Tree Species Distribution in Ayer Hitam Forest Reserve, Selangor, Malaysia

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Abstract: - The study was conducted in Ayer Hitam Forest Reserve (AHFR), Puchong, Selangor a logged-over tropical lowland in Peninsular Malaysia. In this paper, tree species distribution patterns were discussed as one of the outcomes of a larger floristic study undertaken for this forest. The enumeration of trees ≥5 cm dbh in the 5-ha plot recorded 6,621 trees which belong to 50 families, 148 genera and 319 species. The distribution patterns of the tree species found in two types of distributions—random and clumped in the plot study was found to be influenced by the soil type, topography, mother tree and the logging activities. Analysis using General Linear Models (GLM) procedure showed significant differences at level $p<0.05$ between blocks in terms of volume, basal area and biomass and dbh and height for sub-blocks which also shows the richness of this forest in terms of species, stand density and the distribution of tree species of a late stage regeneration.

Keywords:- Tree species composition, distribution, logged-over, tropical forest

1 Introduction

The Ayer Hitam Forest Reserve (AHFR), Puchong is located in the state of Selangor in Peninsular Malaysia, approximately 20 km south-west of Kuala Lumpur The size of this forest is now 1,248 ha after it was further excised for some socio-economic development projects such as housing estates, oil palm plantations, new townships, factories and highways. The Selangor State Government on 7th October 1996 awarded to Universiti Putra Malaysia (UPM) for 80 years with six compartments for the purpose of teaching, research and extension activities. This forest is classified as a disturbed Kelat-Kedondong-Mixed Dipterocarp type of lowland forest [1].

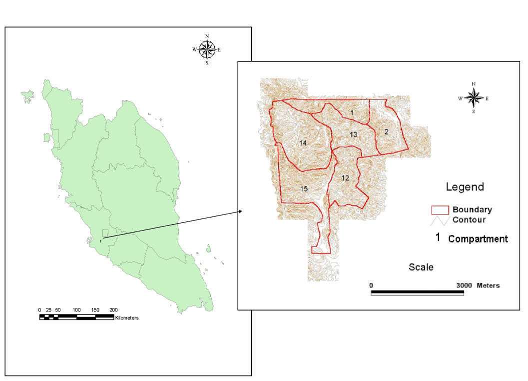
A lack of information hampers our ability to comprehend the magnitude of richness of the biodiversity, and consequently the loss of this biodiversity especially to the forest surrounding the urban areas. It also prevents measure against further losses, and it is difficult to formulate sustainable alternatives to avoid resource depletion. Before this, there was no substantial research plot established in the AHFR for estimation of its biological diversity. Therefore, the forest's biological diversity needs to be specially studied to ascertain the nature of its composition, including the recognition of rare or potentially endangered taxa in need of special attention. It will be expected that there will be forest species that are not readily identified, so that their conservation status cannot be clearly stated. Without this information, proper systematic management of the AHFR cannot be practiced. The work was carried out to investigate the species composition of tree species in 5-ha plot in the Ayer Hitam Forest Reserve, and associated attributes such as spatial distribution that may permit comparison with those of regenerating forests and mature stands elsewhere.

2 Materials and Methods

This plot was located at 3°00′51″N and 101°38′17″E. The soil belongs to the Serdang-Kedah Series and Durian Series and is generally a combination of alluvium-colluvium soil, derived from metamorphic stones, and has a sandy clay loam soil texture (Zainuddin, 1977). The mean annual temperature for the area is 27.8°C with a maximum of 32.6°C and minimum of 24.6°C. The total annual rainfall received in AHFR, Puchong for the year 1999 was 3301.4 mm.

A plot of 250 m × 200 m was divided into 125 quadrats (sub-plots), each with the size 20m × 20m. Each sub-plot was labelled using code references consisting numbers and alphabets. The quadrat method was used in sampling as this method gives more accurate estimates of the species density in less time. All tree species inside the plot were identified and classified according to their family, genera, species and dbh class. The density and distribution patterns of the trees were analysed for each hectare, named A, B, C, D and E, and each hectare was called a block. These five contiguous 1-ha plots were established increasingly according to topography. Each block (hectare) was subdivided into four sub-blocks (1, 2, 3 and 4), each 1.25 ha.

The coordinates (x, y) of the tree location within the subplot (20m × 20m) were recorded and the data were later converted to the coordinates (X, Y) for the 250 m × 200 m plot. The coordinates for the trees were mapped using the EXCEL programme as done by [9]. This study also has been analysed use the Statistical Analysis Systems (SAS) Version 6.12 programme. All data were processed using the General Linear Models (GLM) procedure because of varying numbers of data collected in subblocks within the sampling area. Analysis of variance and Duncan Multiple Tests were used to analyse the five different types of dependent variables—DBH, HT, VOL, BA and Biomass, based on the Block (5-ha) and Sub-block (1.25-ha).



Map : Location of AHFR, Puchong, Selangor.

Fig.1 A map of P. Malaysia showing the location of the study site

3 Results and Discussions

The enumeration of trees ≥5 cm dbh in the 5-ha plot recorded 6,621 trees which belong to 50 families, 148 genera and 319 species. The distribution of trees in AHFR, Puchong was highly heterogeneous for most of the tree species (Fig.1). There are other factors which influence the distribution of the trees such as gully, rock and track logging. The different formation of topography and types of soil series has been discussed as the main factors of the tree species distribution in Pasoh Forest Reserve [11, 12]. The distribution of the trees in 5-ha plot was categorized in three different size groups of dbh classes from 0 to 14.9 cm (small tree) with 4,914 stems, 15.0 to 44.9 cm (medium tree) with 1,499 stems and 45.0 cm and above (large tree) with 208 stems. The ratio for stem number for dbh classes 0 to 14.9 cm, 15.0 to 44.9 cm and 45.0 cm and above was 24:7:1.

The medium sized trees were found evenly scattered in the entire plot and this group formed the main canopy of the forest. The large size tree (45.0 cm and above) were found dominant in the higher slope and stony area, especially the commercial timbers. Most of the large trees left in the flattened slope were from the non-dipterocarp species. In this study the stocking of trees was good for the dbh larger than 45.0 cm with 613 stems (9.26% of all trees) without considering their species. The larger number of trees accumulated for this 45.0 cm dbh classes and above proved that this forest is in the well-regenerated stages. The stocking is considered high in the ridge top (Block E) of the plot of AHFR, Puchong even though this area has been accessible by the logging track. These are shown in Table 1 with the stocking of 1,385 trees in Block E, which is included in the ridge top.

Figure 1: Spatial Distribution of Tree Stems in 5-Ha Plot, AHFR Puchong, Selangor.

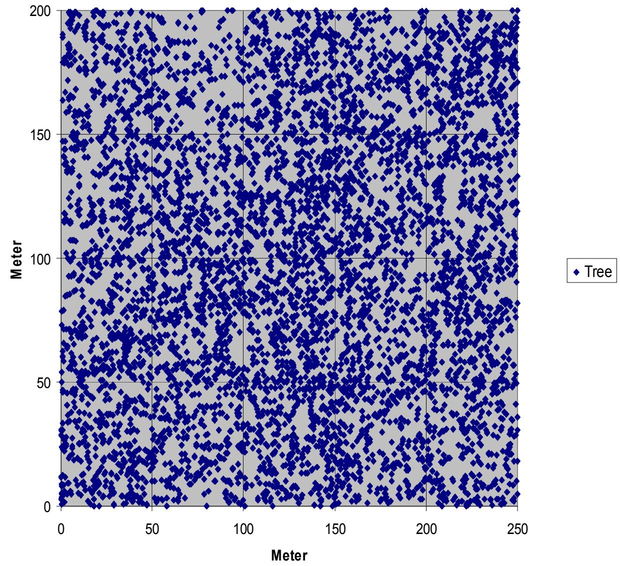


Table 1: Summary of stand density in Block and Sub-block of 5-ha plot.

Sub-block	Parameter	Block A	Block B	Block C	Block D	Block E	Total
1	Number of stem	348	289	362	323	290	1612
	Tree Species	123	96	93	99	94	215
	Mean of dbh	14.29	13.7	14.15	13.53	15.35	14.2
	Mean of height	17.06	16.65	17.38	16.75	18.08	17.18
	BA	10.32	7.89	9.16	7.9	8.99	44.26
	Volume	428.09	324.06	343.2	303.66	357.36	1756.37
	Biomass	120.08	90.93	96.82	85.52	100.54	493.89
2	Number of stem	336	378	392	319	372	1797
	Tree Species	129	98	108	106	114	231
	Mean of dbh	13.59	13.3	12.66	14.14	12.44	13.22
	Mean of height	16.72	16.21	15.88	17.26	15.96	16.41
	BA	8.7	9.57	8.75	8.41	7.46	42.89
	Volume	348.58	377.63	335.24	325.83	270.41	1657.69
	Biomass	97.93	106.26	94.43	91.73	76.36	466.71
3	Number of stem	279	348	402	338	322	1689
	Tree Species	116	128	130	115	115	245
	Mean of dbh	13.95	13.72	12.68	12.94	13.78	13.41
	Mean of height	16.81	16.54	16.13	16.22	16.96	16.53
	BA	7.95	9.55	8.74	7.72	8	41.96
	Volume	330.6	388.26	333.46	295.48	303.76	1651.56
	Biomass	92.72	109.04	93.88	83.22	85.62	464.48
4	Number of stem	296	185	336	305	401	1523
	Tree Species	124	100	129	114	129	244
	Mean of dbh	13.69	15.76	12.19	10.76	11.44	12.76
	Mean of height	16.81	18.14	15.66	14.57	15.13	16.06
	BA	7.94	6.38	6.87	4.49	6.91	32.59
	Volume	326.14	265.04	260.84	151.79	247.06	1250.87
	Biomass	91.48	74.41	73.46	42.99	69.78	352.12
Total	Number of stem	1259	1200	1492	1285	1385	6621
	Tree Species	242	208	213	198	201	319
	Mean of dbh	13.88	14.12	12.92	12.84	13.25	13.4
	Mean of height	16.85	16.88	16.26	16.2	16.53	16.54
	BA	34.91	33.39	33.52	28.52	31.36	161.7
	Volume	1433.41	1354.99	1272.74	1076.77	1178.59	6316.5
	Biomass	402.21	380.64	358.59	303.46	332.3	1777.2

Tropical forest ecosystems are absolutely complex and the distributions of trees have been always referred to the forest topography. There were three types of plant distribution i.e. random, clump and uniform [2] but only random and clump type distribution was found in this plot. The distribution of the tree species in this study area was very complex and difficult to classify because of the smaller range between the contours. Majority of the species was found to be distributed randomly in the plot. The scattered pattern of trees in this lowland forest was almost the same as were described in a 50-ha plot in Pasoh Forest Reserve in Negeri Sembilan, where the distribution of tree species appears to depend on topography, soil moisture, mother trees and formation of gap [3]. Many earlier authors such as [4], [5], and [6] have discussed the same main controlling factors as in Pasoh Forest Reserve of species diversity and trees distribution into their account. [13] listed the species which were believed to be related to the poor mineral contents of soil such as sandy soil and the rocky area

The 5-ha plot was further divided into one hectare each (200 × 50m) namely; block A, B, C, D and E showing the average stems/ha as 1,324.2, with a range of 1,200–1,492 trees/ha (Table 1). Block C recorded the largest total number of trees with 1,492 trees followed by block E with 1,385 trees. Block B (1,200 trees) has the smallest in term of trees stem and this is probably due to it being situated in the gully and rocky area. Comparison in term of species between the five different blocks shows that block A was represented by 242 species which is the richest block in this 5-ha plot. Block A is found as the richest area in species because it was least disturbed and has less palm growth compared to block D which was dominated by gap, palm and *Dicranopteris linearis*.

The average dbh of trees ≥5 cm in every hectare with the range of 12.84 –14.12 cm and the largest dbh average was block B and the smallest was block D (Table 1). Dbh and height of the trees and the number of stems in the block was influencing the total basal area, volume and the biomass. Block A recorded the largest amount of basal area (34.91m^2), volume (1,433.41 m^3) and biomass (402.21t/ha) compared to the other blocks. This was different to block B which recorded the second largest amount of volume and biomass but ranked the third largest amount in term of basal area. The smallest amount of basal area, volume and biomass were recorded by block D. Although the tree number was larger than block A and B, dbh size of the trees that occurred was smaller.

Comparison among four sub-blocks (Table 1) shows that sub-block 1 was the largest for the mean of dbh and height, the total of BA, volume and biomass. Sub-block 1 has the smallest number of species and the third place in term of stem number. Sub-block 2 was the richest in terms of tree stem but it was the second largest of sub-block for the total basal area, volume and biomass. However, sub-block 3 was the richest in terms of tree species (245 species) and also the second largest for the mean dbh and height. The lowest sub-block in term of tree stems, the mean of dbh and height, BA, volume and biomass was sub-block 4.

Results of the means for all parameters using Duncan's Multiple Range Test showed that block A and B have significant differences from block C, D and E except for the mean of height. However, two different groups emerged for the mean volume, basal area and biomass. Among the five blocks, there are no significant differences between block A and B and also no significant differences between block C, D and E. The highest for the mean volume between the blocks was recorded by block A (1,138,513 cm^3) and the lowest was in block D (837,961 cm^3).

Every block and sub-block gave different total basal area, volume and biomass. This shows the different degree of degradation of natural disaster and human impacts within the area. The highly significant difference obtained between the blocks in term of volume ($F=3.91$, $P<0.01$), basal area ($F=3.6$, $P<0.01$) and biomass ($F=3.9$, $P<0.01$) and between the sub-block in term of dbh ($F=5.77$, $P<0.01$) and height ($F=1.3$, $P<0.01$) shows that the distribution of trees in the plot was not balanced. The unbalanced tree distribution in this study may be because of the existence of gaps, secondary species and human level of disturbances are different in the plot area. The higher variable of trees could be shown in the sub-block which has a highly significant difference for the diameter and height even though it has a bigger size in term of the area compared to the block.

The reason of the significant difference for diameter and height was because of the existence of the gaps found dominantly in certain part of the sub-block, especially in sub-block 4. There are large differences in the growing habits between species, tree sizes, number of trees, and even between the same sized individuals of the same species. This kind of distribution was the consequence of forest dynamics in which the available space constrains the number of trees that can be accommodated in variable size classes. The higher difference of analysis of variance for the block and sub-block was probably due to the different growing mechanism of trees that was influenced by the environmental factors such as gap and species that occurred.

Four probably main factors that influenced the distribution of tree species in AHFR was human disturbances especially the logging activities, gaps, mother trees and the degree of soil fertility. It is clear that the opening canopy resulting from logging has favoured the distribution of the faster growing timbers in this forest especially the dipterocarps species such as *Shorea macroptera, S. parvifolia* ssp. *parvifolia, S. acuminata, Hopea beccariana* and *Anisopteranda custisii*. These species are known to be vigorous, aggressive [7], [8] and [3]. [9] and [10] listed that species in the natural forest with high light demand are generally faster growing than understorey species.

4 Conclusions

In the study area, the distribution of tree species were not only affected by the soil but also influenced by the mother tree and topography.. From his list, species such as *Knema kunstleri, Horsfieldia ridleyana, Timonius compressicaulis* and *Sterculia foetida* which were also found in AFHR was evidence of the soil in this area was poor in terms of mineral. Ayer Hitam Forest Reserve has a heterogeneous distribution of trees species all around the area. The higher significant difference obtained between the block in terms of volume (F=3.91, P<0.01), basal area (F=3.6, P<0.01) and biomass (F=3.9, P<0.01) and between the sub-block in term of dbh (F=5.77, P<0.01) and height (F=1.3, P<0.01) shows that the distribution of trees in the plot was heterogeneous.

Distribution of the tree species in this study was found to be of two types-random and clumped. Majority of the tree species were distributed randomly in the plot. The existence of species such as *Knema kunstleri, Horsfieldia ridleyana, Timonius compressicaulis* and *Sterculia foetida* are evidences that the soil in this area is sandy soil and rocky area type which might have effected the successful recovery of the area. The distribution pattern of the species is an interactive outcome of many biotic and abiotic processes, such as geographical form, soil, competition, pollination, seed dispersal, seed and seedling predation, environmental heterogeneity and disturbances before (logging activities). Such basic information is of paramount importance to the understanding of the species availability, distribution, ecological and conservation requirements, and economic potential of the plant resources of this forest. The conservation of AHFR biological diversity is a great challenge that needs to be approached not only with pragmatism but also with the sense that we are but transient custodians of a precious heritage that must be passed on to the future researchers.

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