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Composition and Diversity of Plant Seedlings and Saplings at Early Secondary Succession of Fallow Lands in Sabal, Sarawak

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Abstract Seedlings and saplings represent the juvenile stage of plant life and their presence can reflect the future forests regeneration. However, still less information is available on the composition and diversity of seedlings and saplings under secondary forests at Sarawak, especially in fallow lands after shifting cultivation. In this study, the composition and diversity of plant seedlings and saplings in secondary forests at various age stands was conducted in order to obtain basic information on species under succession of secondary forests after shifting cultivation. A survey was carried out in four stages of fallows land such as 3 years of fallows lands (hereafter called Temuda I), 5 years old secondary forest (hereafter called Temuda II), 10 years old secondary forest (hereafter called Belukar I), and 20 years old secondary forest (hereafter called Belukar II) in Sabal area, Sarawak. Twenty five plots with the size of 20 m × 20 m were established in each study sites and all plant seedlings and saplings within the plot were enumerated and identified. The results showed that Temuda I and Temuda II were mostly dominated by pioneer species such as *Melastoma malabathricum* L., *Ficus aurata* Miq., *Ploiarium alternifolium* Melchior, *Dillenia* spp. and *Macaranga* spp. At Belukar II, significant changes in terms of species composition was obvious where plant species such as *Artocarpus sarawakensis* Jarrett, *Artocarpus integer* (Thunb.) Merr., and *Palaquium decurrens* H.J. Lam were among the most common species in this study site. Among all the study sites, species diversity of Belukar I was the highest based on the indices of diversity (3.12), evenness (0.90), and richness (7.68). By understanding the composition and diversity of plant regeneration at early stages of secondary succession on fallow lands, such information will be useful for biodiversity conservation, and social and economic values for future forest.

Keywords Floristic composition • diversity • seedlings • saplings • secondary succession • fallow lands

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Introduction

Secondary forests cover more than 600 million ha of the land area in the tropics in which, accounts for about 40% of the total forest area with rates of formation are about 9 million ha year^{-1} (Brown & Lugo 1990). FAO (1996) estimated that the area of secondary forest in 1990 in Asia to be 87.5 million ha, while the figures for Latin America and Africa were 165 and 90 million ha, respectively. Such situation in the tropical region suggested that future goods and services such as timber resources, environmental services, biodiversity conservation, and forest products that society obtains from tropical forests will increasingly have to come from secondary forests, or from some other kind of anthropogenically-induced forest (De Jong et al. 2001). For the case of Sarawak, Malaysia, the land use pressure on primary forests to provide ecological services are at stake due to the needs for various activities ranging from commercial activities such as timber logging to shifting cultivation by subsistence farmers. Such activities has purpose being rapidly reduced due to combination of various activities such as logging as well as shifting cultivation and are being replaced by the secondary forests of lower stature and altered species composition (Jomo et al. 2004; Primack & Hall 1992). The human disturbance could bring negative effects to forest and cause the decline of species diversity and simplicity of plant community structure (Dianpei et al. 2004).

Swidden fallows provide rotating habitats for successional species in a primary-secondary forests matrix thus enhancing biodiversity. Due to limited forest destruction and rapid re-growth, the watershed and soil properties of this primary-secondary forest landscape are almost the same as to the land under primary forest (Chokkalingam et al. 2001). Plant species composition, diversity, and growth during the fallow period after shifting cultivation are resulted from complex interactions among a number of conditions and factors which occur before and during the fallow period such as degree of disturbance, historical factors, land management, tree composition and seed sources in soils or from the surrounding forests, soil fertility, and climate conditions (Awang Noor et al. 2008; Kendawang et al. 2007; Van Do et al. 2010).

The plant seedlings, usually the most transitory of life-history stages, provide opportunities to explore novelties, as well as life cycle continuum feature and vulnerability which are responsible for the plant species population and community dynamics (Leck et al. 2008). Intraspecific differences in sapling abundances as characterized by the coefficient of skewness are the potentially useful tool for predicting future trends in vegetation population change (Grime & Hillier 2000). To understand the mechanisms of secondary forest succession, time since abandonment has to be considered as a compound factor integrating variables of community structure (Van Breugel et al. 2006). Many studies have been conducted on the floristic and structure of trees with a DBH > 5 and 10 cm in the tropical forest of Malaya and Borneo Island (Adam & Ibrahim 1992; Faridah-Hanum 1999; Faridah-Hanum et al. 1999, 2008; Ipor et al. 1999; Kartawinata et al. 1981; Nizam et al. 2006; Proctor et al. 1983; Soepadmo 1987; Sukardjo et al. 1990; Yamakura et al. 1986). However, there is still limited information available on the plant floristic composition as well as diversity of seedling and saplings in various ages of secondary forests in Sarawak. This study was conducted in order to determine the composition and diversity of plant seedlings and saplings in secondary forests after shifting cultivation at various fallow periods in Sabal.

Materials and Methods

Study Sites

The study was carried out at sites with four stages of fallow period namely lands with fallow period of 3, 5, 10, and 20 years (hereafter called Temuda I (01°04'35.6"N 110°58'49.7"E), Temuda II (01°04'43.3"N 110°59'02.0"E), Belukar I (01°03'55.9"N 110°55'51.4"E), and Belukar II (01°03'55.9"N 110°55'51.4"E), respectively) in Sabal, Sri Aman, Sarawak, East Malaysia (Figure 1). The study plots at Sabal were located approximately 110 km South East of Kuching along the Kuching-Sri Aman Road and 5 to 15 km from the Sabal Agroforestry Center.

All study sites are formerly shifting cultivation land for upland rice farming with almost similar land use history (fallow cropping rotation). The original vegetation at Sabal site is classified as lowland mixed dipterocarp forest with heath forest (kerangas) (Kendawang et al. 2007; Whitmore 1975). The soils of the study site are derived from non-calcareous sedimentary rocks consisting

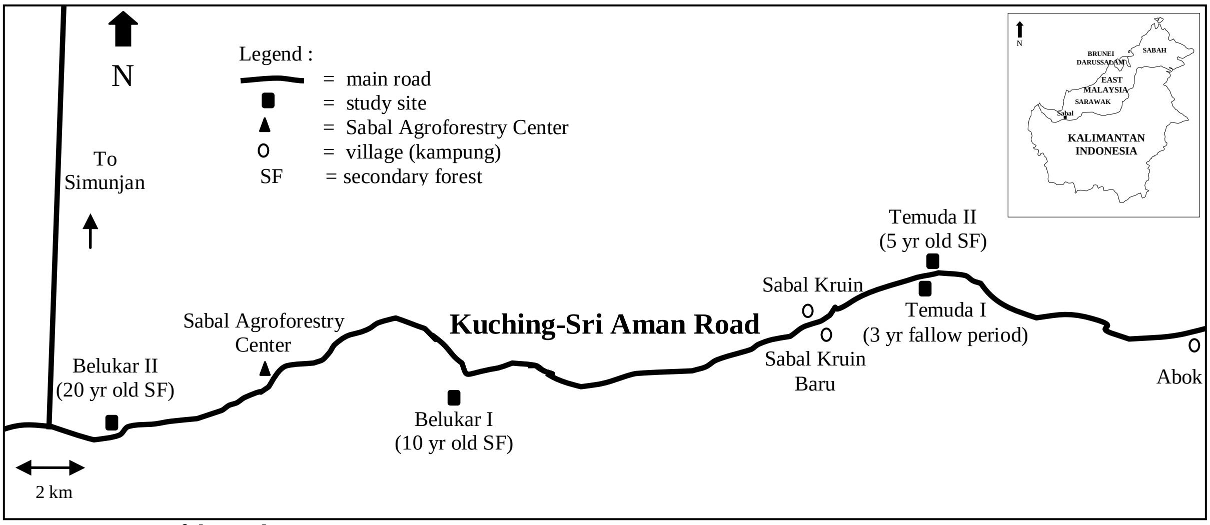

Figure 1 – Map of the study area

of fine and whitish sandstone during the mid Tertiary period (Butt 1983). Most of the soils are classified into Oxyaquic or Spodic Quartzipsamments at Sabal site based on the USDA classification system (Soil Survey Staff 1994). According to the climatic data were collected from Sri Aman Station, which is located nearest to the study area, the area received an average of 3,491 mm year^{-1} of rainfall, 26.6^{o}C of monthly temperature, and 85.1% of relative humidity during the past 20 years (1992-2011). According to the Schmidt-Ferguson classification system (1951), the area is characterized as zone A with Q (Quotient) of 0.013 where very humid area with vegetation of tropical rain forest (Karyati et al. 2012).

Data Collection

The surveys of Temuda I, Temuda II, Belukar I, and Belukar II were conducted from January 2010 to January 2011. Twenty five sub plots of 20 m × 20 m were established from every study sites, enabling sampling and data collection of the main study to be carried out in a systematic manner. All plant seedlings and saplings with diameter at breast height (DBH) of less than 5 cm within the plot were enumerated and identified. Nomenclature was checked in the flora records of the study area (Anderson 1980; Ashton 1988; Jawa & Chai 2007; Soepadmo et al. 1996, 2002, 2004, 2007, 2011; Soepadmo & Saw 2000; Soepadmo & Wong 1995). The habitat condition and all species of each community were recorded.

Data Analysis

The dominant species of forest community were determined by the summed dominance ratio (SDR) of species. To calculate the SDR of a particular species within the plots, the following formulas were used (Krebs 1999; Mueller-Dombois & Ellenberg 1974):

$$RF = \frac{\text{Frequency of species}}{\text{Total of frequencies of all species}} \times 100$$

$$Rd = \frac{\text{Number of individual of a species}}{\text{Total number of individuals}} \times 100$$

$$SDR = \frac{RF + Rd}{2}$$

where, *RF* is relative frequency and *Rd* is relative density.

The floristic similarity of species composition among different communities was evaluated using Sorensen similarity index (ISS) (Fachrul 2007; Misra 1992) and defined as:

$$ISS = \frac{2C}{A+B}$$

where, A = number of species found within site A, B = number of species found within site B, and C = number of species common to both A and B.

Four diversity indices were used to measure species diversity of standing tree in each community, such as, the Shannon-Wiener's index (*H'*) (Ludwig & Reynolds 1988; Magurran 1988; Shannon & Weaver 1949) (diversity index), the Simpson's index (D_s) (Odum 2005; Simpson 1949) (ecological dominance index), Pielou's index (*J'*) (Ludwig & Reynolds 1988, Pielou 1975) (community evenness index), Margalef's index (*R*) (Ludwig & Reynolds 1988; Margalef 1958) (species richness index).

$$H' = -\sum_{i=1}^{s} \left(\frac{n_i}{N} \right) \ln \left(\frac{n_i}{N} \right)$$

$$D_s = \sum_{i=1}^{s} \left(\frac{n_i}{N} \right)^2$$

$$J' = \frac{H'}{\ln(S)}$$

$$R = \frac{(S-1)}{\ln n}$$

As stated here, *ni* = number of individuals of the *i*-th species, *N* = total number of all the individuals in a unit area, and *S* = number of species in each plot.

The category of plant species diversity was adapted from Odum (2005), while classification of plant species according to ecological dominance and community evenness was adapted from Krebs (1999). Odum (2005) classified the Shannon-Wiener index (*H'*) in a community into three diversity categories: $H' < 1$ = low diversity, $1 < H' < 3$ = intermediate diversity, and $H' > 3$ = high diversity. On the basis of ecological dominance (D_s) in a community the species are grouped into three categories: $0.00 < D_s < 0.30$ = low dominance, $0.30 < D_s < 0.60$ = intermediate dominance, $0.60 < D_s < 1.00$ = high dominance (Krebs, 1999). The species may be grouped into three categories of community evenness (*J'*): $J' < 0.4$ = low evenness, $0.4 < J' < 0.6$ = intermediate evenness, and $0.6 < J' < 1$ = high evenness (Krebs, 1999). The mean values of *H'*, D_s, *J'*, and *R* for each site were compared with one-way analysis of variance (ANOVA) by Tukey's tests. All statistical tests were conducted using SPSS version 18 for Windows (SPSS Inc., 2012).

Results and Discussion

Floristic Composition

The survey on various ages of secondary forests showed significant variation with their plant density, species composition, and diversity. The number of plant seedlings and saplings decreased in secondary forests with increasing fallow period. Density of the plant seedlings and saplings (DBH of < 5 cm) was considerably high in Temuda I (3332 individuals per hectare), Temuda II (3149 individuals per hectare), Belukar I (3092 individuals per hectare), and Belukar II (2352 individuals per hectare) as shown in Table 1. Table 2 presented relative frequency (*RF*), relative density (*Rd*), and summed dominance ratio (*SDR*) of ten most common plant species among the seedlings and saplings in each study site. According to density and *SDR*, the plant seedlings and saplings in Temuda I and Temuda II were dominated by light demanding and fast growing species, such as *M. malabathricum*, *P. alternifolium*, and *F. aurata* as well as *Dillenia* spp. and *Macaranga* spp. *Dillenia suffruticosa* Martelli was also common species in both Belukar I and Belukar II. The other common species of Belukar I were *Syzygium arcuatinervum* (Merr.) Craven & Briffin, *Diospyros siamang* Bakh., *Agrostistachys longifolia* Benth. ex Hook. f., *Macaranga caladifolia* Becc., and *Whiteodendron moultonianum* (W.W.Sm.) Steenis. Belukar II was dominated by *P. decurrens*, *Nephelium cuspidatum* Blume, *Antidesma neurocarpum* Miq., and *Syzygium polyanthum* Walp. as well as *Artocarpus* spp.

Seedlings and saplings of *M. malabathricum* was the most dominant species at the early stage of secondary succession period till 5 years after land abandonment. In degraded old fields in Peninsular Malaysia, stands that were dominated by *Melastoma* in the early stages then became occupied by other species after 4-8 years (Kochummen & Ng 1977). During the early fallow period after shifting cultivation (less than about three years), Kemunting (*Melastoma polyanthum*) was dominant with higher frequency and density in the Mujong River area, Sarawak (Tanaka et al. 2007). In burned plots of East

Table 1 – Ten most common species of plant seedlings and saplings (DBH of < 5 cm) in terms of density in 1 hectare of each study site

No.	Species	Family	Temuda I	Temuda II	Belukar I	Belukar II
1	*Agrostistachys longifolia* Benth. *Ex* Hook. F.	Euphorbiaceae			59 (6)	
2	*Alstonia spatulata* Blume	Apocynaceae		111 (9)		
3	*Antidesma neurocarpum* Miq.	Euphorbiaceae				65 (7)
4	*Artocarpus integer* (Thunb.) Merr.	Moraceae				203 (2)
5	*Artocarpus sarawakensis* Jarrett	Moraceae				422 (1)
6	*Cratoxylum arborescens* Blume.	Clusiaceae	120 (10)			
7	*Cratoxylum glaucum* Korth.	Clusiaceae	147 (6)	101 (10)		
8	*Dillenia pulchella* Gilg	Dilleniaceae	141 (7)	140 (6)		62 (8)
9	*Dillenia suffruticosa* Martelli	Dilleniaceae	150 (5)	179 (3)	91 (1)	94 (5)
10	*Diospyros siamang* Bakh.	Ebenaceae			55 (10)	
11	*Euodia glabra* (Bl.) Bl.	Rutaceae	139 (8)	127 (7)		
12	*Ficus aurata* Miq.	Moraceae	171 (3)	173 (4)		
13	*Goniothalamus andersonii* J. Sincl.	Annonaceae				49 (10)
14	*Gonystylus costalis* Airy Shaw	Thymelaeaceae		114 (8)		
15	*Hopea kerangasensis* P.S. Ashton	Dipterocarpaceae			58 (7)	
16	*Leea indica* (Burm.f.) Merr.	Ampelidaceae			57 (8)	
17	*Lepisanthes* sp.	Sapindaceae				56 (9)
18	*Macaranga beccariana* Merr.	Euphorbiaceae	201 (2)			
19	*Macaranga caladifolia* Becc.	Euphorbiaceae			64 (3)	
20	*Macaranga igantean* Mull. Arg.	Euphorbiaceae	135 (9)			
21	*Macaranga trichocarpa* Mull. Arg.	Euphorbiaceae		168 (5)		
22	*Melastoma malabathricum* L.	Melastomataceae	292 (1)	409 (1)		
23	*Nephelium cuspidatum* Blume	Sapindaceae				121 (4)
24	*Palaquium decurrens* H.J. Lam	Sapotaceae				180 (3)
25	*Ploiarium alternifolium* Melchior.	Theaceae	152 (4)	220 (2)		
26	*Shorea faguetiana* Heim	Dipterocarpaceae			60 (5)	
27	*Shorea pinanga* Scheff.	Dipterocarpaceae			56 (9)	
28	*Syzygium arcuatinervum* (Merr.) Craven & Briffin	Myrtaceae			66 (2)	
29	*Syzygium polyanthum* Walp.	Myrtaceae				67 (6)
30	*Whiteodendron moultonianum* (W.W.Sm.) Steenis	Myrtaceae			61 (4)	
	Total		1648	1742	627	1319
	Total per hectare		3332	3149	3092	2352
	Number of families		39	38	55	46
	Number of genera		74	72	140	86
	Number of species		97	93	220	106

The figures in parentheses represent the ranking in terms of density per hectare. (1) represent species with the highest density.

Table 2 – Ten most common species of plant seedlings and saplings (DBH of < 5 cm) in terms of summed dominance ratio (SDR) in 1 hectare of each study site.

No.	Species	Family	RF (%)	Rd (%)	IVi	SDR
A. Temuda I						
1	*Melastoma malabathricum* L.	Melastomataceae	4.49	8.76	13.26	6.63
2	*Ficus aurata* Miq.	Moraceae	4.31	5.13	9.44	4.72
3	*Ploiarium alternifolium* Melchior.	Theaceae	3.56	4.56	8.12	4.06
4	*Dillenia pulchella* Gilg	Dilleniaceae	3.00	4.23	7.23	3.61
5	*Euodia glabra* (Bl.) Bl.	Rutaceae	3.00	4.17	7.17	3.58
6	*Cratoxylum glaucum* Korth.	Clusiaceae	2.62	4.41	7.03	3.52
7	*Macaranga beccariana* Merr.	Euphorbiaceae	0.94	6.03	6.97	3.48
8	*Macaranga gigantea* Mull. Arg.	Euphorbiaceae	2.81	4.05	6.86	3.43
9	*Adinandra dumosa* Jack	Theaceae	3.37	3.12	6.49	3.25
10	*Macaranga havilandii* Airy Shaw	Euphorbiaceae	2.81	3.60	6.41	3.21
B. Temuda II						
1	*Melastoma malabathricum* L.	Melastomataceae	3.93	12.99	16.92	8.46
2	*Ficus aurata* Miq.	Moraceae	4.72	5.49	10.21	5.10
3	*Ploiarium alternifolium* Melchior.	Theaceae	2.55	6.99	9.54	4.77
4	*Macaranga trichocarpa* Mull. Arg.	Euphorbiaceae	3.73	5.34	9.07	4.53
5	*Dillenia suffruticosa* Martelli	Dilleniaceae	2.95	5.68	8.63	4.32
6	*Vitex pubescens* Vahl.	Verbenaceae	4.52	3.14	7.66	3.83
7	*Euodia glabra* (Bl.) Bl.	Rutaceae	3.34	4.03	7.37	3.69
8	*Dillenia pulchella* Gilg	Dilleniaceae	1.96	4.45	6.41	3.21
9	*Leea indica* (Burm.f.) Merr.	Ampelidaceae	3.34	2.70	6.04	3.02
10	*Gonystylus costalis* Airy Shaw	Thymelaeaceae	2.36	3.62	5.98	2.99
C. Belukar I						
1	*Dillenia suffruticosa* Martelli	Dilleniaceae	2.19	2.94	5.13	2.56
2	*Syzygium arcuatinervum* (Merr.) Craven & Briffin	Myrtaceae	1.04	2.13	3.18	1.59
3	*Endospermum diadenum* (Miq.) Airy Shaw	Euphorbiaceae	1.56	1.58	3.15	1.57
4	*Diospyros siamang* Bakh.	Ebenaceae	1.35	1.78	3.13	1.57
5	*Agrostistachys longifolia* Benth. ex Hook. f.	Euphorbiaceae	1.25	1.88	3.12	1.56
6	*Hopea kerangasensis* P.S. Ashton	Dipterocarpaceae	1.25	1.84	3.09	1.55
7	*Macaranga caladifolia* Becc.	Euphorbiaceae	0.94	2.07	3.01	1.50
8	*Whiteodendron moultonianum* (W.W.Sm.) Steenis	Myrtaceae	1.04	1.94	2.98	1.49
9	*Hopea dryobalanoides* Miq.	Dipterocarpaceae	1.35	1.52	2.87	1.44
10	*Santiria rubiginosa* Blume	Burseraceae	1.25	1.62	2.87	1.43
D. Belukar II						
1	*Artocarpus sarawakensis* Jarrett	Moraceae	17.94	0.95	18.89	9.45
2	*Artocarpus integer* (Thunb.) Merr.	Moraceae	8.63	3.09	11.72	5.86
3	*Palaquium decurrens* H.J. Lam	Sapotaceae	7.65	3.33	10.98	5.49
4	*Nephelium cuspidatum* Blume	Sapindaceae	5.14	1.90	7.04	3.52
5	*Antidesma neurocarpum* Miq.	Euphorbiaceae	2.76	3.09	5.85	2.93
6	*Syzygium polyanthum* Walp.	Myrtaceae	2.85	2.85	5.70	2.85
7	*Dillenia suffruticosa* Martelli	Dilleniaceae	4.00	1.66	5.66	2.83
8	*Xylopia ferruginea* Baill.	Annonaceae	2.04	3.09	5.13	2.56
9	*Lepisanthes* sp.	Sapindaceae	2.38	2.38	4.76	2.38
10	*Dillenia pulchella* Gilg	Dilleniaceae	2.64	1.66	4.30	2.15

RF = relative frequency, Rd = relative density, IVi = importance value index, and SDR = summed dominance ratio.

Kalimantan, the occurrence of *M. malabathricum*, *Eupatorium inulaefolium*, *Ficus* sp., and *Vitex pinnata* L. strongly increase with the age of regeneration (last burned 3 years, 4 years, and 9 years previously), but were rarely found in the secondary forest after fire burning (Yassir et al. 2010). *Melastoma* is one of the characteristic species of *Adinandra*-belukar communities which grow in very low-nutrient soils in South-East Asia (Turner 1991). Several studies had reported the similar result on the abundance of *Melatoma* and *Macaranga* spp. at the secondary forests in Sarawak, East Malaysia (Ipor & Tawan 2004), in East Kalimantan, Indonesia (Slik et al. 2003), and in Mindanao, Philippine (Weidelt & Banaag 1982).

The dominance of the fast-growing pioneer trees species were not exist in Belukar II. Although *Dillenia* spp. and *Macaranga* spp. were still encountered in Belukar II, they were not as abundant in Temuda I, Temuda II, and Belukar I. The occurrence of pioneer species, such as *D. suffruticosa* and *M. caladifolia* were still common in Belukar I. In Belukar II, pioneer species were not dominant based on density and SDR, while *A. sarawakensis*, *A. integer*, and *P. decurrens* were dominant in this Belukar. Sorensen's index (Cs) is regarded as one of the most effective presence or absence similarity measures (Magurran 2004; Southwood & Henderson 2000). The similarity index of association Temuda I and Temuda II was the highest (64.21%), followed by Temuda II and Belukar II (56.28%), Temuda I and Belukar II (49.26%), Belukar I and Belukar II (40.49%), Temuda II and Belukar I (37.70%), and Temuda I and Belukar I (37.22%) (Table 3). The development and changes of species composition of plant seedlings and saplings after slash and burn process was mostly influenced by secondary succession process and fallow age in abandoned lands. The result showed that during early stage secondary succession of fallow lands after shifting cultivation, the floristic composition was dominated and obtained by many common and similar species in Temuda I, Temuda II, and Belukar I. However, Belukar II showed relatively different species composition among all study sites. This showed that species composition at abandoned lands after burning begin to change after 20 years of abandonment. Several species of Dipterocarpaceae were also recorded, including *Hopea dryobalanoides* Miq., *Hopea kerangasensis* P.S. Ashton, *Shorea faguetiana* Heim, and *Shorea pinanga* Scheff. in Belukar I. In Belukar II, the density of plant seedlings and saplings was less than those recorded in Belukar I. Late pioneer species and secondary species, such as *A. neurocarpum*, *N. cuspidatum*, *S. polyanthum*, *Xylopia ferruginea* Baill., and *Lepisanthes* sp. were common in this site.

Floristic Diversity

The diversity indices of plant seedlings and saplings in various ages of secondary forests are presented in Table 4. The Shannon-Wiener diversity indices (*H′*) of all study sites were categorized as 'intermediate to high diversities'. This was due to high density of plant seedlings and saplings recorded in every study sites. High species diversity indicates a highly complex community, for a greater variety of species allows for a larger array of species interactions (Brower et al. 1990). The diversity index in Belukar I was significantly higher than Temuda I, Temuda II, and Belukar II perhaps due to the high number of families, number of genera, and number of species were recorded in Belukar I compared to the other sites as shown in Table 1.

The ecological dominance (D_s value) of all studied forests was categorized as 'low dominance'. The D_s value of Belukar II was the highest among the four studied sites (0.17). This value suggested that a few or almost no plant species were dominant in every study sites. The nearly zero values correspond to low diverse or more homogeneous plant ecosystem. The D_s values is an expression of how many equally abundant species would have a diversity equal to that in the observed collection (Brower et al. 1990). The dominance index of Belukar I was significantly lower than the other study sites. It was probably due to the number of individuals of every species and mostly related to diversity index. All study sites had 'high evenness index (*J′*)'. This indicated that every species was distributed evenly within the plant community. As mentioned for *H′* and D_s, the values of *J′* and *R* (species richness index) showed no significant different in three sites of Temuda I, Temuda II, and Belukar II. The *J′* and *R* values of Belukar I were significantly higher compared to the other studied sites. The high values of *J′* and *R* may effected by a large number of number of individuals and number of species observed in the study sites.

The results showed that species

Table 3 – Sorensen similarity index (*ISS*) of plant seedlings and saplings (DBH of < 5 cm) in the study sites.

Type	Temuda I	Temuda II	Belukar I	Belukar II
Temuda I	-			
Temuda II	64.21	-		
Belukar I	37.22	37.70	-	
Belukar II	49.26	56.28	40.49	-

Sorensen similarity index was computed for the entire study plots (1 ha).

Table 4 – Diversity indices of plant seedlings and saplings (DBH of < 5 cm) in the study sites.

No.	Diversity indices	Temuda I (n=25)	Temuda II (n=25)	Belukar I (n=25)	Belukar II (n=25)
1	Shannon-Wiener diversity index (*H'*)	2.41 (±0.07)[a]	2.43 (±0.09)[a]	3.12 (±0.14)[b]	2.28 (±0.10)[a]
2	Simpson dominance index (D_s)	0.13 (±0.01)[ab]	0.14 (±0.02)[b]	0.07 (±0.01)[a]	0.17 (±0.03)[b]
3	Pielou evenness index (*J'*)	0.86 (±0.01)[a]	0.82 (±0.01)[a]	0.90 (±0.01)[b]	0.82 (±0.03)[a]
4	Margalef species richness (*R*)	3.66 (±0.29)[a]	4.03 (±0.25)[a]	7.68 (±0.72)[b]	3.78 (±0.24)[a]

Calculation was done according to the 20 m × 20 m subplots. Values are average and standard error in parentheses. Different letters in each line indicate a significant different at 5% level by Tukey's test among different ages of secondary forests.

diversity indices of plant seedlings-saplings varied widely among the four study sites. These three indices increased as fallow periods increased then at 20 years old secondary forest, these indices showed decreasing value (Table 4). The highest values of *H'*, *J'*, and *R* were recorded in Belukar I. In contrast, the lowest evenness index was also observed in this studied site. It may be due to past intermediate disturbance in this site as compared to Temuda I, Temuda II) and Belukar II. The results showed that, as the *H'*, *J'*, and *R* increased, the D_s decreased. Diversity will be greatest at intermediate disturbance frequencies because the landscape includes patches of a great variety of ages supporting a wide mix of species (Wright 1999). A forest is most rich in species when at an intermediate state of recovery from disturbance, or when disturbance is at an intermediate intensity or frequency, because it will then contains both pioneer and climax species (Whitmore 1993).

The development and changes of floristic composition and diversity of plant seedlings and saplings during early stages of secondary succession process was mostly influenced by secondary succession process and fallow period in various ages of secondary forests after slash and burn process. The floristic composition may affect to values of *H'*, *Ds*, *J*, and *R*. Information on the composition and diversity of seedlings and saplings are useful for predicting future trends in the vegetation succession, especially on secondary succession of fallow lands. By understanding the composition and diversity of plant regeneration at early stages of secondary succession on fallow lands, such information will be useful for biodiversity conservation, and social and economic values for future forest.

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