International Journal of Innovation and Applied Studies
ISSN 2028-9324 Vol. 5 No. 4 Apr. 2014, pp. 344-353

http://www.ijias.issr-journals.org/

Diversity and Dominance of Ectomycorrhizal Fungi on After Burned and Unburned Forests in Kutai National Park (Indonesia)

Djumali Mardji

Laboratory of Forest Protection, Faculty of Forestry, University of Mulawarman, Samarinda (East Borneo), Indonesia

ABSTRACT: Ectomycorrhizal fungi has long been known as benefit microorganism for plants, because the fungi supply nutrients and water from soil to their hosts. But ectomycorrhizal fungi are very sensitive to environmental change of their habitat, thus can be used as bioindicator. One of the change that influence on their presence is forest fire that kill the trees as their hosts. Forest fire is almost occur every year in the dry season in Indonesia, not exception Kutai National Park (KNP), where the fire comes from the society gardens surrounding it. This study aimed to determine species diversity and dominance of ectomycorrhizal fungi on the after burned (Prevab) and unburned forests (Sangkimah). The results showed that the number of species of ectomycorrhizal fungi at Prevab were 12 species and 37 individuals, while at Sangkimah there were found 34 species of 87 individuals, this meant that the numbers of species and individuals of fungi at Sangkimah were more than at Prevab. However, based on biodiversity index, at both locations were low (H'<1), respectively was 0.51528 at Prevab and 0.50233 at Sangkimah. At Prevab, species of fungus with high levels of dominance was *Clavulina* sp., moderate level of dominance were *Mycena pura*, *Coprinus atramentaria*, *C. comatus* and *Russula decolorans*, whereas other species were in the level of low dominance. At Sangkimah, fungi with a high level of dominance was *Clitocybe* sp4, moderate level of dominance were *Leucocoprinus flos-sulfuris* and *Cantharellus* sp3, whereas other species were in the level of low dominance.

KEYWORDS: dipterocarps, ectomycorrhiza, bioindicator, Prevab, Sangkimah.

1 INTRODUCTION

Various studies indicate that many species of fungi are sensitive to changes in habitat environments, such as macro fungi that grow in the ground (ectomycorrhizal), therefore ectomycorrhizal fungi can be used as bio-indicators of forest quality. The assumption is that when many species of ectomycorrhizal fungi found, then the condition of the forest or habitat is good and when bit species of ectomycorrhizal fungi found, the forest conditions are not good (damaged). The growth of ectomycorrhizal fungi are also influenced by environmental factors such as light intensity, temperature, humidity, soil fertility and aeration and plant root exudates.

Reference [1] noted that there were 60 species of ectomycorrhizal fungi in East Kalimantan (Bukit Soeharto, Wanariset Samboja and ITCI area), where mostly of the forest were secondary forest that were dominated by the trees of large dipterocarps. The presence of the fungi were through the adaptation process influenced by environmental conditions. Reference [2] reported that in the unburned forest in Sungai Wain forest had a number of species of ectomycorrhizal fungi much more than the burned forest. Relation to the rate of deforestation was known that in habitats with low deforestation rates (due to logging concessions and illegal logging) had a number of ectomycorrhizal fungi species much more than the highly degraded habitats.

Kutai National Park (KNP) had suffered a huge fire in 1982/1983 and 1997/1998. The data from KNP noted that until 2004 fire caused by human negligence had damaged about 146,080 ha (80%) of the total area. The damage was compounded by illegal logging and encroachment, proven during 2001-2004 the number of illegal timber seized reach 246,082 m^3 [3]. The fire will also affect the macro soil animals, fungi and various species of plants and animals that play an important role in the decomposition and recycling of nutrients [4].

Corresponding Author: Djumali Mardji (djumalimardji@gmail.com)

This research was conducted to determine the diversity and dominance of ectomycorrhizal fungi in burned (Prevab) and unburned forests (Sangkimah) in KNP.

The expected outcome of this research were to provide important information about the species of ectomycorrhizal fungi in the region of Prevab and Sangkimah of KNP in the development and enhancement of the area, and also as material input and consideration for the government and relevant agencies especially the KNP authority in the preservation of species of ectomycorrhizal fungi .

2 METHODE OF RESEARCH

This research was conducted in the area of KNP, precisely at Prevab (forest burned in 1981/1982 and 1997/1998) and Sangkimah (unburned forest) East Kutai regency of East Kalimantan Province and in the Laboratory of Forest Protection, Faculty of Forestry, Mulawarman University, Samarinda. The time required for research reach 4 months (September to December 2012) which included primary data collection in the field as well as the identification of species of fungi in the laboratory.

Sample plots were developed purposively. The size of each plot was 50 m x 50 m and replicated 4 times, so the number of all plots were 2 forest condition (burned and unburned) x 4 replicates = 8 plots (2 ha).

Only big size fruit bodies of ectomycorrhizal fungi were taken (macro fungi/mushroom) with a diameter of hood of at least 0.5 cm. Fungal fruiting body that is too small is not recorded because of the difficulty in the identification process. Collected data were consisted of:

a. Species of fungi found through direct identification in the field and in the laboratory with the help of literatures.
b. The number of species of fungi and the number of individuals, i.e counting the number of species of fungi and the number of individuals of each species.
c. Characteristics of fungi, which describe the morphological characteristics of fruit bodies such as the hood, stem (stipe) and other important characteristics.

2.1. Diversity of Ectomycorrhizal Fungi

To determine species diversity, a diversity index (H') of Shannon-Wiener was used with the formula according to reference [5] as follows:

$$H' = -\Sigma\{(ni/N) \log (ni/N)\} \quad (1)$$

H' = diversity index
ni = sum of individu of each species
N = sum of individu of all species

When H'<1, then species diversity is low, when H' = 1–3 show that species diversity is moderate and when H'>3 show that species diversity is high [6].

2.2. Dominance of Ectomycorrhizal Fungi

To determine which fungi is dominance at each location, it is used dominance index of Simpson as follows [7]:

$$D = ni/N \quad (2)$$

D = dominance index of species
ni = sum of individual of each species
N = sum of individual of all species

Dominance index ranges between 0 to 1, the smaller the value (near 0), it shows that a species is not dominant, but the higher the value (near 1) then the species is dominant.

Based on the determination, the criteria are as follows:

0.00-0.33 = domination level is low
>0.33-0.66 = domination level is moderate
>0.66-1.00 = domination level is high

3 RESULTS AND DISCUSSION

3.1. Diversity of Fungi on Different Location

Number of species of ectomycorrhizal fungi found at Prevab and Sangkimah showed in Table 1. The number of ectomycorrhizal fungi at each location and research plots were different, i.e ranged between 2 to 17 species. At Prevab found only 12 species and 37 individual and the most abundant was at plot 2 as many as 5 species 15 individual. At Sangkimah found 34 species 87 individual and the most abundant was at plot 1 as many as 17 species 49 individual.

Different number of species and individual at each location was caused by different in vegetation. At Sangkimah generally was no dense lower vegetation such as shrubs, wild *Alpinia galanga* (galangal) and other species of non host of ectomycorrhizal fungi, but there were many big trees dominated by dipterocarp species that served as symbiont of ectomycorrhizal fungi. Dipterocarps are the most important species for living of ectomycorrhizal fungi. Low intensity of sun light was also still reach soil surface. Generally for formation fruit body, the fungi need light although with low intensity.

At Prevab, where the site establihed research plots, the dipterocarp species were not found. According to information of KNP authority, formerly illegal logging and forest fire had occured, so the present trees are the result of succession that do not reach climax yet, hence belong to young secondary forest. Young regeneration of dipterocarps species at research plots was not present because there was no mother tree.

Based on environment condition, i.e altitudes at Prevab and Sangkimah were 37–57 m and 32–78 from sea level respectively, while air temperatures at Prevab and Sangkimah at the noon ranged between 29.2–30.0°C and 29.0–31.0°C respectively. Relative air humidities were 80.4–94.5% and 83.0–86.1% respectively. Temperatures, sum of species and individual were far different between both locations. This meant that species of host trees are the most important for development of ectomycorrhizal fungi. In the research plot at Sangkimah found many big trees such as *Shorea johorensis*, *S. laevis*, *S. leprosula* and *Dryobalanops* sp., where the species act as main host of ectomycorrhizal fungi, while at Prevab there was no such species, but dominated by non dipterocarps such as *Cananga odorata* (kenanga), *Croton* sp., *Polyaltia* sp., *Vitex pinnata* (laban) and *Dracontomelon dao* (sengkuang).

Table 1. Number of species and individual of ectomycorrhizal fungi found at Prevab (burned forest) and Sangkimah (unburned forest)

Location	Plot number	Plot position	Altitude (m from sea level)	Air temperature (°C)	Air humidity (%)	Sum of species	Sum of individual
Prevab	1	0.0°32'02"N-117°27'25.8"E	42	29.2	94.5	3	14
	2	0.0°31'57.5"N-117°27'50"E	57	29.6	81.0	5	15
	3	0.0°31'35"N-117°27'30"E	46	29.7	80.4	3	6
	4	0.0°32'3.7"N-117°27'49.8"E	37	30.0	82.3	2	2
	Sum					12*	37
	Average		45.5	29.6	84.6		
Sangkimah	1	0.0°21'51.7"N-117°28'13.4"E	32	29.0	83.0	17	49
	2	0.0°22'3.1"N-117°28'26.5"E	78	30.4	86.1	9	16
	3	0.0°21'59.8"N-117°28'21.2"E	48	30.8	85.1	4	10
	4	0.0°22'1.6"N-117°28'12.7"E	44	31.0	84.3	5	12
	Sum					34*	87
	Average		50.5	30.3	84.7		

*same species was present at different plots

The differences of vegetation species growing in both locations make ectomycorrhizal fungi are also different in species diversity, hence ectomycorrhizal fungi can be used as bioindicator of forest condition, where when abundant species of ectomycorrhizal fungi found, it means that the forest is still good indicated by the presence of big trees as their host, but when few ectomycorrhizal fungi found, it means that the forest is damaged, usually indicated by rare or no big trees as the host of fungi. Although there are only presence small trees, but when the trees are suitable for the host of ectomycorrhizal fungi, then the fungi will grow well. Reference [8] reported that ectomycorrhizal fungi in Czechoslovakia are very sensitive against air pollution, the influence are as follow: i) inhibition of fruitbody formation, ii) reduction of fungal species diversity and iii) lost of part or all of symbiotic fungi. It can also be used to assess the level of forest destruction in connection with the fungal sensitivity to air pollution, the higher the air pollution, the damaged forest and the symbiotic fungi more and more disappear. Reference [9] noted that at three locations i.e forests of Mului, Mount Lumut and Rantau Layung in Paser District (East Borneo), almost all species of fungi growing in soil were ectomycorrhizal fungi and the most commonly found were at Mului as many as 44 species, followed by forest in Mount Lumut 20 species, whereas in Rantau Layung foret only 14 species. These results indicated that the environmental conditions in the forest habitat of Mului was better than at the other two locations. In Mului forest were still many dipterocarp trees with a diameter greater than 50 cm, whereas forest trees at Rantau Layung such trees were rare, but only weathered residual illegal logging, so it can be said, that forest of Rantau Layung in the condition of severely damaged.

If the host is not suitable for the growth of ectomycorrhizal fungi, the fungal fruiting body formation does not occur. This is according to reference [10], that in Muaralawa (West Kutai District), that in land rehabilitation of the former coal mine PT Trubaindo Coal Mining did not find ectomycorrhizal fungi, whereas in secondary forests with lots of dipterocarp tree species found 49 species of ectomycorrhizal fungi.

Reference [11] stated, that ectomycorrhizal fungi can be life threatened by climate change and habitat destruction; reduction ectomycorrhizal fungal species detected in the last few decades in various studies in Europe, where it is an alarming development. The loss of species diversity in ectomycorrhizal fungi are harmless, given the important role of these fungi in forest ecosystems. Ectomycorrhizal fungi in the forest should be preserved because of high species diversity is an important prerequisite for healthy forests and healthy forests are very important for maintaining high species diversity and productivity of the fungi.

When seen from the number of all species found, then the fungi found at Prevab as many as 12 and at Sangkimah 34 species is almost identical to the findings in Mului by reference [9] on 12 November to 3 December 2005 as many as 45 species, which at that time was rainy season. Although the number of species is almost the same, but there were many differences in the species name. This could be due to differences in location, altitude above sea level, weather conditions, especially temperature and humidity as well as the host tree species found in the study site, which was the last seen more real cause.

Research in the KNP was conducted during the dry season month of September 2012. When seen the average rainfall for 11 years from 2000 to 2010, then in September was the least month of rainfall, i.e 108.0 mm, it meant that species on ectomycorrhizal fungi found in KNP were species of resistant to lower precipitation. It is possible that the other species will grow in the months of higher rainfall. Therefore, the species of fungi can be recommended as a seedling-inoculation of the seedling planted in reforestation programs such as Intensive Silviculture (Silin) program which prioritizes the species of dipterocarps to be planted.

In Table 2 is shown ectomycorrhizal fungal species diversity index at Prevab and Sangkimah. The table shows, that the diversity index (H') of the ectomycorrhizal fungi at Prevab (burned forest) of plots 1 to 4 ranged from 0.2211 to 0.5339 so that the value of H'<1 showed that species diversity in each study plot at Prevab was low. Likewise diversity index at Sangkimah (unburned forest) from 1 to 4 replicates ranged from 0.3096 to 1.0912, so that the value of H'<1 to between 1 and 3, it showed that the diversity of ectomycorrhizal fungi in plots 1 was moderately, while in plots 2, 3 and 4 were low level of diversity.

Table 2. Diversity index (H') of ectomycorrhizal fungi found in each plot research

Location I: burned forest (Prevab)

Nr.	Species	Family	Sum of individual	ni/N	Log ni/N	ni/N log ni/N	H’
Plot (replication) 1							
1	*Lepiota* sp	Agaricaceae	1	0.0714	-1.1461	-0.0819	
2	*Clavulina* sp	Clavulinaceae	12	0.8571	-0.0670	-0.0574	
3	*Agaricus* sp1	Agaricaceae	1	0.0714	-1.1461	-0.0819	
	Sum		14			-0.2211	0.2211 (I)
Plot (replication) 2							
1	*Amanita rubescens*	Amanitaceae	1	0.0667	-1.1761	-0.0784	
2	*Mycena pura*	Mycenaceae	8	0.5333	-0.2730	-0.1456	
3	*Amanita* sp	Amanitaceae	1	0.0667	-1.1761	-0.0784	
4	*Agaricus* sp2	Agaricaceae	1	0.0667	-1.1761	-0.0784	
5	*Coprinus atramentaria*	Agaricaceae	4	0.2667	-0.5740	-0.1531	
	Jumlah		15			-0.5339	0.5339 (I)
Plot (replication) 3							
1	*Coprinus atramentaria*	Agaricaceae	4	0.6667	-0.1761	-0.1174	
2	*Rhizopogon* sp	Rhizopogonaceae	1	0.1667	-0.7781	-0.1297	
3	*Coprinus comatus*	Agaricaceae	1	0.1667	-0.7781	-0.1297	
	Jumlah		6			-0.3768	0.3768 (I)
Plot (replication) 4							
1	*Coprinus comatus*	Agaricaceae	1	0.5000	-0.3010	-0.1505	
2	*Russula decolorans*	Russulaceae	1	0.5000	-0.3010	-0.1505	
	Sum		2			-0.3010	0.3010 (I)
	Grand total						1.4328
	Average						0.3582 (I)

Table 2 (continuation)

Location II: unburned forest (Sangkimah)

Nr.	Species	Family	Sum of individual	ni/N	Log ni/N	ni/N log ni/N	H'
Plot (replication) 1							
1	*Hygrophorus* sp	Hygrophoraceae	4	0.0816	-1.0882	-0.0888	
2	*Lyophyllum* sp1	Tricholomataceae	1	0.0204	-1.6902	-0.0345	
3	*Clitocybe* sp1	Tricholomataceae	1	0.0204	-1.6902	-0.0345	
4	*Myrlostoma coliforme*	Geastraceae	1	0.0204	-1.6902	-0.0345	
5	*Laccaria laccata*	Hydnangiaceae	1	0.0204	-1.6902	-0.0345	
6	*Suillus* sp1	Boletaceae	1	0.0204	-1.6902	-0.0345	
7	*Agaricus placomyces*	Agaricaceae	1	0.0204	-1.6902	-0.0345	
8	*Calostoma fuscum*	Sclerodermataceae	8	0.1633	-0.7871	-0.1285	
9	*Cantharellus* sp1	Cantharellaceae	1	0.0204	-1.6902	-0.0345	
10	*Omphalina* sp	Tricholomataceae	3	0.0612	-1.2131	-0.0743	
11	*Clitocybe* sp2	Tricholomataceae	8	0.1633	-0.7871	-0.1285	
12	*Gliophorus* sp	Hygrophoraceae	1	0.0204	-1.6902	-0.0345	
13	*Russula* sp1	Russulaceae	1	0.0204	-1.6902	-0.0345	
14	*Collybia acervata*	Tricholomataceae	4	0.0816	-1.0882	-0.0888	
15	*Boletus* sp	Boletaceae	1	0.0204	-1.6902	-0.0345	
16	*Inocybe* sp	Cortinariaceae	3	0.0612	-1.2131	-0.0743	
17	*Naematoloma* sp	Strophariaceae	1	0.0204	-1.6902	-0.0345	
18	*Tricholoma* sp	Tricholomataceae	8	0.1633	-0.7871	-0.1285	
	Sum		49			-1.0912	1.0912 (m)
Plot (replication) 2							
1	*Lycoperdon perlatum*	Agaricaceae	1	0.0625	-1.2041	-0.0753	
2	*Agaricus placomyces*	Agaricaceae	1	0.0625	-1.2041	-0.0753	
3	*Lyophyllum* sp2	Tricholomataceae	1	0.0625	-1.2041	-0.0753	
4	*Cantharellus* sp2	Cantharellaceae	1	0.0625	-1.2041	-0.0753	
5	*Lepiota sp1*	Agaricaceae	2	0.1250	-0.9031	-0.1129	
6	*Clitocybe sp3*	Tricholomataceae	1	0.0625	-1.2041	-0.0753	
7	*Collybia sp1*	Tricholomataceae	1	0.0625	-1.2041	-0.0753	
8	*Collybia butyracea*	Tricholomataceae	1	0.0625	-1.2041	-0.0753	
9	*Leucocoprinus flos-sulfuris*	Agaricaceae	6	0.3750	-0.4260	-0.1597	
10	*Lepiota* sp2	Agaricaceae	1	0.0625	-1.2041	-0.0753	
	Sum		16			-0.8747	0.8747 (l)
Plot (replication) 3							
1	*Clitocybe* sp4	Tricholomataceae	7	0.7000	-0.1549	-0.1084	
2	*Agaricus placomyces*	Agaricaceae	2	0.2000	-0.6990	-0.1398	
3	*Lepiota* sp3	Agaricaceae	1	0.1000	-0.1000	-0.1000	
	Sum		10				0.3482 (l)
Plot (replication) 4							
1	*Cantharellus* sp3	Cantharellaceae	6	0.5000	-0.3010	-0.1505	
2	*Suillus* sp2	Boletaceae	2	0.1667	-0.7781	-0.1297	
3	*Cantharellus* sp4	Cantharellaceae	1	0.0833	-1.0790	-0.0899	
4	*Collybia* sp2	Tricholomataceae	1	0.0833	-1.0790	-0.0899	
5	*Russula* sp2	Russulaceae	2	0.1667	-0.7781	-0.1297	
	Sum		12			-0.3096	0.3096 (l)
	Grand total						2.6237
	Average						0.6559 (l)

l = low level of diversity. m = moderately level of diversity

When viewed from the average diversity index that describes the diversity of species in two different locations, the species diversity at Prevab was lower than at Sangkimah, respectively 0.3582 and 0.6559, where the diversity of species at both locations were in lower criteria. This is in accordance with the provisions of reference [6], if H'<1, then the species diversity is low, if H' = 1-3 the diversity of species classified as moderate and when H'>3 relatively high species diversity.

In Table 2, the difference of low index of species diversity in two locations due to differences in the number of individuals among species is quite large. According to reference [12], high and low species diversity is influenced by the evenness of the number of individuals of each species within a community, the smaller the difference in the number of individuals among species mean numbers more evenly, thus the higher species diversity.

3.2. Dominance Species of Fungus on Different Locations

In Table 3 is shown the dominance index of each species of ectomycorrhizal fungi in the location Prevab (burned forest) and Sangkimah (unburned forest). Judging from the dominance index range from 0 to 1, where the smaller the dominance index value (close to 0), it indicates that a species is not dominant, whereas if the greater dominance index (close to 1), it indicates the species of dominant [13]. This provision further divided into low-level dominance when the index from 0.00 to 0.33; moderate when > 0.33 to 0.66 and high if > 0.66 to 1.00. Of these details can be seen in Table 3, that at Prevab (burned forest), the species of fungi that contained high levels of dominance in plot 1 was *Clavulina* sp, level of moderately dominance was found on plot 2 i.e *Mycena pura*, *Coprinus atramentaria* on plots 3, *Coprinus comatus* and *Russula decolorans* plot 4, while other species were included in a low level of dominance.

Table 3. Dominance index (Di) species of ectomycorrhizal fungi found in Kutai National Park

Location I: burned forest (Prevab)

Nr.	Species	Sum of individual	H’	Di = ni/N	Level of dominance
Plot (replication) 1					
1	*Lepiota* sp	1		0.0714	l
2	*Clavulina* sp	12		0.8572	h
3	*Agaricus* sp1	1		0.0714	l
	Sum	14	0.2211 (l)	1.0000	
Plot (replication) 2					
1	*Amanita rubescens*	1		0.0667	l
2	*Mycena pura*	8		0.5333	m
3	*Amanita* sp	1		0.0667	l
4	*Agaricus* sp2	1		0.0667	l
5	*Coprinus atramentaria*	4		0.2667	l
	Sum	15	0.5339 (l)	1.0000	
Plot (replication) 3					
1	*Coprinus atramentaria*	4		0.6667	m
2	*Rhizopogon* sp	1		0.1667	l
3	*Coprinus comatus*	1		0.1667	l
	Sum	6	0.3768 (l)	1.0000	
Plot (replication) 4					
1	*Coprinus comatus*	1		0.5000	m
2	*Russula decolorans*	1		0.5000	m
	Sum	2	0.3010 (l)	1.0000	

Location II: unburned forest (Sangkimah)

Plot (replication) 1

Nr.	Species	Sum of individual	H'	Di = ni/N	Level of dominance
1	*Hygrophorus* sp	4		0.0816	l
2	*Lyophyllum* sp1	1		0.0204	l
3	*Clitocybe* sp1	1		0.0204	l
4	*Myrlostoma coliforme*	1		0.0204	l
5	*Laccaria laccata*	1		0.0204	l
6	*Suillus* sp1	1		0.0204	l
7	*Agaricus placomyces*	1		0.0204	l
8	*Calostoma fuscum*	8		0.1633	l
9	*Cantharellus* sp1	1		0.0204	l
10	*Omphalina sp*	3		0.0612	l

Table 3 (continuation)

Nr.	Species	Sum of individual	H'	Di = ni/N	Level of dominance
11	*Clitocybe* sp2	8		0.1633	l
12	*Gliophorus* sp	1		0.0204	l
13	*Russula* sp1	1		0.0204	l
14	*Collybia acervata*	4		0.0816	l
15	*Boletus* sp	1		0.0204	l
16	*Inocybe* sp	3		0.0612	l
17	*Naematoloma* sp	1		0.0204	l
18	*Tricholoma* sp	8		0.1633	l
	Sum	49	1.0912 (l)	1.0000	
Plot (replication) 2					
1	*Lycoperdon perlatum*	1		0.0625	l
2	*Agaricus placomyces*	1		0.0625	l
3	*Lyophyllum* sp2	1		0.0625	l
4	*Cantharellus sp2*	1		0.0625	l
5	*Lepiota sp1*	2		0.1250	l
6	*Clitocybe* sp3	1		0.0625	l
7	*Collybia* sp1	1		0.0625	l
8	*Collybia butyracea*	1		0.0625	l
9	*Leucocoprinus flos-sulfuris*	6		0.3750	m
10	*Lepiota* sp2	1		0.0625	l
	Sum	16	0.8747 (l)	1.0000	
Plot (replication) 3					
1	*Clitocybe* sp4	7		0.7000	h
2	*Agaricus placomyces*	2		0.2000	l
3	*Lepiota* sp3	1		0.1000	l
	Sum	10	0.3482 (l)	1.0000	
Plot (replication) 4					
1	*Cantharellus* sp3	6		0.5000	m
2	*Suillus* sp2	2		0.1667	l
3	*Cantharellus* sp4	1		0.0833	l
4	*Collybia* sp2	1		0.0833	l
5	*Russula* sp2	2		0.1667	l
	Sum	12	0.3096 (l)	1.0000	

l = level of species diversity or level of species dominance is low. m = moderate. h = high

At Sangkimah (unburned forest), the species of fungi with a high level of dominance contained in plot 3 was *Clitocybe* sp4, level of moderately dominance were found on plots 2 and 4, respectively *Leucocoprinus flos-sulfuris* and *Cantharellus* sp3, while other species were included in the rate low dominance. The dominance species of fungi in each of the study plots was dependent on the number of individuals of each species of fungi itself, the more the number of the individual, the greater the dominance index if there were other species found in the plot itself. But on plot 4 (Prevab), *Coprinus comatus* and *Russula decolorans* equally dominant, although each only 1 individual, because only 2 species that were found in the plot. A large number of individuals of each species of ectomycorrhizal fungi depending on the number of suitable host within a particular area, when the same host species present in significant amounts, the number of individuals of the same species of fungi will also be a lot, but when its host tree species varied, the species of fungi and the number of individuals also vary widely, so the dominance of each species of fungi is reduced approaching the lower level of criteria.

Based on the dominance index of each species of fungi in Table 3, it can be concluded the level of dominance by location of research, that at Prevab, the species of fungus with high dominance level was *Clavulina* sp, moderately level of dominance were *Mycena pura*, *Coprinus atramentaria*, *Coprinus comatus* and *Russula decolorans*, while other species were included in a low level of dominance. At Sangkimah, species of fungi with a high level of dominance was *Clitocybe* sp4, moderately level of dominance was *Leucocoprinus flos-sulfuris* and *Cantharellus* sp3, while other species were included in a low level of dominance.

The number of individuals in a species of ectomycorrhizal fungis itself depends on the species of fungi and the suitability of the environment. There is a species of fungi that grows singly (solitary) and some are clustered in one clump. Biotic environment such as the host species and the abiotic environment such as temperature and humidity, and altitude above sea level are also instrumental in the formation of fruiting bodies of an ectomycorrhizal fungus species. According to reference [14], for growth, mycelium of fungi need water, otherwise the fruit body begins to form when the conditions for the growth of the mycelium become unprofitable, such as the availability of water as a solvent nutrients needed for growth to be reduced. As if the mycelium was almost dead, so that all the energy reserves should be kept for a good season to produce fruit body which in turn will produce spores that are necessary for the continuation of the species concerned.

Reference [14] also stated, that the various species of *Morchella*, *Volvaria*, *Coprinus* and *Peziza* growing in undisturbed soil. In contrast to the treated soil, especially if fertilized with chemical fertilizers, then very few mushrooms will be found. The area of contact with the salty spray of sea water is not a good habitat for many species of fungi, but *Psalliota bernardi*, *Bovista plumbea* and *Geaster nanus* growing on sand dunes along the coast, while *Coprinus atramentaria* and some species of the genus *Psalliota* grows in meadows and gardens vegetables fertilized with manure.

4 CONCLUSION

The number of ectomycorrhizal fungi at Prevab (burned forest) were 12 species of 37 individuals, whereas at Sangkimah (unburned forest) found 34 species of 87 individuals, hence the number of species and individuals at Sangkimah was more than at Prevab. However, when viewed from the species diversity index in both locations, including low (H'<1), respectively at Prevab was 0.51528 and at Sangkimah 0.50233.

At Prevab, species of fungi with high level of dominance was *Clavulina* sp., moderately level of dominance were *Mycena pura*, *Coprinus atramentaria*, *Coprinus comatus* and *Russula decolorans*, while other species were included in low level of dominance. At Sangkimah, species of fungi with a high level of dominance was *Clitocybe* sp4, moderately level of dominance were *Leucocoprinus flos-sulfuris* and *Cantharellus* sp3, while other species were included in low level of dominance.

5 RECOMMENDATION

The species of fungi that exist in KNP can be utilized for inoculation on seedlings to be planted on land that has been disturbed such as fire scars, post-mining land, *Imperata cylindrica* land and land with overgrown shrubs.

Preservation of the existence of ectomycorrhizal fungi in the KNP needs to be done for example by preventing forest fires, planting tree species that are host of ectomycorrhizal fungi on burned land, preventing the felling of host trees and dissemination of leaflets and information boards about forest potential of KNP in the entrance counters and so forth.

To determine the species diversity of ectomycorrhizal fungi more, further research needs to be conducted at the same location at different times, because it is possible still to be found other than the species found in this research.

REFERENCES

[1] W. Jülich, "Dipterocarpaceae and Mycorrhizae", *Special Issue, GFG Report of Mulawarman University* no. 9, 103 p, 1988.

[2] M. Noor. *Diversity of Ectomycorrhizal Fungi in Burned and Unburned Forest Area in Sungai Wain Protection Forest, Balikpapan City* (in Indonesian). Master Thesis, Study Program of Forestry Science, University of Mulawarman, Samarinda, 2002.

[3] I. Zulkarnaen, *The Fate of the Present Kutai National Park* (in Indonesian), 2008. [Online] Available: http://www.antaranews.com/view/?i=1211365046&c=ART&s= (February 7, 2013).

[4] J. Arjuna, *Forest Fire and Land* (in Indonesian), 2008. [Online] Available: http://www.terranet.or.id/tulisandetil.php?id=1393.

[5] C.E. Shannon, C.E. "A Mathematical Theory of Communication". *Bell System Technical Journal* no. 27, pp 379–423, 1948.

[6] C.J. Krebs, *Ecological Methodology.* Harper & Row Publ., Inc., New York, 1989.

[7] E.H. Simpson, "Measurement of Diversity". *Nature* no. 163, p 688, 1949.

[8] R. Fellner, "Mycorrhiza-forming Fungi as Bioindicators of Air Pollution", *Journal of Agriculture, Ecosystems & Environment,* vol. 28, no. 1–4, pp 115–120, 1990.

[9] D. Mardji and M. Noor, *Mushrooms Diversity in Mount Lumut Protection Forest*. Research Report for Tropenbos International Indonesia Programme (MoF – Tropenbos Kalimantan Programme), 2006.

[10] D. Mardji, Sugiarto and D. Triadiawarman, *Identify the Species and Potential Ectomycorrhizal Fungi to Support Ex-Mining Land Rehabilitation Program* (in Indonesian). Research Report, Samarinda, 2009.

[11] S. Egli, "Mycorrhizal Mushroom Diversity and Productivity - An Indicator of Forest Health?", *Annals of Forest Science,* no. 68, pp 8–88, 2011.

[12] Anonymous, Ecological Sampling Methods, 2000. [Online] Available: http://www.countrysideinfo.co.uk/ biol_sampl_cont.htm.

[13] E.P. Odum and G. Barrett. *Fundamentals of Ecology*. W.B. Saunders Company, Philadelphia, 1971.

[14] G. Pace, *Mushrooms of the World*. Firefly Books Ltd., Spain, 1988.