Estimation of bird species diversity recovery on post-burnt land in PT Waimusi Agroindah, South Sumatera

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Abstract. Currently, one of the events that are suspected to be the main cause of environmental damage is land fires, that are also a fairly routine event in Indonesia. One of the most highlighted fire issues is the fire in oil palm plantations. These fires have increased community assumptions regarding the impact of fires on ecosystems and biodiversity, including bird species diversity. The impact of the fire which was considered to have only a negative impact, led to various demands so that several palm oil industry companies were charged with paying recovery costs. There was a fire in 2015 at PT Waimusi Agroindah. The accusation that fires have only a negative impact requires further research to determine the potential recovery of bird species diversity on post-fire land, particularly in oil palm plantations. The method for estimating land restoration is to compare the diversity of bird species at 2 years after burning (2017) and 4 years after burning (2019). The observational method used was a line transect every morning and afternoon with three repetitions to inventory bird species diversity. The results showed as many as 40 species of birds found in the soil 4 years after burning, higher when compared to the land 2 years after burning found as many as 36 species of birds. This number is higher than the number of species found in unburned land by 25 species in 2017, and 36 species in 2019. The Margalef index equal to 6.11 in 2019 which increased 5.44 in 2017. Evenness index was 0.89 in 2019 which was originally amounted to 0.83 in 2017. Overall there was a recovery in post-burnt land due to the gain of 12 species and a loss of 7 species. There are 2 species of gained bird included into protected species according to Permen LHK P N0.106 of 2018. An increase bird species diversity indicates the ability of the land to gradually recover.

Keywords: birds, burnt, oil palm, recovery

1. Introduction
The phenomenon of forest and land fires is a fairly routine event in Indonesia. Even the majority of fires occur in peatland areas. One industry that often gets accusations when there is a fire is the palm oil industry. The accusation arises due to the increasing needs of the community for palm oil accompanied by an increasingly widespread land clearing. The opening of oil palm land is considered to be one of the causes of land fires. The community still considers that the phenomenon of fire is related to the deliberate burning of land for the purposes of cultivation, rejuvenation of grass for animal feed, burning of abandoned land and the fondness of playing with fire [1-3]. In recent years, land and forest fires that
occur become a major threat to biodiversity and can be a major factor causing degradation in environmental quality [4].

Forest and land fires that occurred in Indonesia, precisely in 2015 were quite large fires. South Sumatra was one of the provinces that experienced a fire that year and had the highest hotspot in 2015 [5]. One of the oil palm plantations which also experienced a fire that year was PT Waimusi Agroindah. These fires have led to accusations that fires can cause economic, ecological and political losses [6]. As a result of the phenomenon of land fires that are familiar in an area can change the micro-ecosystem, so that it has an impact on changing the function of vegetation as well as the loss of movement of wildlife including birds. Though birds are one type that has many ecological functions. In addition to utilizing forests as their habitat, birds also have a role in ecology as pollinators and seed dispersal [7].

Assumptions regarding the negative effects of fires still cause various debates. Allegations that fires only cause negative impacts without recovery still require further research. According to research conducted by [8], damaged land will have the ability to be able to recover through a succession process. This recovery can also occur on peatlands after burning [9], [10]. In fact, according to research conducted previously at PT Waimusi Agroindah, it was found that the number of bird species found in post-burnt land locations was higher than that of non-burnt bird species which had 36 species [11]. The possibility of recovery after the fire phenomenon causes the need for further research to estimate the condition of species diversity between land 4 years after burning with land 2 years after burning. This is done so that it can be identified whether the recovery can occur on post-burnt land.

2. Method

2.1 Study site

This research was conducted at the oil palm plantation of PT Waimusi Agroindah (PT WMAI) Ogan Komering Ilir District (OKI), South Sumatra. This research focuses on estimating land recovery after experiencing a fire. The location of data collection was carried out on post-burnt land, unburnt land, oil palm plantation land and High Conservation Value / HCV area (control). Post-burnt land is an area that had experienced a fire in 2015. Each age classes have different types and characteristics of land cover.

The location of post burnt land is located in the easternmost area of afdelling 11 and 12. The initial condition of the land affected by the fire was peat soil dominated by chinese water chestnut (Eleocharis dulcis). The types of vegetation that were also present on this land before the fire were several sapling of gelam (Melaleuca leucadendra) and perpat (Combretocarpus rotundatus). The unburnt land that is the location of the study is located in the western part of afdelling 11 and 12. The condition of unburnt land is almost the same as post-burnt land, the difference only that the unburned pathway is surrounded by more dense and taller rija-rijja (Scleria sumatrensis).

2.2 Data Collection

Data on bird species diversity was taken using the transect pathway method, so that more area can be covered per unit census time with transects [12]. The length of the transect used is 1 km with a width of 50 m. Recordings are carried out when a bird is found directly or an encounter through sound. Observations were made on each land cover type path at the same time, namely in the morning at 06.00-08.00 WIB and in the afternoon at 16.00-18.00 WIB with three repetitions. Vegetation analysis was also carried out to determine the composition of plants in the study site using a single plot of 40 m x 40 m for data collection in the form of undergrowth, seedlings, and saplings. While the plot size for pole and tree growth rates is 113.14 m x 113.14 m.
2.3 Data Analysis
The method used to estimate post-burn land recovery is to compare bird species diversity at 2 years after burning (2017) with 4 years after burning (2019). In order to make this comparison we measured the diversity of birds in all land cover, the number of species found in each land cover in PT WMAI was calculated. In addition, the Margalef species richness index [13] is used to count the number of species found in each land cover. Evenness index [13] is used to determine the evenness of species in each land cover and the similarity index [13] is used to determine the similarity of bird species between land cover, and is used as a basis for assessing the effect of fire on bird species diversity, number of losses and also species of birds that increase.

3. Result and Discussion
3.1 Comparison of bird species diversity
Based on research conducted at PT Waimusi Agroindah in the 2 years after burning (2017) and 4 years after burning (2019), it was found that there was a change in the number of species and the number of individuals encountered. In general, there was an increase in the number of bird species found on various land covers at the study site during 4 years after burning. The number of bird species found in the land 2 years after burning amounted to 36 species, whereas after 4 years after burning amounted to 40 species (Table 1). The difference in results is also seen in the number of individuals found. The increasing number of bird species found affects the number of individual species found in each species. This is thought to be due to adjustments to maintain existing resources. [14] states that the condition of vegetation with complete stratification can support the improvement of niches for the birds in it.

New species of birds found on land 4 years after burning include Oriental darter (Anhinga melanogaster), Black bittern (Ixobrychus flavicollis), Javan pond heron (Ardeola speciosa), and Small egret (Egretta garzetta). These bird species belong to the group of water birds as well as fish eaters (Piscivora). The encounter with these bird species is presumably due to the presence of canals and rivers in the HCV area where there are small fish and macrozoo benthos in them. The small-sized fish and macrozoo benthos are a type of food for aquatic birds found on site. In addition, another thing that also supports to encounter a new species is the research location which is a wetland in the form of peat swamps that can be used as a place to live for several species of water birds. There are also several species of birds that make use of the margins of the work area bordering canals filled with weeds as a place to disguise themselves to catch fish. This is done by several types of waterbirds, one of which is purple heron [15].
Table 1. The development of the number of bird species in each land cover and 2 periods of observation

| Unit | 2 Years After Burnt | 4 Years After Burnt |
|------|---------------------|---------------------|
|      | HCV Unburnt (UB)   | Burnt (PB)          |
| S    | 25                  | 36                  |
| S    | 370                 | 629                 |
| N    | 36                  | 40                  |
| N    | 281                 | 592                 |

Note: $S = \text{Number of species}; N = \text{Number of individual}$

An increase in the number of bird species found on land 4 years after burning is directly proportional to the vegetation conditions in the area. Vegetation analysis results obtained at 4 years post-fire have different results from the study at 2 years after the fire. A total of 12 types of undergrowth were obtained at the time of post-burnt land aged 2 years, while at the time of 4 years after burning were obtained under-vegetation as many as 26 species. This difference in results is thought to arise due to the impact of the fire, ie the fire can cause changes in vegetation conditions in a very complex and diverse ecosystem. In addition, other opinions also state that fires can trigger changes in the type and structure of vegetation, and can maintain healthy ecosystems [16].

Based on the analysis of vegetation, it was found that the types that dominated the study area both after burning and not burning were ferns and grass including *Nephrolepis biserrata* (Nephrolepidaceae), *Stenochlaena palustris* (Blechnaceae), and *Imperata cylindrica* (Poaceae). Plants from the Poaceae family are more commonly found in post-burnt land compared to unburnt land, this can be caused by soil conditions after a fire, and also the possibility of more even distribution of seeds by birds in the location resulting in many plant species growing [11].

The recovery that occurs in the vegetation condition is thought to trigger a difference in the diversity of bird species at the site. This is in accordance with the statement of [17] which states that the diversity of vegetation types found in a habitat will be able to support the availability of feed for birds. This means that the more diverse types of vegetation, the birds will get more choices to choose the type of feed. In addition, the location of land that has fire close to other land cover raises the potential for bird species to move to that location to avoid fire. This is in accordance with the opinion of [18] which states that some birds will fly away from their habitat when there is a fire and there are several species of birds that return to the post-burnt land.

![Evennes index vs Richness index graph](image)

**Figure 2.** Graph of changes in the value of richness index and evenness of bird species between 2 periods after the fire

Based on the picture above (Figure 2), it was found that there was an increase in the value of bird species richness index between post-burnt land and unburnt land both in 2 years and 4 years after burning. The richness index characterizes a large number of species in a community. According to [19], species richness shows a comparison of the number of species found in a location with the number of each species found. The increase in the value of the richness index indicates that the land that had experienced a fire began to experience recovery and even the fire that occurred not only caused a
negative impact. Apart from the undergrowth, other vegetation in the location is some seedlings, saplings and some gelam trees (*Melaleuca leucadendra*) and perpat (*Combretocarpus rotundatus*) that grow in the observation land. The positive impact of the presence of the tree for some species of birds is a place to perch, rest and to spy on prey, even for some birds from family Nectariniidae, flowers from the gelam tree are used as a food source. According to [20], one typical bird species utilizing the upper strata is the Accipitridae family, the Accipitridae family utilizes the top canopy to rest and spy on prey.

Different results are shown in the results of the evenness index value. Evenness index at the research location did not have a significant difference, the index value ranged from 0.83 to 0.89. Evenness of species from all locations generally increased in the fourth year after burning, and the index value was close to 1. This indicates that the distribution of bird species in the study site was stable. This is in accordance with the statement according to [21] where the evenness index values ranging from 0.5-1 indicate that the conditions of species distribution are stable. In addition, [22] also explained that the evenness index values ranged from 0-1. Evenness of bird species in a habitat can be characterized by the absence of dominant species. If each species has the same number of individuals, then the evenness of species in the community has a maximum value, but if the number of individuals in each species is very different then it causes the evenness of species has a minimum value [23].

### 3.2 Comparison of bird species composition

The types of birds found at each study location have the same species from one location to another. According to [24] the same community can be seen based on the presence or absence of the same species in the two habitats that are compared. Based on the data generated, the value of community similarity at the location of post-burnt land aged 4 years is higher compared to community similarity in 2017. The community similarity index in 2019 was 0.89, while in 2017 it was 0.73. The value of the community similarity index between land 2 years after burning with land 4 years after burning reached 0.74 (Figure 3). The community similarity index states that the results of the study have high species similarity because they are above 50% or 0.50 [25]. This is due to the possibility of individual species migrating to the nearest unburnt area and being used as a refuge and returning to the location to help the recolonization of animals after the condition of the burned area has recovered [13]. [26] say that the distribution and population of birds in a habitat are influenced by physical/environmental factors such as soil, water, temperature, sunlight and biological factors that include vegetation and other animals so that the existing bird species will adjust.

![Figure 3. Similarity index for bird communities in the study site](image-url)

Post burnt land location is an open habitat area that is overgrown with shrubs, so that at that location many species of birds that like open habitat such as Javan myna (*Acridotheres javanicus*), Yellow-bellied prinia (*Prinia flaviventris*), and Lesser coucal (*Centropus bengalensis*). This is in accordance with the opinion that the types of birds are birds that like open habitats, such as shrubs, open grasslands and rice fields. Pycnonotidae family is a type of family that is also found at each observation location. This family is a type of family that likes to be located near settlements and is a type of insectivorous.

The abundance of bird species included in the insectivorous group was due to the high insect population at the study site. The abundance of insect populations is caused by insects having properties that are sometimes resistant to insecticides, high productivity and their ability to adapt in a changing
Another opinion also states that one order of insects namely Collembola is a type of invertebrate with a wide distribution area because it can be spread by the wind, water flow or attached to the bird's feet. After the fire event, organic matter will accumulate at the soil surface, so that it will trigger the proliferation of Colembollas because one of its natural foods is the decaying parts of plants. Based on the results of this study, there was a change in the condition of the existing bird community, for now, an increase in species of birds is in line with the increasing age of post-burnt land. Changes in species composition, plant density and openness are some of the effects of fires. Although there was a change in species composition as the age of the post-burnt land increased, the difference was not too significant, because the community similarity index in the study location was close to 1.

![Figure 4](image)

**Figure 4.** Conditions of loss and gain of bird species in each land cover within 2 periods after the fire

Based on the graph above (Figure 4) it is obtained that there is a loss and also the acquisition of bird species between post-burnt land and unburnt land. In general, the number of bird species obtained is greater than the number of birds lost. [29] states that the availability of habitat variation greatly affects the high diversity of species. For example, the varying habitat can affect the species of birds found drawn on post-burnt land that has more open environmental conditions and is dominated by understorey and staple plants that are not too high. This condition is also in accordance with [30] opinion which states that canopy openness can affect the number of bird species found, the more canopy cover is opened, the more birds will be found when compared to habitats that have closed and canopy cover. An increase in the form of 12 new species found and the number of species that still survive indicates that the post-burnt land is undergoing a process of recovery after burning marked by the number of surviving species and the presence of new species.
Table 2. List of bird species found on 4 years after burning land (Species gain)

| Common name              | Scientific Name       | Family         | Conservation status | PermenLHK P No.106 of 2018 | IUCN | CITES |
|--------------------------|-----------------------|----------------|---------------------|-----------------------------|------|-------|
| Yellow-vented bulbul     | Pycnonotus goiavier   | Pycnonotidae   | LC                  | -                           |      |       |
| Brown shrike             | Lanius cristatus     | Laniidae       | LC                  | -                           |      |       |
| Javan Pond-heron         | Ardeola speciosa     | Ardeidae       | LC                  | -                           |      |       |
| Tricoloured munia        | Lonchura malacca     | Ploceidae      | LC                  | -                           |      |       |
| Oriental darter          | Anhinga melanogaster | Anhingidae     | Protected           | NT                          |      |       |
| Cave swiftlet            | Collocalia linihi    | Apodidae       | LC                  | -                           |      |       |
| Pacific swallow          | Hirundo rustica      | Hirundinidae   | LC                  | -                           |      |       |
| Eurasian tree sparrow    | Passer montanus      | Ploceidae      | LC                  | -                           |      |       |
| Scarlet-headed           | Dicaeum trochileum   | Dicaeidae      | LC                  | -                           |      |       |
| flowerpecker             |                       |                |                     |                             |      |       |
| Pied fantail             | Rhipidura javanica   | Muscicapidae   | Protected           | LC                          |      |       |
| Little egret             | Egretta garzetta     | Ardeidae       | LC                  | -                           |      |       |
| Common lora              | Aegithina tithia     | Chloropseidae  | LC                  | -                           |      |       |

Based on the results of the study in the table above (Table 2) it can be seen that the increase in species of birds found in the majority is insectivorous birds and also found that there are 2 species of gained bird included into protected species. According to [31] the presence of insectivorous birds in oil palm plantations can have a good impact because it contributes to the control of leaf-eating palm oil pests. Acquisition of species that have a good effect cannot replace lost species, but some species of birds can replace the ecological role of lost birds. Based on the composition of the species of birds that dominate the most or are found, showing that there is no significant change from the types of birds that dominate, because the species of birds most found in the location are still in the same family, Pycnonotidae, with almost similar species, Pycnonotus aurigaster, and Pycnonotus goiavier. This is because the birds in the family Pycnonotidae, are a type of bird that has a wide distribution area. Birds in this family have high adaptability to environmental changes, which have diverse types of feed ranging from insects, seeds, and can consume fruits from local plants that are commonly found in Sumatra [32]. In addition, these birds can survive and not be too disturbed by the existence and human activity around their habitat [29].

4. Conclusion
The number of species and species richness of birds in the four-year post-burnt land is higher when compared to the two-year post-burnt and unburnt land as many as 40 species of birds, while the bird species on unburnt land and two years after burning as many as 36 species. The highest richness index is also found in the land 4 years after burning which is 6.11. The evenness index value in all locations is close to 1, which means it is spread evenly.

The composition of bird species between land four years after burning, two years after burning, and unburnt is almost the same, with a species index similarity value reached 0.89 in 2019. And found 12 species of birds were obtained and 9 species that were lost in 2019. In general, it can be seen that the post-burnt land began to experience recovery marked by the addition of species of birds found.

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