Loss and gain of the bird species after the establishment of oil palm plantation in South Sumatra

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Abstract. The development of oil palm has been documented as one of the factors caused deforestation leading to the loss of biodiversity; however, what extent the impacts of oil palm conversion on biodiversity in South Sumatra remain little-known. To answer this issue, we studied the diversity of birds in the area before and after oil palm establishment by calculating species number, richness, evenness, similarity, and composition. Secondary forest, shrubs, and rubber plantation were identified as area before oil palm establishment through Landsat image analysis, while in the established oil palm plantation area, we classified into young, mature, and old stand of oil palm. We recorded 49 bird species, 25 families, and 298 individuals. Our result showed that conversion secondary forest, shrubs, and rubber plantation to oil palm plantation resulted in the variation of losing, gaining, and persisting of bird species at both habitats. Losses of bird species varied about 16%-38%, but the loss of bird species was more drastic in shrubs. Gaining of bird species also varied about 12.5% to 45% where conversion rubber plantation to oil palm impacted the highest bird species procurement. Meanwhile, bird species persistence ranged between 38%-50%. Secondary forest as the habitat condition before the establishment of oil palm had the highest bird diversity (33 species), while the palm oil plantations had the lowest bird species (11 species). The most of bird species lost were insectivorous birds. However, bird species gain was also dominated by insectivorous birds. Declines in insectivorous bird species that are important for an ecosystem process service in this study area may not significantly decline in that process service because of the other species in the similar functionally group increase in the response. Calculation of loss and gain of biodiversity as a result of land use change is necessary as a strategy for biodiversity conservation in an agricultural landscape.

1. Introduction

Rapid losses of species as a consequence of human activity have been continuing at both global and local scales [1]. At the local level, the dramatic effect of the loss of species occurs when the previously lost species were key species or its functional ecological role was not able to be placed by another species, meanwhile the effects of gain species are probably higher than previous species existed if they have a new ecological role in the new ecosystem [2].

The development of oil palm has been blamed as a major cause of environmental problems such as deforestation and loss of biodiversity in tropical countries [3], [4], [5], [6]. Some studies show that
conversion of forests into oil palm plantations reducing wildlife species such as birds, lizards and mammals [4], [7], [8], loss of High Conservation Value species [9], declining invertebrate richness such as ants and beetles [10], butterflies [6] and loss of soil organic matter [11], and having consequences on microclimate and wildlife species that favor sheltered habitats [8]. However, recent studies have shown that well-managed palm oil plantations are capable of supporting diversity to some extent. The abundance of arthropods and butterflies in oil palm plantations adjacent to forests was similar to natural forests, although the species richness was lower than natural forest. [12], [13], [10].

Understanding how the conversion of habitat into oil palm affects the magnitude of bird species extinction would be particularly useful for highly threatened regions such as Sumatra Island. Birds are good bioindicator of ecosystem change leading to biodiversity loss [14], [15]. The bird is important in the ecosystem because of its role as seed dispersal and pollinator [16]. Also, birds can suppress arthropod density, thereby increasing the yield of oil palm plantations [15], [17]. Previous research has found that insectivorous birds can control leaf-eating pests [15] and owls (Tyto alba) can control plant pest [18]. In this study, we assessed the relative gains and losses of bird diversity before and after the establishment of oil palm plantation and its impact on ecosystem function.

2. Materials and methods
2.1. Study area
The study was conducted in an oil palm plantation with an area of 9700 ha, in Ogan Komiring Ilir District, South Sumatra. Data were collected on different habitat conditions; consisted area before and area after palm plantation establishment. Secondary forest, shrubs and rubber plantation nearby oil palm plantation were identified as a habitat reference before oil palm plantation established. Land use cover before oil palm plantation was analysed by Landsat Imagery. Landsat images of the coverage were acquired for the 3 years before the oil palm was planted. The plantation consisted of different ages of oil palm stands. Therefore we classified into 3 locations, namely: young age of oil palm stand (5 years old), medium/mature age (10 years old), old age (16 years old). In general, oil palm covered by undergrowth plant. The total area of the remnant of the secondary forest is about 22 ha. It was bordered by the river at left and right side. This area has been pointed as High Conservation Value by the oil palm company. Saplings and pole of native tree species such as Malaleuca leucadendron were still found at that area. Furthermore, Shrub area was about 580 ha, most of the area was a swampy area. Its vegetation was dominated by cover crop. However, some saplings and poles of Malaleuca leucadendron and Combretocarpus rotundus were still found. Rubber plantation in research area was 27 years old. Undergrowth was dominated by Melastoma malabathricum, Imperata cylindrica and Mimosa pudica.

2.2. Procedure
2.2.1 Data collection
Birds were observed using binoculars and camera. MacKinnon and Philips field guide [19] was used to identify the birds. Data collection was conducted in 2017 using the combination of line transect method and point observation. Birds were observed along a one-km-long transect within 50 m to the left and right side of transect line. In total we had 6 transects, all transect in each research site were visited in the morning from 6.00 to 9.00 and in the afternoon from 16.00 to 18.00. The bird observation were repeated for 3 days at the same plots to maximize the number of bird species recorded. The observation were delayed during the rainy days.

2.2.2 Data analysis
Bird species diversity at the area before and after the establishment of oil palm plantation was estimated by the total number of species that was actually recorded in the research sites, the Shannon-Wiener Index (H’), Margalef (Dmg) Index, Evennees index (E) followed [20]. The similarity of bird communities among different sites was estimated using the Sorensen Index. Functional diversity of bird was assessed by categorizing birds according to feeding guild based on [19]. To assess particular bird species lost, we counted the number of species exists before conversion and species lost after that. For
the species gain, we assessed the number of species which did not exist before and species was found after conversion, and for the persistence species, we defined as the species existence before and after changing habitat.

3. Results and discussion
3.1. Bird diversity before and after the establishment of oil palm plantation
Our result showed that the conversion of secondary forest, shrubs and rubber plantation caused the decreasing of bird diversity in the research area. The change of bird diversity at habitat after oil palm plantation establishment ranged from 2 species to 17 species. The conversion of secondary forest or High Conservation Value (HCV) into oil palm plantation had the highest bird diversity lost (vary 17 to 22 species at different oil palm stand age), while the conversion of rubber plantation into oil palm had the lowest bird species lost (vary 3 to 5 species). Within the oil palm plantation, different stand age of oil palm responded differently to the habitat change, medium age stands of oil palm plantation accommodated less bird diversity compared to young and old age stand of oil palm (table 1).

The change of habitat into oil palm plantation influenced the abundance of the individual bird. The conversion shrubs into oil palm had the highest decreasing than other habitats before oil palm establishment. It varied about 24% to 63% within the aged stand, where the old stand of oil palm had the highest loss of bird abundance (table 1). Meanwhile, the conversion of rubber plantation into oil palm plantation decreased the number of the individual bird about 11% to 19% at medium and old age stand of oil palm, however at the opposite, young age stand of oil palm, received higher individual bird (64%).

Moreover, evenness index tended to similar at both habitat condition before and habitat condition after oil palm establishment, except at young age stand of oil palm had lower evenness index. It indicated that there are no dominant species occupied the habitat. The change of habitat into oil palm did not influence the distribution of species at each habitat. Most species evenly distributed among habitats both before and after oil palm establishment.

| Species diversity | Area before oil palm establishment | Area after oil palm establishment |
|-------------------|-----------------------------------|----------------------------------|
|                   | HCV | Rubber | Shrubs | Young stand | Medium stand | Old stand |
| Number of species (S) | 33  | 16    | 30     | 16          | 11           | 13        |
| Number of individu (N) | 64  | 36    | 78     | 59          | 32           | 29        |
| Species richness (Dmg) | 7.68| 4.19  | 6.66   | 3.68        | 2.89         | 3.56      |
| Evenness index (E) | 0.93 | 0.93  | 0.92   | 0.86        | 0.92         | 0.92      |

Data source: [21]

Based on Margalef Index, all the habitats before oil palm plantation establishment had the higher species richness (Dmg) which varied from 4.19 to 7.68 (figure 1). The dramatical changes of bird species richness occurred after HCV habitat converted into oil palm. The bird species richness slightly reduced after conversion of rubber plantation area. Our result is consistent with previous research [22], [23], which concluded that the conversion of secondary forest into oil palm plantation in Riau province reduced the bird species richness. However, on the contrary, these results are different from another study in Kalimantan [24] which revealed that the change of habitat after oil palm plantation establishment increased the diversity of birds.
Figure 1. Species richness (dmg) of bird species before and after oil palm plantation establishment in Southern Sumatra

Our study confirmed that the highest loss of bird species richness occurred when secondary forest (HCV) was converted to oil palm plantation. The degradation of the habitat from complex vegetation structure into monoculture system such as oil palm plantation influences the abundance of food availability and variety of niche. The diversity of vegetation is an important factor affecting bird species diversity in the habitat before oil palm plantation established. Forest conversion to palm oil plantation has changed the plant species composition from a heterogeneous to a homogeneous one. Therefore it has altered the food availability and habitat conditions for potential bird species.

3.2. Bird composition, loss and gain of bird before and after oil palm plantation establishment

A total of 49 bird species recorded, 25 families and 298 individuals. The abundant species varied with both habitats, but some dominant bird species were found at both habitat before and after oil palm establishment, namely Sooty-headed Bulbul (Pycnonotus aurigaster), Yellow-vented Bulbul (Pycnonotus goiavier) which are insectivorous and omnivorous species from family Pycnonotidae, Zebra Dove (Geopelia striata), Spotted Dove (Streptopelia chinensis) which are granivorous bird from family Columbidae. Those species are highly adapted species which are often found in the open habitat, shrubs, secondary forest and yard [19]. A swampy bird species such as White-breasted Waterhen (Amaurornis phoenicurus) also was found at both HCV, Shrubs and oil palm. It is because those habitats close to stream, river or there is a swampy area spot surrounded the habitats.

| Scientific name   | Family   | Feeding guild | Area before establishment | Area after establishment |
|-------------------|----------|---------------|---------------------------|--------------------------|
|                   |          |               | Rubber plantation | HCV | Shrubs | Oil palm |
| G. gallus        | Phasianidae | Herbivorous, Insectivorous | √ | √ | √ | √ |
| Ixobrychus cinnamomeus | Ardeidae | Carnivorous | √ | √ | √ | √ |
| Lanius schach    | Laniidae  | Insectivorous | √ | √ | √ | √ |
| Lonchura punctulata | Estrildidae | Herbivorous | √ | √ | √ | √ |
| Lonchura leucogastra | Estrildidae | Herbivorous | √ | √ | √ | √ |
| Centropus bengalensis | Cuculidae | Insectivorous | √ | √ | √ | √ |
| Centropus sinensis | Cuculidae | Carnivorous | √ | √ | √ | √ |
| P. montanus      | Ploceidae | granivorous  | √ | √ | √ | √ |
| Scientific name                  | Family     | Feeding guild | Area before establishment | Area after establishment |
|---------------------------------|------------|---------------|---------------------------|--------------------------|
| Anthreptes malacensis           | Nectariniidae | Nectivorous   | ✓ ✓ ✓                      | ✓ ✓ ✓ ✓                   |
| Aethopyga siparaja              | Nectariniidae | Nectivorous   | ✓ ✓ ✓                      | ✓ ✓ ✓ ✓                   |
| Nectarinia jugularis            | Nectariniidae | Nectivorous   | ✓ ✓ ✓ ✓                    | ✓ ✓ ✓ ✓ ✓                 |
| Dicaeum trochleum               | Dicaeidae   | Insectivorous | ✓ ✓ ✓ ✓                    | ✓ ✓ ✓ ✓ ✓                 |
| Caprimulgus macrurus            | Caprimulgidae | Insectivorous | ✓ ✓ ✓ ✓ ✓                  | ✓ ✓ ✓ ✓ ✓ ✓               |
| Picaoides molucensis            | Picidae     | Insectivorous | ✓ ✓ ✓ ✓ ✓                  | ✓ ✓ ✓ ✓ ✓ ✓               |
| Dendrocosops macei              | Picidae     | Insectivorous | ✓ ✓ ✓ ✓ ✓                  | ✓ ✓ ✓ ✓ ✓ ✓               |
| Ardea cinerea                   | Ardeidae    | Carnivorous   | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Halcyon smyrnensis              | Alcedinidae | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Halcyon chloris                 | Alcedinidae | Carnivorous   | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Cisticola juncidis              | Sylviidae   | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Orthotoma sepium                | Sylviidae   | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Orthotoma sericeus              | Sylviidae   | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Aegithina tipha                 | Aegithinidae | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Pycnonotus aurigaster           | Pycnonotidae | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Elanus caeruleus                | Accipitridae | Carnivorous   | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Haliastur indus                 | Accipitridae | Carnivorous   | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Hemipus hirundinaceus           | Campephagidae | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Lalage nigra                    | Campephagidae | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Amaurornis phoenicurus          | Rallidae    | Insectivorous, Granivorous | ✓ ✓ ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ ✓ ✓ |
| Artamus leucorhynchus           | Artamidae   | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Acridotheres javanicus          | Sturnidae   | Omnivorous    | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Rhipidura javanica              | Rhipiduridae | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Merops philippinus              | Meropidae   | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Pycnonotus plumosus             | Pycnonotidae | Omnivorous    | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Pycnonotus galavier             | Pycnonotidae | Omnivorous    | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Anhinga melanogaster            | Phalacrocoracidae | Carnivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Pelargopsis capensis            | Alcedinidae | Carnivorous   | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Picus miniaceus                 | Picidae     | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Prinia familiaris               | Sylviidae   | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Prinia flaviventris             | Sylviidae   | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Geopelia striata                | Columbidae  | Granivorous   | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Treron curvirostra              | Columbidae  | Carnivorous   | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Alcedo coerulescens            | Alcedinidae | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Alcedo meninting                | Alcedinidae | Carnivorous   | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Gerygone sulphurea              | Acanthizidae | Insectivorous, Fruitsvorous | ✓ ✓ ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ ✓ ✓ |
| Pericrocotus flammeus           | Campephagidae | Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓                | ✓ ✓ ✓ ✓ ✓ ✓ ✓             |
| Streptopelia chinensis          | Columbidae  | Granivorous, Fruitsvorous | ✓ ✓ ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ ✓ ✓ |
| Eurypterynus orientalis         | Coraciidae  | Large Insectivorous | ✓ ✓ ✓ ✓ ✓ ✓ | ✓ ✓ ✓ ✓ ✓ ✓ |
Insectivorous birds dominated the number of bird species lost after conversion into oil palm, such as Scarlet-headed Flowerpecker (Dicaeum trochileum), Sunda Pygmy Woodpecker (Picoides moluccensis), Fulvous-breasted Woodpecker (Dendrocopos macei), Common Iora (Aegithina tiphia), Pied Triller (Lalage nigra), Blue-tailed Bee-eater (Merops philippinus), Banded Woodpecker (Picus miniaceus), Scarlet Minivet (Pericrocotus flammeus) and Oriental Dollarbird (Eurystomus orientalis), but their functional role in ecosystem may be replaced by other insectivorous which was gained or was persisted after conversion, such as Red Junglefowl (Gallus gallus), Cinnamon Bittern (Ixobrychus cinnamomeus), Yellow-bellied Prinia (Prinia flaviventris). The ecosystem functioning is decreased as the number of species in a community decreases. However, the profound effect of the loss of species occurs when the previously lost species were key species, or its functional ecological role was not able to be placed by another species [26].

Table 3. Number of species loss, gain and persist in the habitat before and after establishment of oil palm

| Habitat before converting | Habitat after converting | Loss of bird species | Gain of species | Persist of species |
|---------------------------|--------------------------|----------------------|----------------|------------------|
| HCV                       | Oil palm                 | 14 Species (42 %)    | 6 species (18 %) | 20 Species (61 %) |
| Shrub                    | Oil palm                 | 14 Species (47 %)    | 9 Species (30 %) | 16 Species (53 %) |
| Rubber plantation        | Oil palm                 | 4 species (29%)      | 14 (88%)        | 12 Species (75 %) |

Table 4. Composition of species lost, gain and persist based on feeding guild before and after the establishment of oil palm plantation

| Feeding guild | HCV into oil palm | Shrubs into oil palm | Rubber into oil palm |
|---------------|-------------------|----------------------|----------------------|
|               | Lost   | Gain   | Persist| Lost   | Gain   | Persist| Lost   | Gain   | Persist|
| Insectivores  | 9 Sp   | 5 Sp   | 8 Sp   | 4 Sp   | 7 Sp   | 10 Sp  | 1 Sp   | 10 Sp  | 5 Sp   |
| Omnivores     | 2 Sp   | 2 Sp   |       | 1 Sp   | 1 Sp   |       | 2 Sp   |       | 2 Sp   |
| Carnivores    | 3 Sp   | 4 Sp   |       | 2 Sp   | 5 Sp   |       | 2 Sp   |       | 2 Sp   |
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| Feeding guild   | HCV into oil palm | Shrubs into oil palm | Rubber into oil palm |
|-----------------|-------------------|----------------------|----------------------|
|                 | Lost   | Gain   | Persist | Lost   | Gain   | Persist | Lost   | Gain   | Persist |
| Nectivores      | 1 Sp   | 1 Sp   | 1 Sp    | 2 Sp   |
| Granivores,     | 5 Sp   | 2 Sp   | 1 Sp    | 2 Sp   |
| Fruitsvores     | 1 Sp   | 1 Sp   | 1 Sp    | 2 Sp   |
| Herbivores      | 1 Sp   | 1 Sp   | 1 Sp    | 2 Sp   |

Note: Sp = number of species lost, gained or persisted

4. Conclusion
There were some species loss, gains and persist after the conversion of habitat into oil palm plantation. The secondary forest and shrubs experienced higher loss of bird species than rubber plantation. Meanwhile rubber plantation had the highest bird species gain after habitat conversion. The most bird species that lost, gained and persisted after land use change were insectivorous bird. The large number and variety of individual abundance of insectivorous birds both at habitat before and after conversion related to abundant of insect. Bird declining because of changing habitat may disrupt ecosystem processes and service of potential importance to human well being, however in our study declines in insectivorous bird species that are important for a particular ecosystem process service may not necessarily decline in that process service because of the other species in the similar functionally group increase in the response.

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