# Forest Growth Analysis of Ulu Sat Forest Reserve

IOP Conf. Series: Earth and Environmental Science **549** (2020) 012039 doi:10.1088/1755-1315/549/1/012039

# Forest Growth Analysis of Ulu Sat Forest Reserve

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**Abstract.** A long term monitoring data of the dynamics changes on tree growth in Ulu Sat Forest Reserve, Kelantan was analysed. The growth plot was established in 1997 with status of poor forest. Permanent growth plot area was established to monitor the forest stands. Trees in the growth plot were measured every two years with various parameters include girth increment and tree height. Within sixteen years of observation, mean annual increment of trees in Ulu Sat Forest Reserve was at 0.33 cm/year. In general, mean DBH and tree height in this area was at 31.0 cm and 12.9 m respectively. Forest stands with DBH between 20-30 cm are majorly found in the area with 73 trees/ha. The non-dipterocarp species showed a significant decrease in terms of individual tree number when the diameter of the tree increases. Tree volume of non-dipterocarp species recorded at Ulu Sat Forest Reserve is 40 percent higher than dipterocarp species. Meanwhile, total basal area and tree volume contributed by dipterocarp species was 12.1 $m^2$/ha and 227.0 $m^3$/ha, respectively. Based on the enumeration and data analysis, this long term forest monitoring study is imperative to ensure each forest encompasses with adequate quantity of trees for future production, healthy in condition and could support the sustainability of forest ecosystem.

## 1. Introduction

Tropical rainforests are one of the most diverse in biodiversity and this precious resources should be protected. In order to monitor the forest, a long term monitoring growth plot was established by the Forestry Department in the Permanent Forest Reserve of Peninsular Malaysia. Growth plots were established to record the growth information on individual forest tree which include data on tree stock, basal area and volume of tree per hectare as well as the average of annual growth [1]. A long-term monitoring of growth plots is the key to identify growing patterns and tree changes.

In Malaysia, 96 growth plots were established since 1992 and the enumeration was held every two years [2]. Among the selected area for growth plot establishment in Kelantan was located at Ulu Sat Forest Reserve. Kelantan still has many unexplored forest areas. Therefore, understanding the forest structure, species and distribution are very critical to support the sustainable forest resource planning and management strategy.

Nowadays, technology such as remote sensing and geospatial technique are contemporary methods and in trend for forest monitoring and analysis in tropical and subtropical region [3]. However, the

conventional field enumeration in measuring an individual tree is still a relevant and accurate method. Measuring the diameter-at-breast-height (DBH) is the main indicator to understand the growth performance of a forest stand. Hence, the analysis of this long term data has an important consequence in predicting the future quantity and quality of forest and its products. Therefore, this study focus to assess the dynamic changes of tree growth of dipterocarp and non-dipterocarp species in Ulu Sat Forest Reserve. The enumeration data for was analysed and discussed in following section.

## 2. Materials and Methods

The study was carried out at Ulu Sat Forest Reserve, Machang Kelantan. This forest reserve is one of the 12,000 ha of Permanent Forest Reserve (PFR) in Kelantan managed by the Forestry Department. Most of the natural vegetation is still intact and covered with closed to open broadleaved evergreen or semi-decidious forest [1]. In this forest, specifically located at Compartment 1, growth plots were established by the Foresry Department. The plot was set up in 1997 and the design of the plot as shown in Figure 1.

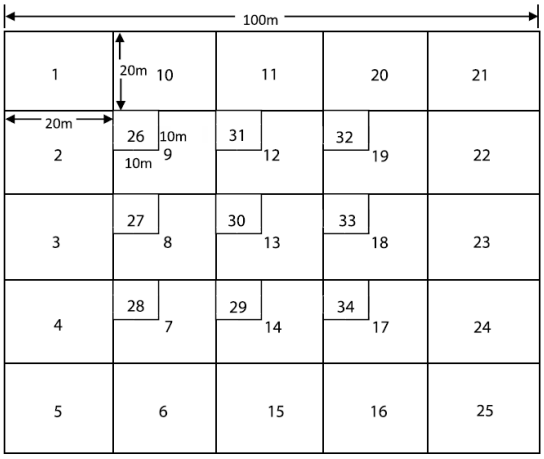


**Figure 1.** Growth plot design with measurement

In total, the area of growth plot is 100 x 100 m. Each set of study growth plot contains 25 plots (20m x 20m) and nine sub plots (10m x 10m). The different sizes of square was designed with specific tree to be measured. For a 20m x 20m plots, all trees with diameter-at-breast height (DBH) 10 cm and above were enumerated. While for the sub-plots (10m x 10m), only tree with DBH 5 <10 cm were surveyed and recorded. Tree DBH and height were measured using diameter tape and Haga altimeter respectively. Only trees that were alive, in good physical standing condition, and with complete stem and crown were considered. Measurement was taken every two years.

Data were analysed using Data Analysis Plots Growth Program which was developed by the German Agency for Technical Cooperation (GTZ) in 1990. The system is capable of generating reports in terms of tree, tree growth by diameter classes, basal area and tree volume.

Tree growth was calculated based on diameter changes for each enumeration year, while basal area was determine using formula below:

Basal area, $BA = л\ r^2$
Where;
BA= basal area
r = radius = diameter/2 = DBH/2 (in m)
л = 3.142

The volume of trees was calculated by:

Tree volume, $v = л\ (DBH)^2 \times L$

Where;

| | | |
|---|---|---|
| v | = | volume in $m^3$ |
| л | = | 3.1417 |
| DBH | = | diameter-at-breast-height (in cm) |
| L | = | merchantable tree height (in m) |

Enumerated trees were categorized according to dipterocarp and non-dipterocarp group. This was done to assess the different growth changes between both group in the study area. Hence, six different range of DBH was setup to quantify the growth change for both species.

## 3. Results and Discussion

A total of 265 trees were enumerated in the one-hectare plot. Overall, the mean DBH and tree height was 31.0 cm and 12.9 m, respectively. Within the sixteen years of growth observation, mean annual increment of trees in Ulu Sat Forest Reserve was found at 0.33 cm/year. Our finding is paralel with research done by [9] in Selangor Forest Reserves. Figure 2 showed the average increment of trees by years.

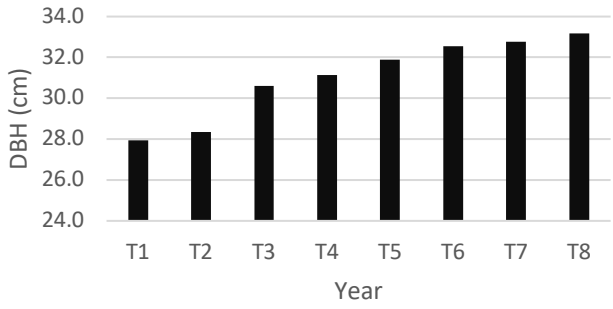


**Figure 2.** Average tree growth (by DBH) in growth plot at Ulu Sat Forest Reserve

The growth analysis from this study showed that the total basal area and tree volume in Ulu Sat Forest Reserve were 178.14 $m^2$ and 614.0 $m^3$, respectively. Six ranges of DBH classes was set up by ten centimeter interval. The highest number of trees per hectare is recorded by DBH class between 20-30 cm with 73 trees/ha. This is followed by DBH class of <20 cm, 30-40 cm, 40-50 cm, >60cm and 50-60 cm with 72 trees/ha, 72 tree/ha, 43 trees/ha, 32 trees/ha, 27 trees/ha, and 17 trees/ha respectively. Non-dipterocarp tree species documented high number of individuals as compared to dipterocarp species, where 73 percent of the enumerated trees were non-dipterocarp species. The highest number of trees per hectare for non-dipterocarp species ranged from 10 to 20 cm (67 trees/ ha) and the least was between 50-60 cm of DBH class with only 9 trees/ha recorded.

Figure 3 showed the mean increment of trees for dipterocarp and non-dipterocarp species in the growth plot of Ulu Sat Forest Reserve. Although the number of trees per hectare for the non-dipterocarp species is higher than the dipterocarp species, the DBH of dipterocarp species was found higher than the other. Table 1 showed the average DBH of dipterocarp and non-dipterocarp species by specific DBH range classes in the study area.

For dipterocarp species, DBH class >60cm recorded the highest number of tree with 16 trees/ha and less tree was found between 10-20 cm (6 trees/ha). Table 2 disclosed the number of tree in different DBH classes for both dipterocarp and non-dipterocarp species. From the results, total basal area and tree volume contributed by dipterocarp species was 12.1 $m^2$ and 227.0 $m^3$, respectively. Meanwhile, the non-dipterocarp species is estimated to produce higher number of tree volume at 387 $m^3$. In most studies on distribution and forest content in tropical rainforest, revealed that number of trees of non-dipterocarp is higher compared to dipterocarp species [4,5,6].

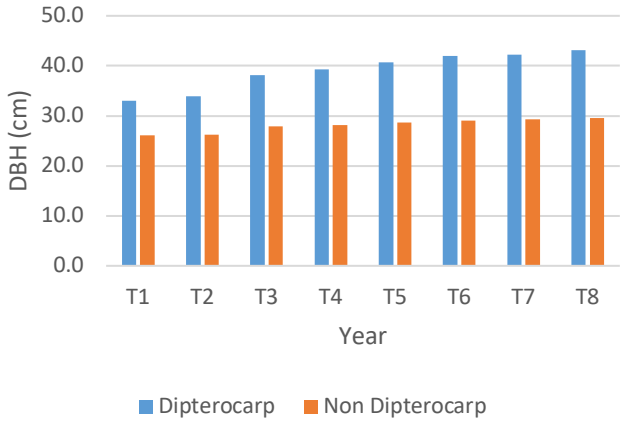


**Figure 3.** Average annual increment of dipterocarp and non-dipterocarp species in the study area

**Table 1.** Average DBH of dipterocarp and non-dipterocarp species by DBH classes

| DBH Class (cm) | 10-20 | 20-30 | 30-40 | 40-50 | 50-60 | >60 |
|---|---|---|---|---|---|---|
| Dipterocarp | 14.9 | 25.7 | 35.7 | 45.4 | 55.7 | 70.7 |
| Non-dipterocarp | 15.7 | 24.3 | 34.1 | 45.4 | 56.6 | 74.8 |

**Table 2.** Total basal area and tree volume for dipterocarp and non-dipterocarp species

| DBH Class (cm) | Dipterocarp | | | | Non-dipterocarp | | | |
|---|---|---|---|---|---|---|---|---|
| | Number of tree | Avg. DBH (cm) | Total basal area ($m^2$) | Total volume ($m^3$) | Number of tree | Avg. DBH (cm) | Total basal area ($m^2$) | Total volume ($m^3$) |
| 10-20 | 6 | 14.9 | 0.1 | 1.0 | 67 | 15.7 | 94.5 | 194.6 |
| 20-30 | 14 | 25.6 | 0.7 | 11.7 | 58 | 24.3 | 61.3 | 158.3 |
| 30-40 | 15 | 35.7 | 1.5 | 24.6 | 28 | 34.1 | 6.9 | 21.4 |
| 40-50 | 12 | 45.4 | 1.9 | 34.0 | 20 | 45.4 | 2.5 | 9.8 |
| 50-60 | 8 | 55.6 | 1.9 | 31.8 | 9 | 56.6 | 0.2 | 0.8 |
| >60 | 16 | 70.7 | 5.8 | 123.6 | 12 | 74.8 | 0.5 | 2.5 |

This study distinctly shows the total number of trees per hectare for non-dipterocarp species are higher and dominates the forest area over the dipterocarps species. However, the non-dipterocarp species showed a significant decrease in terms of number when the diameter of the tree increases. This results are related to [7], which explain that increased number of diameter sizes will decreased the number of individual trees of non-dipterocarp species. This is due to higher competition with dipterocarp and other tree species that grown taller and dominate the upper storey canopy [4]. Study by [8] in tropical forest, described that the average volume and tree diameter decreases when the stand reaches the age of 50 years. The decrease is attributed to the density of the forest area. Following the Selective Management System (SMS), as practiced in Malaysia, tree with DBH of 30-45 cm is expected to produce for the next harvest. Therefore, it is important to note that residual stands must be adequate in specific quantity and quality to ensure a future yield that is both economical and sustainable in a long term forest management planning.

## 4. Conclusion

Tree diameter at breast height (DBH) and tree height are commonly used measures of tree growth. The result of this study has provided some understanding in performance of tree growth in hill dipterocarp forest of Ulu Sat. Tree performance growth in Ulu Sat Forest Reserve showed that mean annual increment of a tree is at 0.33 cm/year. In order to ensure adequate quantity and with specific quality of forest products, the growth monitoring is an important activity in ensuring sustainable management of forest resources. More work need to be done to continuously monitor the regeneration of a forest. Enumeration of the growth plots should continuously run until the recent year to get an accurate result on growth performance which in future can be use in modelling and predicting forest resources and could be benefited in the development of a realistic forest management plan.

## Acknowledgements

Authors would like to thanks the Forestry Department of Peninsular Malaysia and Forest Department of Kelantan States for their guidance and assistance.

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