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Full Paper

Estimation of number and density, and random distribution testing of important plant species in Ban Pong Forest, Sansai District, Chiang Mai Province, Thailand using T-Square sampling

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Abstract: A study by T-square sampling method was conducted to investigate important plant species in Ban Pong Forest, Sansai district, Chiang Mai province by estimation of their number and density, and testing of their random distribution. The result showed that, there were 14 kinds of important plant species, viz. *Dipterocarpus tuberculatus Roxb*., *Shorea obtuse Wall. exBlume*, *Bridelia retusa (L.) A. Juss*, *Derris scandens Benth.*, *Thysostachys siamensis*, *Parinari anamense Hance*, *Vitex pinnata L.f.*, *Canarium subulatum Guill.*, *Litsea glutinosa C.B.Roxb.*, *Alphonsea glabrifolia Craib.*, *Pueraria mirifica*, *Vatica stapfiana van Slooten*, *Walsura robusta Rox.* and *Dipterocarpus alatus Roxb.* By far, *Dipterocarpus tuberculatus Roxb* was greatest in number and density, and all of the species had random distribution, except *Walsura robusta Roxb* and *Dipterocarpus alatus Roxb*

Keywords: plant species, density, random distribution, and T-square sampling

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Introduction

Forests are an important part of nature. For one thing they are the main source of streams and rivers, the lifeblood of humanity. Their variety stems from the differences in climate and geographical area. Thailand has about 32% of its land covered with forests, in which the northern part is richest;

about 54% of its soil is forest area [1], of which a large part is in Chiang Mai, the biggest province of the country.

An important forest of Chiang Mai is Ban Pong Forest in Sansai District. Included in a conservation scheme in 1995, it has nourished and old settlement of ethnic Thai community nearby since 1858, or more than 140 years ago. Nowadays, the settlement has 178 homes and 789 people who depend mainly on agriculture for their livelihood. Ban Pong Forest is still rather virgin. It has a large spring and is the source of an important stream. Coupled with the varied environment-friendly agricultural activities of the Ban Pong settlement, it is potentially an important tourist attraction. Motivated by the importance of this forest, we are interested in studying its plant population, and this investigation is a result of our study, which concentrated on the kind, density, and distribution of the plant species in the forest [2].

Materials and Methods

In this work, the sampling for estimation of the number and density, and the random distribution testing of the studied plant species were performed using the T-square sampling method, whose principle is as follows [3,4].

T-square sampling method

T-square sampling method is one kind of distance-based methods for sampling points in space, which are sometimes called nearest neighbor methods. They are widely used in forestry, for example, to estimate the density of trees in a region. Various types of distances have been used in this context, such as distances from trees to their nearest neighbours or distances from random points to their nearest trees and then to the nearest neighbouring trees. Of course, all these types of distances can also be used for sampling other objects.

One approach to the estimation of the density of points requires the assumption that objects occur at random positions, and that the distances from *m* random points to their nearest objects have been measured as $X_1, X_2, X_3, \ldots, X_m$. This means that the area searched from the i*th* random point before an object was found in the area within a circle with radius X_i, i.e. $A_i = \pi X_i^2$. Hence, an unbiased estimate of the area in the population that is occupied by one object is

$$\overline{A} = \sum_{i=1}^{m} A_i \;/\; m = \frac{\pi \sum_{i=1}^{m} X_i^2}{m}$$

where the summations are over the *m* random points. It follows that an estimate of the density of objects per unit area is

$$\hat{D} = 1/\overline{A} = \frac{m}{\pi \sum_{i=1}^{m} X_i^2}.$$

It can be shown that $\hat{D}$ has the approximate standard error $SE(\hat{D}) = \sigma_A D^2 / \sqrt{m}$ where σ_A is the population standard deviation of A_i values. The standard error can therefore be estimated by $\hat{SE}(\hat{D}) = s_A \hat{D}^2 / \sqrt{m}$ where s_A is the sample standard deviation of A_i values.

For a regular pattern of objects the distance from random points to objects will tend to be smaller than with a random pattern, while the distances from each object to its nearest neighbour will tend to be larger than with a random pattern. The reverse is true with a clustered pattern, so that the distances from random points to their nearest objects will tend to be large and the distances between neighbouring objects will tend to be small. One useful way to obtain both point to object distances involves the use of T-square sampling. Here, the distance is measured from a random point to the nearest object, and then from that object to the nearest neighbour in the direction away from the initial point, as shown in Figure 1. Therefore, the area searched for the first object is omitted in the search for the second object. Hence, if objects are located at random then the search area for the first object and the search area for the second object will be independent random variables.

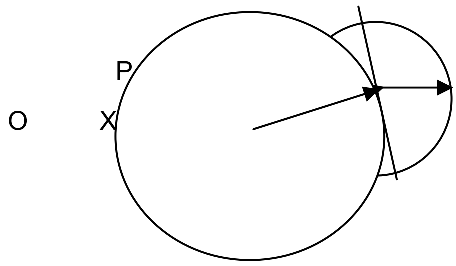

Figure 1. T-square sampling. The point O is randomly chosen, and the nearest object is found at P. The nearest neighbour to P is then found by searching only in the area above the T which is formed by the line OP and the line through P that is perpendicular to OP.

Suppose that a T-square sample of size *m* is taken (this study uses m=10), so that the distances X_1, X_2, X_3,…,X_m from m random points to the nearest objects are determined, and also the distances Y_1, Y_2, Y_3,…,Y_m, from each of the m objects to their nearest neighbours in the directions away from the random points. The search area from the *i*th random point to the nearest object is then $A_{X_i} = \pi X_i^2$, so that an estimate of density based on the X distances is

$$\hat{D}_X = \frac{m}{\sum_{i=1}^{m} A_{X_i}}$$

On the other hand, the half-circle search area from the *i*th object to its nearest $A_{Y_i} = \frac{1}{2}\pi Y_i^2$, so that an estimate of density based on the Y distances is

$$\hat{D}_Y = \frac{m}{\sum_{i=1}^{m} A_{Y_i}} \ .$$

A combined estimate of density that may be somewhat robust to a non-random pattern is then $\hat{D}_p = \sqrt{(\hat{D}_X \hat{D}_Y)}$. The standard errors of $\hat{D}_p$ can be estimated by

$$S\hat{E}(\hat{D}_p) = \frac{\sqrt{S\hat{E}(\hat{D}_X)^2 + S\hat{E}(\hat{D}_Y)^2}}{(2\hat{D}_p)} \ .$$

A test for randomness can be carried out using the same data since for randomly located objects, the statistic U is

$$U = \frac{\sum_{i=1}^{m} \frac{A_{X_i}}{A_{X_i} + A_{Y_i}}}{m} .$$

The U statistic has an approximately normal distribution with mean = ½ and standard error SE(U) = $\frac{1}{\sqrt{12m}}$. Hence the statistic

$$Z_U = \frac{U - \frac{1}{2}}{\sqrt{\frac{1}{12m}}}$$

will approximately have a standard normal distribution. Significantly low values of Z_U indicate regularity in the point pattern, non-significant values indicate randomness, and significantly large values indicate clustering.

Results

The results revealed that there were 14 important plant species of Ban Pong forest, viz. (from the most to the least abundant) *Dipterocarpus tuberculatus Roxb.(1), Shorea obtuse Wall. exBlume(2), Bridelia retusa (L.) A. Juss(3), Derris scandens Benth.(4), Thysostachys siamensis(5), Parinari anamense Hance(6), Vitex pinnata L.f.(7), Canarium subulatum Guill.(8), Litsea glutinosa C.B.Roxb.(9), Alphonsea glabrifolia Craib.(10), Pueraria mirifica(11), Vatica stapfiana van Slooten(12), Walsura robusta Rox.(13)* and *Dipterocarpus alatus Roxb.(14).* The results of the estimation of the number and density, and those of the random testing are shown in Tables 1 and 2.

Table 1 shows that of all 14 kinds of plant species, *Dipterocarpus tuberculatus Roxb* was the highest in number and density, i.e. about 1.08 millions and *Dipterocarpus alatus Roxb.* was the lowest, i.e. about 79.6 thousands.

From Table 2, it was found that of the 14 plant species studied, 12 gave no statistical significance for the randomness test, thus indicating random distribution. These were *Dipterocarpus tuberculatus Roxb., Shorea obtuse Wall. exBlume, Bridelia retusa (L.) A. Juss, Derris scandens Benth., Thysostachys siamensis, Parinari anamense Hance, Vitex pinnata L.f., Canarium subulatum Guill., Litsea glutinosa C.B.Roxb., Alphonsea glabrifolia Craib., Pueraria mirifica,* and *Vatica stapfiana van Slooten*. Only 2 plant species, *Walsura robusta Rox.* and *Dipterocarpus alatus Roxb.,* showed statistical significance for the randomness test implicating non-random distribution.

Table 1. Number and density estimation of plant species

Plant species (descending order)	Average in number (per 100 m^2) $\hat{D}_p$	Interval estimation of number at 95%(per 100 m^2) $\hat{D}_p \pm Z_{\alpha/2}\hat{SE}(\hat{D}_p)$	Interval estimation of number at 95% of Ban Pong forest (9.7152 km^2)
1	11.14	11.14 ± 1.86	1,082,273.28±180,702.72
2	8.63	8.63 ± 1.23	838,421.76±119,496.96
3	5.28	5.28 ± 1.71	512,962.56±166,129.92
4	4.00	4.00 ± 1.33	388,608.00±129,212.16
5	3.01	3.01 ± 1.27	292,427.52±123,383.04
6	2.80	2.80 ± 0.96	272,025.60±93,265.92
7	2.75	2.75 ± 1.45	267,168.00±141,744.76
8	2.70	2.70 ± 1.64	262,310.40±159,329.28
9	2.69	2.69 ± 0.42	261,338.88±40,803.84
10	2.49	2.49 ± 0.56	241,908.48±54,405.12
11	2.22	2.22 ± 0.54	215,677.44±52,462.08
12	1.63	1.63 ± 0.32	158,357.76±31,088.64
13	1.48	1.48 ± 0.38	143,784.96±36,917.76
14	0.82	0.82 ± 0.19	79,664.64±18,458.88

Table 2. Test for randomness of plant species

Plant species (descending order)	U	Z_U
1	1.003	0.551 ns
2	1.477	1.070 ns
3	1.475	1.069 ns
4	1.831	1.458 ns
5	1.564	1.165 ns
6	1.431	1.020 ns
7	1.679	1.292 ns
8	1.134	0.695 ns
9	1.969	1.609 ns
10	1.307	0.884 ns
11	2.231	1.897 ns
12	1.269	0.842 ns
13	2.410	2.093 *
14	2.873	2.600 *

note : ns = no statistical significance at alpha = .05
* = statistical significance at alpha = .05

Discussion and Conclusion

Our conducted survey indicated that there were 14 important plant species in Ban Pong Forest, viz. *Dipterocarpus tuberculatus Roxb., Shorea obtuse Wall. exBlume, Bridelia retusa (L.) A. Juss, Derris scandens Benth., Thysostachys siamensis, Parinari anamense Hance, Vitex pinnata L.f., Canarium subulatum Guill., Litsea glutinosa C.B.Roxb., Alphonsea glabrifolia Craib., Pueraria mirifica, Vatica stapfiana van Slooten., Walsura robusta Rox.*, and *Dipterocarpus alatus Roxb.* Among these, Dipterocarpus tuberculatus Roxb. was found to be highest in number and density. The reasons may stem from the fact that this plant can grow in poor soil and that its wood is less useful for timber than other woods, hence less chance of being cut down. On the other hand, *Dipterocarpus alatus Roxb.* was lowest in density, which is most probably due to the fact that the plant is slow-growing, slowly propagating and is frequently cut for its useful timber. As to the random distribution testing result, this shows that most plant species had random distribution in Ban Pong Forest. Considering its general uniformity in soil type, moisture, and inclination, this finding is not surprising. The exception which is found in Walsura robusta Rox. and *Dipterocarpus alatus Roxb.* is most likely due to the rarity of these 2 plant species, thus making their propagation rather limited to the vicinity of the parent plants.

References

1. Department of Forestry, "Forestry Statistics Annual Report", Ministry of Natural Resources and Environment., **2007**.
2 Ban Pong Forest Conservation Project, "Ban Pong Forest Conservation and Development". Maejo Visions., **2001**, *1*, 16-19.
3. F. J. M. Bryan, "The Design and Analysis of Research Studies.", Cambridge University Press, Cambridge, 1**992**.
4. P. Sakkatat, "T-Square Sampling", *Bang Phra Center Journal*, **1997**, *4*, 27-30.

Photos of Studied plants

Litsea glutinosa C.B.Roxb.

Parinari anamense Hance

Vitex pinnata L.f.

Pueraria mirifica

Canarium subulatum Guill.

Dipterocarpus tuberculatus Roxb.

Walsura robusta Roxb.

Bridelia retusa (L.) A. Jus

Dipterocarpus alatus Roxb.

Shorea obtuse wall exBlume

Thysostachys Siamensis

Derris scandens ROXB. Benth.

Vatica stapfiana van Slooten

Alphonsea glabrifolia Craib.