Response and impact of fire on bird community in the tropical rainforest: a review

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Abstract. Tropical rainforests are often catch by fires. Unfortunately, study on bird community and fire incident was lacking and strongly biased toward temperate forest. The objective of this paper was to provide a review on the response and impact of fire on bird communities inhabiting a tropical rainforest, through an intensive relevant literature review. Most birds are capable to escape fires through flying, although some nestlings, poor fliers and terrestrial birds might not. Thus, direct impacts of the smoke and flames are less significant compared to the indirect effects on habitat alteration. During fires, some birds might respond positively: raptors might circle over fires searching for small mammals exposed on the ground, while insectivorous birds might catch insects in a smoke column. After the fire, habitat was altered, food supply might change (decreased for most birds), while bird community composition might change due to the shift of the population of competitors or predators. Previous studies showed that effects of fire on bird community and their habitat varied widely. In Sumatra and Kalimantan, after fire insectivorous species increased, while the number of frugivorous and omnivorous birds were declined. When fires become too frequent and too intensive, however, vegetation will not able to recover and might lead to the situation where recovery of habitat and the bird community becomes impossible.

Keywords: bird community, forest fire, habitat, insectivores, raptors

1. Introduction
When an Indonesian forest catch a fire, the first issue that draw everybody’s attention is the health and safety of the people living and around the forest. Other concerns are usually related to the intensity of flame and smoke, carbon emission released in the ecosystem, disruption of nutrient cycle, burned litter and its microorganism. Wildlife, however, has been received low concern in the forest fire incident, mostly because it is assumed that wildlife species – especially birds – are able to escape the fire, then later on would establish themselves in a new unburned area.

During and after fire, do we really have to worry about birds, simply because they can fly? Study on forest fire and birds in Indonesia and other tropical Southeast Asian countries are very limited compare to those in the temperate countries. Thus, the response of bird (and other wildlife) to forest fire is poorly understood and could be very dynamic and complex.

The effects of fire to bird community highly varies. It may be instant and direct through immediate mortality, delayed (i.e. survive temporary but eventually die), or adapted to the post-fire condition [1]. Fire can affect forest birds negatively or positively, depending on the type (floor or canopy fire),
intensity (coverage), and duration, as well as the life history of the bird species being studied [2]. Overall, the response of bird species to fire until now is poorly understood [3].

This paper explored what might happened to bird communities in the tropical forest in Indonesia during and immediately after fire, as well as the impact of the fire on birds’ habitat. Information was gathered through an intensive study literature on the impact of forest fire on birds, in Indonesia and other countries as well. The scope of this paper would be limited to the lowland tropical forest in general, although Indonesia also has some other habitat types such as tropical savanna, mangroves, and montane forest.

2. Response of birds during and after fires

Even though fire is a dramatic event that quite frequently happened in the tropics, direct effects of forest fire to birds are considered to be minor [2,4]. However, flightless birds or nesting birds [4] as well as nestlings and fledglings [5] might be very risky from fire, and they could die due to succumbed to smoke asphyxiation [4].

Certain bird species are actually attracted to active burns, including some raptors and scavengers, because their prey is more exposed than on unburned sites [5]. Insectivorous birds might catch insects in a smoke column [6]. Woodpeckers also attracted to burned areas, mainly due to abundant food supply of wood-boring beetles. Recent study on Black-backed Woodpeckers in California (US) showed that the woodpeckers tended to select nest tree in high burn severity forest patches, preferably within 500 m of low-severity patches or unburned edge [7].

In the US, quail will feast on insects and seeds in the edge of burning habitat, even before the vegetation (i.e. grassland) stops smoking. Another species, bobwhites, thrive in areas where frequent fires happened and eliminating woody cover, while wild turkeys frequently spotted congregated and feed on freshly burned areas [8]. In Australia, birds attracted to the fire are wood swallows and swifts. These species have been known to make regional-scale movements to track the fires for insect food. Further, some birds, including butcherbirds, bustards, crows, ibis, magpie-larks and kingfishers are also attracted to the carrion in the immediate aftermath of fires. Recent burnt areas attract various granivores (seed-eating), carnivores, and insectivores because the open grounds are easier to forage [9].

Long term (100 year) response of bird to fire was examined intensively in south-eastern Australia, in a semiarid shrubland habitat. Modelling of bird response revealed that there were six main responses (Figure 1), consistent with generalized response shapes, namely incline response, decline response, bell response, plateau, irruptive response, and null response [3]. This means that maintaining several seral stages is important for bird habitat, mainly the mid- to late-successional vegetation (more than 20 years). This important finding, however, need to be tested in the tropical rainforest, as bird community and its responses maybe differ than semiarid shrubland habitat.

![Figure 1](image-url)
3. **Indirect impact of fires on bird habitat**

The indirect impact of fires on birds is basically related to the post-fire bird habitat. The impact depends greatly on the fire regime. Fire regime is defined as the pattern of fire over time, including intensity, frequency, seasonality, interval between fires, extent and patchiness [9]. The fire caused a strong reduction of foliage in the middle and upper forest canopy, and hence seriously reduce the availability of vertical resources for birds [10].

The elimination or reduction of food and cover for some bird species might leads to starvation, predation or migration (emigration or immigration). Bird species well suited to more open habitats, mainly insectivores and granivores (seed-eaters) may immigrate temporarily from adjacent areas take advantage of an insect flush and seeds generated by the fire [9]. In the tropics, the ex-burned forest also becomes more vulnerable to invasion by weedy grasses and vines. This is because the seed bank is dramatically reduced, creating the condition (mainly abundance of light and low humidity) that favour the establishment of grasses and vines [11].

Post-fire study in Kalimantan unveiled that three year after fire, the bird species and number actually were similar for burned forests and unburned forest. However, species composition, diversity, and turnover differed between the two habitats. The bird species composition differed significantly between undisturbed and burned forests, with a strong decreased in birds preferring closed forest and strong increased in birds prefer open areas. The species diversity and species turnover were significantly lower in the burned forests. As for species diversity, the birds in the burned forest were highly dominated by a few abundant taxa than the unburned forests. Species turnover (i.e., difference in species composition among/ between different sample points) were lower in the burned forest [10].

When an area is unburnt for five or more years, a diverse mid-story shrub develops and regeneration continues. Vegetation diversity, height, and cover increase over time since fire. The change in vegetation as birds’ habitat inevitably favor some bird species but disadvantage others [12]. As habitat regeneration resumes, bird species before the fire begin to return to the ex-burned area. Most populations are able to recover within three to ten years, while a few will take longer (even decades) to return to pre-fire population number. In a slow-regenerate habitat (e.g. old-growth forest), cavity-nesting birds and canopy feeders may still be absent or less abundant decades after an intense fire [9].

4. **Impact of fire on birds based on foraging guild**

The impact of fire has been known to be strongly influenced by foraging guilds (i.e. birds’ main food and the technique to get the food). Some bird species might take advantage of the post-fire habitat, causing population increase, while others might experience population decrease. In the Brazilian Amazonia, arboreal granivores and nectarivores became more abundant after fire, while the rest of the foraging guilds (including insectivores) decreased (Table 1) [13]. This result was differed to a study conducted in Sumatra, where it was insectivorous and foliage gleaners that increased in their abundance after fire (Table 2) [14].

Clearly, the impact of fire on birds is complex and dynamics and might affected by many factors, including the fire severity. Based on the study on the impact of fire on birds according to fire severity gradient in New Mexico, USA, has resulted a response class [15] as shown in Table 3.
Table 1. Impact of ground fires on understory bird community in the tropical forest of central Brazilian Amazonia (modified from [13]).

| Foraging guild                             | Guild explanation                                                                 | Impact on Population |
|--------------------------------------------|----------------------------------------------------------------------------------|----------------------|
| Insectivores                               | Feed on insects                                                                 |                      |
| Terrestrial gleaning                       | Searching insect on forest floor                                                  | Decreased            |
| Ant followers                              | Feed almost exclusively on ants on the forest floor                               | Decreased            |
| Dead-leaf gleaning                         | Searching insect from dead leaves (mostly suspended), may occur near the ground to the top of the canopy | Decreased            |
| Arboreal gleaning                          | Searching insect among, within forest canopy, or among tree stands                | Decreased            |
| Bark searching insectivores                | Searching insect through bark excavation                                          | Decreased            |
| Frugivores (arboreal)                      | Feed on fruit, mostly small-sized fruit, including figs                           | Decreased            |
| Omnivores                                  | Feed on various food sources                                                      | Decreased            |
| Nectarivores                               | Feed on nectar of flowering trees                                                 | Increased            |
| Granivores (arboreal)                      | Feed on seeds and other grains                                                    | Increased            |

Table 2. Impact of fires on bird community in Bukit Barisan Selatan National Park, Sumatra, Indonesia (modified from [14]).

| Foraging guild                             | Examples                                                                 | Impact                                                   |
|--------------------------------------------|--------------------------------------------------------------------------|----------------------------------------------------------|
| Frugivores (small size)                    | Barbets (Megalaima spp.)                                                 | Decreased, most likely migrated to adjacent forest       |
| Frugivores (large size)                    | • Helmeted Hornbills (Rhinoplax vigil)                                    | Decreased by 50%                                        |
|                                            | • Rhinoceros Hornbills (Buceros rhinoceros)                               | Decreased by 50%                                        |
|                                            | • Bushy-crested Hornbills (Anorrhinus galeritus)                          | Did not change                                          |
|                                            | • Wreathed Hornbills (Rhyticeros undulates)                               | Did not change                                          |
| Nectarivores                               | • Sunbirds (Aethyopyga spp., Anthreptes spp., Nectarinia spp.)            | Decreased, most likely migrated to adjacent forest       |
|                                            | • Flowerpeckers (Dicaeum spp.).                                           | Decreased, most likely migrated to adjacent forest       |
| Insectivores - bark searching              | Woodpeckers (Picus spp., Picoides spp.)                                   | Increased                                               |
| Foliage gleaners                           | • Malkohas (Phaenicophaeus spp.)                                          | Increased                                               |
|                                            | • Leafbirds (Chloropsis spp.)                                              | Increased                                               |
Table 3. Impact of fire on birds according to fire severity gradient study in New Mexico, USA, classified based on response class and bird guild (modified from [15]).

| Response class | Trend in bird density with increase fire severity | Foraging guild |
|----------------|--------------------------------------------------|----------------|
| **Negative response to fire** | | |
| I | Strong declines | • Sub-canopy aerial insectivores |
|  |  | • Ground foragers |
|  |  | • Foliage gleaners |
| II | Weak declines | • Cavity nester |
|  |  | • Aerial insectivores |
| III | No significant differences across the fire severity gradient | • Ground foragers |
|  |  | • Mixed open canopies species |
| **Positive response to fire** | | |
| IV | Reach peak densities at low or moderate fire severity | Shrub layer species |
| V | Weak positive responses across the fire severity gradient | Bird species associated with snags or vegetation which may rapidly increase immediately post-fire. |
| VI | Strong increases with increasing fire severity | • Aerial insectivores |
|  |  | • Cavity nester |

5. Management implication

In the temperate countries, fire often has been used as an efficient technique of wildlife habitat improvement through prescribed burning. However, prescribed burning is seldom or even never used in Indonesia’s conservation areas or other forest. High intensity fires are more frequent in Indonesia, and - in many cases - happened in vast areas. When fires become too frequent and too intensive, however, vegetation will not able to recover and might lead to the situation where recovery of habitat and the bird community becomes impossible, as also warned by [10].

In Indonesia, fires might influence bird community indirectly through habitat modification, including habitat elimination or destruction (in a landscape scale), changes in habitat components (including food supply, cover, nesting site, roosting site, water body as part of bird’s habitat), or changes in abundance of competitors and/or predators. After fire, illegal hunting might increase following the diminishing or decreasing forest as cover, although there has been no published report to confirm this.

Knowledge on the impact of fire on birds and other wildlife need to be studied further, considering the poor understanding on this matter, mainly in the tropical rainforest of Indonesia. Wildfires are basically unplanned events and thus pre-fire data on bird diversity and density rarely exist, including in the tropical forest of Indonesia. Effect of fire on bird community typically has been evaluated by using an impact–reference approach, including BACIP (Before-After-Control-Impact design with Paired sampling) [16], in which burned sites are compared to unburned reference sites.
6. Conclusion
Forest fires are always devastated to the ecosystem, including to birds. Although most birds can fly to avoid fire, not all bird species are fortunate to be able to avoid the fire, including young birds, flightless birds, and weak fliers. After fire, bird composition would most likely change. Impact of fires on birds’ habitat could be long-term, and even might irreversible, as the fire could destroy habitat that provided food, cover, and nesting areas for birds.

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