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Distribution Function of Puspa Tree's (*Schima wallicii*) Diameter in the Mulawarman University's Botanical Garden Samarinda, East Kalimantan

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Abstract

The study aims to find out the distribution function which can describe the distribution of vegetation diameter on the Temporary Measurement Plot in Mulawarman University's Botanical Garden, Samarinda. The main data collected in this study is tree diameter of Puspa trees (*Schima wallicii*)in Temporary Measurement Plot with the size 100m x 50 m, which is measured based on diameter at breast height (1,30 m). The category of tree diameter measured is equal to or greater than 5 cm. The result reveals that diameter at breast height of sample trees measured in the secondary burnt forest in Mulawarman University's Botanical Garden Lempaka, only distributed following Gamma distribution function. The Gamma distribution function formed is: f (x) = (0.082.03)/ (2.03) * X 1.03 e -0.08x. This indicates that the Puspa trees in Mulawarman University's Botanical Garden are diverse in its distribution of growth rates of tress, in which the distribution of trees with large dimension is found less than the trees with small dimension.

Key Word: *Distribution Functional, Vegetation Diameter, Mulawarman University's Botanical Garden, Samarinda*

INTRODUCTION

Distribution function defines the form of trees distribution particularly their characteristics based on the sites. The similar type of forests may differ in their elements of distribution functions on different sites. Characteristics of trees that can be identified the function forms are distribution characteristics of diameter at breast height (dbh), branch-free height (tbc), total height (tt), crown projection diameter (dpt), and other parameters that can be measured to produce quantitative data that can be analyzed using the distribution function method.

There are several distribution functions that have been recognized, including discrete distribution function and continuous distribution function. The discrete distribution function consists ofthe Bernoulli, Binomial, Hypergeometric, Poisson, Geometric, Negative Binomial, Normal, Exponential, Gamma, Beta, Cauchy, Lognormal and Double Exponential distribution functions.Furthermore, the continuous distribution function consists of the Weibull distribution function, Logistics, Pareto, Gumbel (extreme value), T distribution, F distribution and X2 distribution.

Nuriansyah (1988) conducted a study on the distribution function of stands in Grand Forest Park in Bukit Suharto and concluded that the distribution of forest trees diameters in Grand Forest Park in Bukit Suharto was dispersed following the normal, lognormal, exponential, gamma and alignment distribution functions. In the similar area, Sugiharto (1993) conducted a study in logged forest (East Kalimantan) and it founded out that for logged forest in which after 7 years, the distribution of forest tree diameter followed the Beta distribution function, 5years logged forest followed the

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Gamma and Weibull distribution functions, while 1 year logged forest followed the distribution functions of Beta, Gamma, Exponential and Weibull. Geridaldo (1998) asserted that the distribution of forest trees diameters in Bukit Suharto Great Forest Park spread according to the distribution functions of the Alignment, Beta, Exponential and Gamma models. These illustrate the distribution function forms founded in lowland tropical forest disturbed by fire.

The characteristic of forest stand distribution function is not only known through the mean and variance parameters, but also can be explained by the mean and generation moment function. The size distribution of diameter at breast height (dbh), branch-free height (bfh), total height (th), crown projection diameter (cpd), and other parameters spread following one of the distribution functions mentioned above. Determining the correct distribution function is to determine the data's distribution through trial and error method that meets to statistic's significant test equation in a certain level of testing. The objective of this study is to determine form of the distribution function that can describe the distribution of diameter at breast height (dbh) of all sample trees in the Temporary Measurement Plot (PUT) at Mulawarman University's Botanical Garden Samarinda.

METHODS

This research was carried outinthe Temporary Measurement Plot (PUT) at Mulawarman University's Botanical Garden Samarinda, East Kalimantan Province for two months (from October to November, 2018). The tools used in the study consist of a compass, rapia rope, meter (phi band), marker and tally sheet, machete, calculator, notes and stationery.Therefore, the primary object of this research was Puspa Tree (*Schima wallicii*). In this study, data was collected in an observation unit in the form of a Temporary Measurement Plot (PUT) with a square shape and in size of 100 m X 50 m.

In this research, data were collected in the form of tree diameter at breast height (dbh) obtained from the conversion of trunk circumference at a measuring position of 1.30 m (breast height). This included the category of trees with a diameter equal to or greater than 5 cm. After the measurement, the measured sample trees were identified. Technically, the research procedures beginwith making a rectangular temporary measuring plot with size 100 mx 50 m, then making its boundary adjusted to field conditions with azimuths of 120º and 30º (not in the direction of North – South), which is bounded by red raffia rope. Measurement and data collection of tree trunk circumference were done at a height of 1.30 m to obtain a diameter at breast height (dbh conversion) for all trees with a diameter equal to or greater than 5 cm. After that, the measurement data of diameter were calculated to get the average diameter. Finally, examining distribution function for all the data of the diameter at breast height (dbh) of the sample trees.

RESULTS AND DISCUSSIONS

The trees measured are all trees' species found in observation plotwith a circumference of ≥15,8 cm. Shape of distribution of the diameter at breast height measured in observation plot which represents type of fire secondary forest is identi l based on investigation in suitability of distribution function which meets tne requirements. In this study, there are four (4) distribution function that will be examined and tested, namely binomial, gamma, poisson and exponential distribution functions.

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The data from measurement of the diameter atbreast height from all vegetations that have a diameter equal to or more than 5 cm is considered asa suitablesample of distribution function test. The measured data is therefore classified into diameter classes and arranged such in the processing table for measuring diameters at breast height of vegetation.

The analysis of distribution function of data is carried out by firstly calculating required parameters such as the mean and variance,then seeking for probability of each class to obtain the expected frequency (expectation value) of each class. The expectation valueis required to get X^2 value. The X^2 value determines the suitability of the data distribution with one of distribution functions by comparing the calculated X^2 value with the table value of X^2. Furthermore, the distribution of circumference data (conversion of diameter at breast height) is presented in Table 1.

Table 1. Distribution of data of diameter data at breast height based on measurement

No.	Class Interval (cm)	Limit (cm)	Middle value (cm)	Foi
1	05.0-16.8	04.95-16.85	10.9	103
2	16.9-28.7	16.85-28.85	22.8	68
3	28.8-40.6	28.85-40.85	34.7	35
4	40.7-52.5	40.85-52.85	46.6	19
5	52.6-64.4	52.85-64.85	58.5	12
6	64.5-76.3	64.85-76.85	70.4	3
7	76.4-88.2	76.85-88.85	82.3	4
	Total			244

The Distribution Function of Tree Diameter

The analysis of the distribution function according to the distribution of tree diameter data in a secondary forest area of 0.50 ha was carried out on 4 distribution functions, which are the binomial, gamma, poisson and exponential distribution functions.

The analysis was carried out by identifying the requirements of the function and thendetermining significance calculated value of X^2. The next is comparing significance calculated value of X^2 with table value of X^2. Below, examination of appropriate distribution function, which is starting from:

1. Binomial Distribution Function

The Binomial Distribution function is expressed by the following mathematical formula: $f(x) = [n,x]\, p^x q^{n-x}$, where $0 \leq p \leq 1$, n = 1, 2, 3, ...($q = 1 - p$), with the average value (Mean) = n.p and variance = n.p.q. The result of data processing according to the binomial distribution function is presented in the table below (Table 2).

Table 2. The result of data processing based on binomial distribution function

No.	Class interval (cm)	Class limits (cm)	Xi (cm)	fo_i	$fo_i.X_i$	$fo_i.X_i^2$	P_i	fe_i	X_i^2
1	5.0-16.8	4.95-16.85	0	103	0	0	0.0494	12.06	686.053
2	16.8-28.7	16.85-28.75	1	68	68	68	0.1929	47.08	9.300
3	28.8-40.6	28.75-40.65	2	35	70	140	0.3139	76.60	22.589
4	40.7-52.5	40.65-52.55	3	19	57	171	0.2724	66.47	33.898
5	52.6-64.4	52.55-64.45	4	12	48	192	0.1330	32.44	12.882

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6	64.5-76.3	64.45-76.35	5	3	15	75	0.0346	8.45	0.596
7	76.4-88.2	76.35-88.25	6	4	24	144	0.0038	0.92	-
				244	282	790	1	244	765.317

Description: $X^2_{0,05(3)}$ = 7,815

mean = 1.16 = n.p; if n = 6 then p = - 0.1926. Therefore q = 0.807377. Variance = 1.9098 = n.p.q; if n = 6 then p.q = 0.3183. Therefore q = 1.652453 (this number is not sufficient for testing).If q = 0.807377 thus p = 0.39424. In this condition, the q value is enough for further distribution function analysis. The result of data processing to find probability value and the expected frequency are shown in Table 2 above. It can be seen that X^2 = 765,317 and $X^2_{0,05(3)}$ = 7,815. Because X^2 value = 765,317 > $X^2_{0,05(3)}$ = 7,815, therefore the investigated data cannot follow binomial distribution function.

2. Gamma Distribution Function

The Gamma Distribution function is expressed by a mathematical formula as follows: $f(x) = \lambda^r / \Gamma(r)\, x^{r-1} e^{-\lambda x}$, where $\lambda > 0$ dan $r > 0$, with average value (Mean) = r/λ Variance = r/λ^2. Based on the calculation, the average value (Mean) is 24.65 cm and Variance is 300.0851, then λ = 0.08214365 = 0.08 and r = 0.08214365 x 24.65 = 2.024833955 = 2.03. Therefore the equation formed isf $(x) = (0.08^{2.03}) / \Gamma(2.03) * X^{1.03} e^{-0.08x}$.The result of data processing based onthe gamma distribution functionis presented in Table 3.

Tabel 3. The result of data processing based on gamma distribution function

Obs. (i)	Class nterval (cm)	Clas limits (cm)	Xi (cm)	fo_i	$fo_i.X_i$	$fo_i.X_i^2$	P_i	fe_i	Xi^2
1	5.0-16.8	4.95-16.85	10.9	103	1122.70	12237.43	0.3360	81.61	5.605
2	16.8-28.7	16.85-28.75	22.8	68	1550.40	35349.12	0.2510	68.72	0.007
3	28.8-40.6	28.75-40.65	34.7	35	1214.50	42143.15	0.1500	40.37	0.714
4	40.7-52.5	40.65-52.55	46.6	19	885.40	41259.64	0.0830	20.700	0.139
5	52.6-64.4	52.55-64.45	58.5	12	702.00	41067.00	0.0430	9.88	0.457
6	64.5-76.3	64.45-76.35	70.4	3	211.20	14868.48	0.0220	4.50	0.502
7	76.4-88.2	76.35-88.25	82.3	4	329.20	27093.16	0.0110	1.99	2.021
		Total		244	6015.40	214017.98	0.8960	-	9.448

Description: $X^2_{0,05(4)}$ = 9,488

Data processing to obtain the probability value and the expected values is shown in Table 3 above. It can be seen that X^2 = 9.448 and $X^2_{0,05(3)}$ = 9.488. The X^2value = 9.448 < $X^2_{(0.05;\,4)}$ = 9.488, therefore thecalculated data follows gamma distribution function.

Poisson Distribution Function

The Poisson distribution function is expressed by the following mathematical formula as follows: f (x) = = $e^{-x}\lambda^x/x!$, where $\lambda > 0$ and $r > 0$, with average value/mean= r/λ and variance = r/λ^2. Furthermore, mean = λ_1 = 1.1557377 cm and variance = λ_2 = 1.90980233, then λ = 1.5327700 cm. The equation formed is $f(x) = e^{-1.53}\, 1.53^x / x!$The result of data processing based on the poisson distribution function can be seen in Table 4.

Table 4. The result of data processing based on poisson distribution function

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Obs. (i)	Class Interval (cm)	Class limits (cm)	Xi (cm)	fo_i	$fo_i.X_i$	$fo_i.X_i^2$	P_i	fe_i	X_i^2
1	5.0-16.8	04.95-16.85	0	103	0	0	0.2160	52.69	48.042
2	16.8-28.7	16.85-28.75	1	68	68	68	0.3310	80.76	2.016
3	28.8-40.6	28.75-40.65	2	35	70	140	0.2537	61.89	11.685
4	40.7-52.5	40.65-52.55	3	19	57	171	0.1296	31.62	5.038
5	52.6-64.4	52.55-64.45	4	12	48	192	0.0497	12.12	0.001
6	64.5-76.3	64.45-76.35	5	3	15	75	0.0152	3.71	1.170
7	76.4-88.2	76.35-88.25	6	4	24	144	0.0039	0.95	
				244	282	790	0.998953	243.74	67.953

Description: $X^2_{0,05(4)}$ = 9,488
Because X^2 = 67.953 >from $X^2_{(0.05;\ 4)}$ = 9.488. Therefore, the calculated data does not follow poisson distribution function.

Exponential Distribution Function

The exponential distribution function is expressed by the following mathematical formula: $f(x) = \lambda e^{-\lambda x}$, where $\lambda > 0$, with average value (Mean) = $1/\lambda$ and variance = $1/\lambda^2$. Therefore, by dividing the mean with variance, we got λ = 0.09 cm. Then, the equation formed is $f(x) = 0.09e^{-0.09X}$. The result of data processing based on the exponential distribution function is presented in Table 5.

Table 5. The result of data processing based on exponential distribution function

Obs.	Class interval (cm)	Class limits (cm)	Xi (cm)	fo_i	$fo_i.X_i$	$fo_i.X_i^2$	P_i	fe_i	X_i^2
1	5.0-16.8	4.95-16.85	10.9	103	1122.7	12237.43	0.625	152.52	16.076
2	16.8-28.7	16.85-28.75	22.8	68	1550.4	35349.12	0.247	60.14	1.028
3	28.8-40.6	28.75-40.65	34.7	35	1214.5	42143.15	0.085	20.61	10.054
4	40.7-52.5	40.65-52.55	46.6	19	885.4	41259.64	0.029	7.06	20.186
5	52.6-64.4	52.55-64.45	58.5	12	702.0	41067.00	0.015	3.53	48.894
6	64.5-76.3	64.45-76.35	70.4	3	211.2	14868.48	0.003	0.83	-
7	76.4-88.2	76.35-88.25	82.3	4	329.2	27093.16	0.001	0.01	-
Total				244	6015.4	214018.0	0.9994	-	96.238

Description: $X^2_{(0.05;\ 2)}$ = 5.992
Table valueof $X^2_{(0.05;\ 4)}$ = 5. 992and calculated value of X^2 = 96.238. Because X^2 = 96.238 > $X^2_{(0.05;\ 4)}$ = 5.992, therefore it can be concluded that the distribution of diameter at breast height does not follow the exponential distribution function.

Presence of Vegetation (species)

The estimation of dimensions of forest stands according to the current forest inventory guidelines is directly done on all trees in one sample of forest stands. Measuring the dimensions of trees (diameter and height) in the forest is considerably difficult, in which it is costly and time consuming. Consequently, it is necessary to find alternatives that can reduce the budget as small as without decreasing the accuracy of

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the required measurements. One method of estimating the dimension of stands is using the structure of the stands, which is the distribution of number of trees per hectare in different classes of tree diameter (Suhendang, 1985).

Mathematically, thisconcept is understood as the relationship between diameter (D) and number of trees per unit area or tree density per hectare (N/Ha), where N = f (D). The stand structure is influenced by the growth of diameter inside the stand, while the growth of plant community is strongly influenced by the condition of site where it grows. That is the totality of all conditions that effectively affect the growth of the plant community hence the shape of the established forest stand structure will be unique as well as have a specific site condition in which it grows(Suhendang, 1985). Oliver and Carson (1990) asserted that the stand structure is the temporary and physical distributions of trees in a forest area that can be described based on tree species, horizontal or vertical spatial shape, tree size or tree part reaching the canopy, leaf area, trunk, cross section of the trunk, age of the tree, combination of these factors and others [5].

Bratawinata (1987) stated that the Unmul Lempake Educational Forest belonged to the lowland wet tropical forest in which its vegetationswere mostly dominated by species from the Dipterocarpaceae family. The Lempake Forest had experienced several big fires in the 1982/1983, and then in 1987 and 1992. These continual fires had caused damage to vegetations in primary forest areas, logged-over forest areas, secondary forest areas as well asex-cultivated forest area which consequently impacted tothe natural succession process. The distribution of trees diameters recorded in temporary measurement plots indicatesthat the damage of the forest caused by fire has left a small number of large diameter trees and these trees are more adaptable and resistant to fire, mainly Ulin species (*E. zwageri*). The endemic species found in the Lempake Forest Park include *Shorea parvifolia*, *Shorea ovalis*, *Shorea polyandra* and *Hopea rudiformis*. The non-Dipterocarpaceae species commonly found in the site are *E. zwageri*, *Baccaurea macrocarpa*, *Cleisthanthus myrianthus*, *Mallotus echinatus* and *Pentaceae laxifolia*(Suselo and Riswan, 1985). Some of these native species are still found at the time of measurement particularly in poles andtrees levels such as *Shorea parvifolia* and*Shorea ovalis*. The non-Dipterocarpaceae species are also found such as*E. zwageri*, *Baccaurea macrocarpa*, *Cleisthanthus myrianthus*, *Mallotus echinatus* and *Pentaceae laxifolia*.

Kostermans (1987) stated that the floristic composition of Lempake Grand Forest in area 1.6 hectares of the measurement plotsconsisted of 445 trees stands with an average base area of 33.74 square meters per hectare. The total species found were 209 species belonging to 125 genera from 44 families. Species composition can be related to several factors such as the fire intensity factor which will affect the population of seed living in the soil, the weather after the fire which will determine the seed germination process, the availability of seeds and the distance to closest seed sources, the flowering/fruiting period, the seed resistance to fire, the and the composition of seeds in the soil (Kartawinata et al, 1983). It shows that the species composition based on the inventory at the time of measurement is found poorer thanthe result before. 21 species are found belonging to 17 families. Some of them are species from the Dipterocarpaceae family and the remain others are non-Dipterocarpaceae species. Suyono (1984) revealed the result of his research in Lempake under conditions 5 months after the fire where the seedlings that appeared in the valley area were mostly dominated by species from the

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Solanaceae family. The slope area was dominated by ferns, *Macaranga* spp and *Trema canabina*. The ridge area was dominated by *Trema canabina, Macaranga* spp and *Zingiber* sp. Thus, the species that can adapt and sprout after experiencing fire were *E. zwageri, Dillenia exelsa, Alangium javanicum, Horsfieldia grandis, Seraca hulletii, Croton caudatus, Cococeras borneensis, Dacryodes* sp, *Zyzypus calopylla, Eugenia* sp, *Cleistanthus myrianthus, Aporosa microsphaera, Polyathia* sp *and Koorersiodendron* sp.

The data in field show that there are a very few plant species can survive to repeated fire disturbance, particularly when the intensity of fire is high and the energy is available abundantly for fire materials which depend on the growth rate of the vegetation species experiencing fire. Physically, these plant species will experience at least physical damage affected by fire. Vegetation species at the seedling and sapling stages that experience high fire intensity will cause permanent death. While, vegetation at the pole and tree stages that experience low fire intensity may only cause bark damage. In principle, there is no vegetation completely resistant to fire. However, there are species of vegetations that are able to adapt and sprout after fire. The types of vegetation that resist to repeated fire are relict groovers and gallery forests (Batchelder and Hirt, 1966). Severe disturbance either will probably cause failure succession or at least the succession achievement period will be longer. This condition occurs in the site where the presence of native species is considered quite difficult to be found. Secondary succession slowly occurs and revegetation in this succession process is considered as the indicator of ongoing the succession process. The secondary succession can still take place, but the presence of endemic species is still difficult and it is proved by the small number of endemic species that grow at seedling and pole stages. It is assumed that the succession process will successfully occur if we look at the condition of the forest that is undertaking a succession process. However, considering the species composition and tree distribution based on diameter class, it can be ascertained that the fire occurs in this location is considered high fire intensity. In the end, the succession will certainly be able to reach climax if the disturbance experienced does not significantly affect the success of the ongoing succession.

Diameter at Breast Height

Diameter is one of the most important tree dimensions due to its role as a substitute for the age dimension on natural forest. The age of trees in tropical natural forests precisely cannot be determined because of it is not known exactly when the trees are started to grow. Hence, age is never used to describe the characteristic of natural forests, yet small diameter of tree is not eternally presenting the young age (Richards, 1964). According to Hart (1929) in Manan (1976), trees growth will be maximized if position of the trees is optimal, which means that the position of tree is approaching a form an equilateral triangle, thus each of trees has the similar growing space. Referring to this, the number of trees per hectare (N) will be equal to (2x104)/ $a^2\sqrt{3}$, or a = (1000$\sqrt{2}$)/ N$\sqrt{3}$, if a is the distance of adjacent trees (m). In natural forest, the tree density usually will increase in small diameter class, but will decrease in large diameter class. This occurs due to the competition between individuals within one species as well as various species, in consequence not every individual class gets the same opportunity to optimally grow, even though it does not die (Richards, 1964). For intolerant species, the tree density will not significantly decrease with increasing diameter class. On the

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other hand, for tolerant species, tree density will decrease as the diameter class increases in the low diameter class interval.

The structure of Mulawarman University's Botanical Garden Samarinda has three different vegetation strata starting from the lowest strata with height around 5m-15m, the middle strata with height around 15m - 30m, and the highest strata with height 30m – 45m. The range of highest tree is around 50m – 65m which is generally occupied by species from Dipterocarpaceae such as *Dryobalanops beccarii*, *Shorea parvifolia*, *Shorea polyandra*, *Shorea ovalis*, *Shorea smithiana* and *Dipterocarpus cornutus*.The number of trees is abundant in the class of height 5 m – 10 m (30.62%) and class of height 11 m – 15 m (30.20%), as with the distribution of individual trees over all classes of heights, the forest structure curve formed is an inverted J curve(normal curve). Based on the species found in the area, which can be used as an indicator, it can be assumed that the area is belong to young secondary forest which is usually dominated by the following species: *Macaranga* spp, *Malotus* sp *Trema* spp, *Omalanthus* spp and several other species. These kinds of species are commonly called pioneer species andgenerally appear when there is a gap in natural forest. Through this gap, the species will germinate and grow fast due to the sunlight obtained through the gap. The gap is well utilized by pioneer species, as a result the species will rapidly grow and fill the gaps. Due to the gap, most of the trees that dominate Mulawarman University's Botanical Garden Mulawarman University's Botanical Garden are still small and showing growth, only a few numbers are large.

CONCLUSION

The diameter at breast height of the sample trees measured in the secondary forest after the fire at Mulawarman University's Botanical Garden only spreads according to the Gamma distribution function. The Gamma distribution function formed is: f (x) = (0.082.03)/ (2.03) * X 1.03 e -0.08x. This indicates that stands in Mulawarman University's Botanical Gardendifferent in the distribution of growth rates of trees in which the distribution of trees with large dimension is found less than the trees with small dimension.

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