The impact of fire on herpetofauna species diversity: case study in PT Waimusi Agroindah, Sumatera Selatan

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Abstract. PT Waimusi Agroindah (PT WMA) is one of the oil palm companies that experienced land fires in 2015 with the burning estimated around 400 ha. This caused PT WMA to be accused of reducing biodiversity in the area. Therefore, this research was conducted to identify the impact of fire on herpetofauna diversity, community similarity and percentage species loss or gain. The observation was done by using visual encounter survey (VES) method in 2017 and 2019 in 2 types area, that is Unburnt (UBA) and post-burnt area (PBA). The result of the study showed that PBA 2017 has the highest of species and individual number, and also richness index (S= 15; N= 61 individuals; Dmg = 3.41). Meanwhile, the similarity index (IS) increased from 0.54 in 2017 to 0.87 in 2019. In addition, the percentage of loss in 2017 was 36.36% to 23.08% in 2019. In addition, the percentage of loss decreased from 36.36% in 2017 to 23.08% in 2019. The impact of a fire is not always negative, this can be seen from the presence of herpetofauna species found in post-burnt areas that are not even found in unburnt areas.

1. Introduction

Oil palm plantations are now the main commodity that foreign exchange income of USD 22.9 billion in 2018 [1]. In addition, oil palm planting and harvesting are labor intensive, so the industry has a role in providing employment to more than 6 million smallholder farmers [2] and generating seven times higher income compared to farmers who rely on food plantations [3].

One of the important problems experienced by oil palm plantations is the occurrence of fires that occur almost every year. South Sumatra is one of the provinces in Indonesia which annually experiences forest and land fires. [4] stated that the conversion of land for oil palm plantations was one of the main factors causing forest and land fires. In 2015, PT WMA was one of the palm oil plantations which suffered 400 ha of fire and led to fines of up to billions of rupiah. [5] states that forest and land fires have negative impacts such as climate change, disrupt human health, harm the country economically and eliminate wildlife habitat. In addition, it can also cause direct death in wildlife [6]. Another case with [7] which states that fires have a positive impact on increasing land productivity because it can destroy pests, stimulate dormant shoots and help spread seeds. Apart from the positive and negative impacts, the fire event is expected to affect the lives of wildlife such as herpetofauna which is a combination of reptiles and amphibians that are very susceptible to environmental changes [8], because all aspects of life are influenced by the climate in the habitat [9].
According to [10] herpetofauna has an important role in balancing ecosystems as predators and prey. Many accusations to oil palm regarding land fires that occur and the lack of information about the impact of fires on herpetofauna species diversity, encourages research on herpetofauna species diversity on the location of oil palm plantations that have been burned or unburned need to be done, so that the impact of forest and land fires can be identified, significantly against the diversity of herpetofauna species. The purpose of this study to estimate the impact of fires on species of herpetofauna and on loss/gain of herpetofauna.

2. Materials And Methods
The impact of fires on the diversity and composition of herpetofauna species is the differences between species diversity and composition in unburnt and post-burnt areas. Unburnt areas are assumed to have the same conditions as post-burnt areas before fires occur.

2.1 Study Area
The study was conducted in February - March 2017 and 2019 at PT WMA, South Sumatra. There are 2 areas to be observed namely post-burnt area (PBA) (burning in 2015) and not burn (UBA).

2.2 Study Method
Study of herpetofauna data using the Visual Encounter Survey (VES) method with transect design (a visual encounter survey designed in parallel) [11] with a length of one kilometer for each lane. The observer walks along the path that was made at a certain time to look for herpetofauna. Observations began at 19:00 WIB and ended at 21.00 WIB and were carried out simultaneously with 3 repetition.

2.3 Data analysis
Data analysis was performed on various types or analyzes of the success rate of the herpetofauna community found in unburnt and burnt areas. The analysis carried out contains quantitative and qualitative analysis. Quantitative analysis uses a collection index, evenness of types and collected by the community with the following calculation [12]:

- Species richness index (Dmg)
  Margalef Index (species richness) used to determine the species richness of each species in the community that found in the field, the formula is:
  \[ Dmg = \frac{S - 1}{\ln N} \]  
  Information:
  Dmg = species richness index
  S = number of species
  N = total number of individuals of all species

- Evenness index (E )
  Evenness Index has a function to determine the evenness of each type in every community.
  \[ E = \frac{H'}{\ln(S)} \]
  Information:
  E = evenness index (a value between 0-10)
  H' = diversity
  ln = natural logarithm
  S = Number of species
Whereas to determine the impact of oil palm plantation on species composition, a number of herpetofauna diversity loss and gain in PT WMA, the following formula is used:

- Similarity index
  Similarity index is used to determine the similarity between the observation location based on the type herpetofauna found [13]:
  \[ IS = \frac{2c}{(a + b)} \]  
  Information:
  IS = similarity index
  a = the number of species that are only found in community A
  b = the number of species that are only found in community B
  c = the number of species found in community A and B

### 3. Result and Discussion

The number of herpetofauna species that were found during the 2017 and 2019 studies was 20 species with a composition of 9 amphibians and 11 reptile species (Table 1). There are 7 species of herpetofauna that can be found in the four observation routes, namely *Fejervarya cancrivora*, *Fejervarya limnocharis*, *Hylarana erythraea*, *Pulchrana glandulosa*, *Homalopsis buccata*, *Eutropis multifasciata* and *Varanus salvator*. This species is known to have a fairly good level of adaptation in various habitats. The results of [14] also found that *Fejervarya cancrivora*, *Fejervarya limnocharis*, *Hylarana erythraea*, and *Pulchrana glandulosa* were amphibians that had a high level of adaptation, this can be proven by the discovery of these species in various types of land cover. [15] also mentions that these species of amphibians can live in fragmented or disturbed areas.

| No | Scientific name               | UBA 2017 | UBA 2019 | PBA 2017 | PBA 2019 |
|----|-------------------------------|----------|----------|----------|----------|
| 1  | *Ingerophrynus biporcatus*    | 1        | 2        | 1        | 1        |
| 2  | *Pseudobufo subasper*         | 6        |          |          |          |
| 3  | *Fejervarya cancrivora*       | 6        | 7        | 17       | 9        |
| 4  | *Fejervarya limnocharis*      | 4        | 5        | 11       | 13       |
| 5  | *Kaloula baleata*             |          | 1        |          |          |
| 6  | *Ammirana nicobariensis*      | 1        | 1        |          | 1        |
| 7  | *Hylarana erythraea*          | 6        | 5        | 3        | 5        |
| 8  | *Pulchrana glandulosa*        | 4        | 3        | 9        | 7        |
| 9  | *Polypedates leucomystax*     |          |          |          | 2        |
| 10 | *Lycodaria subcinctus*        |          |          | 1        |          |
| 11 | *Calamaria sp*                |          |          |          | 1        |
| 12 | *Dendrelaphis pictus*         | 1        | 1        |          |          |
| 13 | *Enhydris enhydris*           |          | 1        | 1        | 1        |
| 14 | *Homalopsis buccata*          | 4        | 3        | 2        | 14       |
| 15 | *Xenocrophis vittatus*        |          |          |          | 1        |
| 16 | *Takydromus sexlineatus*      |          |          | 2        |          |
| 17 | *Eutropis multifasciata*      | 8        | 9        | 1        | 1        |
| 18 | *Varanus salvator*            | 2        | 1        | 3        | 1        |
| 19 | *Cuora amboinensis*           |          | 2        | 1        |          |
| 20 | *Malayopython reticulatus*    |          |          | 1        |          |

**Table 1.** The species of herpetofauna that have been found

| Number of Individuals | 39 | 40 | 61 | 53 |
|-----------------------|----|----|----|----|
| Number of Species     | 11 | 13 | 15 | 10 |

*UBA=Unburnt Area; PBA=Post Burnt area*
Based on Table 2, the number of species on UBA increased from 11 species to 13 species in 2019. Unlike the case with PBA which shows decrease from 15 species to 10 species. [16] also found that the herpetofauna species on land 3 years after burnt had more species than the land 5 years after burnt. The decrease in the number of species in PBA can be caused by the presence of a species of snake that dominates this area, namely Homalopsis buccata. Homalopsis buccata are water snakes that actively search for prey at night [17]. The number of snakes is caused by observational conditions that are in suitable with the habitat of this snake. According to [18] Homalopsis buccata snakes are found in waters with slow currents. Both UBA and PBA have water sources in the form of canals on the right and left. [19] explained that feed from Homalopsis buccata was dominated by frogs. This is thought to be one of the causes of the decline in the number of species and individuals, especially amphibians in PBA from 2017 to 2019. This snake also has a high adaptability. As stated by [20] this water snake can be found in almost all types of water, including swamps and brackish water. In addition, Homalopsis buccata is also tolerant of human activities.

**Table 2.** Comparison of the Number of Herpetofauna in Each Land Cover in 2 Observation Periods

|                | 2 years after burnt (2017) | 4 years after burnt (2019) |
|----------------|-----------------------------|----------------------------|
|                | UBA                         | PBA                        |
|                | 11                          | 15                         |
|                | 39                          | 61                         |
|                | 13                          | 10                         |
|                | 40                          | 53                         |

An increase in the species richness index in the UBA and a decrease in PBA from 2017 to 2019. Can be seen in Figure 1, the species richness index increased from 2.73 to 3.25. Meanwhile, PBA has decreased from 3.41 to 2.27. In contrast to the results of [14] which found that the species richness index experienced a decrease both in PBA and UBA. [21] states the species richness index is influenced by the number of species. The more the number of species found, the index of species richness is also getting bigger. In addition, the number of individuals found also affects of species richness index [22].

![Figure 1](image-url). **Figure 1.** Comparison of species richness and evenness index

For the evenness index is relatively high between the UBA and PBA in 2017 to 2019 which ranges from 0.81 to 0.91. According to [23] the species evenness index approaches one, then the distribution of individuals of each species is evenly distributed. Conversely, if it is close to zero, there are several species that dominate the community. In both the 2017 and 2019 PBA areas they have a lower species evenness index than the 2017 and 2019 UBA (E = 0.91; 0.88). This indicates that the UBA condition is more stable than PBA. High species evenness index indicates that the condition of a habitat is stable and there is no domination of certain species over other species, or in other words, each species has occupied...
its niche [24], [25] stated that the level of herpetofauna diversity in undisturbed habitats is higher than disturbed habitats. In undisturbed habitats, generally have a high balance, because it allows the ecological space to give and receive each other.

If seen from the community similarity index, there has been an increase from UBA and PBA in 2017 to UBA and PBA 2019 (Figure 2). This indicates that the habitat conditions in UBA and PBA are increasingly the same. Although the number of species found in PBA 2019 is smaller than in the PBA 2017. However, the similarity of the community in the UBA and PBA 2019 is higher than in the 2017 UBA and PBA. Another case with [16] found that land 3 years after burnt has a higher community similarity index compared to land 5 years after burnt. Increasing the community similarity index between UBA and PBA illustrates that PBA conditions are increasingly similar to UBA conditions. [26] state that the higher the community's similarity, the more likely the habitat has the same conditions.

Based on Figure 3, the species of herpetofauna lost in 2019 decreased from 36% in 2017 to 23%, while for the number of species there was a gain of 73% and in 2019 there were no gain. In 2017 there were 4 species that were lost and in 2019 there were only 3 species that were lost. The list of the types of herpetofauna lost or gained can be seen in table 3.

**Table 3.** List of species of herpetofauna that are lost and gained

| Year | Loss          | Gain          | Loss          | Gain          |
|------|---------------|---------------|---------------|---------------|
| 2017 | Amnirana nicobariensis | Pseudobufo subasper | Dendrelaphis pictus | - |
|      | Dendrelaphis pictus | Kaloula baleata | Malayophythin reticulatus | - |
|      | Xenocrophis vittatus | Polypedates leucomystax | Cuora amboinensis | - |
|      | Takydromus sexlineatus | Lycodon subcinctus | Calamaria sp | - |
In 2019, dendrelphas pictus, malayopython reticulatus and cuora amboinensis were found in UBA, but not in PBA. In addition to fires, human activities can also reduce the diversity of herpetofauna species. PBA is near the employee mess, so many human activities are carried out at PBA, such as washing, fishing, making fish traps and managing areas to be turned into oil palm plantations. Different from the UBA area far from settlements and rarely passed by humans. According to the [27] human activity and changes in habitat function become one of the causes of the reduced number of amphibians. [28] where the life cycle of the Anura order amphibians (frogs and frogs) is highly dependent on the consistency of diversity of micro habitats, such as leaf litter to escape predators, nest, and protect from drought.

4. Conclusion
After 2 years and 4 years of fire, the number of species and species richness index in UBA (11 to 13 species) was increased and PBA (15 to 10 species) was decreased. Similarity index values increased in 2019 (0.54 to 0.87). Number of species loss in 2019 was decreased and no one species gained. The impact of a fire is not always negative, this can be seen from the presence of herpetofauna species found in post-burnt areas that are not even found in unburnt areas.

Acknowledgments
Thanks to PT WAIMUSI AGROINDAH for funding this research, providing the permission and facilities provided during the study period.

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