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Effects of the 1997 Fires on the Forest and Wildlife of the Bukit Barisan Selatan National Park, Sumatra[1]

By

Timothy G. O'Brien[2], Margaret F. Kinnaird, Sunarto, Asri Dwiyahreni, William Rombang, and Kiki Anggraini

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2 Author to whom correspondence should be addressed.

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We would especially like to thank the staff of PHPA for their dedication in fighting fires at BBSNP. Without their help, the Way Canguk station would have burned.

Finally, we thank Cheryl Chetkiewicz for her time and effort in preparing this report for publication.

RINGKASAN

1. Kebakaran hutan yang baru terjadi di bagian Selatan Taman Nasional Bukit Barisan Selatan telah merusak sekitar 1300-1800 ha hutan, termasuk sebagian studi area Pusat Penelitian dan Pelatihan Way Canguk yang baru selesai dibuat. Survai dampak kebakaran dilakukan oleh PHPA dan WCS-IP untuk mengetahui luas dan tingkat kebakaran, serta dampak awal kebakaran terhadap vegetasi dan hidupan liar.

2. Kerusakan hutan tidak merata, dan berkisar dari kebakaran ringan di lantai hutan sampai dengan kebakaran besar yang merusak tajuk-tajuk pohon. Di dalam sampel hutan terbakar seluas 165 ha, 27% areal terbakar ringan di lantai hutan, 38% areal rusak terbakar di lantai hutan, dan 35% terbakar hebat sehingga menghancurkan lapisan semai dan pancang, serta merusak tajuk.

3. Burung dan mamalia berpindah dari daerah yang terbakar. Kepadatan sebagian besar jenis rangkong, ungulata, primata, bajing, dan tupai menurun setelah terjadi kebakaran. Kelimpahan jenis burung pemakan buah menurun sementara jenis pemakan serangga bertambah. Kelompok reptilia tampaknya paling menderita akibat kebakaran yang terjadi. Kura-kura, ular, dan kadal tidak terlihat setelah kebakaran. Musang dan beruang madu singgah di dekat daerah yang terbakar dan membuang kotorannya yang berisi biji-bijian pohon hutan, yang dapat menolong regenerasi hutan selanjutnya.

4. Kerusakan hutan akibat kebakaran tahun 1997, akan meningkatkan kemungkinan terjadi lagi kebakaran hutan, yang mungkin lebih besar, di masa datang. Terbukanya tajuk hutan dan rusaknya lapisan lantai hutan akan memudahkan masuknya jenis-jenis vegetasi eksotik. Bila vegetasi eksotik tersebut telah berkembang dan menetap, maka proses pemulihan hutan asli akan terhambat.

5. Dampak kebakaran terhadap hidupan liar, termasuk terjadinya stress pada satwa serta hilangnya tempat berlindung, pakan dan daerah teritori. Pemindahan jenis burung dan mamalia yang memiliki daerah teritori akan mengganggu keseimbangan lokal, dan akhirnya akan menyebabkan matinya hidupan liar tersebut akibat satwa yang terpaksa pindah tidak lagi memiliki tempat hidup. Hilangnya pohon berbuah akan menurunkan daya dukung lingkungan hutan, dan secara umum mengakibatkan turunnya kepadatan jenis-jenis yang bergantung pada buah sebagai pakannya. Rusaknya pohon-pohon berlubang serta batang -batang pohon rubuh mempengaruhi sebagian besar mamalia (rodentia, ungulata kecil, kelelawar, carnivora kecil) dan jenis-jenis burung yang bersarang di lubang pohon.

6. Direkomendasikan kepada PHPA untuk meningkatkan kegiatan patroli selama musim panas dan kebakaran, serta mendidik masyarakat lokal untuk selalu memonitor kebakaran. Kebakaran areal hutan taman nasional yang berada dekat kebun dan kebakaran kebun yang berada dalam taman nasional, tidak dapat ditoleransi. PHPA dapat memulai kerja sama dengan fakultas kehutanan di berbagai universitas (mis. UNILA, IPB) untuk melatih para mahasiswa dalam metode penanggulangan kebakaran hutan, sehingga di masa datang dapat diperoleh tenaga yang memadai untuk melawan kebakaran hutan.

EXECUTIVE SUMMARY

1. Recent fires in the southern portion of the BBSNP damaged an estimated 1,300-1,800 hectares of forest, including portions of the recently established study site of the Way Canguk Research and Training Center. Surveys were conducted by PHPA and WCS-IP to determine the extent of the burn and initial effects of the burn on vegetation and wildlife.

2. Damage to forests was uneven, and ranged from light ground fires to crown fires that destroyed canopy trees. Within a 165 hectare sample of burned forest, 27% of the burn was light ground fire, 38% damaged the understory, and 35% was severe, destroying the seedling and sapling layer and causing damage to the canopy.

3. Mobile birds and mammals responded to the fire by moving out of the burn area. Densities of most hornbills, ungulates, primates, squirrels and treeshrews declined following the burn. Among birds, abundance of fruit-eating birds declined while insectivorous birds such as woodpeckers increased. Reptiles apparently suffered most; tortoises, snakes and lizards were not seen alive after the burn. Civets and sun bears are present in the area immediately adjacent to the burn and are defecating seeds of forest trees, which should aid in regeneration of the damaged area.

4. Damage from the 1997 fire will increase the likelihood and severity of future fires. Opening of the canopy and destruction of large areas of understory promotes invasion by exotic vegetation. If this vegetation becomes established, it will slow forest recovery.

5. Effects on wildlife include stress and loss of shelter, food and territories. Displacement of territorial birds and mammals may upset the local balance and ultimately result in the loss of wildlife, since displaced individuals have no where to go. Loss of food trees reduces the carrying capacity of the forest, causing an overall decline in species that rely on fruits for food. The destruction of standing cavity trees as well as dead logs on the ground affects most mammals species (rodents, small ungulates, bats, small carnivores) and cavity nesting birds.

6. We recommend that PHPA increase boundary patrolling during the burn season and educate local people to monitor burning activities. The burning of park forest lands adjacent to ladang areas and of ladang within the park should not be tolerated. PHPA should work with provincial forestry schools, for example, Universitas Lampung **(**UNILA) and Institut Petanian Bogor (IPB), to train students in fire-fighting methods so there is adequate manpower to fight future fires.

INTRODUCTION

Indonesia has been experiencing large scale forest fires that have had profound consequences for the environment, vegetation and wildlife. In 1982/1983 fires in Kalimantan affected an estimated 3.6 million hectares of forest, led to local extinctions of some plant and animal species, and resulted in major economic losses to the forestry, nontimber forest products and agriculture sectors (Lennertz and Panzer 1983, Mackie 1984, Leighton and Wirawan 1986, Petocz *et al*. 1990). Destructive logging practices, plantation clearing and slash-and-burn agriculture, exacerbated by severe drought, are blamed for Indonesia's increasingly frequent large-scale fires (MacKinnon *et al*. 1996).

This year, continued land clearing and severe drought associated with the El Niño Southern Oscillation phenomenon (Cane 1983) once again resulted in disastrous, large scale wildfires on Kalimantan, Sumatra, Sulawesi, and Irian Jaya. The extent of forest damage and loss of biodiversity is still unknown. Given the greater number of timber concessions and increases in agroforestry plantation development and slash-and-burn agriculture relative to 1982/1983, we suspect the extent of damage is much greater.

The greatest loss of biodiversity most likely comes from the burning of parks and protected areas. These areas were chosen to protect and preserve Indonesia's abundant and often unique flora and fauna. Since August 1997, fires damaged at least 17 of Indonesia's parks and protected areas (Supriatna, pers. com). Although undisturbed rainforests of the tropics have generally been thought not to be susceptible to fire (Whitmore 1985), fire is becoming an increasingly common phenomenon (Woods 1989) and now poses a growing but poorly understood threat to the parks and protected areas of Indonesia. In this report, we present findings concerning the damage caused by fires to the biodiversity of the BBSNP in Lampung Province, Sumatra.

BACKGROUND

The BBSNP is the third largest protected area (3,568 km^2) in Sumatra. Located in the extreme south-west of Sumatra, the park straddles the Provinces of Bengkulu and Lampung, extending 120 km in a narrow band along the Barisan mountain range from Tanjung Belimbing northward (Figure 1).

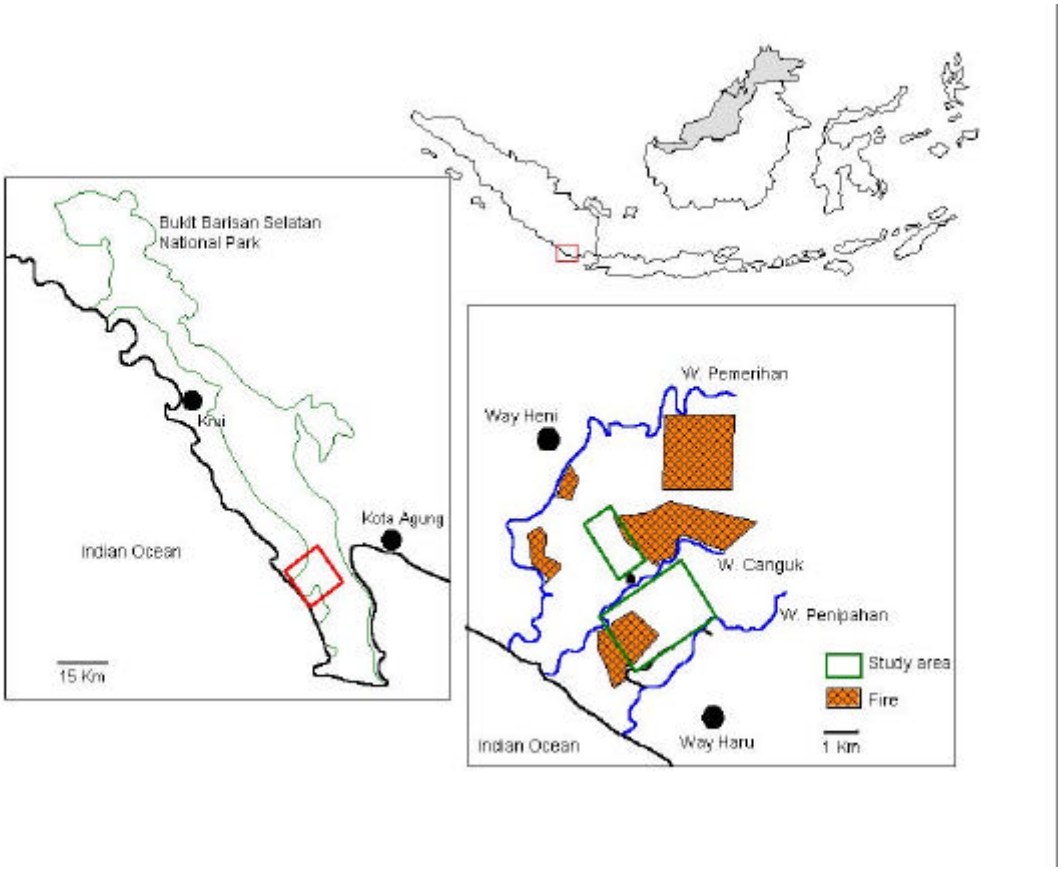


Figure 1. Location of study area.

The long and narrow shape of the park results in a 700 km boundary, and extensive development activity, especially small scale agriculture and logging, is occurring on the boundary and within the park. The park contains some of the last intact areas of lowland rainforest in Sumatra and supports a complete vertebrate fauna, including Sumatran rhino, Sumatran tiger, clouded leopard, Asian dhole, Asian elephant, Malay tapir, 7 hornbill species, and the recently re-discovered giant pitta (O'Brien and Kinnaird 1996).

In March 1997, PHPA and the Wildlife Conservation Society established the Way Canguk Research and Training Center with the objective of training PHPA guards and Indonesian biologists, and to collect basic data on biodiversity within the park. The station is located in lowland forest between the village of Way Heni and the enclave of Way Haru. The study area includes approximately 800

hectares of lowland forest (divided into a 600 ha southern site and a 200 ha northern site) that is used for monitoring wildlife and vegetation. The vegetation is a mosaic of primary forest (50%), lightly disturbed forest (27%), and previously burned forest (23%), the latter category resulting from fires during the 1992/1993 drought.

During the 6 months preceding the fires, rainfall at Way Canguk totaled only 21 mm, with the months of August, September and October experiencing no rainfall. Western parts of BBSNP normally experience up to four meters of rainfall annually. The drought dried out the forest and water stress caused many evergreen trees to shed their leaves, which led to an accumulation of dry litter and provided abundant fuel for the fires. On 27 September 1997, fires entered the northern study area and on 12 October 1997, fire was reported in the southern study area. PHPA spent more than one month fighting these and three other fires in the area. Between 1300 and 1800 hectares of forest burned in and around the study area (Figure 1: *note that only one of the three fires along the Way Pemerihan was measured completely*).

Approximately 165 hectares were damaged in the southern study area, but less than 15 hectares were damaged in the north study area. All fires were caused by human carelessness. An untended campfire was the source of one fire and two others were started from uncontrolled fires used to clear nearby agricultural lands. The fire in the northern section of our study area probably was started by hunters as there are no nearby agricultural fields.

METHODS

Vegetation

To determine the extent and intensity of the fire in the southern study area, we walked transects spaced 200 m apart, and at 50 m intervals we recorded the presence and intensity of fire on each side of the transect. Fire damage was classified as: 0) no burn; 1) light ground fire that destroyed the litter (dead leaf) layer and lightly damaged the sapling layer but most saplings still with green leaves; 2) sapling layer severely damaged up to 5 m and some damage to canopy trees; and 3) sapling layer destroyed, mid-canopy severely damaged and canopy damaged.

We established 100 vegetation plots (50 m x 10 m) in the study area prior to the fires. In these plots we measured, tagged, mapped all trees $\geq$ 10 cm diameter at breast height (dbh) and made preliminary identifications (n=2,107 trees). After the burn, we assessed damage to tagged trees in plots occurring within the burned area (n=15 plots). Tree damage was assessed as: 0) fire did not touch tree; 1) fire touched tree but no damage was incurred; 2) fire touched tree and tree's bark was burned; 3) fire touched tree and tree was burned into the cambium; and 4) fire touched tree and tree incurred severe damage to its cambium (>50% of the bole burned) or fell as a result of burning. We also walked fixed width transects (100 m wide) to estimate the extent of damage to live canopy-sized trees and those trees that were dead but standing.

Wildlife

We used several methods to assess the effect of fire on wildlife. First, we thoroughly searched all vegetation plots within the burned area for carcasses. Next, we walked all transects within the burned area (21 km) immediately after the fire (mid-October) and one month after the fire (mid-November) and recorded all encounters with or sign of mammals and reptiles. Encounter rates were calculated as the number of encounters/hour for other mammals, and used as indices of abundance. Finally, we conducted systematic pre- and post-burn surveys using line transects for hornbills, primates, squirrels and treeshrews, and variable circular plot method (VCP) for birds other than hornbills. VCP sampling was conducted three times before and two times after the burn, and all observation points (n=35) were located within the burn area. Line transects for squirrels and primates were conducted four times before and two times after the fires along 8.8 km of trails in and immediately adjacent to the burned area. Because hornbill densities are low, 22 kilometers of transects were walked on a bi-weekly basis five times before the fires and three times after the fires.

RESULTS

Vegetation

Fire burned approximately 165 hectares of forest, including nearly 100 hectares of forest damaged by fires in 1993, as well as intact, primary forest. Fire damage, however, was patchy; 27% of the burned area was classified as damage level 1, 38% was classified as damage level 2 and 35% was classified as damage level 3. Forest previously damaged by fire burned more than expected based on the distribution of habitat type in the study area, and closed canopy forest burned less than expected ($\chi^2 = 21.67$, d.f. = 4, $P < 0.001$).

Within the 15 burned vegetation plots, 5 plots suffered damage level 1 fires, 6 plots suffered damage level 2 fires and 4 plots suffered damage level 3 fires. Fire touched 88% of all trees in the plots but only 53% of trees were actually damaged. Of these, 81.3% were superficially burned on the bark only, 16.3 % were damaged to the cambium layer and 2.4% of the trees were killed. The fixed width transect estimate of canopy tree death was higher than estimates from plots (4.6% of the canopy trees killed, or 2.5 trees killed/ha). Damage to dead but standing trees was estimated at 16 trees/ha.

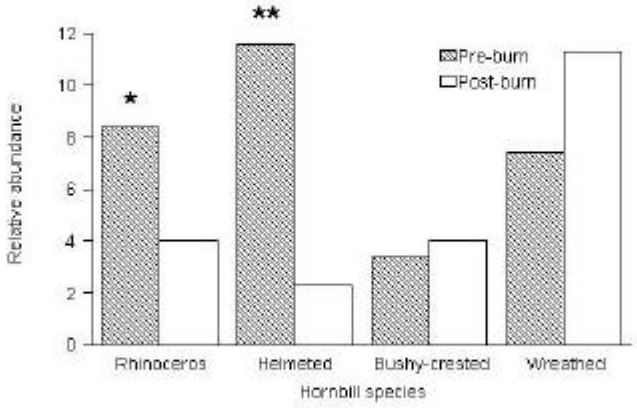
Among the currently burned plots, 2/3 had suffered fire damage from the 1992/1993 fires. The ratio of damaged to undamaged trees was 2.4 times higher (2.1 vs. 0.88) in previously burned plots compared to those that had not burned before this year. In the previously burned plots, overall tree density was 40% lower and large canopy trees were 50% less abundant than in unburned plots. Unburned plots had, on average, 23 tree stems $\geq$10 cm dbh and 2 trees greater than 50 cm DBH, whereas plots in previously burned areas had only 14 stems $\geq$ 10 cm dbh and 1 tree greater than 50 cm.

Wildlife

Hornbills

Although 7 hornbill species occur within the study area, only 4 species, the Rhinoceros (*Buceros rhinoceros*), the Helmeted (*B. vigil*), the Wreathed (*Aceros undulatus*), and the Bushy-crested (*Anorrhinus galeritus*) hornbills are common enough to detect changes due to the fire. Comparisons between encounter rates and density estimates from bimonthly pre- and post-burn surveys show that the four species differed in their response to the fire (Figure 2).

Figure 2. Relative abundance of 4 hornbill species pre- and post- burn. Astrisks denote significance at the P<0.05 (*) and P<0.01 levels.



Encounter rates for the larger, more frugivorous Helmeted and Rhinoceros hornbills declined significantly after the fire, reflecting a 50% change in density for each species. Encounter rates for Bushy-crested and Wreathed hornbills, species that we suspect were nesting during the fires, did not change.

Other Birds

Species richness and the total number of individuals for all species was similar before and after the burn (Table 1).

Table 1. Number of bird species and individuals (N) pre- and post-burn by diet type. Frugivore includes frugivore/insectivore feeding guild.

Census	Frugivore		Insectivore		Carnivore	
Period	# Species	N	# Species	N	# Species	N
Pre-Burn						
1	22	93	14	35	1	1
2	27	123	23	78	0	0
3	17	61	24	91	2	4
Post-Burn						
1	24	81	26	102	0	0
2	11	54	21	76	2	2

The fires however, affected species composition. The number of species and individuals relying on a mixed diet of fruits and insects declined after the fire while the number of species and individuals relying entirely on insects increased after the fire. Interestingly, mixed diet species declined by four species while insectivores increased by four species. Similarly, the changes in numbers of individuals showed opposite trends, with mixed diet species declining by 13 percent and insectivores increasing by 15 percent.

Primates

Leaf monkeys (*Presbytis melalophus*), siamangs (*Hylobates syndactylus*) and pig-tail macaques (*Macaca nemestrina*) were present in the survey area prior to the fire only leaf monkeys and pig-tails were observed after the burn (Table 2).

Table 2. Relative abundance of primate groups by species pre- and post-burn and the percentage of sightings within the boundaries of the burned area before and after the fire.

Species	Relative abundance		% in burned area	
	Pre-burn	Post-burn	Pre-burn	Post-burn
Presbytis melalophus	4.75	7	50	29
Hylobates syndactylus	5	0	26	0
Hylobates agilis	0	0.5	0	0
Macaca nemestrina	0.5	2.0	0	50

Post-fire surveys found no siamang in or immediately around the burned area suggesting that siamang have been eliminated from or have fled the area. Opportunistic sightings of siamang in unburned sections of the study area were of single males (n=2) and a pair of young males, possibly dispersing from their family groups. Leaf monkey groups were sighted more frequently after the fire than before, however the percent of sightings within the burned area was much lower after the fire (Table 2) suggesting that leaf monkeys shifted to the edge of the burn area. Gibbons were never observed in the burned area either before or after the fires. One gibbon group however was observed in intact forest adjacent to the burned area after the fire. Pig-tail macaques were observed within the burn zone only after the fire during systematic surveys. Opportunistic sightings however, indicate that macaques were using the area before the fires.

Squirrels and treeshrews

Squirrel and tupai sightings declined dramatically after the fire with the exception of *Ratufa* spp (Table 3).

Table 3. Number of squirrel sightings by species pre- and post-burn and the percentage of sightings within the boundaries of the burned area before and after the fire.

Species	Number of sightings		% in burned habitat	
	Pre-burn	Post-burn	Pre-burn	Post-burn
Tupaia spp.	16	6	38	50
Ratufa spp.	7	12	14	67
Callosciurus notatus	31	7	23	29
Sundasciurus hippurus	3	0	66	0
Lariscus insignis	20	9	50	44

The horse-tailed squirrel (*Sundasciurus hippurus*), a primary forest specialist in BBSNP, disappeared completely from the burned and adjacent areas. *Ratufa* spp. Increased both in number of sightings and in the percent occurrence in the burn area. Most of these sightings, however were at the edge of the burn where squirrels were feeding in a fruiting tree (Burseraceae). Terrestrial treeshrews (*Tupaia* spp.) and plantain squirrels (*Callosciurus notatus*) decreased post-burn but were observed more often in the burn area than in forest adjacent to the burn. This may be due to better visibility of ground-dwelling animals in the burn area. Three-striped ground squirrel (*Lariscus insignis*) also declined post-fire.

Large ungulates and carnivores

Relative abundance of most large ungulates declined after the fires (Table 4).

Table 4. Relative abundance of ungulates (number of observations per hour) pre- and post-burn.

Species	Pre-Burn	Post-Burn	
		Burn Area	Adjacent
Tragulus spp.	0.09	0.08	0.15
Muntiacus muntjac	0.14	0.0	0.23
Sus scrofa	0.19	0.08	0.08

Relative abundance of mouse deer in the burn area did not change, but mouse deer (*Tragulus napu*) were more abundant in forest adjacent to the burn than in the burn area. Sambar deer (*Cervus unicolor*) were not seen before or after the fires, but they are the most nocturnal deer species and are rarely observed during the day. Pigs (*Sus scrofa*) appear to have been most strongly affected by the fire.

Carnivore species continue to use or pass through the burn area. We found numerous scats of civets as well as sun bear within the burn zone. We also found the tracks of a tiger at 2 sites 200 m apart along a trail through the burn area.

DISCUSSION

Vegetation

Fire damage has had three major consequences for the forests of Bukit Barisan Selatan National Park: 1) It has adversely affected forest regeneration and recovery from the 1992-1993 fire; 2) It has reduced the value of the burned areas as wildlife habitat; and 3) It has increased the likelihood of invasion by exotic plant species. Although the fire did not kill large numbers of live canopy trees outright, many canopy trees are severely damaged but still standing. Canopy mortality estimates will undoubtedly increase over the next 12-24 months as severely injured trees fall, or die from secondary infections of insects, fungus and pathogens. The loss of live canopy trees opens the lower strata of forest to light, increasing the opportunity for regeneration by generalist trees and other sun-loving plants. The extensive damage and loss of the sapling and seedling layer will impede forest regeneration and increases the likelihood that herbaceous plants will establish. Preliminary sampling of seedlings and saplings, showed seedling mortality ranged from 70 to 100%, and sapling mortality ranged from 25 to 70%. During our surveys we noted alang-alang grass, regenerating ginger, the exotic *Lantana* sp., and *Cromolaena odorata* already invading areas that were previously covered with a layer of seedlings and saplings. If alang-alang or exotic shrubs become established, forest quality will suffer. If ginger becomes dominant, forest quality may suffer but habitat for elephants, Sumatran rhino and other ungulates may improve.

Degraded forest has a higher probability of suffering severe burns in the future. Previous burns resulted in the loss of 40% of the canopy trees in the area burned this year, and damage from this year's fire was twice as great in the previously burned areas. As trees die from the current fire, the amount of fuelwood on the forest floor and the number of standing dead trees (snags) will increase. In this fire, we lost an average of 16 dead standing trees/ha. As the snags burn, they fall and facilitate the spread of fires, especially across firebreaks. Finally, the opening of the canopy increases the amount of herbaceous vegetation in the understory and this vegetation often dies and dries quickly during a drought, increasing the availability of fuel.

Wildlife

Because most wildlife species can move away from burning areas, fire is rarely considered harmful (Singer *et al.* 1989; Rabinowitz 1990). The lack of carcasses in the burn area is an indication that most mobile birds and mammals were able to escape the burn. Forest lizards such as skinks (*Mabuya* spp., *Sphenomorphus* spp.), flying lizards (*Draco* spp.) and geckos (*Cnemaspis* sp. and *Peropus* sp.), however, were absent from the burn area even one month after the fire, an indication that reptile mortality may have been substantial. Mobility of birds and mammals is no guarantee that they will escape consequences of the fire. Three aspects of species' ecologies render them susceptible to negative effects of fire: shelter requirements, dietary preferences and territoriality.

The effect of fire on food supply is most apparent for birds. Species that rely primarily on fruit were less common after the burn. Hornbills, barbets, flowerpeckers, and sunbirds rely heavily on

fruits, and most declined after the fire. These species likely found less fruit to eat in the burn area and either shifted to insect foraging or moved to adjacent non-burned areas. Insect specialists became more abundant after the fires. Increases in the occurrence of woodpeckers, and foliage foragers (malkohas and leafbirds) were noticeable after the fire, as they could easily take advantage of insects on dead trees and leaves.

Among mammals, the loss of fruit trees reduces food availability to a large number of omnivorous species, such as primates, squirrels and treeshrews, sun bears, and civets, as well as ungulates such as mouse deer and muntjac. The reduction in densities of ground squirrels and treeshrews suggests that rodent densities in general may have declined which will adversely affect the food supply of small carnivores such as leopard cat, marbled cat, and some civets. Finally, the extensive fires destroyed the leaf litter and its associated arthropod community, further reducing food availability for omnivores and carnivores.

The destruction of dead logs on the ground and standing dead trees with cavities probably affects a large number of bird mammals and reptiles that require shelter. Many lizards and snakes use the shelter of dead tree branches and logs on the forest floor to escape predators. Squirrels, rodents, mouse deer, red muntjac, civets, small cats, also use logs on the forest floor as shelter and, in some cases, as foraging substrates. More than 20% of the lowland birds in BBSNP require tree cavities for nesting. Tarsiers, flying lemurs, bats, rodents also use tree cavities as shelter or roost sites.

The ability to escape direct mortality from the fire by moving is only a temporary respite for territorial species. If they cannot find a new space to settle in, they will eventually die. Displaced territorial species lose all the benefits associated of familiarity with their home range. They are harassed while moving through territories of conspecifics, they do not have easy access to fruit resources, and they are more vulnerable to predation. As refugees attempt to develop new territories, there may be extensive local disruption of the social systems as territories are realigned to accommodate the influx of animals. Among siamangs, we noticed an increase in encounters with lone (probably dispersing) males following the fires. We have no idea of the fates of family groups that formerly inhabited the burn area.

The changes in wildlife abundance after fire in BBSNP are similar to those reported elsewhere. The 1982/1983 fires in Kutai National Park resulted in widespread mortality of reptiles and amphibians, and surviving animals had to contend with decreased food resources due to the loss of fruiting trees (MacKinnon *et al*. 1996, Leighton and Wirawan 1986). Fruit-eating birds and mammals in Kutai declined dramatically and only insectivorous birds, such as woodpeckers, were common. Population densities of large-bodied primates were less affected in Kutai than in BBSNP but most species changed feeding behavior in response to loss of fruit trees. Similarly, Rabinowitz (1990) reports that burned Dipterocarp forest in Thailand is impoverished of small mammals, birds and reptiles, and that carnivores tend to avoid burned over areas.

We have established a long-term monitoring program to evaluate the recovery of vegetation and wildlife from the 1997 fires. We are currently monitoring 30 burned and 10 control plots near Way Canguk. We will document the survival of trees, saplings and seedlings, monitor regeneration, and evaluate invasion by exotics and grasses. Finally, we will continue to monitor the use of the area by wildlife.

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