Diversity of tree vegetation on different slopes in Sangkulirang – Mangkalihat exokarst area

Diversity of tree vegetation on different slopes in Sangkulirang – Mangkalihat exokarst area

R A Suwasono*, P Matius, Sutedjo

Program Study of Forestry Science, Faculty of Forestry, Mulawarman University, Kampus Gn. Kelua, Samarinda 75123, Indonesia

*Coresponding Author: raharjo.nara.luki@gmail.com

Abstract. The Karst ecosystem in East Kalimantan is predominantly located in the Sangkulirang-Mangkalihat covering an area of 1,867,676 hectares. The exokarst are all features that may be found on a surface karst landscape. The objective of this study was to determine the diversity of tree vegetation (diameters >10 cm) on different slopes. Six study locations were selected as replications where each location consisted of the different of slopes. The sample plot was set up 15 plots in each location on quadrants of 10 m x 10 m. 538 individuals had been found in the study sites consisting of 163 species, 100 genera and 43 family. The Dipterocarpaceae was dominant on slopes and the upper ridges, while *Shorea* sp. has dominated on the upper ridges. The highest diversity index (H') of 4.04were found on the slopes and valley while the Species Richness Index (R) and Evenness Index (e) were high in all three slopes. The highest Similarity Index (ISs) of41.06was in the slopes and valley, while the highest Decimilarity Index (ID) of 67.30were in the slopes and upper ridges. Meanwhile, the overall diversity of species in the Sangkulirang-Mangkalihat exokarst area is high.

1. Introducing

Karst ecosystem is one of the unique ecosystems because it has underground river flows and caves.Formed in the past of calcium carbonate ($CaCO_3$), which is secreted by coral animals brachiopods and lilies krinoidea on ancient coral reefs under the sea in prehistoric times.When the tectonic movement on the Sunda Dangkalan created the archipelago of Nusantara, these ancient coral reefs along with other sedimentary rocks were pressed and lifted up and became a large part of Borneo Island [1].

Karst in general terms of the Decree of the Minister of Energy and Mineral Resources No. 17 year 2012 on the Designation of the Karst Landscape Area is a landscape formed by the dissolution of water on limestone and / or dolomite.The notion of karst landscape area is karst which shows certain exokarts and endokarts. Exokarst is karst on the surface while endokarst is karst on the lower surface.

Lime forest is a forest grown on limestone rocks containing calcium / calcite carbonate that is easily dissolved by rainwater,which causes the formation of cracks and tunnels that resemble reliefs, thus forming a typical morphology [2]. This area is a producer for millions liters of water for the various lives of flora, fauna and humans [3].

East Kalimantan Governor Regulation No. 67 Year 2012 stated that the karst ecosystem in East Kalimantan largely contained Sangkulirang Peninsula, extending to the Tanjung Mangkalihat with an area of 1,867,676 hectares. Administratively, this area is included in two districts, Berau and East Kutai.

This area is the headwaters of five major rivers namely Sungai Bengalon, Authorship, Tabalar, Lesan and Pesab [3]. In addition, this area also stores a variety of potential, among others: water underground rivers, caves, lakes, biodiversity, and minerals [4]. Furthermore this Karst ecosystem has at least three important values in human life [3].First, the scientific value is related to earth science, lithology, geological and mineral structures, fossil sites, archeology and paleontology, as well as shelter for endemic flora and fauna. Second, the socio-cultural value, which includes the spiritual aspect especially concerning the existence of caves associated with ritual interests that are also valued aesthetics, recreation and development of science. The third value is the high economic value because it becomes the source of underground river water, swallow producers, tourism and cement materials.

One of the government's efforts in protecting and preserving Karst Sangkulirang Mangkalihat area is by the issuance of Regulation of the Minister of Energy and Mineral Resources (ESDM) which is then followed up by the Provincial Government of East Kalimantan by issuing East Kalimantan Governor Regulation No. 67 of 2012 on Protection and Management of Karst Sangkulirang-Mangkalihat in Berau and East Kutai.

Research have been done by many research institutes from within and abroad, but more to explore the potential of prehistoric culture contained therein. Research on biodiversity potency especially flora has also been done one of them by Lembaga Ilmu Pengetahuan Indonesia (LIPI) and The Nature Conservancy (TNC) in 2004 in Merabu Village area. However, because the Karst Sangkulirang-Mangkalihat is area is very wide, not all locations can be explored its potential.

This study aims to determine the diversity of tree-level vegetation in limestone forest communities, especially inSangkulirang-Mangkalihat exocarst area.

2. Method

This research was conducted in Sangkulirang – Mangkalihat Exokarst Area which is included in the administrative area of Berau and East Kutai Regency.Sampling was conducted at 6 points of observation as repetition, covering Suaran, Ulu Bias, Lobang Kelatak and Biduk-biduk – TelukSulaiman in Berau and Tondoyan and GunungGergaji in East Kutai. At each location were made 15 observation plots divided by slopes i.e. valley, slope and upper ridge.

To determine the study site and location purposive sampling method was used, and then continued with making plot of sample sized 10 m x 10 m.The sketch of the research plot can be seen in **Figure 1**.

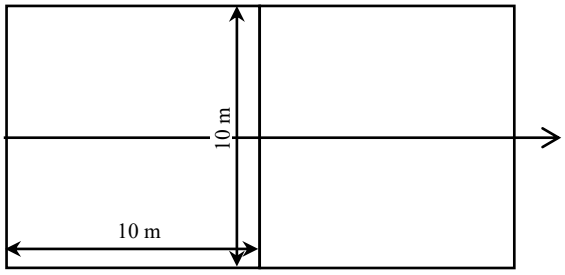

Figure 1. Transect / Path Method Design

Measurements and data collection for tree level (diameter>10 cm) were conducted for names, individual number, stem diameter and total height, chest height (1.3 m above ground) or 20 cm above the banir using phiband. Clinometer was used to measure the total height and 4 meter auxiliary rod.

Plant materials from the unknown species were taken in accordance with the procedure of sampling to make herbarium. Herbarium identification was done in Dendrology and Forest Ecology Laboratory, Faculty of Forestry, Mulawarman University.

The collected data were then analyzed quantitatively usingthe calculation of NPJ (Important Type Value), Richness Index (R) Margalef, Diversity Index (H') Shannon and Wiener, Evenness Index (e) Pielou, Similarity Index (ISs) and Decimilarity Index (ID) Sorensen.

3. Results and Discussion

After two month explorations, datahas been collected for the potential of biological richness in the form of tree level vegetation. Sampling was done on 6 points of observation i.e. Suaran, Tondoyan and Gergaji in the first month and Biatan Ulu, Lobang Kelatak and Biduk-biduk – Teluk Sulaiman in the second month (Figure 2). The results of this study described the condition of limestone forest area especially exokarst area and more specifically represented the habitat of "lowland limestone forest" Sangkulirang - Mangkalihat.

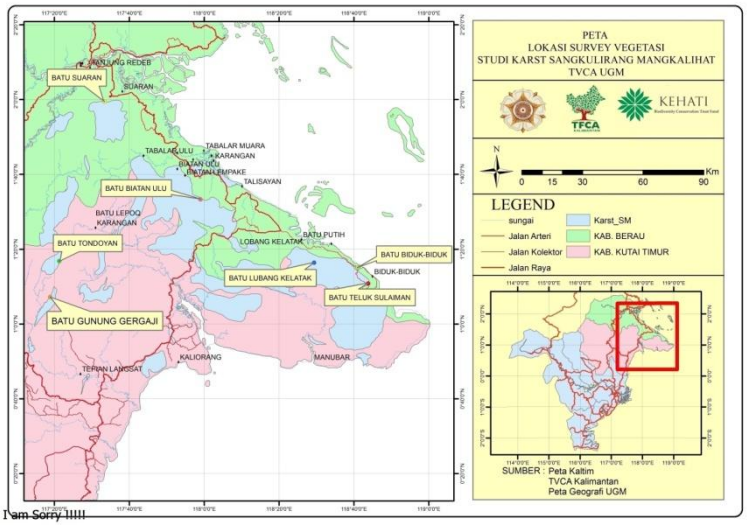

Figure 2. Map of Vegetation Survey Karst Sangkulirang MangkalihatStudy

3.1. Floristic Composition

Results of vegetation data collection in 90 plotsscattered in 6 research sites recorded as many as 538 individual tree-level vegetation belonging to 163 species, 100 genera and 43 families. In the Upper Ridge area it was recorded that the most widely vegetationfound, as many as 228 individuals, was belonging to 82 species, 59 genera and 43 families in 30 plots of samples.In the slope region, there were 155 individuals belonged to 74 species, 50 genera and 24 family (**Table 1.**).

Table 1. Individual, species, genera and family number in each slopes

	Upper ridge	Slope	Valley
Individual number	228	155	155
Species number	82	77	74
Genera number	59	53	50
Family number	31	28	24

This condition indicates that in 3 research sites have fewer species compared to similar research ever conducted by [5], which reported that in Karst Merabu area it was found 247 species belonging to 57 families. This is reasonable, however, because the research was conducted at all growth rates and more focused in an area with broader coverage of the sampling area. However, if it wasviewed as a whole at six locations with an area of 0.9 ha, it potentially have higher species richness than the extent of 4 ha in Merabu.

The main familypossessing the highest NPS in Upper Ridge is Dipterocarpaceae family with NPS of 73.51%,whiletwo main families in Slope are Meliaceae and Dipterocarpaceae with NPS of 37.93%

and 36.88% respectively. Invalley, the Dipterocarpaceaehas the highest value with NPS of 41.61% (**Table 2**).

Table 2. Top 10 highest NPS in every slopes

Upper Ridge	NPS (%)	Slope	NPS (%)	Valley	NPS (%)
Dipterocarpaceae	73.51	Meliaceae	37.93	Dipterocarpaceae	41.61
Malvaceae	29.63	Dipterocarpaceae	36.88	Meliaceae	35.05
Myrtaceae	28.00	Ebenaceae	31.98	Lauraceae	28.12
Meliaceae	26.67	Euphorbiaceae	29.58	Euphorbiaceae	27.12
Sapotaceae	17.41	Annonaceae	20.11	Annonaceae	26.57
Calophyllaceae	15.78	Lauraceae	16.00	Ebenaceae	22.56
Euphorbiaceae	12.12	Moraceae	15.01	Phyllanthaceae	16.34
Ebenaceae	8.74	Phyllanthaceae	14.30	Sapotaceae	16.34
Lamiaceae	8.54	Myristicaceae	12.87	Lythraceae	12.24
Actinidiaceae	7.05	Leguminosae	7.92	Lecythidaceae	11.98

*Shorea*sp. species predominated in Upper Ridge with NPJ of 46.49%, while in slope was dominated by *Cephalomappamalloticarpa*J.J.Sm. with NPJ of 23.48% and in Valley, the presence of tree level vegetation that has the highest NPJ is *Aglaia* sp.with NPJ of 15.83% (Tabel 3).

Table 3. Top 10 highestNPJ in every slopes

Upper Ridge	NPJ (%)	Slope	NPJ (%)	Valley	NPJ (%)
*Shorea*sp.	46.49	*Cephalomappamalloticarpa*J.J.Sm.	23.48	*Aglaia* sp.	15.83
Microcosfibrocarpa(Mast.) Burret	26.33	*Shorea*sp.	17.84	*Shorea*sp.	13.83
*Vaticarassak*Blume	16.78	*Horsfieldia*sp.	11.02	*Duabanga moluccana* Blume	12.17
*Calophyllum lanigerum*Miq.	13.08	*Diospyrosborneensis*Hiern.	10.84	*Macarangabancana*(Miq.) Müll.Arg.	11.96
Vaticaodorata (Griff.) Symington	10.43	*Shoreamujongensis*P.S.Ashton	10.69	*Dipterocarpustempehes*Sloot.	10.75
Syzygiumtawahense (Korth.) Merr. &L.M.Perry	9.57	*Diospyros*sp.	10.66	*Eusideroxylonzwageri*Teijsm. &Binn.	10.32
*Syzygium*sp.	9.30	*Aglaia* sp.	8.83	*Planchoniavalida* (Blume) Blume	8.83
Aglaia sp.	8.16	*Duabanga moluccana*Blume	7.76	*Shoreaguiso*(Blanco) Bl.	8.83
*Callicarpapentandra*Roxb.	7.93	*Polyalthiarumphii* (Bl.) Merr.	6.91	*Cephalomappamalloticarpa*J.J.Sm.	8.69
Palaquium hexandrum(Griff.) Baill.	7.12	*Prainea limpato* (Miq.) Beumee ex K.Heyne	6.56	Sp*5*.	7.73

The dominance of the presence of the Dipterocarpaceae family is accordance with what has been written by MacKinnon, that under 800 m in the not so steep slopes, the forests are higher and mainly consist of Dipterocarpaceae[1]. The survey results in the Karst Merabu area were also reported that the Dipterocarpaceae family was dominant in the area [5].

In addition to important values, also it was also performed calculations to determine the value of other indexes. The calculation of some index values were presented in **Table 4**.

Table 4. Diversity Index (H'), Richness Index (R) andEvenness Index (e) in every slopes

	Upper ridge	Slope	Valley
Richness Index (R)	14.92	15.07	14.47
Diversity Index (H')	3.80	4.04	4.04
Evenness Index (e)	0.86	0.93	0.94

R values on upper ridge, slope and valley were 14.92, 15.07 and 14.47 respectively. Based on the classification of R values made by Magurran, the three slopes has a wealth of species because it has a value of R>5.0 (Table 4).

Slope and valley were known to have a higher H'value rather than in upper ridge with H' value of 4.04, but when it was viewed from its value at all sites it has a high diversity with an H' value above 3.

The evenness index for all locations was classified as *Almost Equal*which had e value on upper ridge, slope and valley is 0.86, 0.93 and 0.94 respectively. This shows that all tree species in all locations have nearly equal numbers of individuals, or no species that have a very dominant number of individuals.

[6]mentioned that slope has low diversity due to soil leaching and faster dry land conditions, and lack of appropriate vegetation.

3.2. Forest Structure

In 90 plots with sized 10 m x 10 m or an area of 0.9 ha was recorded as 538 individual tree levels with diameter>10 cm.

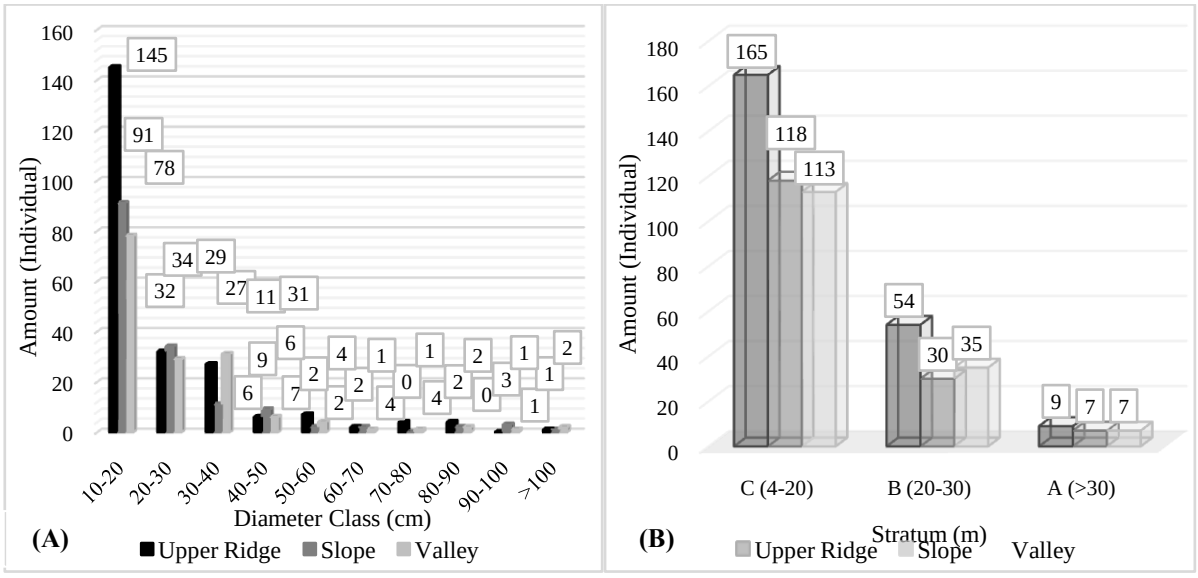

Figure 3. Distribution of class diameter **(A)** and stratum tree on each slope**(B)**

All locations, upper ridge, slope and valley,were dominated by the presence of small trees with a diameter of 10-30 cm, but there was, in few number, still found trees with a diameter of over 100 cm.Species with stem diameter more than 100 cm was *Shorea*sp. in upper ridge, *Horsfieldia*sp. in slope and in the valley it was found the species of *Duabangamoluccana* Blume and *Shorea*sp.

The distribution of individual trees composition in each grade of stem diameter in the slopes is presented in Figure 3 (A). Based on tree height and grouping based on stratum, there are 3 stratumsin all locations. All three sites were both dominated by trees with a height between 4-20 m and belonging to the stratum C(Figure 3 B).

If the points on the diagram above are connected with the line,thus is forming a curve and it will look like a curve to form of letter J but upside down. This illustrates that at the beginning of the growth, the amount of vegetation is quite a lot. But over time, these individuals experienced growth so that there is competition and natural selection resulting in a kind or different typesamong individuals. Naturally, this competition leads to a reduction in the number of individuals who survive at each grade level [7]. The distribution of such diameter class showing the potential of regeneration is quite good, because it has a diameter pattern the smaller number of individuals and more and more [8].

3.3. Simiarity Index (ISs) and Decimilarity Index (ID)

The Similarity Index (ISs) represents the similarity of the composition with comparable type. The highest type of similarity between slope and valley with ISs value is 41.06%, then between upper ridge and valley ISs is 38.46%.The lowest equation between upper ridge and slope with ISs value is only 32.70%. While the Decimilarity Index or Inequality Index is the opposite of the similarity index (**Table 5**).

Table 5. Similarity Index (ISs) andDecimilarity Index (ID) among location.

Level	IndeksSimilaritas (ISs)(%)		
	Upper Ridge	**Slope**	**Valley**
Upper Ridge		32.70	38.46
Slope	67.30		41.06
Valley	61.54	58.94	
DecimilarityIndex(ID)(%)			

There is no ISs value more than 50%,therefore it can be interpret that the similarity of types among sites is low and illustrates that each location has different characteristics (Table 5). [9]suggest that species composition among different locations is suspected because the influence of abiotic factors such as differential light level, nutrient availability, availability of water, wind and temperature. [10]also argued that the environmental factor that is very influential to the distribution of tree species is the height.

4. Conclusion

From the descriptionabove, it can be concluded that the Dipterocarpaceae is the main family of the natural forest of exokarst with the distribution of diameter and height of the multilevel tree and form an inverted J curve. All study sites have medium and low category of INPs, which means there is no dominant species at the study site. All locations have high Diversity Index (H ') and the Evenness Index (e) is almost evenly distributed as well as the type of similarity is low with less than 50% ISs, indicating that each location has its own uniqueness.

5. Acknowledgement

Thank you to TFCA, Kehati Foundation and UGM Karst Study Center which supports the implementation of this research. Mrs. Rita Diana and Fenny Putri M. S. who helped a lot on writing.

References

[1] MacKinnon K, Hatta G, Hakimah H, Mangalik A and Kartikasari S N 2000 *Ekologi Kalimantan* (Jakarta: Prenhallindo) p 273
[2] Achmad A2011 *Rahasia Ekosistem Hutan Bukit Kapur* (Surabaya: Brilian Internasional) p 38
[3] Suprihanto 2014 *Laporan Akhir Studi Sosial Ekonomi Masyarakat Di Sekitar Kawasan Karst Kabupaten Kutai Timur* (Sangatta: Bappeda Kabupaten Kutai timur) p 3,6
[4] Tyas N T, Vitdiawati R, Nusantari R 2016 konservasi dan pemanfaatan berkelanjutan kawasan karst gunung sewu sebagai bagian geopark untuk mempertahankan fungsi ekologi *Prosiding*

Symbion (Symposium on Biology Education) Prodi PendidikanBiologi FKIP Universitas Ahmad Dahlan **27 Agustus 2016** 316

[5] Sasmirul A, Sudiyanto, Jasari, Purnomo, Setiawan P and Haryono E 2013 *Laporan Biodiversity Kawasan Karst Merabu Kecamatan Kelay Kabupaten Berau* (Berau: The Nature Conservancy, Balai Lingkungan Hidup Kabupaten, Balai Konservasi Sumberdaya Alam Propinsi, Lekmapuri) p 41

[6] Karami R, Mehrabi H R and Ariapoor A 2015 the effect of altitude and slope in the species diversity of herbaceous plants (case study: watershed miandarqarootaggilangharb) *Journal of Applied Environmental and Biological Sciences* **5(7)** 201

[7] Abdurachman 2008 struktur tegakan pada hutan alam bekas tebangan *Info Teknis Dipterokarpa* **2(1)** 59

[8] Sunarti S 2011 penelitian vegetasi hutan di wilayah cadas gantung dan cadas pagar, cagar alam gunung tukung gede, serang *Berkala Penelitian Hayati* **Edisi Khusus: 5A** 109

[9] Sutomo, Fardila D 2013 floristic composition of groundcover after the 2010 pyroclastic fire on mount merapi *Jurnal Manajemen Hutan Tropika* **XIX(2)** 88

[10] Kurniawan A and Parikesit2008 persebaran jenis pohon di sepanjang factor lingkungan di cagar alam pananjung pangandaran, Jawa Barat *Biodiversitas* **9(4)** 278