
13	3.82	5.4											0.3	0.41	0.59	3
14	3.82	4.3											0.55	0.4	0.4	3.2
15	3.82	4.7											0.5	0.49	0.56	4.9
16	4.14	6											0.5	0.64	0.86	5.2
17	4.14	6.4											0.45	0.51	0.59	6.25
18	3.82	4.65											0.9	0.58	0.92	3.85
19	4.14	5.75											0.4	0.31	0.4	6.5
20	3.82	3.9											0.45	0.31	0.39	2
21	3.5	5.6											0.25	0.29	0.56	3.65
22	4.14	6											0.2	0.21	0.39	5.5

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
23	4.78	5											0.25	0.3	0.39	5.1
24	1.9	5.2											0.3	0.45	0.4	3.7
25	2.2	5.4											0.28	0.5	0.45	3.9
26	2.9	5.3											0.35	0.4	0.5	3.5
27	2.5	5.2											0.29	0.48	0.52	3.2
													12.82	12.70	15.58	113.92
									10% green weight:				12.82	12.70	15.58	113.92
									Total green weight of 1 ha:				125.83	124.65	152.91	1118.10

Table A2. Plantation site 2: Diameter class 5.1 - 10 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
1	8.92	10.9						4	12	7	9.5	0.0283	3.3	7.4	7.3	3.2
								3.5	7	5	6	0.0099				
2	5.73	5.9									0	0	1.15	1.45	2.35	10.5
3	7.32	7.6						3	9	5	7	0.0115	4.1	2.15	2.2	7.5
											0	0		dried		
											0	0		0.5		
4	6.37	7.1						3.5	9	4.5	6.75	0.0125	2.15	1.45	2.6	5
5	7.64	9						3.5	11	5	8	0.0176	2.35	2.8	4	8.5
6	7.01	11						4	11	7	9	0.0254	3.7	1.35	5.3	6.1
7	6.37	9.6						3.5	10	5	7.5	0.0155	1.3	2.9	1.9	5.8
8	8.28	8.2						4	12	6	9	0.0254	2.8	1.6	2.7	8.3
											0	0		dried		
											0	0		0.6		
9	8.28	10.7						4	11	6	8.5	0.0227	5.8	3	5.8	11.6
10	5.73	7.6									0	0	0.3	0.9	1.5	10.5
11	5.41	7.1									0	0	0.24	1.1	2	10.6
12	8.12	8.75						3.5	11	5.5	8.25	0.0187	4.1	2.3	4	9
											0	0		dried		
											0	0		0.4		
13	8.6	7									0	0	3	2.3	3.7	15.9
14	7.01	9						3	10	5	7.5	0.0132	1.7	1.1	2	8
15	5.45	8.5									0	0	2.4	1.1	2.5	20
16	5.73	6.9									0	0	1	1.9	1	11.4
17	9.87	10.5						3	13	7	10	0.0236	4.5	5.2	6.7	16
18	8.28	10.9						4	11	6	8.5	0.0227	4.4	1.7	3.5	3.5
								3	6	5	5.5	0.0007	dried			
											0	0	0.95			
19	7.01	7.3									0	0	1.6	2.3	3.45	22.3

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
											0	0	dried	dried		
												0	0.5	0.5		
20	9.24	11.3						4	11	6	8.5	0.0227	2.6	2.15	3.95	3.9
								3	6	5	5.5	0.0071				
21	7.32	8.9						3	9.5	5	7.25	0.0124	1.1	1	2	10.9
22	8.28	8.9						4	13	6.5	9.75	0.0298	5.6	2.85	4.85	9.4
23	9.55	13.2						4	13	8	10.5	0.0035	3.15	1.45	3.7	9.8
								3	8	6	7	0.0012				
								3	6	4	5	0.0006				
24	9.55	10.6									0	0	2.8	1.05	1.7	37.7
25	7.64	10						4	10	6	8	0.0201	2.75	1.35	2.95	9
26	9.55	10.55						4	12	6	9	0.0254	5.65	1.67	3.23	10.4
27	5.41	6.3									0	0	0.85	0.71	0.54	8.5
28	8.6	8.9									0	0	2.5	4.71	3.64	31
29	5.1	5.6									0	0	1.4	1.25	1.6	8.9
30	7.01	7									0	0	7.5	1.91	1.74	15.4
31	7.96	11.5						4	11	5	8	0.002	2.4	1.59	3.06	11.4
32	5.1	5.4									0	0	1.5	1.3	1.8	8.6
33	6.1	6.8									0	0	2.2	1.35	2.3	4.2
34	6.4	6.7									0	0	2.1	1.4	2.5	5.1
35	6.7	7.8									0	0	2.5	1.55	2.8	6
36	10	10.5						4	13	6	9.5	0.0028	3.5	6	10.3	9.5
											0	0				
											Total:	0.375	101.44	79.29	117.2	393.4
								10% green weight:					101.44	79.29	117.16	393.4
								Total green weight of 1 ha:					1020	797.31	1178.1	3955.86
								Total volume of construction poles on 1 ha in m ³ :								3.77478

Table A3. Plantation site 2: Diameter class 10.1 - 15 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m³	m	cm	cm	cm	m³	kg	kg	kg	kg
1	10.19	10.15						4	13	6	9.5	0.0283	6	4.12	3.15	11.3
											0	0		dried		
											0	0		0.5		
2	10.83	11.7						4	13	7	10	0.0314	5.15	3.24	4.16	5.4
								3	7	4.5	5.75	0.0078				
3	10.5	12.9						4	14	6	10	0.0314	8.6	4.91	7.59	9.3
								3	6	4.5	5.25	0.0065				
4	11.62	13						5	15	8	11.5	0.0519	5.05	3.33	6.2	29.35
5	11.15	12.2						2.5	14	8	11	0.0237	5.6	10.9	3.37	15.7
											0	0	dried	dried		
											0	0	1.1	1.2		
6	10.51	12.1						2.5	13	10	11.5	0.026	8.9	3.5	3.76	33.65
7	11.15	14						2	15	10	12.5	0.0245	9.65	2.61	4.09	48.85
											0	0	dried	dried		
											0	0	0.5	0.2		
8	10.51	13						5	14	8	11	0.0475	3.2	2.93	2.57	20.1
9	12.42	15.5						1	17	11	14	0.0154	8.3	5.22	6.63	33.5
								5.5	11	8	9.5	0.039				
10	12.42	12.7						2.1	17	9	13	0.0279	23.3	3.88	4.42	3.6
								4	9	6	7.5	0.0177				
								3	6	4	5	0.0059				
11	12.42	14.7						2	16	11	13.5	0.0286	10.3	4.78	6.17	22.6
											0	0		dried		
											0	0		0.3		
12	13.38	15.2	2	19	12	15.5	0.0377				0	0	15.75	9.88	11.22	15.5
								5	12	9	10.5	0.0433				
								3	7	5	6	0.0085				
13	9.55	12.6						1.3	11	8	9.5	0.0092	3.1	3.13	2.97	26.75

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
14	11.46	12.5									0	0	3.7	4.1	3.7	61.9
15	13.06	13.1						2	17	14	15.5	0.0377	10.2			38.6
								4	10	8	9	0.0254				
16	13.06	16.1						1	15	14	14.5	0.0165	18.9	9.95	11.15	16.8
								3	11	10	10.5	0.026	dried	dried		
								3	8	7	7.5	0.0132	3.4	0.5		
								3	7	5	6	0.0085				
17	11.46	14.5						2	13	10	11.5	0.0208	4.2	3.2	2.77	12.6
											0	0	dried	dried		
											0	0	1.5	0.35		
								4	10	7	8.5	0.0227				
								3.5	7	5	6	0.001				
18	13.69	16.4	1.25	20	12	16	0.0251					0	7.3	3.76	4.88	29.2
						0	0				0	0	dried	dried		
						0	0				0	0	1.7	0.5		
						0	0	5	12	9	10.5	0.0433				
						0	0	4	9	7	8	0.0201				
19	12.74	14.1				0	0	2	17	11	14	0.0308	9.3	6.1	8.12	21.9
						0	0	5	11	7	9	0.0318				
20	11.46	10.6				0	0	2	15	10	12.5	0.0245	6.3	2.37	3.37	9.1
						0	0	4.5	10	6	8	0.0226	dried			
						0	0				0	0	1.1			
21	12.42	11.8				0	0	2	15	10	12.5	0.0245	15.9	2.86	5.54	T
						0	0	2	10	8	9	0.0127	dried	dried		12.8
						0	0	3.5	8	5	6.5	0.0116	1.3	1.7		11.3
22	10.51	12.3				0	0	1.4	15	10	12.5	0.0172	9.1	5.11	4.19	T
						0	0	4	9	6	7.5	0.0177	dried	dried		8.8
						0	0				0	0	1	0.6		10.1
23	12.1	14.5				0	0	2	17	11	14	0.0308	9.2	4	4.75	19.8

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
						0	0	5	11	7	9	0.0318				
24	10.51	12.7				0	0	5	13	7	10	0.0393	6.7	2.22	2.77	2.6
						0	0	3	7	6	6.5	0.0099	dried	dried		
						0	0				0	0	1.1	1		
25	12.74	15.4				0	0	2	17	11	14	0.0308	19.4	5.89	6.86	20.2
						0	0	5	11	7	9	0.0318	dried			
						0	0				0	0	0.3			
26	12.74	12.8				0	0	5	16	8	12	0.0565	12.1	30.48	4.82	6.1
						0	0	3.5	8	5	6.5	0.0116	dried	dried		
						0	0				0	0	0.2	0.7		
27	14	16.5	2	21	11	16	0.0402	5	11	8	9.5	0.0035	7.5	4.12	5.6	13
						0	0	4	8	6	7	0.0015	dried			
						0	0				0	0	2			
28	13.7	15.8	1.2	21	12	16.5	0.0256	4	12	9	10.5	0.0035	6.9	3.15	4.5	9.3
						0	0	4	9	6	7.5	0.0018	dried			
													1.5			
29	14.7	17	2.2	21	14	17.5	0.0529	2.2	14	12	13	0.0029	6.8	3.9	5.3	13.6
						0	0	4	12	8	10	0.0031	dried			
						0	0	4	8	5	6.5	0.0013	1.6			
30	14.3	16.2	2.2	21	13.7	17.35	0.052	4	13.7	7	10.35	0.0034	7.8	4.15	5.7	15.7
						0	0	3	7	5	6	0.0008				
31	13.4	15	2.2	19	12	15.5	0.0415	4	12	9	10.5	0.0035	6.4	5.1	6.3	12.8
						0	0	3.5	9	5	7	0.0013	dried			
						0	0				0	0	2.1			
32	14.1	15.5	2.2	20	12	16	0.0442	4	12	8	10	0.0031	9.3	5.8	6.57	9.1
						0	0	4	8	5	6.5	0.0013	dried			
						0	0				0	0	1.8			
33	14	15	2.2	19	12	15.5	0.0415	4	12	9	10.5	0.0035	19.3	6.5	9.1	30.8
						0	0	4	9	6	7.5	0.0018	dried			

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
						0	0				0	0	1.5			
34	14	14.8	2.2	21	12	16.5	0.047	4	12	7	9.5	0.0028	10.2	4.8	6.3	15.7
						0	0	3	7	5	6	0.0008	dried			
						0	0				0	0	1.9			
35	15	17	2.2	22	15	18.5	0.0591	2.2	15	13	14	0.0034	20.5	7.2	9.4	36.72
						0	0	1.2	13	12	12.5	0.0015	dried			
						0	0	4	12	10	11	0.0038	2.5			
36	14	15.6	2.2	20.9	12	16.45	0.0467	4	12	9	10.5	0.0035	8.3	6.2	8.9	21.3
						0	0	3.5	9	6	7.5	0.0015				
37	14	16	2.2	21	12	16.5	0.047	1.2	12	11	11.5	0.0012	8.6	5.3	7.4	18.6
						0	0	4	11	9	10	0.0031	dried			
						0	0	3	7	5	6	0.0008	2.2			
38	14	16.3	2.2	20	11	15.5	0.0415	4	11	8.5	9.75	0.003	7.4	5.8	8.2	9.3
						0	0	4	8.5	5.5	7	0.0015	dried			
						0	0				0	0	1.3			
39	15	17.5	2.2	22	13	17.5	0.0529	2.2	13	11	12	0.0025	12.3	8.3	11.9	28.17
						0	0	5	11	8	9.5	0.0035	dried			
						0	0	3	8	5	6.5	0.001	2.3			
40	14	16.5	2.2	19.5	11	15.25	0.0402	5	11	8	9.5	0.0035	14.2	9.8	12.7	22.9
						0	0	4	8	6	7	0.0015	dried			
													2.1			
						total	0.6952				Total:	1.221	426.7	230.14	237.09	814.39
								10% green weight:					426.7	230.14	237.09	814.39
								Total green weight of 1 ha:					4267	2301.4	2370.9	8143.9
								Total volume of construction poles in m ³ :								12.2101
								Total volume of saw log in m ³ :								6.95166

Table A4. Plantation site 2: Diameter class 15.1 - 20 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)				Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)	
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.					Volume
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
1	16.8	18.1	3.2	21	14	17.5	0.0769	2.2	14	13	13.5	0.0315	20.9	9.88	14.32	15.8
						0	0.0000	2	13	11	12	0.0226	dried			
						0	0.0000	5	11	8	9.5	0.0354	0.2			
2	19.75	18	1.2	21	19	20	0.0377	2	13	11	12	0.0226	31.8	13.7	16.83	T
						0	0.0000				0	0.0000	dried	dried		54.9
						0	0.0000				0	0.0000	0.7	0.2		10.4
						0	0.0000	3.2	16	13	14.5	0.0528				
3	15.92	16	1.2	20	16	18	0.0305	1.2	16	13	14.5	0.0198	19.2	5.43	6.67	11.8
						0	0.0000	2	13	12	12.5	0.0245				
						0	0.0000	3	12	9	10.5	0.0260				
4	18.78	18.1	2.2	20	14	17	0.0499	1.2	14	13	13.5	0.0172	11.8	6.9	9.57	16.4
						0	0.0000	2	13	10	11.5	0.0208	dried	dried		
						0	0.0000	2	10	9	9.5	0.0142	0.65	0.8		
						0	0.0000	4	9	7	8	0.0201				
						0	0.0000	3	7	6	6.5	0.0099				
5	18.15	18.8	2.2	24	16	20	0.0691	2.2	16	13	14.5	0.0363	27.5	12.1	13.4	3.6
						0	0.0000	1.2	13	12	12.5	0.0147				
						0	0.0000	2	12	11	11.5	0.0208				
						0	0.0000	5	11	8	9.5	0.0354				
						0	0.0000	3	8	5	6.5	0.0099				
6	17.52	16.7	2.2	19	14	16.5	0.0470	1.2	14	13	13.5	0.0172	14	7.83	9.57	T
						0	0.0000	2	13	11	12	0.0226	dried			21.9
						0	0.0000	4	9	8	8.5	0.0227	0.06			19.7
						0	0.0000	3.5	8	6	7	0.0135				
7	15.2	17.2	2.2	21	15	18	0.0560	2.2	15	13	14	0.0338	21.8	6.93	9.57	33.75
						0	0.0000	1.2	13	12	12.5	0.0147				
						0	0.0000	4.5	12	10	11	0.0427				
8	16.88	15.6	1.2	20	16	18	0.0305	2	14	12	13	0.0265	27.4	6.8	9.57	T

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)	
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume					
				Bottom diam.	Top diam.				Bottom diam.	Top diam.							
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg	
			1.2	16	14	15	0.0212	2	12	10	11	0.0190	dried	dried		4.5	
						0	0.0000	2	10	9	9.5	0.0142	2.1	0.5		26.4	
9	19.11	18.9	2.2	25	19	22	0.0836	2	13	12	12.5	0.0245	24.5	10.45	13.4	T	
							0.0000					0.0000					
			3.2	19	13	16	0.0643	2	12	11	11.5	0.0208	dried			33.5	
						0	0.0000				0	0.0000	0.5			7.4	
10	17.83	13.8	2.2	21	15	18	0.0560	1.2	15	13	14	0.0185	36.1	13.04	14.52	T	
						0	0.0000	2	13	11	12	0.0226	dried	dried		6.1	
						0	0.0000	2	11	9	10	0.0157	1.2	0.3		2.3	
						0	0.0000	2.5	7	5	6	0.0071					
11	17.52	13.5	1.2	21	16	18.5	0.0322	1.2	14	13	13.5	0.0172	27.7	13.09	15.11	38.5	
			2.2	16	14	15	0.0389	2	13	11	12	0.0226		dried			
						0	0.0000				0	0.0000		0.5			
12	19.43	51.1	1.2	24	19	21.5	0.0435	1.2	14	12	13	0.0159	49.2	9.99	12.41	65.4	
			1.2	19	16	17.5	0.0288	2	12	10	11	0.0190	dried	dried			
			1.2	16	14	15	0.0212				0	0.0000	3.9	2.2			
13	15.6	17.5	2.2	22	16	19	0.6234	2.2	14	13	13.5	0.0315	20.5	6.4	9.3	20.42	
			2.2	16	14	15	0.0389	2.2	15	11	13	0.0292	dried				
						0	0.0000	4.5	11	7	9	0.0286	1.8				
14	17.2	15.6	2.2	20	15	17.5	0.0529	2	13	11	12	0.0226	25.3	7.1	10.5	19.47	
			2.2	15	13	14	0.0338	2	11	9	10	0.0157	dried				
						0	0.0000	4	9	6	7.5	0.0177	2.1				
						0	0.0000				0	0.0000					
						Total:	1.411				Total:	0.991	370.91	134.1	164.7	412.24	
									10% green weight:				370.91	134.14	164.74	412.24	
									Total green weight of 1 ha:				3709.1	1341.4	1647.4	4122.4	
									Total green volume of construction poles in m ³ :								9.90544
									Total green volume of saw-log in m3:								14.1079

Table A5. Plantation site 2: Diameter class 20.1 - 25 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)				Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)	
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.					Volume
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
1	24.2	18.4	1.2	31	24	27.5	0.0712	1.2	15	13	14	0.0185	68.7	16.57	17.23	31.9
			1.2	24	21	22.5	0.0477	2	13	10	11.5	0.0208				
			3.2	21	17	19	0.0907				0	0.0000				
			2.2	17	15	16	0.0442				0	0.0000				
2	22.61	17.4	3.2	28	19	23.5	0.1387	1.2	14	13	13.5	0.0172	89.6	20.79	29.3	31.7
			3.2	19	14	16.5	0.0684	2	13	12	12.5	0.0245		dried		
						0	0.0000				0	0.0000		0.7		
3	20.7	17.1	3.2	25	18	21.5	0.1161	3.2	15	12.5	13.75	0.0475	36.5	10.46	16.4	T
			1.2	18	15	16.5	0.0256				0	0.0000	dried	dried		15
						0	0				0	0.0000	1.5	2		30.6
4	23.3	18.1	2.2	29	22	25.5	0.0112	2	13	10	11.5	0.0208	32.5	15.2	16.3	26.7
			3.2	22	15	18.5	0.0086	2	10	7	8.5	0.0113	dried			
			2.2	15	13	14	0.0034				0	0.0000	1.8			
						Total:	0.603				Total:	0.161	230.60	65.72	79.23	135.90
									10% green weight:			230.60	65.72	79.23	135.90	
									Total green weight of 1 ha:			2075.4	591.5	713.1	1223.1	
									Total volume of construction poles in m ³ :							1.44472
									Total volume of saw-log in m ³ :						5.4243	

Table A6. Plantation site 2: Diameter class 25.1 - 30 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)				Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)		
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.					Volume	
				Bottom diam.	Top diam.				Bottom diam.	Top diam.							
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg	
1	26.43	20.3	3.2	32	23	27.5	0.1900	1.2	13	12	12.5	0.0147	13.5	28	39.3	31.9	
			3.2	23	18	20.5	0.1056	2	12	10	11	0.019	dried	dried			
			3.2	18	13	15.5	0.0604						10.5	0.2			
						0	0										
						Total:	0.356				Total:	0.034	24	28.2	39.3	31.9	
									10% green weight:				24.00	28.20	39.30	31.90	
									Total green weight of 1 ha:				72.0	84.6	117.9	95.7	
									Total volume of construction poles in m ³ :							0.10115	
									Total volume of saw-log in m ³ :							1.06766	

Table A1. Plantation site 3: Diameter class 0 - 5 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)				Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)	
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.					Volume
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m³	m	cm	cm	cm	m³	kg	kg	kg	kg
1	3.8	5											1.5	0.57	0.13	3
2	4.78	3.5											0.6	0.57	0.53	6.1
3	4.78	7											0.3	0.59	0.17	5.7
														dried		
														0.3		
4	4.14	5.7											0.5	0.37	0.33	3.45
														dried		
														0.1		
5	4.14	7.8											0.35	0.37	0.33	5.8
6	3.5	7.3											0.4	0.32	0.13	6.2
7	4.5	6											0.4	0.34	0.25	4.5
										Total:			4.05	3.53	1.87	34.75
									10% Total green weight:				4.05	3.53	1.87	34.75
									Total green weight of 1 ha:				39.343	34.291	18.1657	337.57

Table A2. Plantation site 3: Diameter class 5.1 -10 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)				Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)	
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.					Volume
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
1	5.4	7.7						3	6	4	5	0.00589	0.7	0.24	0.46	3.2
											0	0	dried			
											0	0	0.08			
2	6.05	9.5						3	9	5	7	0.01154	3.4	0.48	0.92	6
												0		dried		
											0	0		0.2		
3	5.73	9						4	8	4	6	0.0113	1.1	0.3	0.59	3.4
											0	0		dried		
											0	0		0.1		
4	7.32	9						4	8	4	6	0.0113	0.7	1.58	1.71	5.3
5	7.96	9.4						4	10	5	7.5	0.01766	3.2	0.6	2.1	5
											0	0	dried			
											0	0	1.1			
6	6.36	9.4						4	9	4	6.5	0.01327	2	0.65	1.25	4.5
											0	0	dried			
											0	0	0.5			
7	6.37	8						3	10	5	7.5	0.01325	2	1.15	1.25	3.6
											0	0	dried			
											0	0	0.2			
8	6.05	11.5						4	10	4	7	0.01539	0	0.97	0.73	6.5
											0	0		dried		
											0	0		0.2		
9	6.36	10.8						3	10	5	7.5	0.01325	0.9	0.91	0.99	7.4
10	7.32	8.1						3.5	9	5	7	0.01346	5.7	1.69	2.51	3
											0	0		dried		
											0	0		0.4		
11	6.37	7.6						3.5	10	4	7	0.01346	2.9	0.71	0.54	2.1

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
12	8.59	10.5						4.5	12	6	9	0.02861	6	1.78	1.72	8.4
13	7.96	11.2						5	12	5	8.5	0.02836	4.4	1.25	1.65	6.2
											0	0	dried			
											0	0	0.5			
14	8.59	10.2						4	12	6	9	0.02543	3.6	2.06	2.64	11.5
15	6.37	8.2						3.5	10	4	7	0.01346	1.3	0.91	0.99	4.5
											0	0	dried			
											0	0	0.3			
16	6.37	9.5						3.5	8	4	6	0.00989	1.5	1.75	1.45	9.3
											0	0		dried		
											0	0		0.2		
17	7.01	10.5						4.5	10	5	7.5	0.01987	2	0.68	1.32	5.8
											0	0		dried		
											0	0		0.2		
18	7.64	10.1						4.5	10	5	7.5	0.01987	1.5	1.65	1.45	8.3
19	5.73	7.2						3.5	7	3	5	0.00687	2.3	0.84	0.86	2.9
20	8.92	11.6						5	10	5	7.5	0.02208	3.8	1.86	3.04	10.1
21	7.96	9.5						4	11	5	8	0.0201	3.3	2.16	2.24	8.5
22	7.96	9						5	10	4	7	0.01923	2.8	2.23	1.45	3
23	8.28	9						4	6	5	5.5	0.0095	1.6	1.05	2.05	21.3
											0	0	dried	dried		
											0	0	0.5	0.5		
24	7.01	7						3.5	10	5	7.5	0.01545	2.7	1.58	1.32	3
25	7.96	9						4	10	5	7.5	0.01766	2.7	1.75	1.45	5.4
											0	0		dried		
											0	0		0.65		
26	6.37	7						4	7	3	5	0.00785	1	1.21	0.79	2.1
27	8.28	7						4	8	4	6	0.0113	2.2	1.38	1.32	4.9

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
28	6.37	6						4	8	3	5.5	0.0095	0.7	0.84	0.66	3
29	6.37	8						3.5	8	4	6	0.00989	1.6	1.44	0.46	3.3
30	8.92	11						4	10	5	7.5	0.01766	4.8	3.29	2.51	15.6
31	6.05	9						3.5	8	4	6	0.00989	0.7	1.13	1.52	5
32	5.66	7						3	7	4	5.5	0.00712	1.1	0.78	1.12	2.8
33	7.96	11						4	10	5	7.5	0.01766	1.2	0.98	0.92	8.5
											0	0		dried	dried	
											0	0		0.4	0.1	
34	5.73	7						4	7	4	5.5	0.0095	3	1.06	1.25	3.8
35	7.96	10						3.5	10	5	7.5	0.01545	4.1	1.01	1.19	8.5
											0	0	dried			
											0	0	0.3			
36	7.32	9						4	9	5	7	0.01539	5.3	1.31	0.79	3.6
37	7.01	9						4	10	4	7	0.01539	6	1.95	1.85	5.5
											0	0				
									Total in Volume:			0.54277				
									10% Total green weight:				97.28	50.06	51.16	224.8
									Total green weight of 0.8 ha:				959.65	493.84	504.686	2217.6
									Total green weight of construction poles 10%:							0.5428
									Total green weight of construction poles 1 ha in m ³ :							5.3543

Table A3. Plantation site 3: Diameter class 10 - 15 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
1	11.78	16.4						4	15	9	12	0.04522	6.5	4.14	4.35	18.2
								4.5	9	7.5	8.25	0.02404				
2	13.69	15.7						4	16	10	13	0.05307	10.2	3.64	4.15	14.2
								4	10	8	9	0.02543				
3	11.46	10						4	11	9	10	0.0314	7.9	4.94	4.75	T
											0	0				16.1
4	11.78	10.3						2	15	10	12.5	0.02453	9	5.65	5.34	14.3
											0	0		dried		
											0	0		0.5		
5	10.51	11.7						3.5	13	8	10.5	0.03029	5.3	4.17	4.22	7.3
								3.5	8	6	7	0.01346	dried	dried		
											0	0	1.3	0.8		
6	11.46	12.5						2	11	10	10.5	0.01731	3.1	3.31	4.09	36.2
7	13.6	14						2	16	10	13	0.02653	5.1	2.09	2.71	T
								2	2	10	9	0.01272	dried	dried		39.7
											0	0	0.4	0.7		6.4
8	12.1	15.8						4	15	10	12.5	0.04906	6.1	3.74	4.15	20.8
								3.5	10	9	9.5	0.0248	dried		dried	
											0	0	1.8		0.1	
9	12.74	15						5	17	10	13.5	0.07153	6.1	3.87	4.42	38.1
10	12.42	16						4	16	10	13	0.05307	7.6	4.3	4.09	6.65
								4	10	8	9	0.02543	dried	dried		
								4	8	6	7	0.01539	2.6	0.2		
11	11.15	14.3						5	15	10	12.5	0.06133	9.8	2.61	4.09	28.1
											0	0	dried	dried		
											0	0	0.8	0.2		
12	11.78	17.5						6	15	10	12.5	0.07359	6.2	3.76	5.94	8.1
								5	10	7	8.5	0.02836				

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
13	13.1	14						2	16	11	13.5	0.02861	9.9	3.35	9.6	3.6
								4	11	9	10	0.0314	dried			
								4	9	5.5	7.25	0.0165	0.5			
14	11.8	15						2	14	12	13	0.02653	30.7	6.92	7.03	11.9
								4	10.5	8	9.25	0.02687	dried			
								3.5	8	6	7	0.01346	0.3			
15	12.7	16						4	15.5	9.5	12.5	0.04906	9	7.56	6.89	4.5
								4	9.5	7.5	8.5	0.02269				
								4	7.5	5	6.25	0.01227				
16	13.1	16.5						4	16	10	13	0.05307	4.6	5.49	5.61	9.4
								4	10	8.5	9.25	0.02687	dried			
								3	7.5	6	6.75	0.01073	0.4			
17	11.8	13.5						2	14	10	12	0.02261	11.7	6.65	5.54	7.3
								4	10	7.5	8.75	0.02404				
								3.5	7.5	4.5	6	0.00989				
18	10.5	15.5						4	13.5	9	11.25	0.03974	8.5	4.4	4.45	5.4
								4	9	7	8	0.0201	dried			
								3	7	5	6	0.00848	1.7			
19	12.4	14						2	16	11	13.5	0.02861	11.9	6.4	7.45	5.7
								4	11	8	9.5	0.02834				
								3.5	8	5.5	6.75	0.01252				
20	12.7	15						4	17	10	13.5	0.05723	7	8.35	7.75	11.5
								4	10	7	8.5	0.02269				
21	12.1	16						4	18	12	15	0.07065	11.9	9.24	9.4	24
								4	12	10	11	0.03799				
22	14	16.3						4	17	10	13.5	0.05723	14.9	6	7	7.75
								4	10	7	8.5	0.02269				
23	14.3	18						2	17	12.5	14.75	0.03416	16.1	5.36	5.74	3.02

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
								4	12.5	10	11.25	0.03974	dried			
								4	10	8	9	0.02543	1.6			
								3.5	8	5	6.5	0.01161				
24	11.8	15						4	13	9.5	11.25	0.03974	7.1	4.33	4.48	2.5
								4	9.5	7	8.25	0.02137	dried			
								4	7	5	6	0.0113	0.5			
25	10.8	17						4	13	9	11	0.03799	8.7	3.78	4.02	4.8
								4	9	7.5	8.25	0.02137	dried			
								4	7.5	4.8	6.15	0.01188	1.6			
26	13.4	22						4	15	10	12.5	0.04906	4	7.59	5.61	10.1
								4	10	8.1	9.05	0.02572	dried			
								4	8.1	5.8	6.95	0.01517	1.1			
27	13.4	17						4	17	10	13.5	0.05723	4.6	7.29	7.65	6
								4	10	8.5	9.25	0.02687	dried	dried		
								4	8.5	6	7.25	0.0165	0.5	0.3		
28	12.4	15						4	17	10.5	13.75	0.05937	22.3	10.41	7.59	14.1
								4	10.5	7	8.75	0.02404				
29	12.4	15.3						4	17.5	11	14.25	0.06376	19.3	9	6.56	12.2
								4	11	7	9	0.02543				
30	10.8	16.5						4	13.5	9.5	11.5	0.04153	14.2	5.71	6.66	7.38
								4	9.5	7.3	8.4	0.02216				
31	12.1	17.2						4	15	11	13	0.05307	12.5	9.71	9.87	10.71
								4	11	9	10	0.0314				
								3	9	6	7.5	0.01325				
32	12.1	16.5						4	16	11.5	13.75	0.05937	12	9.31	9.48	10.28
								4	11.5	9	10.25	0.03299				
								3	9	6.4	7.7	0.01396				
33	14	17						4	18	12	15	0.07065	13.5	10.49	10.66	29

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume				
				Bottom diam.	Top diam.				Bottom diam.	Top diam.						
No.	cm	m	cm	cm	cm	cm	m ³	m	cm	cm	cm	m ³	kg	kg	kg	kg
								4	12	10.5	11.25	0.03974				
34	14.3	17						4	18.5	12.5	15.5	0.07544	10	7.74	7.85	9.7
								4	12.5	9.5	11	0.03799				
								3.5	9.5	6	7.75	0.0165				
35	14.7	17	2.2	21	14			2.2	14	12	13	0.02919	6.7	3.7	5.4	13.8
								4	12	8	10	0.0314	dried			
								4	8	5	6.5	0.01327	1.2			
36	15	17.5	2.2	22	15			2.2	15	13	14	0.03385	19	6.9	9.2	22.2
								1.2	13	12	12.5	0.01472	dried			
								4	12	9	10.5	0.03462	2			
								3	9	6	7.5	0.01325				
37	14.7	16	2.2	20	13.5			2.2	13.5	11.5	12.5	0.02698	8.2	5.05	7.05	17.75
								4	11.5	8	9.75	0.02985	dried			
								3	8	5	6.5	0.00995	2			
38	10.2	15						4	13	8	10.5	0.03462	6	4.16	3.7	11.5
								3	8	5	6.5	0.00995	dried			
													0.5			
											Total:	2.894835	407.5	223.81	234.64	530.24
									10% Total green weight:				407.5	223.81	234.64	530.24
									Total green weight of 1 ha:				4117.89	2261.66	2371.10	5358.21
									Total green weight of construction poles of 1 ha in m ³ :							29.25307

Table A4. Plantation site 3: Diameter class 15 - 20 cm

Tree No. in DHB class	Diameter at DBH	Total tree height	Log No.	Saw-logs (green)				Construction poles (green)					Total branch wood (green)	Total twigs (green)	Total leaves (green)	Tops and lops (green)	
				Diameter		Avrge diam.	Volume	Pole length	Diameter		Avrge diam.	Volume					
				Bottom diam.	Top diam.				Bottom diam.	Top diam.							
No.	cm	m	cm	cm	cm	cm	m³	m	cm	cm	cm	m³	kg	kg	kg	kg	
1	16.88	18	2	20	15	17.5	0.0481	4	15	12	13.5	0.05723	18.3	12.26	12.73	23.5	
						0	0	4	12	9	10.5	0.03462	dried	dried			
						0	0				0	0	0.7	0.6			
2	15.29	15	2	20	15	17.5	0.0481	5	13	9	11	0.04749	36.5	9.09	11.81	T	
						0	0				0	0	dried	dried		6.7	
						0	0				0	0	0.4	0.2		30.4	
3	16.56	17.4	2	22	15	18.5	0.0537	3.5	15	13	14	0.05385	20.35	14.86	18.7	44	
						0	0	3.5	11	10	10.5	0.03029					
						0	0	3.5	8	6	7	0.01346					
4	17.51	17	2.2	20	15	17.5	0.0529	4	15	11	13	0.05307	17.1	11.09	13.92	25.3	
						0	0	4	11	9	10	0.0314					
5	15.92	18.8	2.2	19	14	16.5	0.047	4	14	11	12.5	0.04906	22.46	9.84	13.66	13	
						0	0	4	11	8.5	9.75	0.02985					
6	15.29	19	4	17.5	13	15.25	0.073	4	13	10	11.5	0.04153	10.4	8.77	10.23	12.2	
								4	10	8.5	9.25	0.02687	dried				
								3	8.5	5	6.75	0.01073	0.5				
7	15.92	17.2	4	20	13	16.5	0.0855	4	13	11	12	0.04522	10.6	8.66	9.04	12.8	
								3.5	10	6	8	0.01758					
						total	0.408314	58	179.5	139	159.25	0.542244					
											total	1.084487	137.31	75.37	90.09	167.9	
									10% Total green weight:				137.31	75.37	90.09	167.9	
									Total green weight of 1 ha:				1392.72	764.47	913.77	1702.99	
									Total volume of construction poles of 1ha in m³:							10.84487	
									Total volume of saw-log of 1 ha in m³:							4.083138	

Annex 7: Investment Record

Activity	Plantation site 1 Mr. Lung Vi	Plantation site 2 Mr. Thongbai	Plantation site 3 Burapha Co., LTD
	Baht/ha	Baht/ha	Baht/ha
Land clearing	679	0	679
Soil preparation	0	1,358	1,359
Seedlings	1,642	1,642	821
Fertilizer	0	1,450	1,493
Barbed wires	0	2,220	0
Fencing	0	200	0
Marking planting spot	48	48	24
Planting	193	193	72
Replanting	19	19	7
Fertilizing 1	0	109	48
Fertilizing 2	0	109	48
Insecticide	0	0	0
Insecticiding	0	0	0
Weeding 1 year 0	408	408	1,359
Weeding 2 year 0	408	408	0
Weeding 1 year 1	408	408	1,359
Weeding 2 year 1	408	0	0
Weeding 3 year 1	0	0	0
Weeding 1 year 2	408	408	1,359
Weeding 2 year 2	408	408	0
Weeding 1 year 3	408	408	1,359
Weeding 1 year 4	0	0	0
Weeding 1 year 5	0	0	0
	5,436	9,794	9,987
	USD	USD	USD
	147	265	270
Interest Per Year	5	5	5
8%	2,174	3,918	3,995
	7,610	13,711	13,982
Investment cost in wood	30	55	56
(250 baht per ton)			

Note: Burapha Agro-Forestry Co., LTD mostly gave plantation loans to farmers in the form of seedlings, fertilizer and barbed wire. The rest of the work was carried out by the farmers themselves. In this calculation, the cost of the rest of the work was estimated by the author.

Investment and returns of private farmers

	Mr. Lung Vi tons	Mr. Thongbai tons
Total Investment in wood value	30	55
Total revenue from plantation	42	58
First rotation net revenue	12	3
Expected second rotation net revenue	50	70
Expected third rotation net revenue	42	58
	Mr. Lung Vi Baht	Mr. Thongbai Baht
Total investment in money value	7,610	13,711
Total revenue from plantation	(144+8,655)	(13,776+10,227)
	8,799	24,003
First rotation net revenue	1,189	10,291
Expected second rotation net revenue	11,443	33,095
Expected third rotation net revenue	8,799	24,003

Note: Time period of one rotation is 5 to 6 years or 7 years if there is a delay.