MICROHABITAT INFLUENCE ON GROWTH DISTRIBUTION PATTERN OF RAMIN (*Gonystylus bancanus*) IN SIAK, RIAU PROVINCE**

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Received 12 April 2012/ Accepted 31 December 2014

ABSTRACT

Plant growth distribution patterns are influenced by habitat characteristics, ability of adaptation and association with other plant species or animals. The influence of those factors, especially habitat characteristic, needs to be defined to support plant conservation management. This study was aimed to: 1) measure plant growth dependence on their microhabitat; 2) define microhabitat variables that significantly influence the growth; and 3) develop suitable conservation measures at species level. Ramin (*Gonystylus bancanus*) is one of major timber species that has been facing high exploitation in Indonesia. This species is usually found on specific "peat swamps" ecosystem. Data were collected through primary surveys in Riau Province and analyzed by clustering the adult based on total height and basal area variables and describing the distribution pattern of the cluster. Then, Discriminant Function Analysis (DFA) was used to overlay the cluster with the distribution of microhabitat characteristic consisting altitude, slope, soil humidity, soil pH, peat depth and canopy cover (measured in percentage). The results showed that distribution of microhabitat matched with 67.4% of height distribution and 78.3% of width distribution of tree basal area. Altitude and canopy cover percentage had significant correlation with total height distribution (α=0.05). Meanwhile, altitude, canopy cover and slope had significant correlation with basal area (α=0.1). However, peat depth variable showed an interesting pattern since shallower peat depth was followed by wider basal area. High correlation between plant growth and its microhabitat suggested that to conserve *G. bancanus*, *in-situ* conservation offered better strategy than *ex-situ* conservation.

Keywords: Discriminant Function Analysis, *Gonystylus bancanus,* microhabitat, peat swamp forest, plant growth distribution, ramin

INTRODUCTION

Ramin (*Gonystylus bancanus*) wood is one of the most valuable timbers in Indonesia. It has various local names such as gaharu buaya, medang keladi or pulai miang. It is known as an expensive wood which is similar to merbau (*Intsia* spp., especially *Intsia bijuga* and *Intsia palembanica*), meranti (*Shorea* spp.), bangkirai (*Shorea* spp. and *Hopea* spp.), eboni (*Diospyros* spp.) and cendana (*Santalum album* L.). People usually use it as material for construction, making doors and windows and producing various kinds of furniture. Ramin wood is produced from genus *Gonystylus*, a member of Thymelaeaceae family and *Gonystyloideae* subfamily (Sidiyasa 2005). Approximately, 30 species of *Gonystylus* are distributed in Brunei Darussalam, Fiji, Indonesia (Kalimantan and Sumatera), Malaysia (Peninsular Malaysia, Sabah and Sarawak), Singapore, Nicobar Island, Solomon Island and the Philippines (Soerianegara *et al*. 1994). There are ten species which are found in Indonesia namely *G. affinis* Radlk., *G. bancanus* (Miq.) Kurz., *G. brunnescens* Airy Shaw, *G. confusus* Airy Shaw, *G. forbesii* Gilg., *G. keithii* Airy Shaw, *G. macrophyllus* (Miq.) Airy Shaw, *G. maingayi* Hook f., *G. velutinus* Airy Shaw, and *G. xylocarpus* Airy Shaw (Shaw 1954; Purba *et al.* 2002).

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**This paper was presented at Association for Tropical Biology and Conservation (ATBC) Conference 2010 on Tropical Biodiversity: Surviving the Food, Energy and Climate Crisis (19-23 July 2010). Sanur-Denpasar, Bali, Indonesia

Gonystylus bancanus is the most valuable ramin wood traded in international market. It can be found in Peninsular Malaysia, Sabah, Sarawak, Sumatera, Bangka, Kalimantan and Brunei Darussalam (Lim *et al.* 2004; Sidiyasa 2005). It grows in peat swamp forest having wet climate and waterlogged soil. It mostly becomes dominant tree at peat depth of 350-600 mm (Istomo 2006; Rostiwati *et al*. 2007).

In the early 1980s, Indonesia had become the biggest exporter of ramin followed by Sarawak and Peninsular Malaysia (Soerianegara *et al*. 1994). In the 1970s the annual harvested volume of ramin in Indonesia was about 1.5 million m^3, and it decreased drastically to 131,000 m^3 in the year of 2000 (Lim *et al*. 2004) which indicated that exploitation of ramin wood had exceeded their regeneration capacity (Bismark *et al*. 2005). Therefore, ramin protection and conservation efforts have been started by including *Gonystylus* spp., especially *G. bancanus*, in Appendix II CITES in 2004 (Samedi 2005). It means that the trade of *Gonystylus* spp., especially *G. bancanus*, has been restricted by certain quota every year.

Trade restriction is among policies which are expected to reduce ramin wood's exploitation. However, since illegal logging activities and the loss of forestland are still continuing in Indonesia, it should be coupled with direct conservation measures in the field. Bogor Botanical Garden is one of the Indonesian conservation institutions having responsibility to conserve such kind of plants. Therefore, this research becomes important to analyze the growth pattern of *G. bancanus* in its habitat, thus conservation management could be defined properly.

Plant growth distribution patterns are influenced by habitat characteristics, ability of adaptation and association with other plant species or animals. Recently, studies on the natural distribution of plants and animals species are growing not only to assess the impact of anthropogenic effect or climate change on their habitat, but also to define appropriate conservation management of the species (Guissan & Thuiller 2005; Sinclair *et al*. 2010). Every species has different strength of relationship with its habitat, thus some species have endemism distribution and the others have cosmopolitan distribution. The endemicity level of a species will determine the effectiveness of conservation management effort either in *ex-situ* or *in-situ* conservation.

Based on the above reasons, the aims of this research were: 1) to measure growth dependence of *G. bancanus* on their microhabitat; 2) to define microhabitat variables that significantly influence the growth of *G. bancanus*; and 3) to formulate suitable conservation measures for *G. bancanus*. Few parts of the research had been orally presented during ATBC (Association for Tropical Biology and Conservation) 2010 Conference in Bali.

MATERIALS AND METHODS

Site Description

The research was conducted in Danau Pulau Besar/Danau Bawah Wildlife Sanctuary that encompasses an area of 25,000 ha. This area is located in Dayun Village, Siak District, Siak Municipality, Riau Province. Geographically, this area lies between $00^0$35'-$00^0$45' N and $102^0$10'-$102^0$19' E (IPB & UKSDA Riau 2000). It is managed by Balai Besar Konservasi Sumber Daya Alam, Riau Province.

Generally, this area consists of peat swamp area which has flat topography, low altitude from 2 to 6 m above sea level and slope ranging from 0^0 to 3^0 (IPB & UKSDA Riau 2000). It is situated in an alluvium area which was produced by Siak River sedimentation, thus it contains high organic and inorganic matters.

Based on climate type of Schmidt-Fergusson, this area is classified into type A which has rainfall from 2,200 to 2,600 mm per year. Temperature of the area is 26.2 ^{0}C per year on average, with maximum temperature of 32.4 ^{0}C and minimum temperature of 21.7 ^{0}C. Air humidity in this area can reach 84% on average with maximum humidity of 97% and minimum humidity of 60% (IPB & UKSDA Riau 2000).

Research Time and Location

The research was conducted from 5 to 17 December 2007. The location of the study site was Danau Pulau Besar/Danau Bawah Wildlife Sanctuary, Siak Municipality, Riau Province.

Survey Methods

Field survey was conducted to collect primary data which consisted of spatial distribution of *G. bancanus*, total height and diameter breast height of adult tree, including microhabitat characteristics in each location of *G. bancanus* comprising altitude, slope, soil humidity, soil pH, peat depth and canopy cover (in percentage). To investigate the microhabitat characteristics, unbound plots of ca. 100 m^2 were applied with at least one individual of *G. bancanus* centered within the plot. The sample was taken based on purposive random sampling method because the research was only focused on *G. bancanus* as the target species.

Data Analysis

Data were analyzed by clustering the adult based on total height and basal area variables. The criteria used to define the cluster were as follows:

- Cluster 1: more than average + standard deviation
- Cluster 2: average ± standard deviation
- Cluster 3: less than average – standard deviation

Furthermore, Discriminant Function Analysis (DFA) was used to overlay the cluster with the distribution of microhabitat characteristics consisted of altitude, slope, soil humidity, soil pH, peat depth and canopy cover. DFA is one of multivariate analyses used to evaluate the accuracy of cluster formation based on several quantitative variables. In this study, cluster of growth formation based on height and width of basal area was evaluated by microhabitat characteristics. The correlation between cluster of growth (based on height and width of basal area) and microhabitat characteristics were used to estimate influence value of microhabitat characteristics on growth distribution of *G. bancanus*. In addition, DFA was also used to discover which microhabitat characteristics best explained differences on distribution of the species (McGarigal *et al*. 2000). When correlation between the plant and its habitat is relatively high, it means that the adaptation of the plant in different habitat is relatively low.

RESULTS AND DISCUSSION

Based on height variable, *G. bancanus* was divided into three clusters: 1) Cluster 1 consisted of 9 individuals with 32-35 m of total height; 2) Cluster 2 consisted of 29 individuals with 22-30 m of total height; 3) Cluster 3 consisted of 8 individuals with 15-20 m of total height. Based on basal area, *G. bancanus* was divided into three clusters: 1) Cluster 1 consisted of 7 individuals with 2,428-2,307 cm^2; 2) Cluster 2 consisted of 31 individuals with 594-1,698 cm^2; 3) Cluster 3 consisted of 8 individuals with 154-330 cm^2.

Each cluster of height and basal area had microhabitat characteristics that were shown in Table 1 and 2, respectively. There were 6 measured microhabitat characteristics i.e. altitude, slope, soil humidity, soil pH, peat depth and canopy cover. Each cluster had respective mean and standard deviation for each microhabitat characteristic.

Based on the above results, DFA was conducted to evaluate whether clustering of height matched with distribution of microhabitat characteristics. The result showed that distribution of microhabitat characteristics only 67.4% matched with cluster of height. However, further DFA analysis on microhabitat characteristics expressed that the individuals of *G. bancanus* could be grouped only in 2 clusters with detailed explanation as follows (Table 3):

a. Nine individuals member of Cluster 1 of height should be included in Cluster 2 of microhabitat characteristics;
b. From 29 individuals member of Cluster 2 of height, 26 individuals should be included in Cluster 2 of microhabitat characteristics, while the other 3 individuals should be included in Cluster 3 of microhabitat characteristics;
c. From 8 individuals member of Cluster 3 of height, 3 individuals should be included in Cluster 2 of microhabitat characteristics, while the other 5 individuals should be included in Cluster 3 of microhabitat characteristics.

Since the correlation between distribution of height with microhabitat characteristics was only

Table 1. Microhabitat characteristics of each cluster for total height

Group Statistics

No,	Total height	Mean	Standard deviation	Valid N (Listwise)	
				Unweighted	Weighted
1	Alt	23.8889	1.90029	9	9.000
	Slope	12.2222	6.96020	9	9.000
	SRH	94.4444	11.30388	9	9.000
	SPH	5.3556	.46934	9	9.000
	PD	119.8889	26.47666	9	9.000
	CC	.0000	.00000	9	9.000
2	Alt	23.1724	2.81665	29	29.000
	Slope	12.7241	5.94406	29	29.000
	SRH	95.7931	10.23083	29	29.000
	SPH	5.4069	.59036	29	29.000
	PD	112.3966	29.87510	29	29.000
	CC	18.2759	24.79472	29	29.000
3	Alt	18.7500	4.97853	8	8.000
	Slope	9.6875	4.78791	8	8.000
	SRH	94.3750	10.50085	8	8.000
	SPH	5.1125	.41897	8	8.000
	PD	121.0625	34.62290	8	8.000
	CC	55.6250	29.20830	8	8.000
Total	Alt	22.5435	3.55094	46	46.000
	Slope	12.0978	5.95410	46	46.000
	SRH	95.2826	10.26897	46	46.000
	SPH	5.3457	.54353	46	46.000
	PD	115.3696	29.69824	46	46.000
	CC	21.1957	28.65862	46	46.000

Notes:
Alt = altitude; Slope = slope; SRH = soil humidity; SPH = soil pH; PD = peat depth; CC = canopy cover

67.4%, it was predicted that there were other factors affecting plant total height distribution such as genetic factors, age differences, or even other physiological factors (Ryan *et al*. 2006). Although the influence of age differences was minimized by selecting only adult plants which had similar appearance, however, the age of the plants was not measured quantitatively (e.g. tree rings approach) in this study.

Another result of DFA showed that there were only two variables having significant influence on the tree height distribution consisting altitude and canopy cover (Table 4). Based on information from Table 1, it was described that increasing altitude was followed by increasing tree total height, while decreasing canopy cover was followed by increasing total height. Figure 1 shows that Cluster 2 (higher tree height) was located in higher altitude and lower canopy cover, whereas Cluster 3 (lower tree height) was located in lower altitude and higher canopy cover. This explained light sufficiency is important to support the height growth of *G. bancanus*. Higher altitude and less canopy cover gave more open space to the plant for getting more light intensity.

Table 2. Microhabitat characteristics of each cluster for basal area

Group Statistics

No.	Basal area	Mean	Standard deviation	Valid N (Listwise)	
				Unweighted	Weighted
1	Alt	23.8571	2.85357	7	7.000
	Slope	17.8571	4.94734	7	7.000
	SRH	95.7143	11.33893	7	7.000
	SPH	5.2000	.46547	7	7.000
	PD	106.0571	38.28607	7	7.000
	CC	4.2857	11.33893	7	7.000
2	Alt	23.1613	2.55730	31	31.000
	Slope	11.2903	5.74424	31	31.000
	SRH	96.0645	9.93960	31	31.000
	SPH	5.4194	.58276	31	31.000
	PD	113.8097	27.25907	31	31.000
	CC	15.4839	24.60877	31	31.000
3	Alt	19.0000	5.31843	8	8.000
	Slope	10.1875	5.02805	8	8.000
	SRH	91.8750	11.31923	8	8.000
	SPH	5.1875	.42908	8	8.000
	PD	129.5625	30.02075	8	8.000
	CC	58.1250	24.19231	8	8.000
Total	Alt	22.5435	3.55094	46	46.000
	Slope	12.0978	5.95410	46	46.000
	SRH	95.2826	10.26897	46	46.000
	SPH	5.3457	.54353	46	46.000
	PD	115.3696	29.69824	46	46.000
	CC	21.1957	28.65862	46	46.000

Note:
Alt = altitude; Slope = slope; SRH = soil humidity; SPH = soil pH; PD = peat depth; CC = canopy cover

Table 3. Evaluation result for cluster of total height membership based on microhabitat characteristics by using DFA

Classification Results[a]

	Total height	Predicted group membership			
		1	2	3	Total
Original count	1	0	9	0	9
	2	0	26	3	29
	3	0	3	5	8
%	1	.0	100.0	.0	100.0
	2	.0	89.7	10.3	100.0
	3	.0	37.5	62.5	100.0

Notes:
1. [a] = 67.4% of original grouped cases were correctly classified
2. cluster of height are represented by row, while cluster of microhabitat characteristics are represented by column

Table 4. Significant influences from microhabitat characteristics on tree total height distribution

Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Significance level
Alt	.748	7.236	2	43	.002
Slope	.964	.811	2	43	.451
SRH	.996	.093	2	43	.911
SPH	.959	.918	2	43	.407
PD	.982	.386	2	43	.682
CC	.627	12.772	2	43	.000

Note:
Significance level of respective variable is shown by value in the sixth column which is less than 0.05

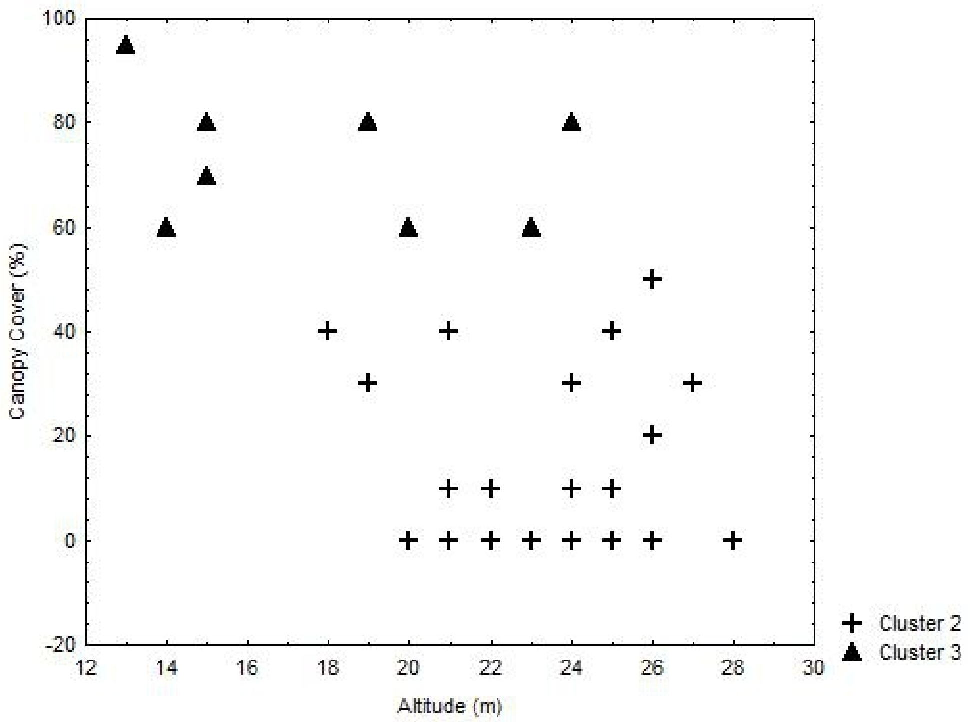

Figure 1. Plot of cluster of tree height based on altitude and canopy cover variables

Simultaneously, DFA was also conducted to evaluate whether clustering of basal area matched with distribution of microhabitat characteristics. The result showed that distribution of microhabitat characteristics only matched 78.3% with the cluster of basal area. Detailed explanation of the result was as follows (Table 5):

a. From 7 individuals member of Cluster 1 of basal area, 2 individuals should be included in Cluster 1 of microhabitat characteristics, while the other 5 individuals should be entered in cluster 2 of microhabitat characteristics;
b. From 31 individuals member of Cluster 2 of basal area, 1 individual should be included in Cluster 1 of microhabitat characteristics, 28 individuals should be included in Cluster 2 of microhabitat characteristics, while the other 2 individuals should be included in Cluster 3 of microhabitat characteristics;
c. From 8 individuals member of Cluster 3 of basal area, 2 individuals should be included in Cluster 2 of microhabitat characteristics, while the other 6 individuals should be included in cluster 3 of microhabitat characteristics.

Distribution of microhabitat characteristics had higher correlation with variable of basal area than with variable of height. It described that 78.3% of basal area distribution were influenced by microhabitat characteristics and the rest was influenced by other factors such as genetic factors or age differences. As mentioned before, we did not measure the influence of age differences.

Table 5. Evaluation result for cluster basal area width membership based on microhabitat characteristics by using DFA

Classification Results[a]

			Predicted Group Membership			
		Basal area	1	2	3	Total
Original	Count	1	2	5	0	7
		2	1	28	2	31
		3	0	2	6	8
	%	1	28.6	71.4	.0	100.0
		2	3.2	90.3	6.5	100.0
		3	.0	25.0	75.0	100.0

Notes:
1. [a] = 78.3% of original grouped cases were correctly classified
2. Cluster of basal area are represented by row, while cluster of microhabitat characteristics are represented by column

Table 6. Significant influences of microhabitat characteristics on basal area distribution

Tests of Equality of Group Means

	Wilks' Lambda	F	df1	df2	Significance level
Alt	.781	6.035	2	43	.005
Slope	.823	4.609	2	43	.015
SRH	.976	.525	2	43	.595
SPH	.961	.870	2	43	.426
PD	.942	1.319	2	43	.278
CC	.623	12.995	2	43	.000

Note:
Significance level of respective variable is shown by value in the sixth column which is less than 0.05

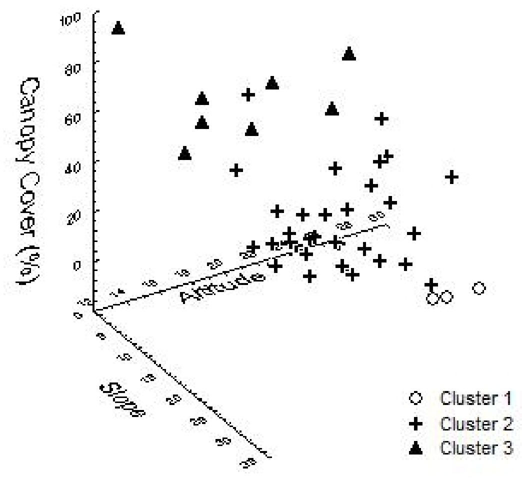

Figure 2. Plot of cluster of basal area based on altitude, slope and canopy cover

Another result of DFA showed that there were three variables having significant influence on basal area distribution consisting of altitude, slope and canopy cover (Table 6). Based on information from Table 2, the increasing altitude, slope and decreasing canopy cover were followed by increasing basal area. This could also be seen from Figure 2 where Cluster 1 (the widest basal area) was located in higher altitude, higher slope and lower canopy cover, whereas Cluster 3 (the narrowest basal area) was located in lower altitude, lower slope and higher canopy cover. Peat depth variable showed an interesting pattern since shallower peat depth was followed by wider basal area, although not significant.

The above result indicated that the distribution of microhabitat characteristics had 67.4% correlation, with distribution of *G. bancanus* vertical growth. Microhabitat characteristics which could support vertical growth of *G. bancanus* were higher altitude and decreasing canopy cover. This meant that *G. bancanus* needs sufficient light intensity to support its vertical growth. Therefore, sufficient light intensity should be provided if *G. bancanus* would be cultivated in *ex-situ* conservation to produce longer log. A research by Jans *et al*. (2012) showed that the seedling growth of *G. bancanus* was the highest in partial sunlight and reduced with decreasing light intensity. Afterwards, big-sized tree will flourish in full sunlight (Partomihardjo *et al.* 2008).

The result also indicated that distribution of microhabitat characteristics had higher correlation with distribution of basal area than with vertical growth. The correlation of microhabitat characteristics with basal area was 78.3%. Microhabitat characteristics supporting basal area growth of *G. bancanus* were higher altitude, increasing slope, decreasing canopy cover, while level and shallower peat depth could also support basal area growth.

Peat swamp ecosystem is usually developed in a basin area. Therefore, the result actually indicated that *G. bancanus* would have maximum basal area if they grew at the edge of the basin area which had higher altitude, higher slope, lower canopy cover and shallower peat depth. The result followed Istomo (1998) and Bismark *et al*. (2005) where deeper peat depth gave higher density, thus shallower peat depth gave lower density and higher basal area. It showed that the range of their habitat actually was relatively narrow. The distribution of adult *G. bancanus* at the edge of the basin area, recorded by GPS, in Danau Pulau Besar / Danau Bawah Wildlife Sanctuary could be seen in Figure 3.

From the correlation between microhabitat characteristics and distribution of vertical growth and basal area, it could be estimated that planting of *G. bancanus* without any treatments in the outside area of their habitat would not be optimal. The survival rate would be low, and if they were successfully grown, the growth rate would be very slow in terms of height and tree basal area. Ismail *et al.* (2007) found that planting of *G. bancanus* in non-peat swamp area after 11 years resulted to low survival rate (52%), low average of total height (8.16 m), and low average diameter breast height (9.1 cm). Therefore, even though *G. bancanus* can be planted in non-peat swamp areas, limiting factor on utilization will be the relatively small diameter and log length. New or existing technology that can utilize smaller size logs may solve the problem (Ismail *et al*. 2007). Apparently, planting of *G. bancanus* is not easy and its growth is relatively very slow.

According to the above discussion, although there is a possibility to conserve *G. bancanus* in an *ex-situ* conservation area, but the role of *in-situ* conservation becomes more important to conserve *G. bancanus* in an optimal condition. Therefore, massive exploitation and land use change in peat swamp ecosystem become two important challenges in conserving *G. bancanus*. However, a technology breakthrough to cultivate *G. bancanus* outside their habitat is still needed to strengthen the conservation of this species. As suggested by Krigas *et al*. (2010) this kind of study can provide valuable information to facilitate the transfer from wild habitats to man-made habitats like botanical garden. This transfer is important to produce material for reintroduction and reinforcement of this species when its existence in nature becomes increasingly rare (Guerrant *et al.* 2004). Bogor Botanical Garden has been planting seedlings of *G. bancanus* since year 2007, but their growth are still insignificant despite their survival.

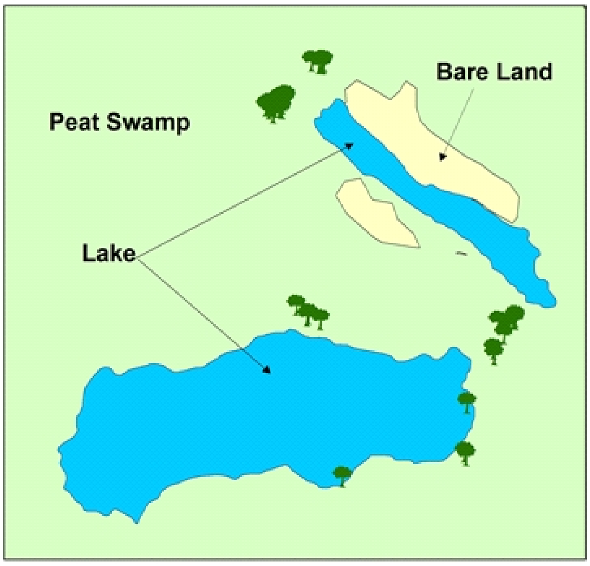

Figure 3. Distribution of *G. bancanus* within the study area in Riau Province in 2008

CONCLUSIONS

High correlation between the distribution of tree growth and microhabitat characteristics suggested that *in-situ* conservation offers better strategy than *ex-situ* conservation to conserve *G. bancanus*, especially when an appropriate planting method is not yet developed.

ACKNOWLEDGEMENTS

We thanked our colleagues (Yupi Isnaini, Enda Suhenda and M. Madhari) for their assistance in various aspects of this study. We also thanked the people in DPB-DW (Sutrisno, Jumaat, Beni Ishak Silalahi) for their hospitality, and BKSDA Riau for the permission support. The study was funded by DIPA - Center for Plant Conservation Bogor Botanical Gardens-LIPI.

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