



RESEARCH ARTICLE

**REVISED** Birds of primary and secondary forest and shrub habitats in the peat swamp of Berbak National Park, Sumatra [version 2; referees: 2 approved]

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**Abstract**

**Background:** Tropical lowland rainforests are threatened by deforestation and degradation worldwide. Relatively little research has investigated the degradation of the forests of South-east Asia and its impact on biodiversity, and even less research has focused on the important peat swamp forests of Indonesia, which experienced major losses through severe fires in 2015.  
**Methods:** We acoustically sampled the avifauna of the Berbak National Park in 2013 in 12 plots split in three habitats: primary swamp forest, secondary swamp forest, and shrub swamp, respectively representing non-degraded, previously selectively logged, and burned habitats. We analysed the species richness, abundance, vocalisation activity, and community composition across acoustic counts, plots, feeding guilds and IUCN Red List categories. We also analysed community-weighted means of body mass, wing length, and distribution area.  
**Results:** The avifauna in the three habitats was remarkably similar in richness, abundance and vocalisation activity, and communities mainly differed due to a lower prevalence of understory insectivores (Old-World Babblers, Timaliidae) in shrub swamp. However primary forest retained twice as many conservation-worthy species as shrub swamp, which harboured heavier, probably more mobile species, with larger distributions than those of forest habitats.  
**Conclusions:** The National Park overall harboured higher bird abundances than nearby lowland rainforests. Protecting the remaining peat swamp forest in this little-known National Park should be a high conservation priority in the light of the current threats coming from wildlife trade, illegal logging, land use conversion, and man-made fires.

**Keywords**

primary forest, secondary forest, shrub swamp, swamp forest, community ecology, forest disturbance, forest fires, selective logging

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**REVISED** Amendments from Version 1

We clarified our methods description for estimating bird distances from audio recordings, as well as the survey design (number of recordings/counts per plot and sites). We give more details about the study site including its area, and the survey times. We provided summary statistics for the total DBH in each habitat.

We explained the conservative measure we used for counting individuals for our analysis of abundance, and elaborated how we calculated alpha and beta richness values in addition to the already cited study about additive richness partitioning. We clarified in the methods that the ADONIS analyses were based on data pooled from both counts.

The rationale behind using 83% confidence intervals is now supported with a proper citation, and we cite the study of Azhar et al. 2011 in the introduction and discussion about the secondary forest value. We also developed the importance of the trapping for the bird populations at hand.

After a code update allowing better handling and counting of simultaneous detections, we achieved a greater number of bird detections. It resulted in updated numbers for the results text, the statistical tests, and the tables, as well as slightly adjusted figures (Figure 2, Figure 3, and Figure 4 and Supplementary Figure 3 and Supplementary Figure 4). All the new findings still support the same message.

**See referee reports**

## Introduction

We are losing tropical forests and their associated biodiversity worldwide to deforestation, and this loss is irreplaceable<sup>1</sup>. Forest loss also occurs because of degradation: selective logging affects large areas<sup>2</sup>, which in turn become more susceptible to other disturbances like fire<sup>3</sup>. Most studies focus on the Amazon region, but forests in Southeast Asia also face great threats<sup>4</sup>. Forest losses due to fire have recently gained more attention in Indonesia<sup>5,6</sup>. Indonesia has the highest deforestation rate of all countries<sup>7</sup>, and even protected forests suffer losses<sup>8</sup>. The effectiveness of protecting forests in Indonesia has been questioned for Kalimantan<sup>9</sup>, but for Sumatra, modest progress has been made, especially as large-scale logging has slowed down<sup>10</sup>.

The impacts of forest loss and degradation on biodiversity are better known in the Amazon region, for instance for birds<sup>11</sup>. In Southeast Asia, most primary forest bird species still occur in previously logged forests<sup>12–14</sup> (Azhar *et al.* 2011). Globally, bird feeding guilds respond differently to disturbance<sup>15</sup>, but forest understory insectivores were identified as the most sensitive<sup>16</sup>. The severity of the disturbance and its impact on soils largely determine the duration of recovery, while the surrounding landscape acts as a source of biota<sup>17</sup>.

We lack studies investigating the impact of disturbances - from logging or fire - on bird communities in peat swamp forests, despite their crucial importance for biodiversity, flood control, carbon stocks, potential greenhouse gas emissions, and their high vulnerability to drainage and fires<sup>18,19</sup>. Theoretical and modelling approaches are usually used to analyse the potential benefit of disturbances for overall landscape biodiversity<sup>20,21</sup>.

In this paper we describe the bird communities in a tropical peat swamp on Sumatra, Indonesia. Bird surveys of the Berbak area date far back<sup>22,23</sup>. We sampled birds in three habitats defined according to Keddy (2010)<sup>24</sup>: primary swamp forest, secondary swamp forest resulting from selective logging, and shrub swamp resulting from forest fire. We compare species richness and bird communities between these habitats both taxonomically (species richness, abundance) and functionally (vocalisation activity, body mass, wing length, distribution area). We ask the question whether disturbances increase the overall diversity of the landscape. We discuss the implications of our results for maintaining the overall bird diversity of the peat swamp and for bird conservation in Berbak.

## Methods

### Study site

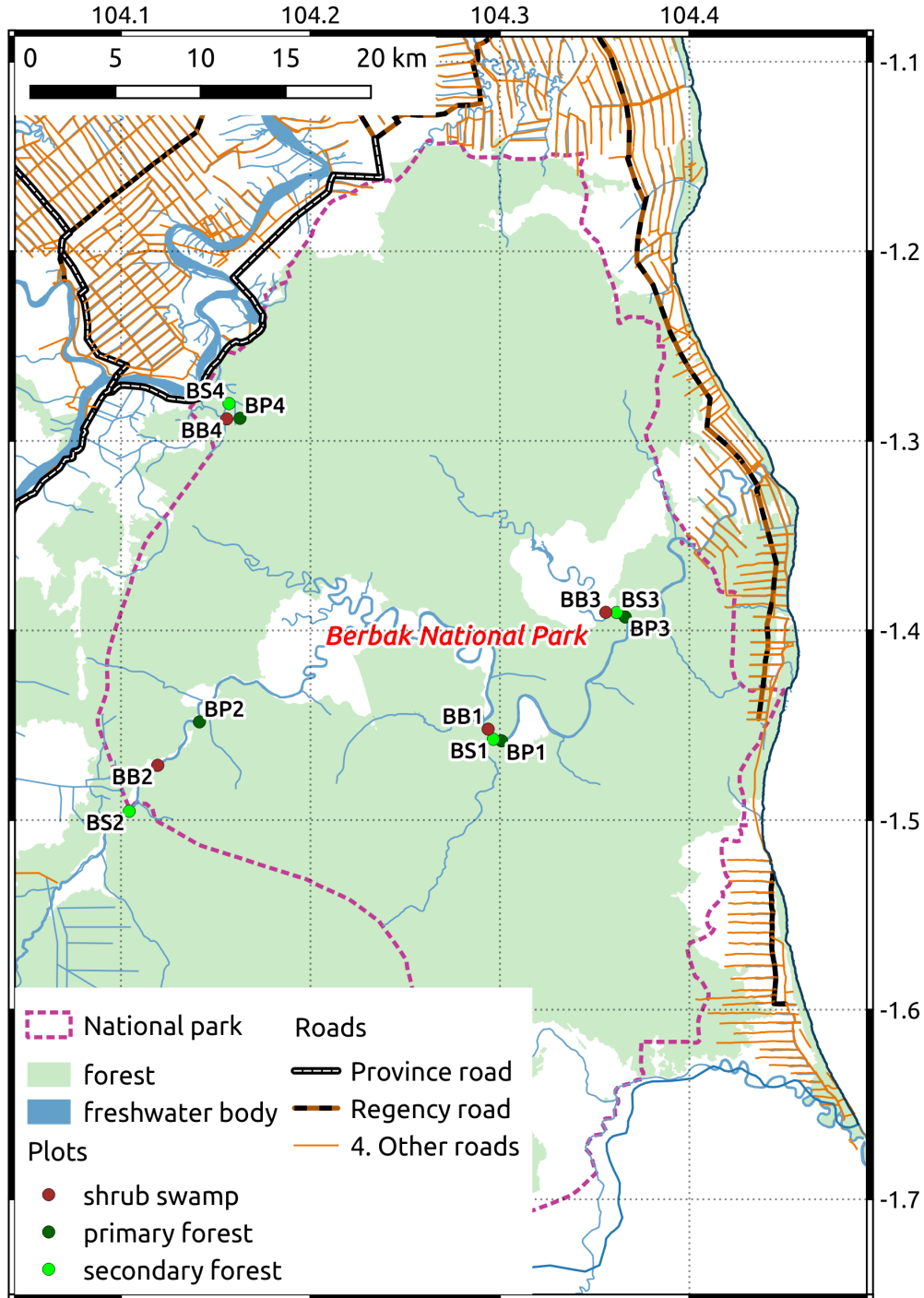
We surveyed birds in Berbak National Park, a peat swamp situated in the province of Jambi, on the east coast of the island of Sumatra in Indonesia (Figure 1). Berbak National Park is a Ramsar site<sup>25</sup> and an Important Bird Area<sup>26</sup>. A severe drought in 1997 facilitated forest fires which were aided by human disturbance due to natural rubber collection (*Dyera costulata*). The burned areas subsequently developed into shrub swamp. Tree stumps also reveal that illegal selective logging affected several areas of the park, resulting in secondary forest habitats.

We chose 12 plots for counting birds, divided in four sites for each of three habitat types of the peat swamp area, representing different past disturbance levels: primary forest (no disturbance), secondary forest (selective logging), and shrub swamp (fire). The secondary forest plots were last subject to selective logging until 2008 for BS1, 1999 for BS2, 2003 for BS3, and 2010 for BS4. The shrub swamp plots burned in 1997, and BB2 burned yearly since.

**Field surveys.** We recorded audible sound in all 12 plots two times. We used autonomous sound recorders (SM2+ recorders with SMX-II microphones, *Wildlife Acoustics Inc.*) and did not carry out visual surveys, since acoustic recording constitutes a valid survey method for assessing bird richness<sup>27</sup>, especially for cryptic birds in tropical forests. From February to November 2013, we sampled all three plots of one site each month for 48 hours, starting at midnight. It was not possible to conduct the survey each month, or to repeat the same plot sampling sequence for the second set of recordings because of access and transportation restrictions. Before the recording started, we counted and measured the diameter at breast height (DBH) of all trees with a circumference above 20 cm (diameter at breast height of ~6.4 cm) inside an area of 14 × 14 m delimited by spanning 10 m coloured ropes from the central tree where the sound recorder was attached to all cardinal directions. We also recorded whether the plot was flooded or not at the time of the sound recorder installation.

### Data analysis

We uploaded 20 minutes recordings starting at sunrise from each plot from each month (24 recordings in total, 2 per plot) to our online platform (<http://soundefforts.uni-goettingen.de/>). The provenance of the recordings was hidden and all birds within the sound recordings were identified by author IF. The distance of bird



**Figure 1.** Map of the study area.

vocalisations was estimated by ear to the meter; even though the accuracy is lower, estimation error was assumed to be random. Distance estimates were made based on the call loudness in the sound recording compared to the ambient sound level and knowledge of the source sound level of each species. The start and end time of each vocalization was recorded to compute the duration of the bird vocalisations. We complemented

our data set with species-specific information about the feeding guild<sup>28,29</sup>, body mass data<sup>28,30</sup>, wing length data<sup>31</sup>, the IUCN Red List threat status<sup>32</sup> and distribution area<sup>33</sup> to analyse conservation and functional aspects of bird community differences.

The data were analysed in R 3.4.3 and graphs were generated with the package ggplot2<sup>34</sup>. We excluded detections that were not

identified to species, as well as detections above 50 m to compare plots at a common detection radius<sup>35</sup>. We computed species richness, bird vocalizing activity in minutes, and bird abundance per acoustic count (i.e. recording). Bird species richness was further computed at the plot (alpha richness) and habitat (gamma richness) levels. For counting bird abundance, we first derived the maximum number of simultaneously vocalising individuals in each species, and then summed these maxima over all species, leading to a conservative estimate of the number of individuals per count. We calculated community-weighted means (hereafter CWM, also called community functional parameter<sup>36</sup>) for body mass, wing length, and distribution area for each count. Due to microphone failure, the second recording of one of the forest plots had only one audible audio channel and was therefore removed from the count-level analysis.

At the count level, the species richness and abundance between habitats was modelled using generalised linear mixed effects models of the poisson family (lme4 package<sup>37</sup>), with plot as random variable. Similarly, vocalizing activity was analysed with a linear mixed effects model. We checked that the models were not over-dispersed and that the standardised residuals did not indicate heteroscedasticity. At the plot level, we used generalised linear models of the poisson family to model alpha and beta bird species richness, which we calculated using the additive partitioning approach<sup>38</sup>: alpha richness was the mean number of species per plot, and beta richness was defined as the total number of species in the plot's habitat (gamma richness) minus its alpha diversity. For all models, we used tree number, tree basal area, and habitat type as predictors. We generated all possible predictor combinations and compared the models using Akaike's Information Criterion for small sample sizes (hereafter AICc, MuMIn package, dredge function) to choose the best model (with the lowest AICc).

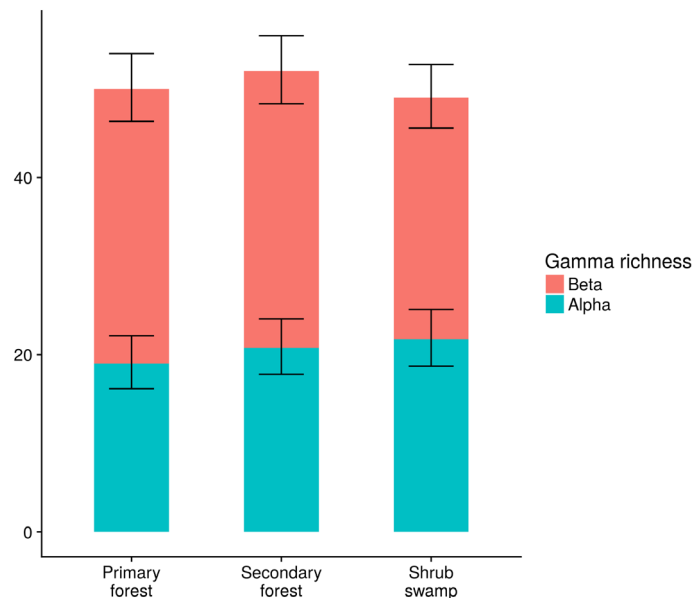
We pooled the data from both acoustic counts and visualized the composition of the bird communities in non-metric multidimensional scaling graphs generated with the package vegan<sup>39</sup>, and tested the significance of the habitat in structuring these communities with an ADONIS test<sup>40</sup>. We also plotted the abundance of birds within different families in each of the habitats along with their conservation status. To investigate whether the combined, different habitats lead to higher species richness than one primary forest area of similar size, we calculated the rarefied richness based on the entire bird community, rarefied to 4 sampling plots, to compare it to the number of species found in the 4 forest plots.

## Results

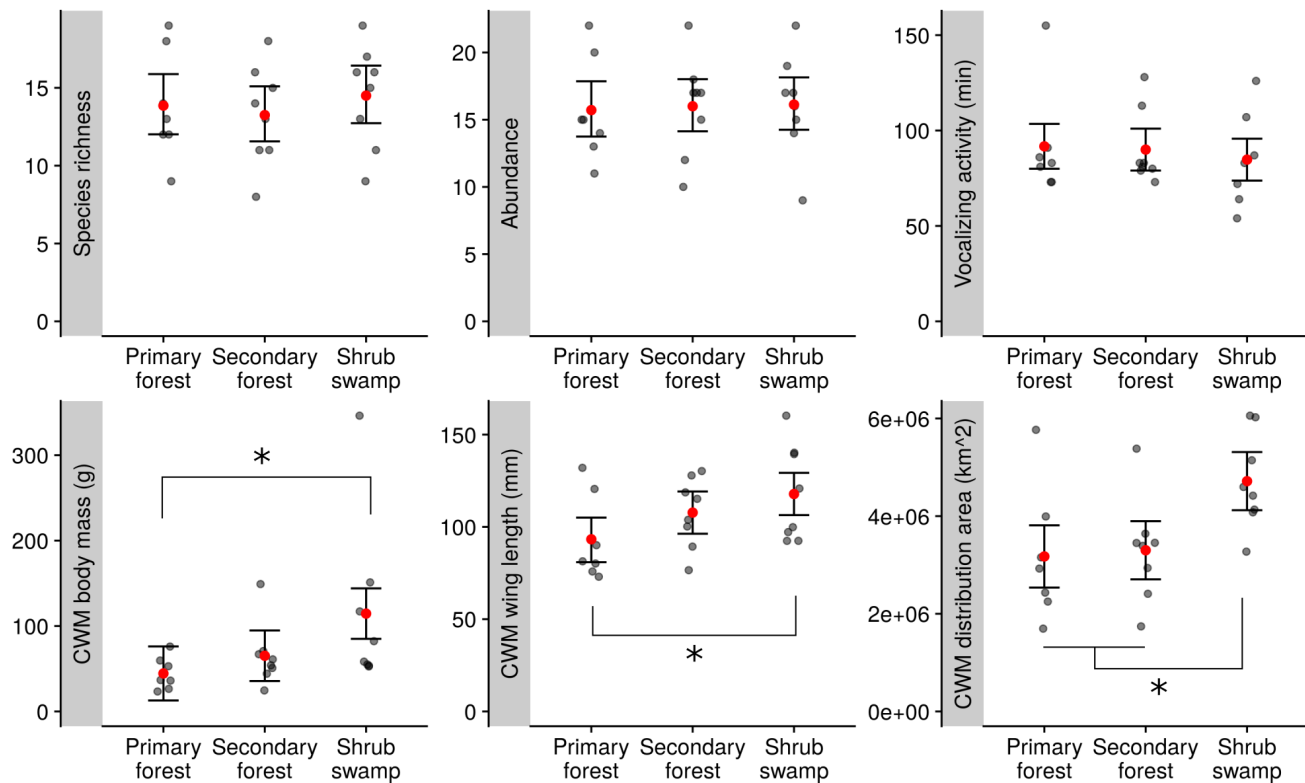
We detected 426 birds overall. Among those, 30 individuals were not identified to species level and 2 were detected above 50 m, resulting in a working dataset of 394 individuals, belonging to 88 species (Table S1). The three habitats differed considerably based on their vegetation structure (Figure S1) and the distribution of their DBH values, with primary forest having the highest basal area, secondary forest intermediate values, and shrub swamp having the smallest basal area (Figure S2).

Species richness and abundance at the count level, and mean alpha and beta species richness at the plot level were similar between the habitats (Figure 2 and Figure 3).

These variables were best explained by null models. Gamma species richness per habitat was as follows: primary forest: 50 species, secondary forest: 52 species, bush swamp: 50 species. Bird richness and abundance between habitats, split into different functional groups and IUCN red list threat categories, were similar between habitats (Figure S2).



**Figure 2. Bird richness components at the plot scale.** Total (gamma) richness for each habitat type, split by alpha and beta richness components. Error bars show the 83% confidence intervals for the mean alpha and beta richness values, which do not differ significantly at  $P=0.05$  when they overlap (Krzywinski, 2013).



**Figure 3. Bird taxonomical and functional traits in each habitat.** Bird species richness, abundance, vocalizing activity, community-weighted mean (CWM) of body mass, wing length, and distribution area<sup>33</sup> per count in three different habitats of the peat swamp of the Berbak national park. Mean values are represented with red dots and their 83% confidence intervals are indicated with error bars. Means are significantly different at  $P=0.05$  when their confidence intervals do not overlap (Krzywinski, 2013), and significant differences are indicated with asterisks.

Bird vocalisation activity at the count level was similar among habitats (Figure 3) and best explained by a null model. CWMs of body mass, wing length and distribution area however were increasing along the disturbance gradient and the CWMs in shrub swamp were significantly higher than in primary forest. Wing length CWM was also higher in shrub swamp than in secondary forest (Figure 3).

Bird communities differed greatly between primary forest and bush swamp, with secondary forest being an intermediate habitat having overlap with both of the latter (Figure S3). The ADONIS test revealed that habitat structured bird community composition with marginal significance ( $P=0.068$ ). The difference in the bird communities arose mainly from the higher abundance of Timaliidae (Old World babblers) in the forest habitats. Pycnonotidae (Bulbuls) and Alcedinidae (Kingfishers) were more prevalent in shrub swamp, while Nectarinidae were more frequent in the forest habitats (Figure 4).

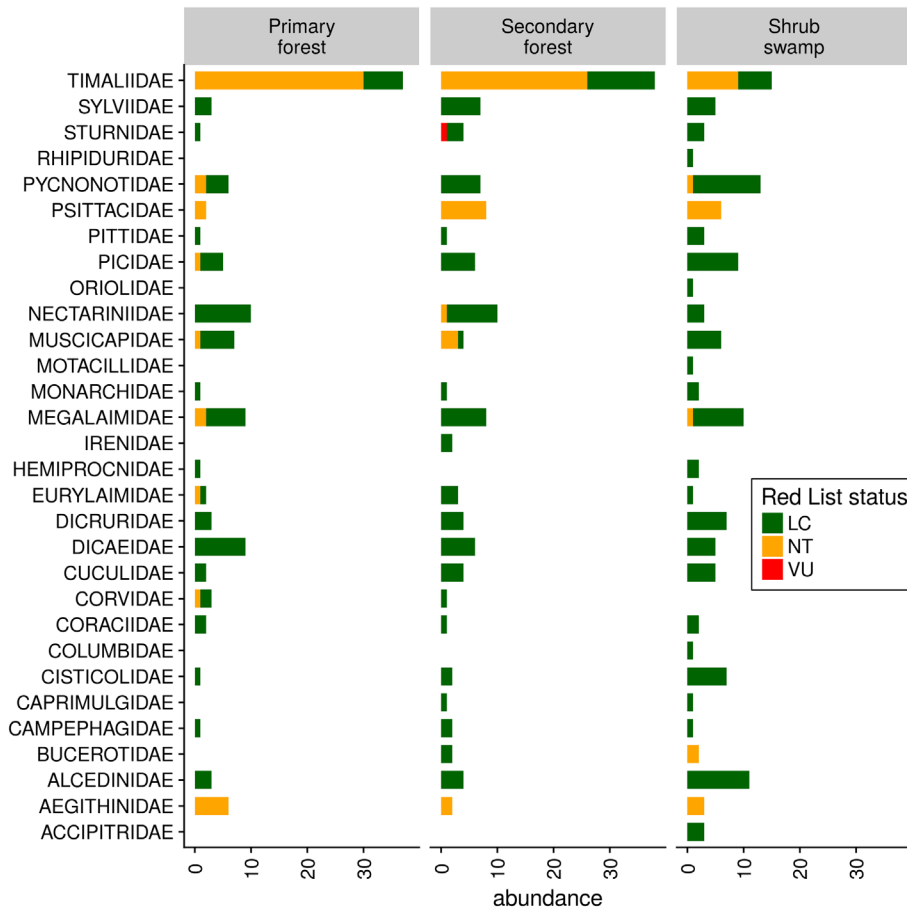
**Dataset 1. The data and R script required to reproduce our graphs and results are provided**

<http://dx.doi.org/10.5256/f1000research.13996.d203364>

This file contains: Berbak birds.csv contains the bird detection data; Berbak vegetation.csv contains the individual DBH values for all plots; Berbak birds analysis.R is the R script that performs the analysis and graphing.

**Discussion**

We have shown that all three habitats inside the Berbak peat swamp forest have similar abundance, vocalizing activity and species richness. The habitat, tree number or basal area were not related to these measures. Even the richness and abundance of the bird feeding guilds and abundances inside families were similar between habitats. However, we detected differences in the bird community composition, notably a decrease in understory insectivores (Old World Babblers, Timaliidae) which was



**Figure 4. Bird abundance in each family.** Abundances are split by habitat and shown for different IUCN Red List statuses.

compensated by the appearance of other species in shrub swamp. This change in the community also became apparent in a shift to bigger and more mobile species with greater distribution ranges in shrub swamp.

The Berbak peat swamp forest is threatened from many sides. It is difficult to access as only waterways (irrigation canals and rivers) lead into it, and large parts are temporarily flooded due to tides. However, wild bird extraction for the caged bird market, illegal logging, land-use conversion at its margins, and natural rubber (jelutung) collection are all currently happening<sup>41</sup>. Wild bird trapping threatens bird populations directly (Harris *et al.* 2016), and is especially worrisome as birds from the Berbak region are increasingly traded in the caged bird market of Jambi city (pers. obs. KD). All these human activities increase the risk of fires, especially during dry spells caused by the warm phases of the El Niño Southern Oscillation, which led to the especially severe fires of 1994, 1997, and 2015 (after our survey).

Primary forest had high conservation value because we found 16 species of conservation concern (“near threatened” status according to IUCN Red List status), twice as many as in shrub swamp. More acutely threatened, rare species might be detected with higher sampling effort by processing more recordings.

Secondary forest was exactly intermediary with 12 species of conservation concern, although one bird, the Javan Myna (*Acridotheres javanicus*), has recently been classified as vulnerable. Javan Mynas are commonly sold on the market in Jambi city and might establish feral populations when occasionally breaking free. The absence of hornbills in primary forest seems fortuitous, as we also detected one *Buceros rhinoceros* in forest also, but at an estimated distance of 60 m. Compared to the secondary forest plots surveyed by Prabowo *et al.*<sup>42</sup> in the same province (Harapan rainforest) and year, the detected bird abundance was much higher in Berbak (4 birds per count in Prabowo *et al.* versus 13 birds per count in the present study for the same detection radius). Our secondary forest plots seemed relatively well-preserved, as we could not detect any typical loss of understory and terrestrial insectivores due to changes in understory vegetation<sup>43</sup>. It is noteworthy that even extensively logged peat swamp forest can harbor large species numbers. (Azhar *et al.* 2011). Considering that the detected abundance of birds in the other habitats was similarly high, this indicates that the National Park of Berbak still provides relatively good living conditions for birds, and especially conservation-worthy species thrive in the primary forest tracts.

Nevertheless, bird communities differ between habitats as was shown in the non-metric multidimensional analysis (Figure S4).

It turned out that the differences in bird communities arose mainly from the absence of Timaliidae in shrub swamp. Timaliidae are mainly understory insectivores, which are generally recognised to be sensitive to forest disturbance and thus act as indicator species<sup>44</sup>. The higher prevalence of generalist bulbuls and open-area kingfishers in shrub swamp is also typical of disturbed habitats in the region, such as oil palm plantations<sup>42</sup>. Notably, sunbirds were almost absent in shrub swamp, which does not seem to provide enough floral resources (pers. obs. KD). Interestingly, the species in shrub swamp were heavier, had longer wings and wider distribution ranges, indicating they may be more mobile, widespread species that are less of a conservation concern; these features are also typical of generalist species. The higher body masses may arise from the prevalence of kingfishers and bulbuls, which are relatively big.

### Conclusion and outlook

The different habitats lead to a high diversity at the national park level: while the total species count per habitat was almost identical (around 50), the overall species richness reached 88 species. It is tempting to conclude that the heterogeneity introduced by disturbances such as logging or fires (which created these different habitats) increased bird species richness. However, in comparison to an equally large area consisting only of primary forest, the combination of different habitats does not lead to a markedly higher species richness, as we found a nearly identical rarefied species richness of 51 for all habitats combined. The fact also remains that primary forest harboured a higher proportion of conservation-worthy bird species, while generalists were more prevalent in the shrub swamp.

Our autonomous acoustic sampling protocol gathered many more data than we analysed so far: we only processed around 0.7% of the available data, albeit the most promising dawn choruses. Also, due to logistical restrictions, we only surveyed four sites that were close to waterways, so that that large parts of the park remain little known. We would determine a higher proportion of the bird community with random or carefully chosen time windows throughout the day<sup>45</sup>. We welcome interested prospective co-

authors to process more recordings to complete the species list of the still only superficially studied avifauna of Berbak. Repeated surveys to the same sites, after the major fires from 2015, would also yield insights into how bird populations are changing in the longer term in response to these and other disturbances from wildlife trade.

### Data availability

**Dataset 1: The data and R script required to reproduce our graphs and results are provided.** This file contains: Berbak birds.csv contains the bird detection data; Berbak vegetation.csv contains the individual DBH values for all plots; Berbak birds analysis.R is the R script that performs the analysis and graphing. DOI, [10.5256/f1000research.13996.d203364](https://doi.org/10.5256/f1000research.13996.d203364)<sup>46</sup>.

The source audio material is available at <http://soundefforts.uni-goettingen.de/biosounds/collection/show/3>.

### Competing interests

No competing interests were disclosed.

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### Supplementary material

#### Table S1: Detected bird numbers in each habitat.

[Click here to access the data.](#)

#### Figure S1: Examples of sampling plots.

1: BB3 shrub swamp with burned tree stump; 2: BP2 primary swamp forest; 3: BS2: secondary swamp forest with installed sound recorder and coloured ropes for the vegetation survey.

[Click here to access the data.](#)

#### Figure S2: Distribution of tree sizes in the different habitats.

We measured the diameter at breast height (DBH) of all trees with a DBH above approximately 6.4 cm (circumference of 20 cm).

[Click here to access the data.](#)



**Figure S3: Species richness per habitat and IUCN Red List threat status.**

[Click here to access the data.](#)

**Figure S4: Non-metric multidimensional scaling of bird communities in the different habitats.**

Brown represents shrub swamp, light green secondary forest, dark green primary forest.

[Click here to access the data.](#)

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# Open Peer Review

Current Referee Status:  

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## Version 2

Referee Report 23 July 2018

doi:[10.5256/f1000research.16242.r33970](https://doi.org/10.5256/f1000research.16242.r33970)



**Erin M. Bayne** 

Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada

The authors have addressed my primary concerns and the manuscript is much clearer now.

**Competing Interests:** No competing interests were disclosed.

**Referee Expertise:** Conservation biology, bioacoustics

**I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.**

Referee Report 21 May 2018

doi:[10.5256/f1000research.16242.r33969](https://doi.org/10.5256/f1000research.16242.r33969)



**Badrul Azhar** 

Faculty of Forestry, Institute of Bioscience, Universiti Putra Malaysia, Serdang, Malaysia

The authors have addressed all the major comments. I'm satisfied with the explanations and justifications given by the authors.

**Competing Interests:** No competing interests were disclosed.

**Referee Expertise:** Conservation biology

**I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.**

Author Response 21 May 2018

**Kevin Darras**, University of Goettingen, Germany

Thank you for your time and interest!

**Competing Interests:** No competing interests were disclosed.

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**Version 1**

Referee Report 04 April 2018

doi:10.5256/f1000research.15212.r32057

**Erin M. Bayne**

Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada

The article "Birds of primary and secondary forest and shrub habitats in the peat swamp of Berbak National Park, Sumatra" by Darras et al. summarizes a survey of birds via autonomous recording units in this poorly understood ecosystem. Any information on systems such as these is valuable and providing the type of data given is useful for providing baseline information that give us an idea of what species are present and thus at risk. Thus, the data as shared is very valuable for the scientific and conservation community.

The introduction is fairly generic in my opinion and focuses on issues that are not the central tenet of the results that are shown. It seems that the theoretical concepts of resilience/ resistance are the actual working concepts behind this paper that would make the results better contextualized. The three habitats sampled make a nice gradient for assessing how much things are the same/ different in this system. Rather than focus on issues that you did not measure (i.e. hunting, flooding, etc) keep the introduction more centralized on the things you did measure and it would be a clearer paper.

In the methods there are number of very large assumptions made of the reader. I previously have read your work on measuring distance to birds from ARUs. While I find the logic of doing this reasonable, I do not remember you having this level of accuracy in distance estimation (i.e. to the metre). It seems like given the novelty of your approach that you need to provide an appendix highlighting how you do this and where this level of accuracy comes from. At a minimum I think you must let the reader know that this is an estimate and recognize there is error because I find it very unlikely that you can do this to a metre for every species. Thus, some of your birds within the sampling radius were probably past 50 metres and some birds outside 50 were likely excluded. It is likely that such error is random between habitats but you have to make this an explicit assumption.

The use of 20 minute point counts from the same day is very reasonable for richness and calling rates etc. But I have significant concerns about double counting of the same individual over that duration. Birds move and how a listener can track the number of individuals that occur over that interval is likely very problematic. You need to justify that this did not occur for people to believe this numerical estimates. How you analyzed abundance is unclear regardless (see below).

In the methods you never use the terms alpha, beta or gamma when describing richness. Yet the figures do. You need to clarify the equations used to calculate beta in particular. How beta is computed needs to be described and the results described given the figure that includes it. No measurement of beta diversity that I have read would have the range you shown in figure 2 so clarification of how is essential.

I am somewhat confused as to the amount of replication you have. I understand there to be 12 sites. At each site you have 48 hours of data. From that you picked 20 minutes at a set time. You then repeatedly sampled one morning from each month, I think. As such you have repeated measures throughout your

design. As it reads, I think your analyses using models with random effects are reasonable. What I am not clear is whether or not the ADONIS test incorporates this repeated measure component. The other issue in analyses that is unclear is you say you use the sum of the maximum number of individuals vocalizing simultaneously. Does this mean you modelled the sum of the max for all repeated surveys? If so then is this a mixed model or are you using the maximum from each count with a random effect for site? Would you not then need to control for month of the year?

Nowhere do I see rationale for using an 83% confidence interval. It is rather atypical so should be justified.

The discussion fails to recognize the significant limitation of this study which is replication. You only have 4 replicates for each treatment so the ability to find differences, particularly in alpha is limited. Since most of the other variables build from alpha richness it is not particularly surprising that the null models fit the best. So making a really strong statement that there is no difference is not really a solid argument. There is not a huge effect size clearly, but with 100 replicates in each habitat then I suspect you would support far more complex models and be able to draw stronger conclusions.

The discussion also goes into talking about issues of this park that are not presented with the actual results. While these things maybe happening their role in what is described as the question of concern seem like filler rather than important context from the research that was conducted.

**Is the work clearly and accurately presented and does it cite the current literature?**

Partly

**Is the study design appropriate and is the work technically sound?**

Partly

**Are sufficient details of methods and analysis provided to allow replication by others?**

No

**If applicable, is the statistical analysis and its interpretation appropriate?**

Partly

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

Partly

**Competing Interests:** No competing interests were disclosed.

**Referee Expertise:** Conservation biology, bioacoustics

**I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.**

Author Response 04 May 2018

**Kevin Darras**, University of Goettingen, Germany

Thank you very much for your critical appraisal of our manuscript. We addressed most of the issues you raised.

We did not change the focus of the introduction: hunting or poaching is not mentioned in the introduction, and flooding is only mentioned once in the introduction when enumerating the importance of peat swamp forests without further discussion. Wild bird trapping is actually mentioned in the discussion but it is central to it because it poses a direct threat to the bird populations that we surveyed. Flooding is a defining element of swamp forests that the reader needs to bear in mind. That is why we kept both of these themes in the manuscript, even though we did not measure them.

We do not introduce or develop the resilience concept in this paper as the study was rather designed for documenting the bird communities and to establish their conservation value and as such, it does not address that theme satisfactorily. We think that a much more stringent selection of many more sites would be needed to address this interesting subject. Our sentence “Few studies have focused on the potential benefit of disturbances for overall landscape biodiversity apart from theoretical and modelling approaches” was changed to “Theoretical and modelling approaches are usually used to analyse the potential benefit of disturbances for overall landscape biodiversity” to avoid implying that we will investigate that topic. We also merged that part with the previous paragraph.

We clarified in the text that although bird distances were estimated to the metre, accuracy is not as high, as this led to a misunderstanding: “The distance of bird vocalisations was estimated by ear to the meter; even though the accuracy is lower, estimation error was assumed to be random. Distance estimates were made based on the call loudness in the sound recording compared to the ambient sound level and knowledge of the source sound level of each species.” It is better to do fine-grained estimates even when accuracy is low as estimation errors should be normally distributed and averaged out in the end. Our corresponding manuscript about estimating bird detection distances is in minor revisions.

We clarified how we counted individuals for our analysis of abundance. We now write “For counting bird abundance, we first derived the maximum number of simultaneously vocalising individuals in each species, and then summed these maxima over all species, leading to a conservative estimate of the number of individuals”. Thus, double-counting individuals was prevented.

We did not change the statistical models description itself, as it became clearer with the new text that describes how abundance was calculated, and the existing text is straightforward: “At the count level, the species richness and abundance between habitats was modelled using generalised linear mixed effects models of the poisson family (lme4 package <sup>37</sup>), with site as random variable”. We do not use month as an additional random effect as our models would then be over-fitted with one random effect per data point.

We clarified what our sampling units are and now use the terms “plot” and “site” consistently throughout, as it was sometimes unclear. We also explain better when each plot was sampled: “We recorded audible sound in all 12 plots two times. [...] From February to November 2013, we sampled all three plots of one site (one from each habitat) each month for 48 hours, starting at midnight.”

Concerning alpha and beta richness, we now elaborate how we calculated both richness values in addition to the already cited study about additive richness partitioning: “alpha richness was the mean number of species per plot, and beta richness was defined as the total number of species in

the plot's habitat (gamma richness) minus its alpha diversity.”

We clarified in the methods that the ADONIS analyses were based on data pooled from both counts, so that we only investigate the general composition of the habitats without considering seasonal effects.

The rationale behind using 83% confidence intervals is now supported with a proper citation.: Krzywinski, M., Altman, N., 2013. Points of significance: error bars. *Nature methods* 10, 921–922. This confidence interval value corresponds to intervals that touch each other at a 5% P-value.

We agree that our spatial replication is limited with only four plots per habitat. However, most ecological studies fail to satisfactorily cover the geographical ranges of the ecosystem of interest, and having more plots was not possible in our case. Moreover, we disagree with the statement that most of our measures build upon alpha richness: abundance, richness, and call activity are only correlated and one cannot replace the other. However our community-weighted means of functional traits are totally independent of richness. Instead, this is precisely the point that we make in our study: even though alpha richness is similar or indistinguishable across sites, we find significant differences in the composition and function of the respective bird communities, underlining the fact that richness (or abundance) does not tell the whole story. We made that clearer in the first paragraph of the discussion that summarises the findings: “This change in the community also became apparent in a shift to bigger and more mobile species with greater distribution ranges in shrub swamp.”

As you mention, with more replicates we would be able to make finer inferences, and it is indeed our aim to maximise the use of our larger raw data set at hand with future manuscript versions. However, even with our limited data set, the differences we have found so far are statistically significant and thus solid enough to support the message we tell. Still, we added the following sentence to our discussion: “[...] due to logistical restrictions, we only surveyed four sites that were close to waterways, so that that large parts of the park remain little known. “

We would like to keep the conclusion as is since this study is focused strongly on conservation, and highlighting the threats to this national park and its animals seems to be in line with our message. To develop the wild bird trapping theme further, we added: “Wild bird trapping threatens bird populations directly (Harris, J.B.C., Tingley, M.W., Hua, F., Yong, D.L., Adeney, J.M., Lee, T.M., Marthy, W., Prawiradilaga, D.M., Sekercioglu, C.H., Suyadi, Winarni, N., Wilcove, D.S., 2016. Measuring the impact of the pet trade on Indonesian birds. *Conservation Biology* n/a-n/a. <https://doi.org/10.1111/cobi.12729>), and is especially worrisome as birds from the Berbak region are increasingly traded in the caged bird market of Jambi city (pers. obs. KD).“

**Competing Interests:** No competing interests were disclosed.

Referee Report 12 March 2018

doi:10.5256/f1000research.15212.r31795



**Badrul Azhar**

Faculty of Forestry, Institute of Bioscience, Universiti Putra Malaysia, Serdang, Malaysia

Darras et al. present their findings about avian biodiversity in primary swamp forest, secondary swamp forest, and shrub swamp. However, I have some major concerns regarding the way the study was conducted and little information is provide to explain the study areas.

“We surveyed birds in Berbak National Park, a peat swamp situated in the province of Jambi, on the east coast of the island of Sumatra in Indonesia (Figure 1). Berbak National Park is a Ramsar site<sup>25</sup> and an Important Bird Area<sup>26</sup>. A severe drought in 1997 facilitated forest fires which were aided by human disturbance due to natural rubber collection (*Dyera costulata*). The burned areas subsequently developed into shrub swamp. Tree stumps also reveal that illegal selective logging affected several areas of the park, resulting in secondary forest habitats.”

Comments: Provide additional information, size area of each study area? When the secondary forest was logged? Explain about the shrub swamp here.

“We recorded audible sound in all 12 sites. We used autonomous sound recorders (SM2+ recorders with SMX-II microphones, Wildlife Acoustics Inc.) and did not carry out visual surveys, since acoustic recording constitutes a valid survey method for assessing bird richness<sup>27</sup>, especially for cryptic birds in tropical forests. From February to November 2013, we sampled all three habitats at one site each month for 48 hours, starting at midnight.”

Comments: I'm quite confused about the field survey because not much information is provided in the current text. Do you have enough number of spatial replicates to perform GLMMs. And with just data from 12 sites, you can confidently say the results really have answered the research questions. In addition, the sample size is small i.e. 12 sites. Why you did not move the autonomous recorders to other points or sites? You established four sites in each habitat. I think you need to use point method. For example, 30-40 points at each site. I suggest the authors to write a caveat regarding the small sample size in the discussion. The 48 hours were continuous? The sound recording method should be complemented with other sampling methods next time.

“we counted and measured the diameter at breast height (DBH) of all trees with a circumference above 20 cm (diameter at breast height of ~6.4 cm) inside an area of 14 × 14 m delimited by spanning 10 m coloured ropes from the central tree where the sound recorder was attached to all cardinal directions.”

Comments: Provide the summary statistics for each variable.

“For all models, we used tree number, tree basal area, and habitat type as predictors.”

Comments: Did you include the different sampling month into the modelling work?

“We detected 379 birds overall, belonging to 90 species.”

Comments: After doing bird survey for ten months, your results are not very impressive compared to conventional sampling methods. Perhaps you need to have more sites or at least 30-40 points/lines per site. How many endangered/vulnerable species were recorded?

#### References

Comments: The reference list is not comprehensive. Authors should search and cite recent published bird studies in tropical peat swamp forest of SEA. Some articles cited in the text are not about studies from tropical peat swamp forests.

#### **Is the work clearly and accurately presented and does it cite the current literature?**

Partly

#### **Is the study design appropriate and is the work technically sound?**



No

**Are sufficient details of methods and analysis provided to allow replication by others?**

No

**If applicable, is the statistical analysis and its interpretation appropriate?**

Partly

**Are all the source data underlying the results available to ensure full reproducibility?**

Yes

**Are the conclusions drawn adequately supported by the results?**

Partly

**Competing Interests:** No competing interests were disclosed.

**Referee Expertise:** Conservation biology

**I have read this submission. I believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.**

Author Response 04 May 2018

**Kevin Darras**, University of Goettingen, Germany

Thank you very much for your critical appraisal of our manuscript. We addressed most of the issues you raised.

We added the total size of the national park to the legend of figure 1 (1476 km<sup>2</sup>). Each one of our plots was a point, and we used the birds within a 50 m radius of that point for our analysis, as explained in the methods. We stated until when the secondary forest sites were logged and the shrub bush burned: "The secondary forest plots were last subject to selective logging until 2008 for BS1, 1999 for BS2, 2003 for BS3, and 2010 for BS4. The shrub swamp sites burned in 1997, and BB2 burned yearly since."

We provided summary statistics for the total DBH in each habitat in the Fig S2 caption: 89 m<sup>2</sup> per ha in primary forest, 64 m<sup>2</sup> per ha in secondary forest, and 29 m<sup>2</sup> per ha in shrub swamp.

We also clarified the data collection schedule, as this also explains why we could not systematically test for the seasonal effect in our models: "From February to November 2013, we sampled all three plots of one site each month for 48 hours, starting at midnight. It was not possible to do the survey each month, or to repeat the same site sampling sequence for the second set of recordings because of access and transportation restrictions."

Also, we did not use the sampling month as a predictor in our models as we only sampled 4 sites each month and that effect would be confounded with the spatial effect from the 4 plots being close to each other.

We did not move the recorders to other sites because it would have been difficult to do so. The park is very difficult to reach and go through, and we could not do more than what we achieved in 8

months of sampling. Also, we lacked skilled ornithologists to carry out point counts and it would have been prohibitively expensive. To get an impression of the field work, you can have a look at our blog post here: <https://blog.f1000.com/2018/04/10/can-hear-birds/>

We now cite the study of Azhar et al. 2011 in the introduction and also in the discussion about the secondary forest value: “It is noteworthy that even extensively logged peat swamp forest can harbor large species numbers.(Azhar, B., Lindenmayer, D.B., Wood, J., Fischer, J., Manning, A., McElhinny, C., Zakaria, M., 2011. The conservation value of oil palm plantation estates, smallholdings and logged peat swamp forest for birds. *Forest Ecology and Management* 262, 2306–2315.)”

We would like to point out that the statistical analysis has been explained: “At the count level, the species richness and abundance between habitats was modelled using generalised linear mixed effects models of the poisson family (lme4 package [37](#)), with site as random variable [...]”. Since we have two counts (=data points) per site, mixed models were adequate. Also, the number of replicates was sufficient for proving our points about the functional changes observed in the bird communities of the different habitats, since our statistical analysis yielded significant P-values, even when using these stringent mixed effects models.

The 48 hours were continuous indeed, and we will process more data as soon as we find people interested in doing this. 387 birds found in 8 months is not impressive *per se* indeed, but please bear in mind that this is the result of analysing only 0.7% of our data. We also updated these numbers by better counting of simultaneous detections, yielding a data set of 426 birds (of which 394 were used in the analysis after discarding far and unidentified birds).

We added the following sentence to our discussion: “[...] due to logistical restrictions, we only surveyed four sites that were close to waterways, so that that large parts of the park remain little known. “

**Competing Interests:** No competing interests were disclosed.

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