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Correlation between soil physicochemical properties and vegetation parameters in secondary tropical forest in Sabal, Sarawak, Malaysia

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Abstract. The tree growth is influenced by soil morphological and physicochemical properties in the site. The purpose of this study was to describe correlation between soil properties under various stage secondary forests and vegetation parameters, such as floristic structure parameters and floristic diversity indices. The vegetation surveys were conducted in 5, 10, and 20 years old at secondary tropical forests in Sarawak, Malaysia. Nine sub plots sized 20 m × 20 m were established within each study site. The Pearson analysis showed that soil physicochemical properties were significantly correlated to floristic structure parameters and floristic diversity indices. The result of PCA clarified the correlation among most important soil properties, floristic structure parameters, and floristic diversity indices. The PC1 represented cation retention capacity and soil texture which were little affected by the fallow age and its also were correlated by floristic structure and diversity. The PC2 was linked to the levels of soil acidity. This property reflected the remnant effects of ash addition and fallow duration, and the significant correlation were showed among pH (H_2O), floristic structure and diversity. The PC3 represented the soil compactness. The soil hardness could be influenced by fallow period and it was also correlated by floristic structure.

1. Introduction

Swidden fallow secondary forests provide rotating habitats for succession species in a primary forest matrix thus, enhancing biodiversity. Due to the rapid re-growth in secondary forest ecosystem, the watershed and soil properties of this primary-secondary forest landscape are ecologically at par with each other [1]. The diameter increment of dominant tree species determine growth rate in the secondary forest [2]. Forest succession alters the chemical, physical, and biological properties of the soil through their occupancy of the area, and it is likely that these alterations contribute to the relative changes in the abundance of the dominant plant species that characterizes succession aspect on the land [3].

A number of soil characteristics affect plant growth and its well-being. These include soil texture (size distribution of particles), structure (arrangement of soil particles), and soil depth. Soil reaction primarily influences plant growth indirectly through its effects on the solubility of ions and the activity

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of microorganisms [4]. In addition, five easily observable properties of soil (texture, structure, color, depth, and stoniness) can be used to infer a great deal about how a particular soil influences plant growth [3]. It is the ability of the soil to supply nutrient elements in the amounts, forms, and proportions required for maximum plant growth. The plant growth depends on the physicochemical properties and organic matter content of the soil [5].

There are associations between species and soil characteristics under homogenous parent rock and elevation range [6] as well as correlation among topography, soil nutrient, and floristic [7]. In addition, several soil properties showed positive and negative correlation to floristic parameters ([8] [9]). On the other hand, several studies reported that there was not significant correlation between soil nutrient availability and tree growth pattern under forest succession process in the tropics [10] [11] [12]. The purpose of this study was to describe correlation between soil physicochemical properties and vegetation parameters. The information on correlation between soil properties and vegetation growth is important for addressing future management and sustainability of secondary forests.

2. Materials and methods

2.1. Study sites

The study was carried out in three stages of fallows or period of abandonment such as 5, 10, and 20 years old of secondary forests in Sabal, Sri Aman, Sarawak, East Malaysia (figure 1). The geographic locations of these sites are 01°04'43.3"N 110°59'02.0"E, 01°03'55.9"N 110°55'51.4"E, and 01°03'59.3"N 110°53'34.4"E, respectively. The study plots at Sabal were located approximately 110 km southeast of Kuching along the Kuching-Sri Aman Road and 5 to 15 km from the Sabal Agroforestry Centre. The study sites had the similar histories of abandonment after shifting cultivation based on interviews with the land owner as well as confirmation by staff of Sabal Agroforestry Centre.

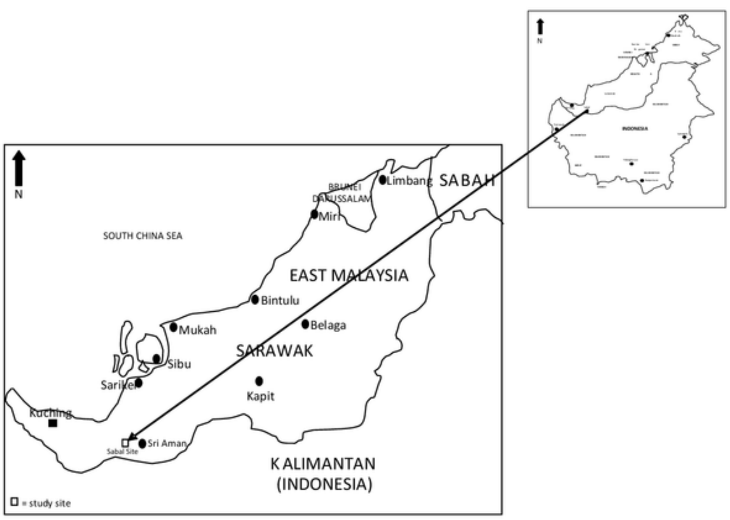

Figure 1. Map of study area in Sabal, Sarawak, Malaysia.

2.2. Data collection

The surveys of 5, 10, and 20 years old at secondary forests were conducted during 6 months from January - July 2013. Nine plots sized 20 m × 20 m were established within each study site. The diameter at breast height (DBH) and total height of all woody trees with DBH of ≥ 5 cm within the plot were enumerated and their species were identified.

2.3. Data analysis

Individual basal area (BA) and volume (V) were measured by using formulas [13]:

$$\text{Individuals BA} = \pi\ (\text{DBH}/2)^2.\ 10^{-4} \tag{1}$$

$$\text{Individuals V} = \tfrac{1}{4}\ \pi \times \text{DBH}^2.\ 10^{-4} \times \text{H} \times f \tag{2}$$

where: DBH is diameter at breast height (cm), 'H' is tree height (m), and 'f' is form factor.

Four diversity indices of Shannon-Wiener's diversity index (H'), Simpson's dominance index (D_s), Pielou's evenness index (J'), and Margalef's richness index (R) were used to measure species diversity of standing tree in each community [14]:

$$H' = -\sum_{i=1}^{s}\left(\frac{n_i}{N}\right)\ln\left(\frac{n_i}{N}\right) \tag{3}$$

$$D_s = \sum_{i=1}^{s}\left(\frac{n_i}{N}\right)^2 \tag{4}$$

$$J' = \frac{H'}{\ln(S)} \tag{5}$$

$$R = \frac{(S-1)}{\ln n} \tag{6}$$

As stated here, n_i = 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 correlations between soil physicochemical properties and vegetation parameters both floristic structure and diversity were determined using Pearson correlation analysis [15]. The soil physicochemical properties in the study sites had been reported by Karyati et al. [16]. The floristic structure parameters included average DBH, average height, total BA, and total volume, while floristic diversity indices were H', Ds, J', and R. Principal Component Analysis (PCA) of soil physicochemical properties were performed to prove and confirm correlation between soil properties and vegetation parameters in each study sites. All statistical tests were conducted using SPSS version 18 for Windows (SPSS Inc. 2012).

3. Results and discussion

3.1. Correlation between soil physicochemical properties and vegetation parameters

The result of the Pearson's correlation analysis between soil properties and vegetation parameters of the study sites was presented in Table 1. The soil pH (H_2O) showed positive correlation to H, BA, H', and R (P value <0.01) and to age and V (P value <0.05). A negative correlation (P value < 0.01) was also shown by the relationship between pH (H_2O) and Ds. In contrast, relationship between pH (KCl) and Mg showed no correlation to all vegetation parameters. The soil EC value showed negative correlation with H' and J' (P value < 0.05) and positive correlation to Ds (P value < 0.05). The soil T-C showed positive correlation to age stand of the study sites (P value < 0.01), DBH, H, and V (P value < 0.05) and negative correlation to N' (P value < 0.05). The negative correlation were shown by the relationship between T-N and N' (P value < 0.01) as well as H' (P value < 0.05).

The soil CEC level showed positive correlation to age, DBH, H, BA, and V (P value < 0.01) and Ds (P value < 0.05). There was negative correlation between CEC and N' (P value < 0.01) and CEC to H' and R (P value < 0.05). The exchangeable Ca showed positive correlation to BA (P value <0.01) and V (*P* value < 0.05). The positive correlation was shown by the relationship between exchangeable K to DBH, BA, V, *Ds* (*P* value < 0.05), and age (*P* value < 0.01). While the relationship between exchangeable K to *H'* and *R* showed negative correlation (*P* value < 0.05). The exchangeable Na showed positive correlation to age, DBH, H, BA, V (*P* value < 0.01) and negative correlation to *N'* (*P* value < 0.01). The CEC showed negative correlation to diameter growth rate (DGR) as well as relationship between Ca and basal area growth rate (BAGR). Meanwhile, Mg and K had negative correlation to DGR and BAGR [9].

The strong positive correlation (*P* value < 0.01) was shown by the relationship between percentage of clay to age, DBH, H, BA, and V. The positive correlation was also shown by the relationship between percentage of silt to age, DBH, H, V (*P* value < 0.01), and BA (*P* value < 0.05). The percentage of silt showed positive correlation to H (*P* value < 0.01) and negative correlation to *N'* (*P* value < 0.01). However, the percentage of sand showed a negative correlation (*P* value < 0.01) to age, DBH, BA, V, and positive correlation (*P* value < 0.05) to *N'*. The percentage of sand showed positive correlation (*P* value < 0.01) to average DBH, BA, V, and negative correlation (*P* value < 0.01) to H. In Toledo et al. [9] study, the percentage of silt had negative relationship to DGR. The soil texture had major effects on forest growth, but these effects are indirect, manifested through the effect of texture on features such as water-holding capacity, aeration, and organic matter retention [3]. The soil bulk density showed negative correlation to age (*P* value < 0.01), DBH, H, and V (*P* value < 0.05) of the study sites. In contrast, positive correlation was showed by relationship between porosity to DBH, V (*P* value < 0.05) and age and H (*P* value < 0.01). The relationship between soil hardness to age, H, BA, V, and biomass showed negative correlation (*P* value < 0.05).

Table 1. Correlation between soil properties and vegetation parameters.

Soil properties	Age (years)		N		Average DBH (cm)		Average H (m)		BA (m^2)	
	r	*P* value	*r*	*P* value	*r*	*P* value	*R*	*P* value	*r*	*P* value
pH (H_2O)	0.48*	<0.05	0.31	0.114	0.32	0.107	0.51**	<0.01	0.49**	<0.01
pH (KCl)	-0.09	0.655	-0.07	0.743	-0.04	0.861	-0.22	0.262	-0.11	0.593
EC (µS)	0.00	0.993	-0.16	0.437	0.22	0.272	0.13	0.511	0.23	0.255
T-C (%)	0.50**	<0.01	-0.41*	<0.05	0.46*	<0.05	0.39*	<0.05	0.30	0.130
T-N (%)	0.37	0.058	-0.53**	<0.01	0.32	0.107	0.14	0.501	0.06	0.766
C/N ratio	-0.21	0.302	0.42*	<0.05	-0.16	0.431	0.03	0.882	0.07	0.739
CEC	0.68**	<0.001	-0.54**	<0.01	0.73**	<0.001	0.51**	<0.01	0.53**	<0.01
Exch. Ca	0.37	0.055	0.36	0.066	0.34	0.086	0.34	0.08	0.53**	<0.01
Exch. Mg	0.32	0.099	0.22	0.267	0.23	0.255	0.25	0.205	0.35	0.071
Exch. K	0.49**	<0.01	-0.22	0.278	0.46*	<0.05	0.30	0.123	0.39*	<0.05
Exch. Na	0.92**	<0.001	-0.52**	<0.01	0.84**	<0.001	0.69**	<0.001	0.66**	<0.001
Sum of exch. bases	0.93**	<0.001	-0.33	0.088	0.85**	<0.001	0.71	<0.001	0.75**	<0.001
Clay (%)	0.81**	<0.001	-0.32	0.109	0.72**	<0.001	0.62**	0.001	0.60**	<0.01
Silt (%)	0.77**	<0.001	-0.59**	<0.01	0.70**	<0.001	0.50**	<0.01	0.44*	<0.05
Sand (%)	-0.83**	<0.001	0.46*	<0.05	-0.74**	<0.001	-0.59**	0.001	-0.55**	<0.01
BD	-0.63**	<0.001	0.13	0.518	-0.44*	<0.05	-0.511**	<0.01	-0.36	0.067
Porosity	0.65**	<0.001	-0.13	0.516	0.45*	<0.05	0.53**	<0.01	0.38	0.054
Hardness	-0.39*	<0.05	-0.11	0.595	-0.34	0.084	-0.44*	<0.05	-0.47*	<0.05
Soil properties	V (m^3)		*H'*		*Ds*		*J'*		*R*	
	r	*P* value	*r*	*P* value	*r*	*P* value	*R*	*P* value	*r*	*P* value
pH (H_2O)	0.45*	<0.05	0.56**	<0.01	-0.50**	<0.01	0.36	0.069	0.54**	<0.01
pH (KCl)	-0.07	0.715	-0.33	0.097	0.26	0.200	-0.15	0.466	-0.35	0.071
EC (µS)	0.21	0.296	-0.41*	<0.05	0.42*	<0.05	-0.47*	<0.05	-0.37	0.058
T-C (%)	0.42*	0.031	-0.10	0.635	0.10	0.635	0.07	0.743	-0.06	0.771
T-N (%)	0.23	0.248	-0.39*	<0.05	0.35	0.074	-0.16	0.439	-0.35	0.077
C/N ratio	-0.07	0.713	0.44*	<0.05	-0.38	0.053	0.23	0.247	0.41*	<0.05
CEC	0.65**	<0.001	-0.48*	<0.05	0.47*	<0.05	-0.25	0.201	-0.42*	<0.05
Exch. Ca	0.42*	<0.05	0.14	0.489	-0.03	0.877	-0.06	0.754	0.19	0.346
Exch. Mg	0.26	0.189	-0.12	0.55	0.23	0.255	-0.31	0.113	-0.05	0.808
Exch. K	0.41*	<0.05	-0.46*	<0.05	0.47*	<0.05	-0.37	0.06	-0.41*	<0.05
Exch. Na	0.80**	<0.001	-0.14	0.493	0.11	0.574	0.05	0.808	-0.11	0.603
Sum of exch. bases	0.84**	<0.001	-0.11	0.575	0.13	0.513	-0.02	0.909	-0.06	0.759
Clay (%)	0.69**	<0.001	-0.19	0.331	0.20	0.326	-0.06	0.752	-0.14	0.500
Silt (%)	0.59**	0.001	-0.34	0.088	0.28	0.155	-0.06	0.776	-0.30	0.126

Sand (%)	-0.68**	<0.001	0.27	0.174	-0.25	0.216	0.06	0.752	0.22	0.270
BD	-0.42*	<0.05	-0.23	0.246	0.21	0.303	-0.24	0.224	-0.27	0.180
Porosity	0.44*	<0.05	0.25	0.214	-0.22	0.276	0.25	0.213	0.28	0.150
Hardness	-0.39*	<0.05	-0.23	0.243	0.16	0.420	-0.05	0.813	-0.28	0.158

Note: Soil properties were at the depth of 0-10 cm (n=27); Calculation of vegetation parameters were done according to the 20 m × 20 m subplots (n=27); N=number of individuals (tree); DBH=diameter at breast height (cm); H=height (m); BA=basal area (m^2); V=volume (m^3); H'=Shannon-Wienner diversity index; Ds=Simpson dominance index; J'=Pielou evenness index; R=Margalef richness index; EC=electrical conductivity; T-C=total carbon; T-N=total nitrogen; CEC=cation exchange capacity ($cmol_c\ kg^{-1}$); Exch. Ca, Mg, and K=exchangeable Ca, Mg, and K ($cmol_c\ kg^{-1}$); Clay, Silt, and Sand=percentage of clay, silt, and sand; BD=bulk density ($g\ mL^{-1}$); Soil hardness (mm) was measured using a Yamanaka-type penetrometer; r are Pearson's correlation coefficients; P values of correlation are shown; * and ** correlations are significant at the 0.05 and 0.01 level (2-tailed).

In general, soil physicochemical properties showed positive and or negative correlation to one or more vegetation parameters, except pH (KCl) and exchangeable Mg. This result was contrast with reported by Buschbacher et al. [17]. According to Toledo et al. [9], non-significant or even weak negative correlation is found between growth rates and individual and composite soil variables. Similarly, no significant correlations between soil nutrient availability and tree growth variation were found in Borneo [10] [18], Costa Rica [11] and Brazil [12].

3.2. Principal component analysis (PCA)

Factor loading of the surface soil properties by Principal Component Analysis (PCA) was shown in table 2. The three components of PC1, PC2, and PC3 explained 74.66% of the total variability and each component represents a series of variables which simplifies the analysis and interpretation. The first principal component score (PC1) was defined as cation retention capacity and soil texture, such as CEC, exchangeable K, clay, silt, and porosity exhibited high positive factor loading, while sand and bulk density to a lesser degree. The second principal component (PC2) showed a high positive factor loading for T-N and a high negative factor loading for pH (H_2O), reflecting the soil acidity. Meanwhile, the third principal component (PC3) was related to soil compactness as soil hardness showed a high positive factor loading (table 2). The result indicated that the factor analysis provides statistical evidence of the ability of the three principal component scores to integrate soil physicochemical properties within the components.

Figure 2 shows the correlation between PC1 and PC2 scores from PCA in the study sites. The figure showed that the selected soil physicochemical properties grouped at each site following fallow ages. The positive factor loading of PC1 were CEC, exchangeable K, clay, silt, and porosity. The negative factor loading showed for sand and bulk density in PC1. The clear differences were observed for several soil properties which categorized into cation retention capacity, such as CEC, exchangeable K, and clay content related to PC1 based on fallow period. Hence, clay content of the soil was one of the determining factors that influenced the nutrient retention capacity such as the soil CEC level and the amount of exchangeable K. These three soil properties were affected by the succession process during fallow periods. In addition, no clear tendencies were showed for several soil physical properties, such as silt and sand contents, porosity, and bulk density related to PC1. However, the soil CEC and exchangeable K correlated significantly to floristic structure parameters and diversity indices. Meanwhile, soil texture (contents of clay, silt, and sand), porosity, and bulk density had significant correlations with several floristic structure parameters, but no correlation showed between these soil properties and floristic diversity indices of the study sites (table 1).

Figures 3 and 4 show the correlation among PC1 scores from PCA, floristic structure parameters, and floristic diversity indices of the study sites. The results indicated that soil properties may influence to both floristic structure and diversity. The analysis showed that the floristic structure parameters and floristic diversity indices were grouped according to the soil properties and fallow period of the study sites. The floristic structure parameters, such as DBH, H, BA, and V increased with increasing fallow period in three study sites. This trend was also showed by several soil properties that were included in PC1, such as soil CEC, exchangeable K, and clay content, particularly for surface soils at 0-10 cm depth. In addition, many soil physicochemical properties were significantly correlated with floristic structure parameters, except pH (KCl), electrical conductivity, and exchangeable Mg as shown in table

1. Although the correlation among floristic diversity indices and soil properties which were included in PC1 resulted the similar pattern among the study sites (figure 4), most of the soil properties such as pH (KCl), exchangeable Ca, sum of exchangeable bases, soil texture, bulk density, porosity, and hardness showed no correlation with floristic diversity indices as presented in table 1.

The result of PC1 showed that the study sites which consisted of soils with high CEC level, amount of exchangeable K, higher clay and silt contents, and higher soil porosity possessed consist high values of floristic structure parameters such as DBH, H, BA, and V. Meanwhile, the study sites with the low sand content and bulk density in soil may affect the values of floristic diversity indices, such as *H'*, *Ds*, and *R*. The lower bulk density showed the higher porosity of soil and it was an advantage for plant growth because it will provide higher water infiltration rates which reduce runoff, then improve the water availability and retention in subsoil.

Table 2. Factor loading of surface soil physicochemical properties by Principal Component Analysis.

Variables analyzed	pH (H_2O), T-C, T-N, CEC, Exch. Ca, Exch. Mg, Exch. K, Clay, Silt, Sand, BD, Porosity, and Soil hardness			
	Value	PC1	PC2	PC3
Variables with a high positive factor loading (> 0.70)	+	CEC, Exch. K, Clay, Silt, and Porosity	T-N	Hardness
Variables with a high negative factor loading (> 0.70)	-	Sand and BD	pH (H_2O)	ND
Contribution name of PC axis		43.28%	19.13%	12.26%
		Cation retention capability & soil texture	Soil acidity	Soil compactness

Note: (+)=factor loading with a positive value; (-)=factor loading with a negative value; ND=not determined; T-C=total carbon; T-N=total nitrogen; CEC=cation exchange capacity; Exch. Ca, Mg, and K=exchangeable Ca, Mg, and K; Clay, Silt, and Sand=percentage of clay, silt, and sand; BD=bulk density.

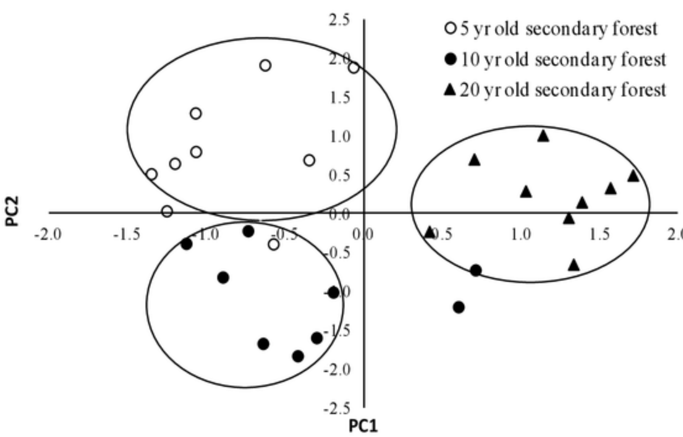

Figure 2. Correlation between PC1 and PC2 scores from Principal Component Analysis (PCA) in the study sites.

The factor loadings of the PC2 showed high positive factor for T-N and negative factor for pH (H_2O). In term of the fallow periods of the study sites, there was no clear difference for T-N and pH (H_2O) related to PC2. In addition, the analysis showed that both T-N and pH (H_2O) were correlated well to several floristic structure and diversity parameters as shown in table 1. This was mainly related to variation of soil texture and the content of exchangeable bases under similar parent materials. The high values of floristic structure and diversity probably tended to increasing T-N.

For factor loading of PC3, the correlation analysis showed that soil hardness was significant correlated to floristic structure parameters, but no correlation showed between soil hardness and floristic diversity indices as presented in table 1. The floristic structure parameters increased with decreasing soil hardness, particularly at surface soils (0-10 cm depth) following fallow period in the study sites. The soil hardness related to soil aggregates and compaction. Fisher and Binkley [3] stated that soil physical properties profoundly influence the growth and distribution of trees through their effects on soil moisture regimes, aeration, temperature profiles, soil chemistry, and even the accumulation of organic matter.

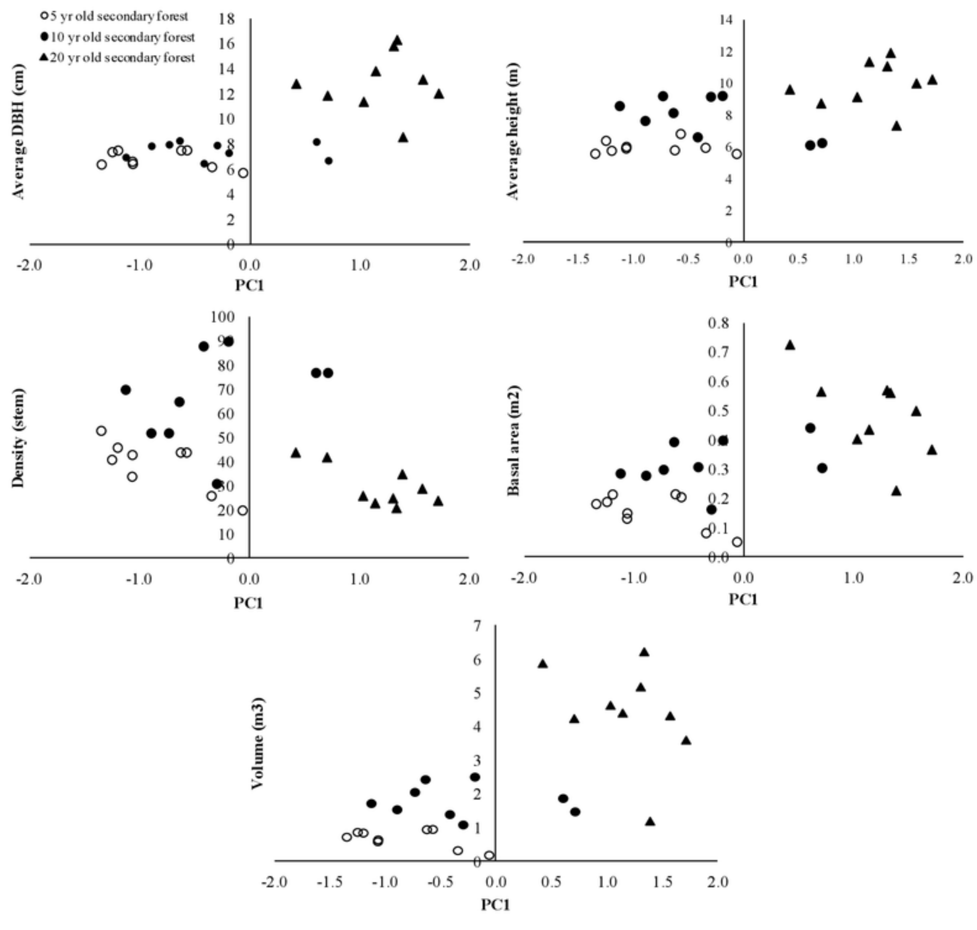

Figure 3. Correlation between PC1 scores from PCA and floristic structure parameters in the study sites.

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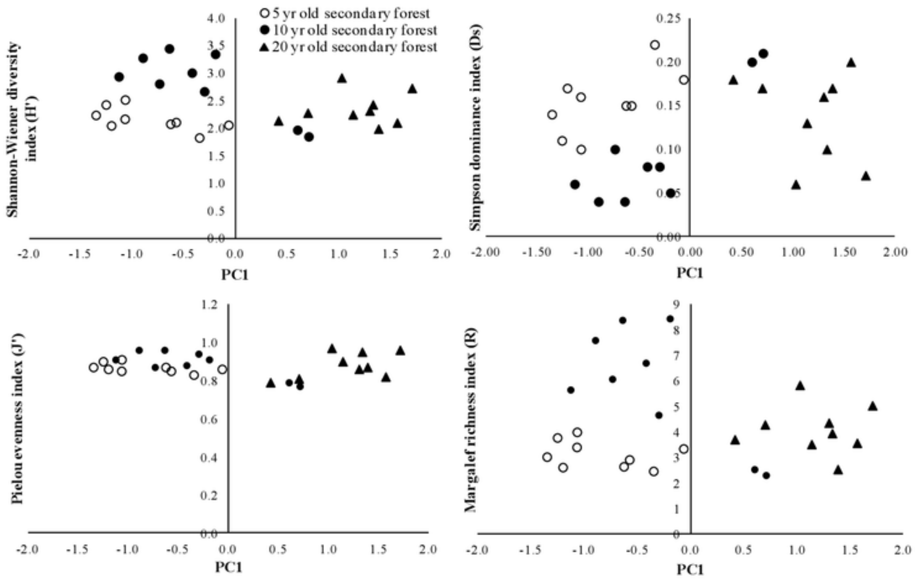

Figure 4. Correlation between PC1 scores from PCA and floristic diversity indices in the study sites.

4. Conclusion

We conclude that soil physicochemical properties were significantly correlated to floristic structure parameters and floristic diversity indices. Three principal component scores integrating and grouping soil physicochemical properties and floristic structure parameters as well as floristic diversity indices in terms fallow age within the same components. The development of floristic structure during early succession process may probably effect to improve soil physicochemical properties.

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References
[1] Chokkalingam U, Smith J and de Jong W 2001 A conceptual framework for the assessment of tropical secondary forest dynamics and sustainable development potential in Asia *J. Trop. For. Sci.* **13**(4) pp 577-600
[2] Karyati, Ipor I B, Jusoh I and Wasli M E 2017 The diameter increment of selected tree species in a secondary tropical forest in Sarawak, Malaysia *Biodiversitas* **18**(1) pp 304-11
[3] Fisher R F and Binkley D 2000 *Ecology and Management of Forest Soils, 3rd Ed* (USA: John Wiley & Sons, Inc) p. 35
[4] Harris R W 1992 *Arboriculture: Integrated Management of Landscape Trees, Shrubs, and Vines* (New Jersey: Prentice Hall Career & Technology) pp. 88-117
[5] Hazra P and Som M G 2006 *Vegetable Science* (New Delhi: Kalyani Publishers) pp. 37-108
[6] Nizam M S, Norziana J, Sahibin A R and Latiff A 2006 Edaphic relationships among tree

IOP Conf. Series: Earth and Environmental Science **144** (2018) 012060 doi:10.1088/1755-1315/144/1/012060

species in the national park at Merapoh, Pahang, Malaysia *Jurnal Biosains* **17**(2) 37-53
[7] Potts M D, Ashton P S, Kaufman L S and Plotkin J B 2002 Habitat patterns in tropical rain forests: A comparison of 105 plots in northwest Borneo *Ecology* **83**(10) pp 2782-97
[8] Kumar J I N, Kumar R N, Bhoi R K and Sajish P R 2010 Tree species diversity and soil nutrient status in three sites of tropical dry deciduous forest of Western India *Trop. Ecol.* **51**(2) pp 273-79
[9] Toledo M, Poorter L, Peña-Claros M, Alarcón A, Balcázar J, Leaño C, Licona J C, Llanque O, Vroomans V, Zuidema P and Bongers F 2011 Climate is a stronger driver of tree and forest growth rates than soil and disturbance *J. Ecol.* **99** pp 254-64
[10] Ashton P S and Hall P 1992 Comparisons of structure among mixed Dipterocarp forests of North-Western Borneo *J. Ecol.* **80** pp 459-81
[11] Clark D B, Clark D A and Read J M 1998 Edaphic variation and the meso-scale distribution of tree species in neotropical rain forest *J. Ecol.* **86** pp 101-12
[12] Vieira S, de Camargo P B, Selhorst D, Da Silva R, Hutyra L, Chambers J Q, Brown I F, Higuchi N, dos Santos J, Wofsy S C, Trumbore S E and Martinelli L A 2004 Forest structure and carbon dynamics in Amazonian tropical rain forests *Oecologia* **140** pp 468-79
[13] Husch B, Miller C I and Beers T W 1982 *Forest Mensuration* (New York: John Wiley and Sons Publishing) 402 pp
[14] Odum P E 2005 *Fundamentals of Ecology 5th Ed* (Belmont CA: Thomson Brooks/Cole) 598 pp
[15] Gogtay N J, Thatte U M 2017 Principles of correlation analysis *Journal of The Association of Physicians of India* **65**(3) pp 78-81
[16] Karyati K, Ipor I B, Jusoh I and Wasli M E 2014 Soil properties under various stages of secondary forests at Sarawak, East Malaysia *Journal of Tropical Forestry and Environment* **4**(01) pp 28-39
[17] Buschbacher R, Uhl C and Serrão E A S 1988 Abandoned pastures I Eastern Amazonia. II. Nutrient stocks in the soil and vegetation *J. Ecol.* **76** pp 682-99
[18] Zakaria R, Nik Rosely N F, Mansor M and Zakaria M Y 2008 The distribution of *Macaranga* Genus, (family Euphorbiaceae) in Penang Island, Peninsular Malaysia *J. Biosci.* **19**(2) pp 91-99

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