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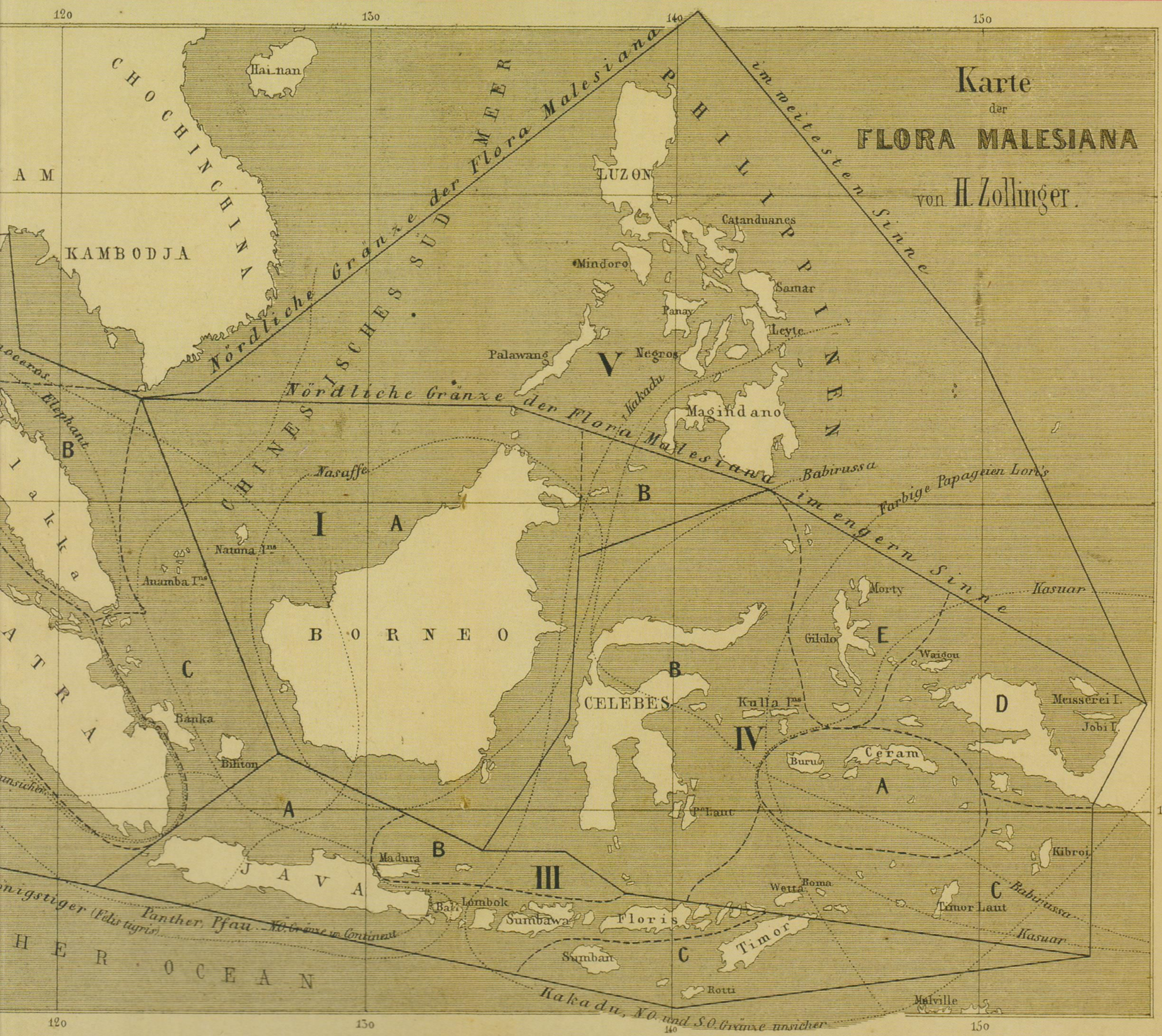

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Cover image
Map presented by Zollinger, first reference in print to 'Flora Malesiana'. See also Raes & Van Welzen, p. 6–8.
Zollinger H. 1857. Ueber den Begriff und Umfang einer 'Flora Malesiana'. Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich 2: 318–349.

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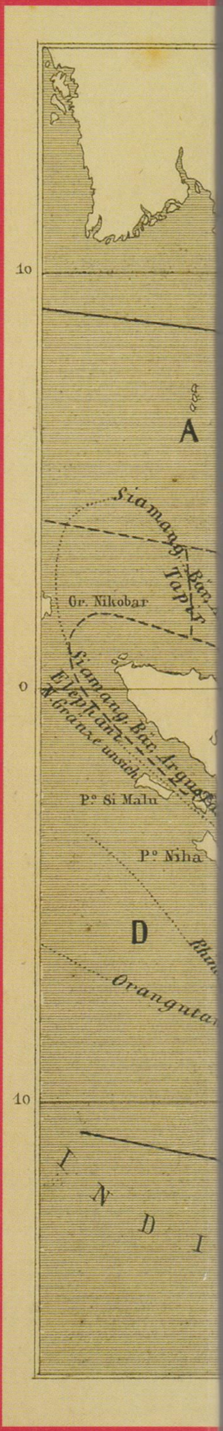

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RESEARCH ARTICLE

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Succession on tin-mined land in Bangka Island

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Key words

Bangka
succession
tin-mined land

Abstract A quantitative study of floristic composition and vegetation structure was conducted at Bangka Island, Indonesia. Six different vegetation types were chosen, riparian forest, abandoned farmland, and natural regeneration of tin-mined lands of different ages: 0 and barren, 7, 11 and 38 years' old tin-mined land. The seedling composition of the oldest tin-mined land was less than 2 % similar to that of a riparian forest. Natural regeneration on 7-year old tin-mined land began with herb species belonging to *Cyperaceae*, *Poaceae*, and *Melastomaceae*; followed by herb species belonging to *Asteraceae* and *Poaceae* on 11-year old; then by *Poaceae* and shrub species of *Myrtaceae* on 38-year old tin-mined land. Older tin-mined land tended to have less sand, higher nutrients and cation-exchange capacity. The phosphate solubilizing bacteria showed a gradual increase along with the more newly abandoned tin-mined land but decreased in barren tin-mined land, while the number of arbuscular mycorrhizal fungal spores showed the opposite.

Published on 30 October 2009

INTRODUCTION

Tin deposits in Bangka Island have been exploited for about a hundred years with increased intensity during the Dutch colonial period. Bangka is the largest tin producing island in Indonesia, contributing 40 % of world demand of tin (ASTIRA 2005). Tin mining leaves disturbed land and ex-tin mining ponds ('kolong'), damages natural drainage and habitats, and causes pollution. Reliance on natural succession to restore sand tin tailings without any human intervention requires a long time, during which the tin tailings remain economically barren (Mitchell 1959, Ang 1994, Elfis 1998).

To obtain a more detailed picture of succession on tin-mined land, especially sand tin tailings in Bangka Island, floristic and species composition, soil properties, and soil flora and fauna of different ages of natural regeneration of tin-mined sites was needed. This study will be useful for the re-establishment of diverse native forests. Dominant among the species planted in Bangka since 1993 are a number of exotic species (Nurtjahya 2001), but ecological caution suggests it is unwise to continue to rely on such a limited species mix for all future rehabilitation efforts (Lamb & Tomlinson 1994). While there is no list of local tree species as candidates for revegetating tin-mined land in Bangka Island, some scholars, however, have suggested some local species (Sambas & Suhardjono 1995, Van Steenis in Whitten et al. 2000). Other suggested sources for species that are suitable for revegetating sand tin tailings are Padang-vegetation (Van Steenis 1932), regarded as degraded heath forest (Whitten et al. 2000); coastal mixed forest with *Barringtonia* formation (Whitten et al. 2000), and heath forest (MacKinnon et al. 1996).

The aim of this study was to understand the succession on tin-mined land in Bangka Island, in order to develop better criteria for the selection and identification of local species with the potential to revegetate these lands.

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METHODS

Study sites

A quantitative ecological study of tin tailings in the Bangka Regency, Province of Bangka Belitung, Indonesia was carried out from May 2004 to November 2005 on six different types of vegetation (Fig. 1, 2). The study involved field surveys, interviewing locals, and consulting the tin mining map (PT Tambang Timah 2004), and land use and land system maps (Bakosurtanal 1986, Widagdo et al. 1990). Study plots were a 13 ha riparian forest at Sempan (01°53'38.5"S 105°58'14.5"E), a 4-year old 1.6 ha abandoned farmland ('ladang' at Sempan), and natural regeneration of tin-mined lands of different ages: 0-year old 2 ha barren tin-mined land at Riding Panjang (01°59'53.4"S 106°06'45.3"E), 7-year old 0.5 ha land at Sempan, 11-year old 0.6 ha at Gunung Muda (01°37'0.01"S 105°54'47.9"E), and

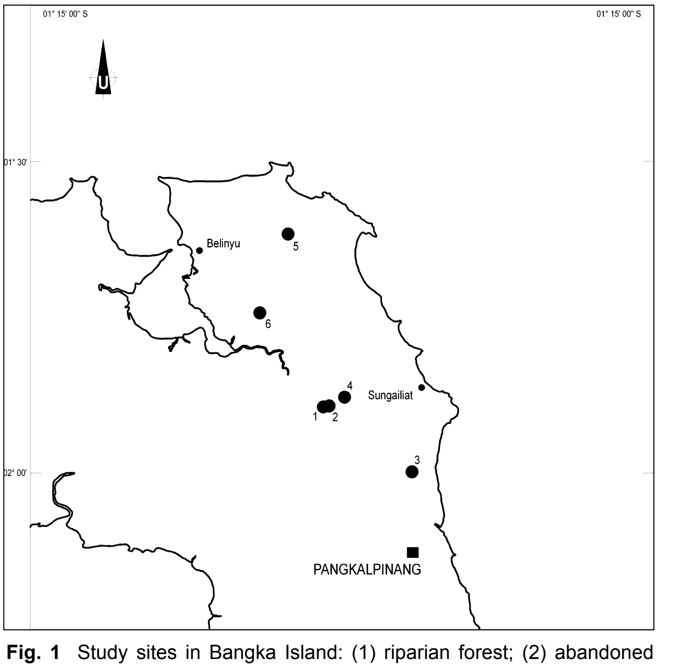

Fig. 1 Study sites in Bangka Island: (1) riparian forest; (2) abandoned farmed-land; (3) 0-year old barren tin-mined land; (4) 7-year old tin-mined land; (5) 11-year old tin-mined land; (6) 38-year old tin-mined land.

38-year old 2 ha at Riau (01°44'33.8"S 105°51'66.4"E). All plots located are below 50 m asl.

Data collection and analysis
Soil properties, arbuscular mycorrhizal fungi, and phosphate solubilizing bacteria

Soil was sampled at 0–20 cm and 20–40 cm depth using an 8 cm auger. Diagonal composite (Setyorini et al. 2003) sample of nine subsamples and single replicate were analyzed. A composite of eight rhizosphere points of 500 g samples for phosphate solubilizing bacteria (PSB) and arbuscular mycorrhizal fungi (AMF) spores, which were taken at 0–10 cm and 10–20 cm depth and three replicates, were collected using a modified CSM-BGBD Project protocol (2004) under three highest important value index (IVI) domination at each site. Fungal spores were recovered by wet sieving and decanting (Gadermann & Nicolson 1963), and genera were identified (Schenck & Perez 1988; INVAM). Soil solution was seeded in the surface of Picovskaya agar and colonies showing transparent halos around them were counted, and re-isolated and maintained in nutrient agar.

Vegetation analysis

A minimum study plot size of 0.2 ha per study site was determined on basis of the species-area curve (Setiadi & Muhadiono 2001). The study was conducted on 20 contiguous plots of 10 by 10 m at each of the study sites using the modified quadrat sampling technique of Oosting 1956 (Soerianegara & Indrawan

Fig. 2 Vegetation aspects of study sites. a. Riparian forest; b. abandoned farmed-land; c. 38-year old tin-mined land; d. 11-year old tin-mined land; e. 7-year old tin-mined land; f. 0-year old barren tin-mined land. Photos E. Nurtjahya.

1995). Quadrats of 10 by 10 m were used for measuring trees > 20 cm dbh, and for poles with diameter 10–20 cm; 5 by 5 m for saplings with height taller than 1.5 m and diameter less than 10 cm; and 1 by 1 m quadrats for seedlings with height less than 1.5 m. For trees and poles the number of individual plants for each species and diameter class was recorded, for saplings and seedlings only the species. Herbarium specimens were collected for identification at Herbarium Bogoriense, Bogor. Vegetation structure was determined by species importance value index (IVI, Mueller-Dumbois & Ellenberg 1974); Pielou's evenness index (Odum 1971), Margalef's species richness (Odum 1971), Shannon/Wiener species diversity (Odum 1971); and similarity index using Sǿrensen formula (Mueller-Dumbois & Ellenberg 1974). Canonical correspondence analysis was analyzed using the statistical package MSV 3.1.

RESULTS

Soil properties, arbuscular mycorrhizal fungi, and phosphate solubilizing bacteria

A comparison of soil properties (Table 1) shows that sand fraction in forest at 0–20 cm and 20–40 cm depth (78 and 66 %) and abandoned farmland (47 and 48 %) was less than in the four tin-mined lands (80–97 %). Except for the 11-year old tin-mined land, C/N ratio of tin-mined lands was higher than forest and abandoned farmland. The concentration of P_2O_5, K_2O, K, and Na of undisturbed land generally was higher than of disturbed land, and gradually decreases along with the newly abandoned tin-mined land. The cation-exchange capacity (CEC) of all tin-mined lands was very low (0.4–3.9). The concentrations of other soil properties showed different relations to each of tin-mined lands.

Table 1 Soil properties of study sites.

Study sites	Depth	Texture			pH	Soil organic matter			HCl 25%		Cation-exchange							
						Walkley & Black	Kjeldahl				(NH4 - Acetate 1 N, pH 7)							KCl 1 N
		Sand	Silt	Clay	H_2O	C	N	C/N	P_2O_5	K_2O	Ca	Mg	K	Na	Total	CEC	B	Al^{3+}
	cm	%				%			mg/100g		cmol(+)/kg						%	cmol (+)/kg
Forest	0–20	78	13	10	4.7	1.6	0.2	10	22	5	0.2	0.1	0.1	0.1	0.4	5.8	7	2.0
	20–40	66	18	16	4.7	1.2	0.1	14	20	5	0.1	0.1	0.1	0.1	0.4	5.2	7	2.0
Abandoned farmed-land	0–20	47	22	31	4.5	3.2	0.3	12	35	8	0.3	0.2	0.1	0.0	0.7	14.7	4	4.8
	20–40	48	22	31	4.6	1.7	0.1	12	36	7	0.3	0.2	0.1	0.1	0.6	9.6	6	3.7
Tin-mined land 38 yrs	0–20	96	2	2	5.1	0.3	0.0	14	5	2	0.2	0.1	0.0	0.1	0.4	1.0	40	0.2
	20–40	95	2	3	5.0	0.2	0.0	10	4	2	0.1	0.1	0.0	0.1	0.3	0.9	31	0.2
Tin-mined land land 11 yrs	0–20	83	5	13	4.9	0.2	0.0	10	11	4	0.2	0.1	0.0	0.0	0.3	2.0	28	0.9
	20–40	80	3	18	4.8	0.3	0.0	10	11	4	0.2	0.1	0.0	0.0	0.4	2.3	30	0.9
Tin-mined land land 7 yrs	0–20	94	4	3	4.8	1.0	0.1	13	49	3	0.2	0.1	0.0	0.1	0.3	3.3	16	0.6
	20–40	93	6	2	4.8	1.2	0.1	14	71	3	0.2	0.1	0.0	0.1	0.4	3.9	19	0.7
Barren tin-mined land	0–20	94	2	4	4.8	0.2	0.0	15	2	3	0.1	0.2	0.0	0.0	0.3	0.4	73	0.3
	20–40	97	1	2	4.5	0.1	0.0	13	3	3	0.3	0.2	0.0	0.0	0.6	1.4	40	0.1

Table 2 Status of phosphate solubilizing bacteria (PSB) and arbuscular mycorrhizal fungi (AMF) in study sites.

Study site	Dominant vegetation	Depth (cm)	Total average of PSB colonies (105 / g soil/ dominant plant species)	Total average of AMF spores (/50 g soil / dominant plant species)	No. of AMF genera	Dominant AMF genus
Forest	*Tristaniopsis whiteana* *Syzygium* sp. *Ilex cymosa*	0–20	4.4	15.0	4	*Glomus* 57%
Abandoned farmed-land	*Trema orientalis* *Melastoma malabathricum* *Pternandra galeata*	0–20	12.7	45.3	5	*Glomus* 44%
Tin-mined land 38 yrs	*Rhodomyrtus tomentosa* *Eriachne pallescens* *Ischaemum* sp.	0–20	1.3	261.7	5	*Glomus* 95%
Tin-mined land 11 yrs	*Paspalum orbiculare* *Blumea balsamifera* *Melastoma malabathricum*	0–20	4.2	57.0	4	*Glomus* 59%
Tin-mined land 7 yrs	*Fymbristylis pauciflora* *Trema orientalis* *Melastoma malabathricum*	0–20	6.2	47.0	5	*Glomus* 67%
Barren tin-mined land 0 yrs	-----------	0–20	6.0	2.0	1	*Glomus* 100%

Table 3 Number of individuals, species, and families in study sites, per growth phase.

Study site	Number of individuals / ha					Number of species					Number of families				
	seed lings	sap lings	poles	trees	total	seed lings	sap lings	poles	trees	total	seed lings	sap lings	poles	trees	total
Forest	2,665	4,155	305	170	7,295	42	66	24	11	85	24	30	14	8	44
Abandoned farmed-land	1,640	5,495	40	0	7,175	48	47	4	0	71	27	25	4	0	38
Tin-mined land 38 yrs	2,125	55	0	0	2,180	15	1	0	0	16	12	1	0	0	13
Tin-mined land 11 yrs	1,675	45	0	0	1,720	7	2	0	0	8	4	2	0	0	5
Tin-mined land 7 yrs	890	0	0	0	890	6	0	0	0	6	4	0	0	0	4
Barren tin-mined land 0 yrs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 4 Similarity indices between different study site, per growth phase.

Study sites		Growth phases			
		Seedling	Sapling	Pole	Tree
0-year old tin-mined land	7-year old tin-mined land	0	0	0	0
	11-year old tin-mined land	0	0	0	0
	38-year old tin-mined land	0	0	0	0
	abandoned farmed-land	0	0	0	0
	forest	0	0	0	0
7-year old tin-mined land	11-year old tin-mined land	27.8	0	0	0
	38-year old tin-mined land	18.6	0	0	0
	abandoned farmed-land	17.6	0	0	0
	forest	0	0	0	0
11-year old tin-mined land	38-year old tin-mined land	15.4	0	0	0
	abandoned farmed-land	16.9	0	0	0
	forest	0	0	0	0
38-year old tin-mined land	abandoned farmed-land	19.9	0	0	0
	forest	1.5	0	0	0
Abandoned farmed-land	forest	13.7	25.0	2.0	0

Table 2 shows the development of some microbiological parameters. The average number of arbuscular mycorrhizal fungi (AMF) spores per 50 g soil per dominant plant species in 0–20 cm in forest soil (15.0) was less than that of abandoned farmland (45.3) and the number of spores in 38-year old tin-mined land was the highest (261.7). The number of AMF spores increases strongly with the period of abandonment of tin-mined land, with lowest values in 0-year old barren tin-mined land. The number of genera was between three and five, and *Glomus* Tul. & C.Tul. (*Glomaceae*) was dominant (44–100 %). In contrast to AMF, the average number of phosphate solubilizing bacteria (PSB) in tin-mined lands showed a slight increase at 7 years, and a gradual decrease after that. The average number of PSB per g soil in 0–20 cm in forest soil (4.4 10^5) was less than that of abandoned farmland (12.7 10^5) and the smallest number of spores was found in 38-year old tin-mined land (1.3 10^5).

Floristic composition

The number of individuals, species, and families was highest in riparian forest, and gradually decreased in abandoned farmland, 38-year old tin-mined land, 11-year old tin-mined land, 7-year old tin-mined land (Table 3). Trees (11 species) and poles were only found in forest (24 species) and abandoned farmland (4 species). Saplings were found at all study sites except on the 7-year old tin-mined land. Similarities between study sites with different regeneration phases could be assessed only on basis of seedlings (Table 4), and show that similarity is generally low (less than 28 %), and that the similarity index (seedlings) of the oldest tin-mined land and that of riparian forest is still only 1.5 %.

A comparison of the development of structural properties and diversity of the vegetation is presented in Table 5.

Species composition (see Appendix)

Species composition (measured by Importance value index, IVI) for all stages of plant development differs between all study sites. *Gaertnera vaginata* (*Rubiaceae*), *Calophyllum pulcherrimum* (*Clusiaceae*), *Calophyllum lanigerum*, *Syzygium lineatum* (*Myrtaceae*), and *Garcinia parvifolia* (*Clusiaceae*) have the five highest seedling IVIs in secondary riparian forest; *Scleria levis* (*Cyperaceae*), *Trema orientalis* (*Ulmaceae*), *Dicranopteris linearis* (*Gleicheniaceae*), *Melastoma malabathricum* (*Melastomataceae*), and *Paspalum conjugatum* (*Poaceae*) on abandoned farmland; *Rhodomyrtus tomentosa* (*Myrtaceae*), *Eriachne pallescens* (*Poaceae*), *Ischaemum* sp. (*Poaceae*), *Crotalaria* sp. (*Fabaceae*), and *Melastoma malabathricum* on 38-year old tin-mined land; *Blumea balsamifera* (*Asteraceae*), *Paspalum conjugatum*, *Imperata cylindrica* (*Poaceae*), *Fimbristylis pauciflora* (*Cyperaceae*), *Melastoma malabathricum* on 11-year old tin-mined land; *Fimbristylis pauciflora*, *Imperata*

Table 5 Structure indices for study sites, per growth phase.

Growth phases	Indices	Study sites					
		0-year old tin-mined land	7-year old tin-mined land	11-year old tin-mined land	38-year old tin-mined land	Abandoned farmed-land	Forest
Seedling	Dominance (*c*)	0	0.23	0.36	0.09	0.05	0.06
	Species richness (*d*)	0	2.22	2.38	5.33	18.68	15.04
	Evenness (*e*)	0	0.79	0.55	0.90	0.82	0.77
	Shannon Wiener (_)	0	0.61	0.46	1.06	1.37	1.25
Sapling	Dominance (*c*)	0	0	0.65	1.00	0.05	0.03
	Species richness (*d*)	0	0	1.05	0	15.13	22.26
	Evenness (*e*)	0	0	0.05	0	0.77	0.82
	Shannon Wiener (_)	0	0	0.15	0	1.28	1.50
Pole	Dominance (*c*)	0	0	0	0	0.48	0.12
	Species richness (*d*)	0	0	0	0	4.43	12.88
	Evenness (*e*)	0	0	0	0	0.77	0.84
	Shannon Wiener (_)	0	0	0	0	0.47	1.16
Tree	Dominance (*c*)	0	0	0	0	0	0.15
	Species richness (*d*)	0	0	0	0	0	6.53
	Evenness (*e*)	0	0	0	0	0	0.87
	Shannon Wiener (_)	0	0	0	0	0	0.91

cylindrica, *Melastoma malabathricum, Eupatorium inulaefolium* (*Asteraceae*), *Paspalum orbiculare* on 7-year old tin-mined land. No seedlings have been recorded on 0-year old tin-mined land.

Similarly, each study site had different sapling species. *Calophyllum lanigerum*, *Pternandra galeata* (*Melastomataceae*), *Tristaniopsis whiteana* (*Myrtaceae*), *Syzygium lineatum*, and *Rhodamnia cinerea* (*Myrtaceae*) were the five highest sapling IVIs in secondary riparian forest.

Trema orientalis, *Pternandra galeata*, *Gynotroches axillaris* (*Rhizophoraceae*), *Adinandra dumosa* (*Theaceae*) and *Schima wallichii* were the five highest sapling IVIs on abandoned farmland. One species of *Myrtaceae* was the only sapling found on 38-year old tin-mined land. *Commersonia bartramia* (*Sterculiaceae*) was the only sapling found on 11-year old tin-mined land, and no saplings were recorded on 7-year and 0-year old tin-mined lands. *Ilex cymosa* (*Aquifoliaceae*), *Calophyllum pulcherrimum*, *Adinandra dumosa*, *Tristaniopsis whiteana*, and *Syzygium lineatum* were the five highest pole IVIs in secondary riparian forest. *Syzygium* sp.6 (*Myrtaceae*), *Sapium baccatum* (*Euphorbiaceae*), and *Artocarpus integer* (*Moraceae*) were the only poles on abandoned farmland, and no poles were found on tin-mined land of any age. Trees were only found in riparian forest and the five highest IVIs were: *Schima wallichii*, *Tristaniopsis whiteana*, *Ilex cymosa*, *Syzygium lineatum*, and *Cratoxylum formosum* (*Clusiaceae*).

DISCUSSION

It appears that the combination of high sand component, and low macronutrients, CEC, and soil organic matter in the tin-mined lands determine the floristic composition and species composition. Older tin-mined lands were shown to be more fertile than younger ones, and to be richer floristically and in species composition. From the PSB and AMF point of view, it appears that the presence of PSB in tin-mined lands reflects phosphate concentration availability in soil. In contrast to PSB, the number of AMF spores in tin-mined lands was likely supported by the soil fertility and its vegetation development above ground. As the availability of phosphate in the soil is low, root hairs and spore production seemed to increase. In general, with increasing soil fertility, PSB population increased while the number of AMF spores tended to decrease. The severe conditions in barren tin-mined land supported only one *Glomus* species.

Concentration and distribution of species in disturbed study sites was higher than for undisturbed sites because the number of species and the number of plants at disturbed sites were less. Therefore, the species richness of disturbed sites was poorer than for undisturbed sites. The floristic composition of older abandoned tin-mined lands is gradually more similar to the site with forest, but, similarity of forest to 38-year old tin-mined land is still low. The high dissimilarity among study sites confirms that succession takes a long time and supports the projection in Singkep Island (Elfis 1998).

Succession is initiated by herb species, followed by shrub species, but the time required for poles and finally trees to appear apparently exceeds the 38 years covered in this study. The slow succession reflects the long period of time needed to increase soil fertility, accumulate organic material and so improve the quality of the soils' microclimate. During this time, apparently also minerals are added, reducing the sand and increasing the silt and clay component. Much older tin-mined lands are needed to present a more comprehensive conclusion. Unfortunately, illegal mining and illegal re-mining in revegetated tin-mined lands (Bangka Pos 2004) make these difficult to find.

To accelerate succession, potential species candidates can be identified, starting with herb species belonging to *Cyperaceae* and *Poaceae*, or shrub species belonging to *Melastomataceae* and *Myrtaceae*.

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Appendix 1 Floristic composition and Importance value index of 0-year, 7-year, 11-year, 38-year, abandoned farmed land, and forest.

Species	Family	0-year	7-year	11-year	38-year	Farmed-land	Forest
Seedlings							
Adinandra dumosa Jack	*Theaceae*					4.05	
Ancistrocladus tectorius Merr.	*Ancistrocladaceae*						4.35
Anonim sp.1	*Orchidaceae*					4.73	
Anonim sp.2						1.45	
Anonim sp.3					15.66		
Anonim sp.4							1.18
Anonim sp.11	*Orchidaceae*						0.99
Anonim sp.12	*Araceae*						1.37
Anonim sp.13							1.18
Anonim sp.14	*Arecaceae*						1.99
Aporosa cf. *aurita* (Tul.) Miq.	*Euphorbiaceae*					1.15	1.18
Archidendron clypearia (Jack) Nielsen	*Fabaceae*					3.21	
Archidendron microcarpum (Benth.) Nielsen	*Fabaceae*					1.15	
Artabotrys suaveolens Blume	*Annonaceae*						2.18
Arthrophyllum diversifolium Blume	*Araliaceae*						0.99
Blumea balsamifera (L.) DC.	*Asteraceae*			111.51			
Breynia cernua (Poir.) Müll.Arg.	*Euphorbiaceae*					1.15	
Calamus sp.	*Arecaceae*						8.03
Calophyllum lanigerum Miq.	*Clusiaceae*					4.05	13.26
Calophyllum pulcherrimum Wall. ex Choisy	*Clusiaceae*					2.60	18.68
Chaetocarpus castanocarpus (Roxb.) Thwaites	*Euphorbiaceae*						3.55
Chionanthus ramiflorus Roxb.	*Oleaceae*					3.81	1.18
Commersonia bartramia (L.) Merr.	*Sterculiaceae*					1.15	
Cratoxylum glaucum Korth.	*Clusiaceae*					1.15	
Crotalaria sp.	*Leguminosae*				17.17		
Daphniphyllum laurinum (Benth.) Baill.	*Daphniphyllaceae*					1.15	
Dianella nemorosa Lam.	*Liliaceae*					5.50	
Dicranopteris linearis (Burm.f.) Underw.	*Gleicheniaceae*					14.87	
Dillenia suffruticosa (Griff.) Martelli	*Dilleniaceae*				4.64		
Dioscorea alata L.	*Dioscoreaceae*					1.45	
Eragrostis chariis (Schult.) Hitchc.	*Poaceae*			7.75			
Eriachne pallescens R.Br.	*Poaceae*				20.47		
Eupatorium inulaefolium Humb., Bonpl. & Kunth	*Asteraceae*		19.64		7.12	6.95	
Eurya acuminata DC.	*Theaceae*					1.15	4.11
Eurycoma longifolia Jack	*Simaroubaceae*						6.81
Ficus fistulosa Reinw.	*Moraceae*					1.15	
Fimbristylis pauciflora R.Br.	*Cyperaceae*		66.82	14.31	14.22		
Freycinettia sp.	*Pandanaceae*						5.55
Gaertnera vaginata Poir.	*Rubiaceae*					2.36	31.91
Garcinia parvifolia (Miq.) Miq.	*Clusiaceae*						9.23
Glechenia sp.	*Gleicheniaceae*				12.33		
Guioa pubescens (Zoll. & Moritzi) Radlk.	*Sapindaceae*						1.37
Gynotroches axillaris Blume	*Rhizophoraceae*						1.18
Ilex cymosa Blume	*Aquifoliaceae*						0.99
Imperata cylindrica (L.) P.Beauv.	*Poaceae*		50.25	16.68		4.96	
Ischaemum sp.	*Poaceae*				18.82		
Ixora miquelii Bremek.	*Rubiaceae*						4.16
Kibatalia maingayi (Hook.f.) Woodson	*Apocynaceae*					1.45	3.36
Lepisanthes amoena (Hassk.) Leenh.	*Sapindaceae*						0.99

Appendix 1 (cont.)

Species	Family	0-year	7-year	11-year	38-year	Farmed-land	Forest
Lithocarpus blumeanus (Korth.) Rehder	*Fagaceae*						0.99
Litsea forstenii Blume	*Lauraceae*						8.40
Litsea umbellata (Lour.) Merr.	*Lauraceae*					1.15	
Lycopodium cernuum L.	*Lycopodiaceae*					12.13	
Macaranga javanica (Blume) Müll.Arg.	*Euphorbiaceae*					4.89	
Macaranga trichocarpa (Rchb.f. & Zoll.) Müll.Arg.	*Euphorbiaceae*					1.15	
Mallotus paniculatus (Lam.) Müll.Arg.	*Euphorbiaceae*					1.15	
Melastoma malabatricum L.	*Melastomataceae*		37.75	12.21	15.86	14.04	
Mussaenda frondosa L.	*Rubiaceae*					4.05	0.99
Nephelium mangayi Hiern	*Sapindaceae*						0.99
Nephenthes sp.1	*Nephentaceae*				3.09		
Nephenthes sp.2	*Nephentaceae*					6.41	
Ormosia bancana (Miq.) Merr.	*Papilionaceae*					1.75	1.18
Pandanus sp.	Pandanaceae						9.15
Paspalum conjugatum P.J.Bergius	*Poaceae*		12.49	33.07		12.14	
Paspalum orbiculare G.Forst.	*Poaceae*		13.05				
Ploiarium alternifolium (Vahl) Melch.	*Theaceae*					1.15	
Pternandra galeata (Korth.) Ridl.	*Melastomataceae*					2.36	7.65
Puar hijau	*Zingiberaceae*					1.45	
Rhodamnia cinerea Jack	*Myrtaceae*						4.73
Rhodomyrtus tomentosa (Aiton) Hassk.	*Myrtaceae*				36.87		
Sapium baccatum Roxb.	*Euphorbiaceae*					1.15	
Schima wallichii (DC.) Korth.	*Theaceae*				7.73	1.45	2.98
Scleria levis Retz.	*Cyperaceae*			4.47	10.89	23.12	
Stenochlaena palustris (Burm.f.) Bedd.	*Stenochlaenaceae*					2.29	
Symplocos cochinchinensis (Lour.) S.Moore	*Symplocaceae*						2.55
Syzygium claviflorum (Roxb.) Wall. ex A.M.Cowan & Cowan	*Myrtaceae*					4.35	3.98
Syzygium lineatum (DC.) Merr. & L.M.Perry	*Myrtaceae*					1.15	12.46
Syzygium sp.2	*Myrtaceae*					2.90	
Syzygium sp.6	*Myrtaceae*					1.45	
Syzygium zeylanicum (L.) DC.	*Myrtaceae*					2.29	0.99
Taenitis blechnoides (Willd.) Sw.	*Taenitidaceae*						5.42
Tarrena fragrans (Blume) Koord. & Valeton	*Rubiaceae*						2.87
Timonius flavescens (Jack) Baker	*Rubiaceae*					1.75	
Trema orientalis (L.) Blume	*Ulmaceae*				6.55	19.07	
Tristaniopsis whiteana (Griff.) Peter G.Wilson & J.T.Waterh.	*Myrtaceae*						1.37
Urceola brachysepala Hook. f.	*Apocynaceae*					1.45	3.49
Vernonia arborea Ham.	*Asteraceae*					3.21	
Vitex pinnata L.	*Verbenaceae*				8.57		
Saplings							
Adinandra dumosa Jack	*Theaceae*					10.13	0.67
Anonim sp.5							0.43
Anonim sp.6	*Arecaceae*						1.58
Anonim sp.9							0.43
Anonim sp.15							0.86
Anonim sp.16							1.29
Anonim sp.17	*Myrtaceae*				200.0		
Aporosa cf. *aurita* (Tul.) Miq.	*Euphorbiaceae*					5.90	3.81
Archidendron clypearia (Jack) Nielsen	*Fabaceae*					2.46	
Arthrophyllum diversifolium Blume	*Araliaceae*						0.43
Artocarpus sp.	*Moraceae*						0.67
Baccaurea bracteata Müll.Arg.	*Euphorbiaceae*					0.57	0.98
Brackenridgea palustris Bartell.	*Ochnaceae*						0.43
Brucea javanica (L.) Merr.	*Simaroubaceae*					0.57	
Calophyllum lanigerum Miq.	*Clusiaceae*						14.43
Calophyllum pulcherrimum Wall. ex Choisy	*Clusiaceae*					0.57	2.95
Chaetocarpus castanocarpus (Roxb.) Thwaites	*Euphorbiaceae*						6.72
Chionanthus ramiflorus Roxb.	*Oleaceae*						4.15
Clerodendrum villosum Blume	*Verbenaceae*					0.57	
Commersonia bartramia (L.) Merr.	*Sterculiaceae*			44.44		5.99	
Cratoxylum formosum Benth. & Hook.f. ex Dyer	*Clusiaceae*						0.55
Cratoxylum glaucum Korth.	*Clusiaceae*					1.80	0.55
Daphniphyllum laurinum (Benth.) Baill.	*Daphniphyllaceae*					1.32	1.10
Decaspermum fruticosum J.R.Forst. & G.Forst.	*Myrtaceae*					2.91	
Dicranopteris linearis (Burm.f.) Underw.	*Gleicheniaceae*					2.32	
Elaeocarpus mastersii King	*Elaeocarpaceae*						0.86
Elaeocarpus valetonii Hochr.	*Elaeocarpaceae*					0.57	2.40
Eugenia densiflora DC.	*Myrtaceae*					3.96	1.72
Eurycoma longifolia Jack	*Simaroubaceae*						2.45
Ficus consociata Blume	*Moraceae*						0.43
Ficus grossularioides Burm.f.	*Moraceae*					3.60	
Garcinia parvifolia (Miq.) Miq.	*Clusiaceae*					1.14	5.73
Gordonia excelsa Blume	*Theaceae*						0.43
Gynotroches axillaris Blume	*Rhizophoraceae*					12.04	3.93
Helicia serrata (R.Br.) Blume	*Proteaceae*						2.83
Ilex cymosa Blume	*Aquifoliaceae*					7.95	6.75
Kibatalia maingayi (Hook.f.) Woodson	*Apocynaceae*						0.43
Leea indica (Burm.f.) Merr.	*Leeaceae*					3.69	

Appendix 1 (cont.)

Species	Family	0-year	7-year	11-year	38-year	Farmed-land	Forest
Lepisanthes amoena (Hassk.) Leenh.	*Sapindaceae*						0.43
Lithocarpus blumeanus (Korth.) Rehder	*Fagaceae*						4.10
Lithocarpus sp.2	*Fagaceae*						1.89
Litsea forstenii Blume	*Lauraceae*						0.43
Litsea umbellata (Lour.) Merr.	*Lauraceae*						2.71
Lophopetalum javanicum (Zoll.) Turcz.	*Celastraceae*						0.86
Macaranga javanica (Blume) Müll.Arg.	*Euphorbiaceae*					2.94	0.43
Macaranga trichocarpa (Rchb.f. & Zoll.) Müll.Arg.	*Euphorbiaceae*					1.71	
Mallotus paniculatus (Lam.) Müll.Arg.	*Euphorbiaceae*					0.57	
Melaleuca cajuputi Powell	*Myrtaceae*					3.67	
Ormosia bancana (Miq.) Merr.	*Papilionaceae*						2.71
Pternandra galeata (Korth.) Ridl.	*Melastomataceae*					14.95	14.17
Rhodamnia cinerea Jack	*Myrtaceae*						7.46
Sapium baccatum Roxb.	*Euphorbiaceae*					0.57	
Schima wallichii (DC.) Korth.	*Theaceae*					9.52	2.15
Symplocos cochinchinensis (Lour.) S.Moore	*Symplocaceae*					0.66	0.43
Syzygium claviflorum (Roxb.) Wall. ex A.M.Cowan & Cowan	*Myrtaceae*					4.24	6.54
Syzygium lineatum (DC.) Merr. & L.M.Perry	*Myrtaceae*						8.83
Syzygium sexangulatum (Miq.) Amshoff	*Myrtaceae*						0.55
Syzygium zeylanicum (L.) DC.	*Myrtaceae*					9.38	2.08
Syzygium sp.2	*Myrtaceae*						2.64
Syzygium sp.4	*Myrtaceae*					0.66	
Syzygium sp.5	*Myrtaceae*					1.02	
Syzygium sp.6	*Myrtaceae*					4.01	3.19
Tarrena fragrans (Blume) Koord. & Valeton	*Rubiaceae*					2.16	3.02
Timonius flavescens (Jack) Baker	*Rubiaceae*					6.38	1.53
Trema orientalis (L.) Blume	*Ulmaceae*					16.84	
Tristaniopsis whiteana (Griff.) Peter G.Wilson & J.T.Waterh.	*Myrtaceae*						11.81
Vitex pinnata L.	*Verbenaceae*					0.66	
Poles							
Adinandra dumosa Jack	*Theaceae*						21.72
Artocarpus integer (Thunb.) Merr.	*Moraceae*					27.04	
Calophyllum cf. *ferrugineum* Ridl.	*Clusiaceae*						7.33
Calophyllum pulcherrimum Wall. ex Choisy	*Clusiaceae*						24.02
Chaetocarpus castanocarpus (Roxb.) Thwaites	*Euphorbiaceae*						13.15
Combretocarpus rotundatus (Miq.) Danser	*Anisophyllaceae*						4.15
Cratoxylum formosum Benth. & Hook.f. ex Dyer	*Clusiaceae*						4.68
Elaeocarpus mastersii King	*Elaeocarpaceae*						4.12
Eugenia densiflora DC.	*Myrtaceae*						5.39
Garcinia parvifolia (Miq.) Miq.	*Clusiaceae*						7.72
Gynotroches axillaris Blume	*Rhizophoraceae*						4.49
Ilex cymosa Blume	*Aquifoliaceae*						89.29
Lophopetalum javanicum (Zoll.) Turcz.	*Celastraceae*						3.98
Nauclea subdita (Korth.) Steud.	*Rubiaceae*						4.35
Nephelium eriopetalum Miq.	*Sapindaceae*						4.79
Pternandra galeata (Korth.) Ridl.	*Melastomataceae*						8.73
Rhodamnia cinerea Jack	*Myrtaceae*						4.27
Sapium baccatum Roxb.	*Euphorbiaceae*					30.69	
Schima wallichii (DC.) Korth.	*Theaceae*						3.95
Symplocos cochinchinensis (Lour.) S.Moore	*Symplocaceae*						12.16
Syzygium lineatum (DC.) Merr. & L.M.Perry	*Myrtaceae*						16.61
Syzygium sp.6	*Myrtaceae*					41.84	6.11
Tristania merguensis Griff.	*Myrtaceae*						15.65
Tristaniopsis whiteana (Griff.) Peter G.Wilson & J.T.Waterh.	*Myrtaceae*						18.15
Vaccinium bancanum Miq.	*Ericaceae*						10.89
Xanthophyllum vitellinum (Blume) D.Dietr.	*Polygalaceae*						4.31
Trees							
Calophyllum pulcherrimum Wall. ex Choisy	*Clusiaceae*						16.98
Cratoxylum formosum Benth. & Hook.f. ex Dyer	*Clusiaceae*						20.18
Gluta velutina Blume	*Anacardiaceae*						7.76
Gordonia excelsa Blume	*Theaceae*						7.71
Ilex cymosa Blume	*Aquifoliaceae*						59.76
Ixonanthes petiolaris Blume	*Linaceae*						8.45
Lithocarpus sp.	*Fagaceae*						15.00
Lophopetalum javanicum (Zoll.) Turcz.	*Celastraceae*						9.36
Schima wallichii (DC.) Korth.	*Theaceae*						65.30
Syzygium lineatum (DC.) Merr. & L.M.Perry	*Myrtaceae*						27.51
Tristaniopsis whiteana (Griff.) Peter G.Wilson & J.T.Waterh.	*Myrtaceae*						62.01