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Study on minimum landscape patch of coastal vatica forest in Shi Mei Bay, south China

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ABSTRACT

The coastal Vatica forest in Hainan is a special type of tropical rainforest. The methods of landscape patch analysis included both quantitative mathematical modeling and qualitative comparison—8 kinds of species-area mathematic modeling curve and community characteristics. Shannon-Wiener index,Pielou index、evenness index, importance value, layers′ Gleason index were used to analyze species-diversity. The aim of the study was to reveal the minimum landscape patch and species constitution of this forest type in Shimei Bay. This circumstance differed greatly from that of mountain rainforest in Hainan Island. The study revealed that minimum landscape patch of coastal Vatica forest in Shimei Bay was lowest in the global rainforest types. On the other hand, natural rainforest climax community, with low species diversity and salient single dominant community characteristics, was also located in Shimei Bay, Hainan Island.

KEYWORDS

Modeling curve; Minimum landscape patch; Species diversity; Coastal *Vatica* forest; China.

INTRODUCTION

Tropical rain forest structure is complex, containing a variety of forest types, but also because of their constituent species and have different features[1-3]. Dipterocarp forest is widely distributed in the Asia Pacific region, Dipterocarpaceae plants a total of about 14 genera and 470 species, is characteristic of Asian rainforest,In addition, there are 2 genera and 34 species Africa rainforest[4-7]. In Hainan, Dipterocarpaceae plants of 2 genera and 3 species, of which, Pericarpium Citri Reticulatae viride (*Vatica hainanensis*) is the dominaShi Mei Bay natural v.mangachapoi forest growth on the coast to strip the way, in addition to Shi Mei Bay, the Vatica mangachapoi forest were grown on the slopes, mainly distributed in China's Hainan Province, hills and low mountains in, in Bawangling, Jianfengling ridge, more concentrated in macaquesnt species in lowland rainforest of Hainan[8,9]. Mei Wan has Dipterocarpaceae only a growth in coastal sandy soil in the green forest, white sand is poor; in the tropics, small changes in soil properties resulting plant community completely different[10], Vatica forest in Shi Mei bay a typical soil climax "(edphic clamax)"[4-6], is one of the tropical rain forest of Hainan unique plant communities; the purpose of this paper is to explore the reasonable minimum landscape pateh area in this type of rain forest area and species structure.

The minimum landscape patch is one of the basic point of community ecology, depending on the type of community, Watson in 1859 for the first time in drawing the curve -- area of plant communities. In 1974, Dieter believes that the minimum area implies the need to choose sampling size, in the size range, the relevant community species composition can be true[11]. The minimum area is at the minimum area, provide enough space for a particular type of community can (characteristics of environmental and biological), or can ensure that show the real characteristics of the species composition and the structure of the communities[12]. The plant community structure, the minimum area and species of understanding is an important starting point and the basic process, many scholars have studied on the method[13]. In China tropical rain forest in Hainan, study the minimum area and species mainly in lowland rain forest and montane rain forest[4,14-15], but the research on coastal *Vatica hainanensis* Forest no detailed reports.

THE SITE AND RESEARCH METHODS

Shi Mei Bay in southeastern coast of Hainan Island, belongs to Wanning City, set up in 1980 here v.mangachapoi Forest Nature Reserve (provincial). Because of its hard material corrosion, the reign of Qing Emperor Guangxu carved no, since then has been a special management. Reserve center position is longitude $110^0 09'$, latitude $18^0 11'$ 18011, green, forest, altitude 6-12M, with total area of 949ha, including 319ha core areas, in the primitive forest area of more than 67ha state.Shi Mei Bay is located in the north along the tropical, subtropical maritime monsoon climate, year-round hot, no cold and frost, with an average annual temperature of 24.5^0C, lighting rate of 50%, about 2230h per year, mean annual precipitation is 2032mm, rainfall concentrated in the 5-10 month, precipitation throughout the year accounted for 89%; coastal Beach distribution is advanced marine new sand deposition and the modern beach sedimentary lithology, light yellow, gray white sand, thickness of 1.5-8m, water depth 2-5m.Coastal *Vatica hainanensis* forest from the tide line 150m, the existing green forest wide and 400 - 1000m, zonal distribution along the coast. The forest can be divided into A layer, B layer tree tree, shrub layer and herb layer, due to the impact of the Linhai typhoon and other ecological factors, canopy height and branch height are lower than the mountain rain forest; liana species and quantity are many, but the lack of woody vines huge, found the maximum a vine stem diameter of only 1.5cm vascular epiphytes; generally, in landscape patch to find Ya Jiang and Nest Fern 22 strains, there are epiphytic woody; because of species composition, board root and stem flower poor. Looking from the sea or the high ground overlooking the green forest, canopy shape of a typical forest appearance, appearance, composition of canopy layer to peel (*Vatica hainanensis*) accounted for absolute advantage.

In May 8, 2012, in the Shi Mei Bay *Vatica* forest the original core area, with random method according to the different range selected 10 pieces of representative sample, sample size in a unified set to 10m×10m, 1000m^2. For every tree investigation for all plant plots at high above 1.5m, one by one, measuring and recording the species, DBH, tree height, under branch height, crown width; set up a 1m×1 m small plots in each plot, seedling and herb layer plants investigation, record type, height, size, quantity etc. The important value -- area curve (IVAC): Curitst and McIntosh important value in 1951 by America have been used in the process of vegetation communities in the Wisconsin continuum[16], an important value = relative density and relative frequency and relative dominance, which is the comprehensive quantitative index for the community, for the research on complex sampling and structure of forest communities which have good practical[17-18]. By this method of subtropical evergreen broad-leaved forest are discussed, the group of important value and curve plot area fall of dominant species important value is relatively constant, stable community the landscape patch, the hour, the important value of species fluctuations, along with the increase of sample size, curve has become smooth, can reflect the real situation of the community. Species -- area curve (SAC): as the basic method to determine the minimum area, with increasing quadrat area, the number of species increases, increase is limited, finally stabilized at a specific number; the species -- area curve, in order to make comparison, a total of 8 selected species to calculate[13,19]:

$$S = aA/(1+bA) \quad \textbf{(1)}$$

$$S = c/(1+ae^{-bA}) \quad \textbf{(2)}$$

$$S = c - ae^{-bA} \quad (3)$$

$$S = a(1 - e^{-bA}) \quad (4)$$

$$S = b + a \ln A \quad (5)$$

$$S = a \ln(A + 1) \quad (6)$$

$$S = a \ln(bA + 1) \quad (7)$$

$$S = aA^b \quad (8)$$

The above formula, A size, S number of species, a, B, C as the adjustable parameter, formula 1 and formula 4 as saturated species -- area curve function, formula 5 and formula 8 unsaturated species -- area curve function. The original statistical data were calculated using SAS[20,21], curve fitting using Origin[22]. Through the transformation of the 8 formula, in selected some p (the proportion of total community species, between 0 and 1), the minimum area respectively[13,21]:

$$A = p/(b(1 - p)) \quad (9)$$

$$A = -\ln((1 - p)/ap)/b \quad (10)$$

$$A = -\ln(c(1 - p)/a)/b \quad (11)$$

$$A = -\ln(1 - p)/b \quad (12)$$

$$A = e^{(S_p - b)/a} \quad (13)$$

$$A = e^{S_p/a} - 1 \quad (14)$$

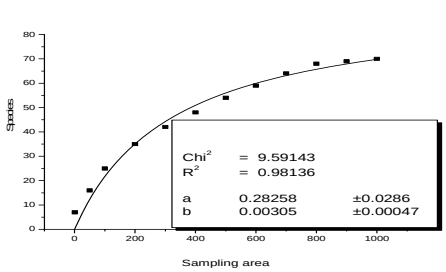
$$A = (e^{S_p/a} - 1)/b \quad (15)$$

$$A = \sqrt[b]{S_p/a} \quad (16)$$

Species diversity and spatial distribution pattern. In all 10 plots for the object, analysis and vertical distribution of species of the whole. Species diversity analysis using the Shannon-Wiener index and the basis of a Pielou evenness index[21]; the important value of the number of methods of index species[23]; the calculation of diversity in vertical direction of the species richness index: IGleason=S/lnA, S as the number of species, A area, characterization the unit area of the number of species, species diversity index for the whole community index (It), A index (IA), B index (IB), shrub layer, herb layer index (Ish) index (Ih), reflect the distribution of vertical layers.

RESULTS AND ANALYSIS

Get the corresponding parameter formula 1, formula 8 and simulation curve by fitting (respectively, see Figure 1 (a) - 1 (H)), results show that the formula 5, formula 6, formula 7 and the actual status of fitting is not good, R^2 less than 0.8, the correlation is less than 0.900; the other 5 formula fitted very well, R^2 in 0.979, the correlation is greater than 0.985, the choice of the 5 formula (formula 1, formula 2, formula 3, formula 4, formula 8) into the calculation of the minimum area of the next step.



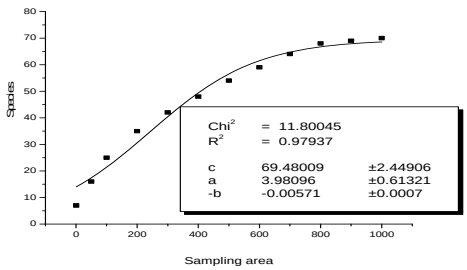
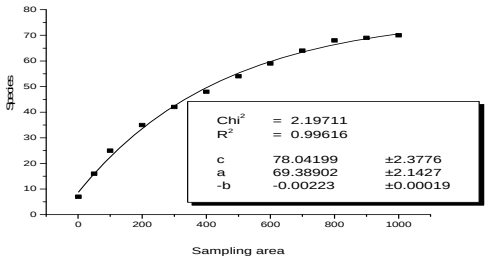


Figure 1(a) : Simulating of function 1 and parameters Figure 1(b) : Simulating of function 2 and parameters



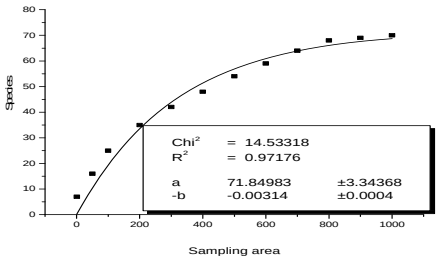
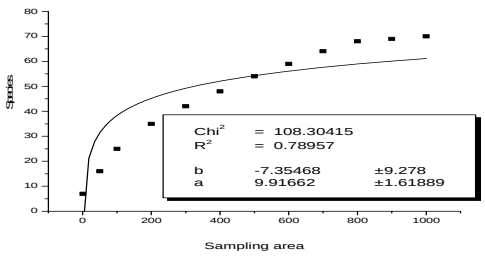


Figure 1(c) : Simulating of function 3 and parameters Figure 1(d) : Simulating of function 4 and parameters



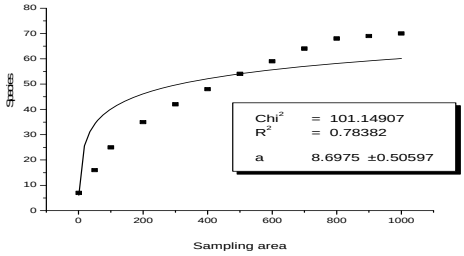
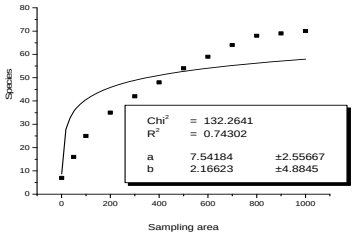


Figure 1(e) : Simulating of function 5 and parameters Fig.1(f) : Simulating of function 6 and parameters



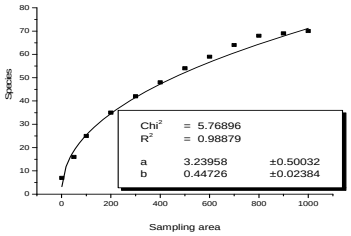


Figure 1(g) : Simulating of function 7 and parameters Figure 1(h) : Simulating of function 8 and parameters

The corresponding formula 9, formula 12 and formula 16, the scale factor P value of 0.5, 0.6, respectively 0.7, 0.8, 0.9, 0.95, the minimum area of the TABLE 1. By numerical fitting found that although the asymptotic formulas are good, but the great results; when the p value of 0.8, including 80% species, a minimum area of equation 10 and equation 12 derived ($485m^2$, $500m^2$) equation with only 16 1/5, the fitting curve of R^2 were 0.97937, 0.97176, 0.99438, although the fitting curve is better, but the data entry; R^2=0.99616 11 equation, is the best fitting results, the calculating result is including 50% species of minimum sample size was 258 m^2, including 80% species of minimum sample size was 669 m^2, the calculation results of equation 9 is 11 higher than that of equation, but modest; the fitting result difference is big, because mathematics different asymptotic curve fitting, in the application of numerical calculation is large, the minimum area still needs further confirmation.

TABLE 1 : Minimum landscape patch corresponding *p* value (m^2)

Equation	*P*=0.5	*P*=0.6	*P*=0.7	*P*=0.8	*P*=0.9	*P*=0.95
9	328	492	765	1311	2951	6229
10	242	313	390	485	627	758
11	258	357	487	669	980	1291
12	221	292	383	513	733	954
16	857	1287	1817	2450	3189	3598

The important value -- area curve. The main species of *Vatica hainanensis* forest has *Vatica hainanensis, Mischocarpus sundaicus*, *Psychotria rubra*, *Salacia grandiflora*, *Randia spinosa*, *Cansjera rheedii*, *Litsea verticillata*, *Pentaphylax euryoides*, *Tarenna attenuata, Rhapis excelsa*, *Uvaria grandiflora*, etc. By the calculation of the $1000m^2$ data display, the important value of the highest is *Vatica hainanensis*, the following order: *Mischocarpus sundaicus*, *Psychotria rubra*, *Salacia grandiflora*, *Randia spinosa.* By calculating the importance value found: in the landscape patch is less than 600m2, the important value of the numerical fluctuations, after the sample size is greater than 700m2, the important values of

main species become more stable, by drawing shows important value curves of these species becomes smooth (see Figure 2), this time only then can reflect the real situation of the community species composition, the further support is provided for the calculation, fitting at this point, a minimum landscape patch area of *Vatica hainanensis* forest recognition for 800m^2.

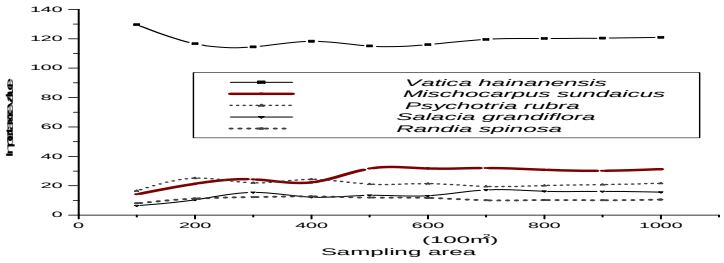


Figure 2 : Importance value of chief species in tree layer of the coastal *Vatica* forest

Distribution of species diversity and spatial. H 'Shannon-Wiener index and evenness index[24]. The calculation results show: the *Vatica hainanensis* forest Shannon-Wiener index is 0.949, evenness index is 0.156. According to research in Hainan, Jianfengling mountain rainforest H 'highest, for 6.218, the lowest rain forest of Diaoluoshan, 4.195, Wuzhishan, Bawangling between two between, Pielou index for 0.7-0.9[6,14], specific data see TABLE 2. Data show: Hainan and other types of tropical rain forest, Shi Mei Bay *Vatica hainanensis* forest species diversity is not high, and the kinds of individual heterogeneity in the distribution of significant.

TABLE 2 : *H*✓ and Evenness index of coastal *Vatica* forest and several other types of rainforest in Hainan

Study site	Elevation	Shannon-Wiener index	Evenness index	Data source
Shi Mei Bay *Vatica hainanensis* forest	5-15	0.949	0.156	
Bawabfling *Vatica hainanensis* fores	480	5.350	0.800	(Hu Yujia, 1997)
Bawabfling mountain rainforest	700-1250	5.190	0.748	(Wang Bosun, 2001)
Diaoluoshan mountain rainforest	900-980	4.195	0.880	(Wang Bosun, 2001)
Diaoluoshan *Vatica hainanensis* forest	700	6.060	0.850	(Hu Yujia, 1997)
Wuzhishan mountain rainforest	820-870	5.900	0.859	(Wang Bosun, 2001)
Jianling *Vatica hainanensis* forest	400	5.860	0.870	(Hu Yujia, 1997)
Jianfengling mountain rainforest	790	6.218	0.867	(Wang Bosun, 2001)

Quantitative characteristics of main species. TABLE 3 lists the 1000m^2 plots are mainly a community characteristics, can be found from the data: *Vatica hainanensis* is an important value is 121, higher than the other species; the relative density of green is 40.3. In the study, the number of individuals is 2.1 times the second *Mischocarpus sundaicus*, its canopy coverage accounted for the total coverage of 74.2%; each kind of all species present *Mischocarpus sundaicus*, *Psychotria rubra*, 10 samples appeared 9 times with *Salacia grandiflora, Randia spinosa*, the other kind of frequency below 5. These instructions and characteristics indicate single *Vatica hainanensis*, on the other hand, *Mischocarpus sundaicus, Psychotria rubra, Salacia grandiflora, Randia spinosa* companion species.

TABLE 3 : Quantitative characteristics of chief species(%)

Species	Relative density	Frequency	Relative dominance	Importance value
Vatica hainanensis	40.3	6.5	74.2	121.0
Mischocarpus sundaicus	18.8	6.5	6.0	31.3
Psychotria rubra	11.0	6.5	4.2	21.7
Salacia grandiflora	5.8	5.9	4.0	15.7
Randia spinosa	3.5	5.9	1.2	10.6
Tarenna attenuata	1.1	3.2	1.1	5.4
Pentaphylax euryoides	1.1	2.6	1.0	4.7
Litsea verticillata	1.3	2.6	0.7	4.6
Cansjera rheedii	1.0	3.2	0.4	4.6

The level of space diversity index. TABLE 4 for each layer of vaticamangachapoi forest species diversity index Gleason index, the size of the order: B layer tree >A tree layer > shrub layer > herb layer; this point and typical montane rain forest is not the same, Hainan Diaoluoshan montane rain forest tree layers of the A Gleason, followed by B tree layer, shrub layer, herb layer[14]. And the B layer of coastal *Vatica hainanensis* forest tree species were most abundant, followed by the A tree layer, herb layer species at least. It is also for this reason, resulting from the appearance, composition of canopy layer *Vatica hainanensis* accounted for absolute advantage, the formation of significantly different from montane rain forest appearance.

TABLE 4 : Spatial species diversity $I_{Gleason}$ of coastal *Vatica* forest

Total community	Layer A	Layer B	Shrub layer	Herb layer
10.134	2.751	5.935	2.461	0.868

CONCLUSION

Asymptotic formula is meaningful to determine the minimum area community, can avoid the subjective factor. Due to different curve its asymptotic model, assumptions and variables, will lead to significant difference of the calculated results, the difference and the fitting effect, R^2 has nothing to do, so, in the choice of asymptotic formula, should try to avoid method only takes a curve model, try to choose a few more, to compare. The investigation of 8 kinds of fitting curve shows 50% species: the minimum sample size was 2.9 times. The important value -- Method of area curve in estimating the minimum area, emphasis on community characteristics, landscape patch gradient in this study is $100m^2$, other research has chosen 200 m^2[6], $500m^2$[24], 2000 m^2[25] and so on, due to the non continuous landscape patch the size of the data, so that the system error caused by the minimum area, quantitative analysis of fuzzy judgment, on the smallest problems; therefore, the combination of these two methods need to be of minimum area of judgment, in the area of Mathematics -- asymptote fitting on the basis of qualitative analysis, through the important value on Community Characteristics -- area curve fitting results were confirmed.

Because of different tropical rain forest type and location, the difference is obvious between the minimum landscape patch. Minimum landscape patch of this study showed that Shi Mei of Hainan Bay Coastal Vatica hainanensis forest is $800m^2$, is so far the landscape patch of tropical rainforest in the world the smallest forest types, than the usual Hainan montane rain forest 6000 - $9000m^2$[15] the minimum area of many small, some scholars believe that the minimum area of Hainan mixed forest is more than $2000m^2$[4,6]; tropical rainforest the optimal landscape patch of $2500m^2$[25,26], this point and the Bangka area of Indonesia forest $2500m^2$[27]. In other forest areas, $1500m^2$ can reflect the characteristic of the community southeast Sumatra Ketamber area, Sekundur area of rainforest in Indonesia, and Africa Garner and New Guinea Rainforest[28].

This study shows that the tropical rainforest equally climax species diversity is not high, significant single excellent characteristics, but also has a unique canopy shape, Shi Mei Hainan Bay Coastal *Vatica hainanensis* forest is one of them. In vertical structure, the Gleason index of *Vatica* forest in Shi Mei Bay, B tree layer than A layer tree index, contrast and mountainous rain forest, and formed unique to peel the remarkable characteristics of canopy. Hainan *Vatica* forest distributed in lower altitudes; Shi Mei Bay lowland coastal *Vatica* forest, occupy the important value of 40.3% of the total; the elevation of 400m mixed *Vatica* forest in Bawangling, *Vatica hainanensis* occupies the important value of 29.3% of the total; the elevation of 700m Diaoluoshan mixed *Vatica hainanensis* forest, occupy the important value of 11.2% of the total; Jianling mixed *Vatica hainanensis* forest at 480m, accounted for 10.1% of the total green important value[4,6]. Hainan Shi Mei Bay *Vatica hainanensis* forest, relative density, relative dominance, important value is much higher than other species, showing obvious characteristics of single.

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