Is it true that forest and land fires caused the extinction of biodiversity...?

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Abstract. Every year forest fire are raging across Indonesia, causing economic and ecological losses. The thought that forest fire is pushing species towards extinction resulted in a lawsuit against fires in industrial forest, although the lawsuit sometimes are not based on scientifically studies. Since 2015 some studies has been held to learn more about the effect of forest fire on species diversity. Based on the word meaning of extinction, it shows that forest fires did not cause an extinction of a species, when a species is extinct or gone in some areas but still can be found in another areas, it is called extirpation. Extinct is when no doubt that the last individual species in the world is died. Furthermore, based on many researches that have been held before, 29% research showed that the fire impact on the decrease of the species number, while 58% showed the increasing impact and 13% resulted in no change. In line with that, the impact on species richness resulted with 27% of decrease, 61% increase, 12% has no change. Meanwhile on the impact of species composition, 33% research mention that there are change 50-75% in species composition and 67% research mention that there are <50% change in species composition. The opposite of the most lawsuit that has been given, it showed that fire impact tends to increase the number of species and species richness, compared to the value of the decrease, with tendencies that the change in species composition is not significant (<50%). In conclusion, forest fire did not result in species extinction, it results in the form of a decrease and or even an increase in the number of species or species richness index and changes in species composition.

1. Introduction
After the 1997/98 El Nino (ENSO) disaster which devastated 25 million hectares of forest worldwide [1], forest and land fires are not only a national issue, but also a regional issue and have even attracted international attention as an environmental and economic issue. Specifically for Indonesia, The World Bank [2] estimates that losses from fires in Indonesia in 2015 are estimated to reach IDR221 trillion or around US $ 16.1 billion. The fires that occurred in Indonesia continued to increase from 2017 to 2019, in 2017 the area of fires from 165,483.92 ha, drastically increased to 1,592,010 in 2019, where the worst area that caught on fire was in Central Kalimantan with total of 303,881 ha and South Sumatera with total of 328,457 ha [3].

Forest and land fires are one of the events that cause the most losses compared to other forest disturbing and destructive factors. Fire is the biggest threat to biodiversity worldwide [4], including in Indonesia. One of the losses from forest fires is the decrease in wildlife diversity due to loss of native habitat [5]. On the other hand, several researchers Komarek [6], Floyd [7], Fredericksen and Fredericksen [8], Purba [9], Nugroho [10] suggested that fires can increase the number of species, both undergrowth and wildlife. This contradiction is very interesting to be studied further through searches of publications on the topic "the impact of forest and land fires on the diversity of wildlife species" so
that it will be able to answer the public question "is it true that forest and land fires cause the extinction of biodiversity…?".

2. Method
The data and information presented in the results and discussion below are all obtained from the results of a literature review of 20 scientific publications both national (9) and international (11). The variables being compared are the number of species and species composition measured/observed in land/burned and unburned areas in pairs. Furthermore, the data were analysed tabulatively in the form of percent so that it can be distinguished what percentage of the total publications examined results show that the impact of fire is positive (increasing the number of species or changing the composition of species) and what percentage if otherwise.

3. Result and Discussion

3.1. Literatures that provide information of forest and land fire impacts on wildlife
In Indonesia forest and land fires are raging in every year and not a few of the origin fires are allegedly related with forest and plantation production activities. There are many law cases regarding that incidents and based on information disclosure to GAKUM KLHK, in 2019 it’s been recorded that legal proceedings were carried out on 55 concessions holder companies and 1 individual [11]. Many charge and accusation related to the biodiversity, where the fires accused to cause species, flora and fauna extinctions that occurred 100%, also change in population that occurred 100%. Meanwhile, in accordance with impact definition, the estimation of the impact on biodiversity can only be done if the condition of the diversity of flora and fauna from the baseline or before the fire is known. Most studies did not provide the estimation of the diversity from the baseline, and it is actually unclear whether these mortality data reflect the deaths of only a few individuals or entire population fires. However, there are some few researches that have been done to value the impact of forest and land fire on wildlife, including mammals, birds, herpetofauna and butterflies. From there, overview of the published research undertaken to date on the effects of fire on wildlife, using examples both from national and international research. Table below shows the list of the literatures.

| Taxa                | International Literature Source | Taxa     | National Literature Source |
|---------------------|--------------------------------|----------|---------------------------|
| Mammals and reptile | Letnick et al. [12]            | Mammals  | Nugroho GG [27]           |
| Mammals             | Tony et al. [14]               | Mammals  | Purba HS [9]              |
| Birds               | Peres et al [20]               | Mammals and birds | Dima [13] |
| Birds               | Barlow et al [21]              | Birds    | Kartiko I [28]           |
| Birds               | Taylor dan Barmore [22]        | Birds    | Sugiharti W [29]         |
| Birds               | Pfister [23]                   | Herpetofauna | Maulana P [30]       |
| Birds               | Smucker et al. [24]            | Herpetofauna | Rejeki SS [31]        |
| Herpetofauna        | Fredericksen and Fredericksen | Butterflies | Nuveaestutti A [17]    |
| Herpetofauna        | Floyd et al [7]                | Butterflies | Nugroho SS [10]        |
| Butterflies         | Huntzinger [25]                | Butterflies |                    |
| Butterflies         | Force [26]                     |           |                           |
From the total of 20 literatures, 55% or 11 literatures are international and 45% or 9 literatures are domestic. More studies have concerned in birds, whereas fewer studies have examined the effects of fire on herpetofauna and butterflies (Table 1). The studies figured the impacts by comparing the number of diversity in burned area and non-burned area. Where from those literatures the research conducted in various land covers, from hummock grassland [12] some take place in oil palm plantation, production forest, and also forest area, including in national park [13].

3.2. Forest and land fires impact on species diversity and composition
So far forest fires have been seen as a disaster, which caused negative impacts on living things that exist in and around the fires location. Fire is considered as a cause of the diversity loss, even extinction, of both flora and fauna species. However, based on the literatures review, the results show that post-fires effect sometimes didn’t cause any change on wildlife species diversity and sometimes caused the increase of species diversity (Figure 2).

The figure above shows that there are more literatures stated that the fires tend to increase (50%) the diversity and less (15%) stated that after fires effect doesn’t change the species diversity. Tony et al [14] research that has been conducted at the Northern Chihuahuan Desert, stated that the diversity of small mammal species is not affected by fires, which is different from other related studies of mammals, apparently because the study looks only at the short-term effects. Other statements from Floyd et al. [7], Fredericksen and Fredericksen [8] show that the fires doesn’t cause change either, they stated that
amphibians and reptiles were not significantly affected by fire and did not differ significantly between burned and unburned areas. Cited in Stebbins and Cohen [15] that amphibians have moist, permeable skin and eggs, and that helps increase their vulnerability to heat and microhabitat drying. Another research also showed that amphibians and reptiles did not appear to be disturbed by approaching fire, they responded in adaptive manners that minimized mortality [6].

There are 35% literatures stated that the fires negatively impact the species diversity and decreasing the number of species. Fires can cause canopy strata to decrease, which can reduce or eliminate the habitat of some species. In spite of that, greater percentage (75% of the literatures) shows the opposite. Purba [9] and Letnick et al. [12], stated that the number of mammals species, especially for the small mammals were increased. Most small mammals can avoid fires by using protection such as culverts, rocks and wet leaves pile [4]. Small mammals will seek protection under the ground or a place that is protected from fire, but it will be more difficult for large mammals, they must find a safe location outside the fire or in an unburned place. And after the fires the habitat will slowly recuperate and the death trees, also a pile of leaf litter and understorey piles will provide plenty of shelter for small terrestrial mammals and others [16].

Some of the literatures also count the changes in species composition that occurred after the fire. None showed a 100% change, few show significant changes range of changes from 50%-75%, and most of the literatures show a little change (Figure 3).

**Figure 3** Forest and land fire impact on wildlife species composition based on literatures

Significant changes in species composition can occur due to changes in the habitat and environment as well. Post-fire vegetation has a structure and composition that is not always identical to vegetation before the fire so that it can affect the presence of existing species. In reference [17], the number of species that found was small, 7 species in unburned area and 6 species in burned area, so that even a little different of the species from the baseline, can make a great changes. Meanwhile 75% of literatures show that changes do happen but not significant, it shows that the species can survive the fires and after the fires they will come back to their habitat. Big mammals return to their burnt habitats because they are already familiar with the area before burning, in addition many large mammals return because of the quantity and quality of food in the area. Some changes happen because the growth of new vegetation after a fire can cause abundant forage for certain species, so it allows the appearance of certain types of specialists and change species composition, as in Hutto's research [18], stated that seed-eating birds, such as (*Nucifraga Columbiana*), (*Carpodacus cassinni*), (*Loxia curvirostra*), and (*Carduelis pine*), which are more abundant in recently burnt forest areas in the first year after the fire disaster.

Overall none of the literatures cited that extinction of a species occurred. Extinction in biology means the loss of the existence of a species or group of taxon. A species is declared extinct if the last member of the species dies, which means it only occurs when there are no more living creatures of that species that can breed and form generations. IUCN [19] states ‘Extinct’ if there is no doubt that the last individual is dead and there is a term ‘Extinct in the wild’ (EW) when the taxon is known can only be found in certain captivity and no subjects are present in natural habitats. Meanwhile, if the extinction
only occurred in a study area, but this species can still be found elsewhere called extirpation. Fires allow the emergence of different resources and heterogeneity at the landscape level. This is what causes differences in species composition on land before and after burning, also bring through the loss or gain of new species and decreasing or increasing the amount of species diversity after fires.

4. Conclusion
Forest and land fires do not result in the extinction of all species of fauna, but only in the form of a decline and or even an increase in the number of species or species richness index and changes in species composition. As fire character and diversity of flora and fauna are site-specific, then a study of the impact of fires and their compensation calculations must be carried out specifically for each fire location. In accordance with impact definition, the estimation of the impact on biodiversity can only be done if the condition of the diversity of flora and fauna before the fire is known.

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