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Preliminary Study of the Ecological Impact of Forest Fires in G. Massigit, G. Gede-Pangrango National Park, West Java

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Abstract: Gunung Gede Pangrango National Park is one of the Long-term Ecological Research Site in Indonesia. In the late 1997, the fires have burnt and destroyed nearly 300 ha forest in this park, and G. Masigit was the largest burnt area (250 ha) of nine locations of hot spot recognized. Undergrowth vegetation got the most severe impacts. Almost undergrowth vegetation in various location were totally burnt. However, within three months following burning new seedlings such as *Omalanthus populneus, Macaranga, Trema orientalis* and *Eupatorium* appeared in the forest floor. The number of mycoflora recorded in burnt forest was interestingly increased in post forest fires site. Forest fires in G. Masigit had also affected the wild life population and diversity. For example, the number of bird species and the number of soil insects in burnt forest was significantly reduced. The forest fires had also great impact on soil, such as on soil organic contents, bulk density, colour, consistency, permeability and the activity of soil microorganisms.

Key Words: Forest fire, Indonesia, Soil, Vegetation, Wildlife.

INTRODUCTION

Gunung Gede Pangrango National Park, is one of the Long-term Ecological Research Site in Indonesia. In the late 1997, the fires have burnt and destroyed nearly 300 ha forest in this park. There were nine locations of hot spot, i.e., Gunung Sela (32 ha) was burnt in September 13 ; G. Pangrango (0.1 ha) burnt in September 22; G. Masigit (250 ha) burnt in September 26; Alun-Alun Suryakencana (11 ha) burnt in October 27; Gegerbentang (one ha) burnt in November 1; Arcamanik (3.5 ha) burnt in November 1; Perum Perhutani (5 ha) burnt in October 13; Bale Kambang (5 ha) burnt in November 1; and Golf course (0.1 ha) burnt in September 29. Six locations are located in the core area of the Gede Pangrango National Park, and the other three locations i.e., Perum Perhutani, Bale Kambang and Golf Course are in adjacent of park boundary.

It is reported that the causes of forest fires were related to the human error, long dry season, strong wind and low humidity. The effects of long dry season were the dryness of undergrowth species dominated by ferns. The dominant species of ferns such as *Dryopteris* spp, *Nephrolepis, Athyrium, Pteris* and *Cyclosorus* commonly have shallow roots system. Those species are therefore more susceptible to the long dry conditions.

Forest fires in late 1997 in G.Gede Pangrango National Park have affected the biodiversity of the reserve. Results of preliminary observation are presented in this paper.

IMPACT ON VEGETATION

Fire is a natural component of many forest ecosystems, where it plays an important role in ecology. However, in other cases, fire is also destructive and causes alteration to vegetation. Burning in a fire-dependent forest will have little permanent impacts on vegetation. However, burning in forest not adapted to fire can cause long term or permanent changes. At worst, forests can be totally lost and replaced by other vegetation. For example repeated burnings in Kalimantan have created large areas of unproductive alang-alang grassland in place of the original dipterocarp forest.

Based upon the observation in the field shows that not all burnt trees in some locations were killed. It suggests that the impact of forest fires much depend upon the local conditions such as topography, undergrowth vegetation and thickness and dryness of litterfalls, temperature and the wind. Therefore the effects of fire on the vegetation are also different.

Undergrowth vegetation got the most severe impacts. Almost undergrowth vegetation in various location were totally burnt. However, within three months following burning new seedlings such as *Omalanthus populneus, Macaranga, Trema orientalis* and *Eupatorium* appeared in the forest floor. Abdulhadi *et al.* (1994) reported

that those species were found as the component of seed bank in a permanent plot this forest. Thus, it is believed that those seedlings might be recruited from seed bank or seed rain.

Fires mostly burnt part of root in the soil surface and part of stem (even in some places up to the crown), with the black dark color. Trees with the thick bark usually demonstrated the dark color outside but not across to the stem.

Forest fires have effected on the floral and faunal diversity in the forest. However, it is difficult to measure precisely the impact of fires on flora and fauna. Despite the impact is distributed widely and unevenly, it is not felt for months or years and the ultimate impact is dependent upon a chain of intermediate events (Schweithelm 1998).

There are many plant species which are not resistant to fires, so the loss of such species cannot be prevented. The importance of long-term permanent plot in assessing of the species loss due to forest fires were shown from the permanent plot of mixed Dipterocarp forest in Wanariset Samboja and Lempake, Samarinda, East Kalimantan. Mixed Dipterocarp forest at the Wanariset is known as one with the richest tropical forest tree species (Kartawinata *et al.* 1981, Whitmore 1984). After 1983 and 1998 forest fires, about 90% of 240 tree species in the 1.6 ha research permanent plot died, while in the same forest type at Lempake only about 20% of species (Bratawinata pers. comm) were still found alive in the research plot after fires. Yeager (1997a) reported that a team who studied in peat swamp forest at Tanjung Putting National Park, Central Kalimantan, found that the average number of tree species declined from 60 per hectare in unburnt areas to fewer than 15 after burning. The total number of trees that survived after burning is highly correlated with the degree of prior disturbance, and fires in the peat swamp forest can travel below the ground surface, killing trees by destroying their root systems.

The strategy of plant species to exist is not always in the form of mature plant, but they occur as viable seeds stored in the soil which is well known as seed bank. The population of seed bank is often much higher than the population of growing plant, although seed bank in a rain forest is relatively lower than other vegetation types such as savanna, grassland, sclerophyll forest, etc. The occurrence of soil seed bank is well recognized, and it is considered to be important in the initiation of forest recovery following disturbance.

However, soil heating significantly reduced the number of species and seeds that remained viable in the seed bank. Various ecological studies regarding the effects of a brief period of high rain forest soil temperature on the seed bank was dramatic. Hopkins and Graham (1984) found only 50% of the species and seeds were killed at 60℃. In Costa Rica, Ewel (1981) found 27% of the species and 52% of seeds were killed in a slash burn while Brinkman and Vieira (1971) found that 66% of the seeds in the top 5 cm surface soils were killed following burning. Even Abdulhadi (1992) reported that 83% of the species and 90% of all seeds were killed by one hour heating at 60℃.

Reductions in the size of seed banks following soil heating indicate the loss of species occur in the seed bank. It may depend on the composition of that seed since survival rate differ from species to species, and it must also depend on the extent to which seeds are distributed at different depths in the soil.

Interestingly, a preliminary survey on the impact of forest fires on G. Masigit, G.Gede Pangrango National Park shows increasing number of mycoflora recorded in burnt forest. As shown in Table 1, a total of 18 species of mushrooms were recorded in burnt forest G. Masigit, G.Gede Pangrango National Park.

Table 1. List of mushrooms recorded in burnt forest of G. Masigit, G.Gede Pangrango National Park

	Unburnt	Burnt
Bisporella sp.	Dead trees	Burnt trees
Coprinus sp.	Soil	-
Crepidotus sp.	Trees	-
Ganoderma lucidum	Trees	-
Ganoderma sp.	Trees	-
Hygrocibe punicea	Soil	-
Hypoxylon fragiforme	-	Burnt trees
Marasmius sp.	Dead trees	-
Mycena sp.	Soil	-
Polyporus sp.	Trees	Burnt trees
Xylaria sp.	-	Burnt trees
Flammulina velutipes	-	Burnt trees
Phaehelotium subcarneum	-	Soil
Pholiota carbonaria	-	Soil
Scutelinia trechispora	-	Mossy soil
Schizophyllum commune	-	Burnt trees
Thelephora terrestris	-	Soil
Myxomycetes 1	-	Burnt trees
Myxomycetes 2	-	Burnt trees
Myxomycetes 3	-	Burnt trees
Auricularia auricula	-	Burnt trees
Auricularia sp.	-	Burnt trees
Coprinus picaceus	-	Soil
Coprinus sp.	-	Soil
Daldinia concentrica	-	Burnt trees
Ramaria sp.	Dead trees	-

Table 2. List of soil fungi recorded in burnt and unburnt forest of G. Masigit, G.Gede Pangrango National Park

SPECIES	UNBURNT	BURNT
Rhizopus stolonifer	-	**
Trichoderma sp.	-	***
Aspergillus niger	**	*
Monascus ruber	-	*
Mucor sp.	**	*
Penicillium sp.	-	*
Rhizopus sp.	**	*
Trichoderma viride	**	*
Neurospora sitophila	-	**
Acremonium sp.	-	***
Botrytis sp.	-	*
Gliocladium sp.	-	*
Trichoderma koningii	**	-

Thirteen of 18 mushroom species (72.2%) were found growing in the burnt trees, and the other five species (27.8%) found in bare and mossy soil. *Pholiota carbonaria, Scutelinia trechispora* and *Flammulina velutipes* were noticed as the most common mushroom found in burnt forest, but not found in unburnt forest nearby. In unburnt forest nearby, only 10 species were recorded. *Polyporus* sp. is the only species found in both burnt and unburnt forest.

The occurrence of above three common species in burnt forest area is to some extent allied to the high carbon content in the burnt area, since the humidity in burnt and unburnt forest was relatively the same. In fact, those species were not found in unburnt forest nearby, and *Pholiota carbonaria* is well known as the post fire species. The similar feature was also shown by the soil fungi (Table 2).

IMPACT OF FOREST FIRES ON WILDLIFE

As illustrated by many case studies, forest fires can have disastrous impacts on many species of wildlife. It is difficult to document the effects of fires in the tropical rain forest animals, but many case studies showed the disastrous impacts on many wildlife species. Boer (1989) and Yeager (1997b) point out that wildlife may be killed directly by the heat and smoke of fires or may subsequently be weakened and die from lack of food and water or habitat loss. Small, slow moving animals are most likely to be killed outright by fires. Animal with very specific food, habitat, shelter, or climate requirements are most at risk during the immediate post-fire period. Individuals of territorial species fleeing to unburned areas often encounter aggression from residents, and may be killed or injured. The lost of key organism (keystone species), such as pollinators, decomposers and fruit trees can significantly affect the recovery of the forest ecosystem (Yeager 1997b). In the months and years after a fire, the changing composition of vegetation and fruits in a recovering forest provide alternate, or even superior food sources for some animals and insects, sometimes leading to dramatic increases in their population after fires, and thereby changing the faunal composition of the forest.

The escaping animals from the habitat by the fire apparently were captured by the villagers and sold in the markets. These conditions appeared because the people experienced the economic crisis that hit Indonesia. Forest fires that drive away the animals from the forest appears had stimulate people to trade wildlife to improve their economic conditions.

Fires in East- and Central Kalimantan had threatened the orangutan existence which can be eliminated or destroyed from Kalimantan. Apparently there are no chance for the orangutan to survive; even there is a presumption that the orangutan will be finished in the next 100 years. About 366 orangutan were returned to nature in Wanariset, and after the fires only 19 orangutan were found. In the meantime Wanariset Rehabilitation Center had received more than 140 orangutan for being checked-up their health condition and recovered after fires. While in East Kalimantan about 120 old orangutan and 60 juveniles were supposed dead from fires. The protected forest of Sungai Wain in East Kalimantan, which was home of 100 rehabilitated orangutan was also damaged by fires. The fate of those orangutan in that forest is not known.

The Kutai National Park was attacked by great fire, which had a great effect on the life of the flora and fauna in it. About 50.000 ha of 198.000 ha Kutai National Park were burnt down by fires, whereas this national park was important habitat of around 2000 orangutans and a number of orangutan had been driven away from the habitat for looking their food. The life of orangutan group is not stable and the number decreasing compared to those before the fires. The decrease of their juveniles and elder orangutans is about 38% in each group. Two primitive primates, western tarsiers (*Tarcius bancanus*) and slow loris (*Nycticebus coucany*) were extremely reduced in number as of 1986.

Kalimantan which is home for at least 600 bird species with unique characteristics and even endemic, will become a life and death battle for various bird species due to loss of their good habitat. As a result of the great fires, there will

not be any fruits in the near future, and it means there will be food shortage for the birds. Birds are found in weak condition and difficult to breathe because of haze. Birds which have been driven from their habitat become disoriented, flying without any direction, even crashed themselves on the windows of the houses nearby.

The preliminary survey of forest fire impacts in G.Gede Pangrango National Park suggest that fire has indeed reduced species diversity and species richness of forests, although the community evenness did not seem to be affected, and followed a rule of thumb for community evenness of tropical forest bird, i.e. many species with small population and an even distribution of individuals amongst species (Table 3). There were 15 species not-shared by the two forests, of which seven were found in burnt forests but not in unburnt forests, and they were *Ictinaetus malayensis*, *Accipiter gularis*, *Aerodramus brevirostris*, *Psaltria exilis*, *Pteruthius flaviscapis*, *Cochoa azurea*, and *Cettia vulcania*. Such species as *Ictinaetus malayensis*, *Accipiler gularis*, and *Aerodramus brevirostris* would be difficult to record in unburnt forests since they would be flying over the canopy, and even when perched (i.e. *Ictinaetus malayensis* and *Accipiter gularis*) their very existence would be secretive, while *Aerodramus brevirostris* would prefer open areas for flying and foraging for flying insects.

On the other hand, the other eight species were only found in unburnt forests, i.e. *Megalaima corvina*, *Megalaima armillaris*, *Pomatorhinus montanus*, *Pneopyga pursilla*, *Brachypteryx montana*, *Orthotomus cuculatus*, *Ficedula hyperythra*, and *Lopozosterops javanieus*. These species would not be found in open areas such as those in burnt forests because their existence would depend on the abundance of forest vegetation. For example, *Megalaima corvina* and *Megalaima armillaris* need tall trees with dense leaves for perching, singing, and foraging which could not be found in burnt forests. While *Pomatorhinus montanus*, *Pneopyga pusilla*, *Brachypteryx montana*, *Orthotomus cuculatus*, *Ficedula hyperythra*, and *Lopozosterops javanicus* need dense ground vegetation or bushes and scrubs for their living activities.

Forest fires in G. Masigit had also affected the population of soil insects. The number of soil insects in burnt forest was significantly reduced (Table 4).

Direct effect of forest fires is estimated to have killed all species of small snake lizards, and turtles, because of their disability to escape from fires. Amphibian species which are able to jump on trees were also killed. Even iguana species was unable to escape from fires although they can move fast. Crocodiles and several other species which can live in deep water, such as lake and big rivers have chances to survive.

Table 3. Community structures of bird in burnt and unburnt forests in G.Gede Pangrango National Park

Species	Unburnt	Burnt
Ictinaetus malayensis	0.00	2.00
Aerodramus brevirostris	0.00	5.00
Harpactes reinwardtii	1.00	0.00
Megalaima corvina	1.00	0.00
Megalaima armillaris	1.00	0.00
Pericrocotus miniatus	22.00	5.00
Dicrurus remifer	1.00	1.00
Psaltria exilis	0.00	2.00
Parus major	15.00	3.00
Sitta azurea	5.00	12.00
Pomatorhinus montanus	2.00	0.00
Pnoepyga pusilla	1.00	0.00
Brachypteryx montana	3.00	0.00
Myophoneus glaucinus	1.00	3.00
Turdus poliocephalus	1.00	1.00
Phylloscopus trivirgatus	21.00	23.00
Orthotomus cuculatus	2.00	0.00
Cettia vulcania	0.00	2.00
Ficedula hyperythra	1.00	0.00
Ficedula westermanni	6.00	14.00
Culicicapa ceylonesis	15.00	5.00
Rhipidura phoenicura	9.00	2.00
Aethopyga eximia	9.00	7.00
Lopozosterops javanicus	2.00	0.00
The Shannon diversity index	1.06	0.99
Evenness	0.81	0.85
Number of species	20	15

Table 4. Number of insects recorded in G. Masigit

	Faeces		Chiken Meat	
	Unburnt	Burnt	Unburnt	Burnt
Predator	56	34	211	76
Scavenger	67	44	233	63
Phyto-phagus	1	1	0	2
Decomposer	67	12	36	3
Wood-borer	2	2	-	-
Parasitoid	14	3	13	5
Unknown	0	4	0	3

Long term effects of forest fires on the existence of amphibians and reptiles are especially on their damaged habitat, loss of place to lay eggs, water contamination, and decrease in food resources. Forest lizards were completely absent from burned areas of Bukit Barisan Selatan National Park one month after the 1997 fires, indicating that reptile mortality may have

been substantial (O'Brien *et al.* 1998). No lizards were found in open burned peat swamp in Central Kalimantan during a rapid WWF Indonesian survey immediately after the 1997 fires, but some snakes were found in nearby areas (Lilley 1998). Three land turtle species known to inhabit the area were not observed in burned and unburnt areas. Frogs and tadpoles were still observed in the survey areas.

IMPACT ON SOIL

Forest fires have apparently affected the soil. Based on the early observation on the newly established post forest fires plot indicated that the forest fires changed the soil organic contents, consistency and the activities of soil organisms. The total nitrogen content was much lower in the burnt soil, in contrast the sodium content was vice versa. The soil permeability of burnt andisol soil was very high (107 cm/hour). This condition was supported by the soil bulk density which less than one, high porosity, and this can easily create the landslide in the steep study site. During the observation the activities of soil microorganisms such as earthworms, ants etc., were not shown in the burnt soil.

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