The Potential of Oil Palm Landscapes to Support *At Risk* Species

A science-for-policy paper by the SEnSOR programme

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Cover photo: Bornean orangutan, Photo credit: J M Lucey

Key messages

1. When forest is degraded or converted to a different land-use, **the types of species present at a site change**, with primary forest specialists being replaced by species that are adapted to more disturbed and open habitats.

2. In the context of this study for oil palm industry policy development, **at *risk* species are those that have difficulty persisting** when their forest habitat is replaced with oil palm plantations and are therefore vulnerable to extinction in oil palm dominated landscapes.

3. **Large tracts of selectively logged and degraded forest** can support over **70% of primary forest animal species**, and specialists can return as the forest recovers, if the forest is not isolated or heavily degraded. **HIGH CONFIDENCE**

4. By contrast, the **oil palm** planted area supports **less than a quarter** of primary forest animal species. **REASONABLE CONFIDENCE**

5. **Forest fragments** (less than 1000ha in size) support **around 40% of primary forest animal species**. Generally, larger fragments with less disturbance support more species, therefore the larger the fragment the more conservation value it will have. **REASONABLE CONFIDENCE**

6. **Other tree plantations** can support **more primary forest animal species than oil palm plantations (~50% of those found in primary forest)** but this is dependent on the type and complexity of vegetation in these plantations. **REASONABLE CONFIDENCE**

7. **Many IUCN red-listed species appear to do well in large tracts of logged forest**, (**HIGH CONFIDENCE**). These species are **likely to be negatively impacted by severe fragmentation, degradation and conversion to oil palm plantations**, but data are lacking for fragmented and non-forest land cover types. **LOW CONFIDENCE**

8. **Key indicators of the impact of RSPO certification** on the conservation of primary forest species and IUCN red-listed species therefore include: **avoided deforestation**, especially of large tracts of forest, and the **amount, size, quality, shape and connectivity of forest patches** retained in the landscape, as well as **the complexity** of the intervening commercial planted area.

Scope of the report

The aim of this report is to provide quantitative information about the number of *at risk* species that are supported in different land cover types relevant to oil palm landscapes. This information will help develop a set of landscape characteristics (such as the amount of forest cover needed) which can be used to measure the impact of RSPO certification on biodiversity conservation. To do this, we focus on two key metrics of biodiversity:

1) **Primary forest species:** We look at the number of primary forest species remaining in oil palm and other human-modified land cover types. We focus on this group of species because they **represent the natural biodiversity of unmodified forest**, and we can exclude open-habitat/ non-forest species which are at much less risk from habitat modification. A primary forest species ***is not necessarily a specialist***: the only criterion is that it inhabits primary forest (but might also occupy other habitat types).
2) **IUCN red-listed species:** The International Union for the Conservation of Nature (IUCN) Red List (www.iucnredlist.org) is the most comprehensive global assessment of the conservation status of species. We include in our study those species that are cited by the IUCN red list as being critically endangered, endangered, vulnerable, or near threatened. IUCN information was available only for mammals, birds, some butterflies and trees in this study. Many of these species are also primary forest species. ***The IUCN red-listed species are discussed qualitatively in this report due to inadequate data for quantitative analysis.***

To compare the change in the number of species in different species groups across the different land cover types more easily, these metrics are converted to a percentage of the levels recorded in lowland primary forest. We also present levels of total biodiversity (the number of primary forest species plus disturbance-adapted/ open habitat species). The confidence intervals expressed in the key messages are explained in appendix 3.

Geographical scope: This report focuses on ***Malaysia and Indonesia*** because these countries are the largest producers of palm oil globally. There is also a large body of scientific evidence to draw on from these regions, giving us a higher level of confidence in our conclusions. While general patterns may be consistent, the results may have limited applicability to other tropical countries such as those in Africa and Central or South America.

Important notes:

- **The levels of biodiversity recorded in primary forest are likely to be underestimated because studies of canopy and soil biodiversity are lacking.**
- **Only one study of plants (bryophytes) was available for the synthesis of primary forest species, therefore the results relate mainly to animal species, and patterns of plant diversity may be different.**

Rationale

One of the key aims of the Roundtable on Sustainable Palm Oil (RSPO) is to avoid biodiversity losses as a consequence of the development of oil palm plantations, and there is growing pressure for the RSPO to show that certification is having a positive impact in this respect. In order to monitor the impact of RSPO we need to identify the species that are vulnerable to conversion of forest to oil palm plantations and understand the features of the landscape which can improve their survival. Using this information we can develop measures to assess the impact RSPO certification is having on biodiversity based on the characteristics of the landscape (such as whether there is enough forested area).

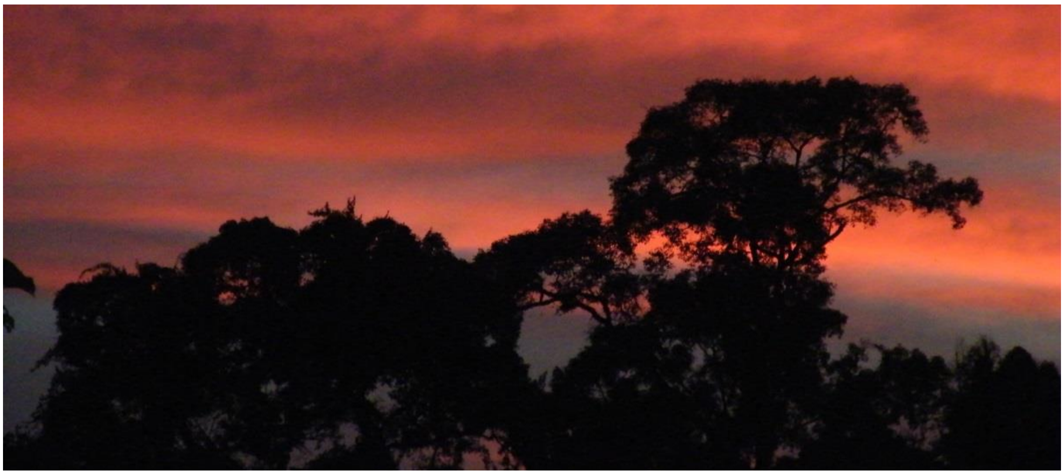
A previous science-for-policy report by Lucey et al. (2015) reported changes in biodiversity across land cover types and found that the total number of species in oil palm was less than half the number in primary forest. The total number of species is an important indicator for understanding the overall health of an ecosystem; however, the type of species changes as well as the number, and some species are more vulnerable to conversion of forest to oil palm plantations than others. For example, estimates of the total numbers of species in plantation landscapes are boosted by the occurrence of widespread, non-forest species of low conservation value, and studies that ignore the type of species may conceal losses of vulnerable species. This report expands on the information provided in Lucey et al. (2015) by focusing on *at risk* species and quantifying changes in these species following habitat degradation and conversion to oil palm plantation landscapes.

IUCN red-listed Bornean Clouded Leopard, photo credit: Ch'ien C. Lee www.wildborneo.com

The IUCN Red List is a globally recognized authority on the conservation status of species. Therefore, we applied this categorisation to our species lists collated from the literature to see how well globally threatened species were supported in oil palm landscapes. However, many taxa, particularly invertebrates, fungi and some plant groups are under-represented in the IUCN Red List due to a lack of information on these species. Therefore, we also investigated the effect of changing land cover on all species that were recorded in primary forest within the same study, to capture the impacts on under-represented groups in the Red List. This analysis allows us to understand how many of the species in a particular land cover type are either 1) primary forest species that can persist in modified habitats or 2) open habitat, or disturbance adapted species that would not ordinarily be present in primary rainforest.

The RSPO uses the High Conservation Value approach (www.hcvrn.org) to address issues of biodiversity loss. The premise of this approach is to retain areas of natural habitat within plantation concessions that are important to conserve "high conservation values", which include species of conservation concern.

Our analysis of the published data aims to help RSPO stakeholders understand what proportion of primary forest species would be supported in a landscape, depending on the land cover types present.



Primary rainforest canopy at sunset, photo credit: J M Lucey

Quantifying the number of primary forest species supported across different land cover types

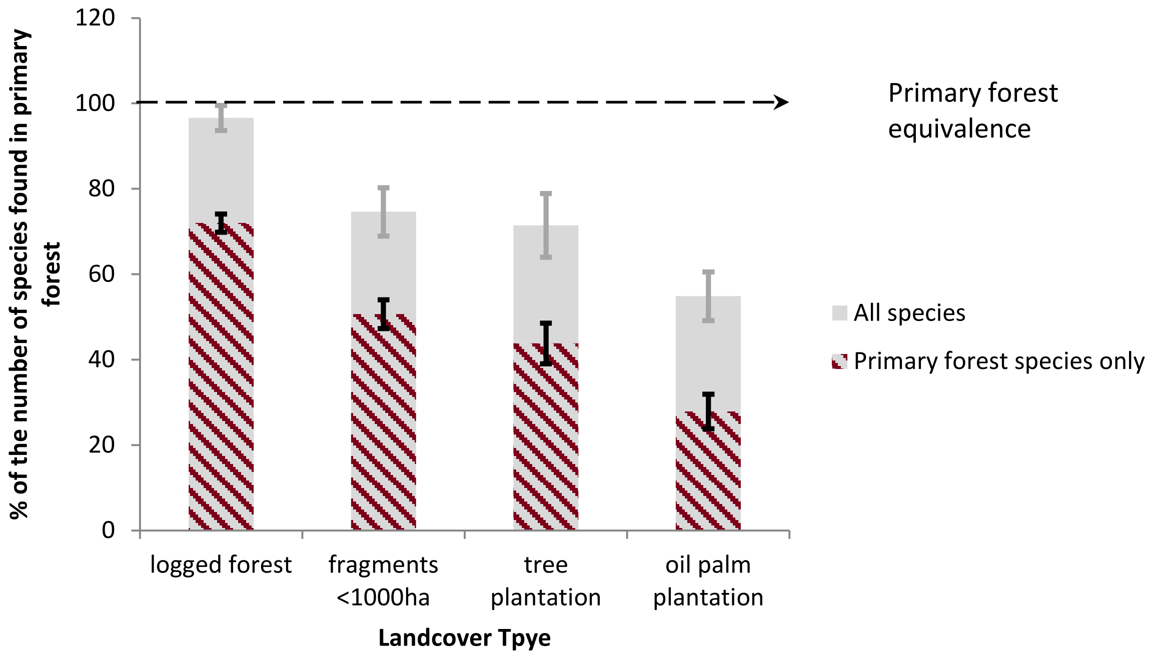


Figure 1. **Numbers of primary forest species in different land cover types, shown as the percentage of primary forest species recorded in each modified habitat (red hatching).** The total number of species recorded in each land cover type is also shown (in grey), plotted as a percentage of the total number of species recorded in primary forest in each case. Data are from Malaysia and Indonesia, collated from almost 50 published studies covering four vertebrate groups - mammals, birds, reptiles and amphibians, eight invertebrate groups- Hymenoptera (ants/bees/wasps), beetles, Lepidoptera (butterflies/moths), flies, isopods (woodlice), springtails, termites, true bugs, and one plant group- bryophytes (not all groups are represented in all land cover types). Error bars indicate the standard error around each mean. For detailed methods see Appendix 1and for sample sizes see Appendix 2.

Large areas of forest

Primary rainforests are characterized by a complex physical structure, created by the high canopy and many layers of trees, understory vegetation, leaf litter and soil.

This habitat complexity supports the high biodiversity levels which are found in primary forest, with different species able to occupy the wide variety of niches available. When this habitat is modified, degraded or converted to agriculture the habitat structure becomes simpler, meaning that fewer species can be supported. Some forest species have niches that are wider than others, meaning they can tolerate higher levels of disturbance, and are more adaptable to a changing environment. The most specialist species are often at highest risk from habitat modification and conversion. The greater the change in habitat, the fewer forest species can survive, and the more non-forest species move into the environment, changing the species composition and interactions among species in the community.

Large tracts of logged forest retain some aspects of the structure of primary forest, although the canopy can be lower and there are more open spaces where large trees have been removed, allowing denser vegetation to grow at lower levels. They support similar overall levels of biodiversity to primary forest (i.e. ~100%). However, 30% of these species are opportunistic species taking advantage of changes in vegetation structure and composition resulting from logging activities. Despite the disturbance, 70% of the logged forest community comprises primary forest species meaning that, even if the forest is quite degraded, these areas are very important for conserving primary forest biodiversity (Edwards et al. 2011). Recent studies also indicate that as the forest recovers, the primary forest specialists that were lost tend to return and depending on the intensity of logging, the community can recover within decades (e.g. Brodie et al. 2015).

IUCN red listed species: We were able to gather information on red-listed mammal, bird, butterfly and tree species which indicate that on average, around the same number of the red-listed species that were recorded in primary forest occurred in large tracts of logged forest, indicating that these areas are important refuges for endangered species. IUCN red-listed species may be endangered not only because of habitat loss, but also because of hunting, illegal logging and harvesting. Large tracts of forest not only appear to provide sufficient resources, but could also provide protection from illegal activities because of the difficulty in accessing deep into these forests, although logging activities, especially road building, can increase access.

Oil Palm Planted Area

The oil palm planted area comprises a drastically simplified habitat, usually with just two distinct vegetation layers: a uniform canopy layer of a single species (oil palm), and a groundcover vegetation layer of disturbance-tolerant herbaceous plants including grasses and ferns.

As a result, the oil palm planted area supports only about 50% of the number of species found in rainforest. Only about half of this community (25% of the total) are primary forest species and remaining species are open-habitat, disturbance-adapted, or invasive species. Additionally, due to the methods of data collection in these studies, we cannot be sure whether the forest species recorded in plantations can persist solely in plantations. It is likely that many of the primary forest species recorded require at least some natural forest habitat in order to survive. Studies of insects have shown that species can "spill over" from natural forest into oil palm plantations boosting the numbers of forest species that occur in the planted area (Lucey et al. 2012; 2014; Gray et al. 2016; Scriven et al. in review). Therefore high levels of natural habitat in oil palm plantations are likely to boost numbers of primary forest species that occur in the oil palm landscape.

Some studies suggest that increasing habitat complexity in the planted area could help boost the diversity and abundance of these primary forest species that can occasionally use oil palm plantations (Azhar et al., 2015), and research from Africa suggests that intercropping could achieve greater habitat heterogeneity (Amoah et al., 1995; Nchanji et al., 2015). Research is underway in SE Asia to investigate the potential of inter-planting with other commercial tree species and increasing levels of groundcover to support biodiversity, and assess the role of this biodiversity in supporting ecosystem functioning and productivity (EFFORTS project: www.uni-goettingen.de/en/310995.html; and BEFTA Programme: http://oilpalmbiodiversity.com). However, the increase in biodiversity from these activities may be small compared to conserving natural habitat and they are more likely to benefit less specialist species than to increase levels of the sensitive species that are most at risk.

IUCN red-listed species: There were too few data to analyse the presence of IUCN red-listed species in the oil palm planted area quantitatively, largely due to the types of taxa sampled in studies and the lack of studies that compare directly with primary forest. Edwards and colleagues (2010) investigated birds listed as threatened or near-threatened by Birdlife International and found that virtually none of these species occurred in oil palm plantations. Yue and colleagues (2015) found that although most of the red-listed mammal species they recorded in forest were also recorded in oil palm, abundance was very low and few of these species were likely to be permanent residents in the planted area, which was close to large forest reserves. Species that are targets for illegal activities or involved in human- wildlife conflict are brought into closer proximity with humans in oil palm landscapes creating added risk (Azhar et al. 2013).

Forest fragments

Natural forest areas are often fragmented when land is converted to agriculture. Degrading edge effects (such as elevated temperatures), and restrictions on population sizes and resources, mean that a patch of fragmented forest may support far fewer species than the same area within a large tract of forest (Haddad et al. 2015).

The HCV approach aims to ensure that important natural habitat is retained within oil palm concessions, which could help to boost the number of primary forest species that can be supported in the landscape. Yet the effectiveness of these HCV areas to support primary forest species is very dependent on how fragmented the remaining forest is.

For the purposes of this analysis we considered fragmented forest to have an area less than 1000ha. On average these forest patches supported 70% of overall biodiversity but only 40% were species that were also recorded in primary forest, and a substantial proportion of the community comprised open-habitat species. This result is expected due to increased disturbance within fragments, and because species that survive in small forest areas probably benefit from also being able to utilize or disperse through the oil palm planted area.

Research has shown that there is a strong effect of fragment size and vegetation quality on biodiversity, with very small fragments (a few tens of hectares) unable to support many more species than the surrounding oil palm, but fragments in the region of a few hundred ha able to support a substantial proportion of forest species (Benedick et al. 2006; Edwards et al. 2010; Struebig et al. 2011; Lucey et al. 2014; Tawatao et al. 2014; Lucey et al. in review). The number of species that a fragment can support may decrease over time due to a time lag between fragmentation and extinction (Haddad et al. 2015).

Additionally, a study by Lucey et al. (2014) suggests that for some insects at least, forest patches only give rise

IUCN red-listed species: Currently, almost no data are available to quantitatively assess the capacity of fragmented forest to support IUCN red-listed species. One study (Edwards et al. 2010) found that small patches (<100ha) were unable to support threatened birds, while Bernard and colleagues (2014) recorded four red-listed species of mammals in small fragments embedded within oil palm plantations. However, these mammals may have been vagrants from a large wildlife reserve within a few hundred metres of the fragments studied. Yeong and colleagues (in review) identified several IUCN red-listed species of dipterocarp tree in fragments ranging in size from 12ha upwards, but found that regeneration was absent or greatly reduced in small fragments, implying that these fragmented dipterocarp populations are not viable without conservation management. Fragmented forest is also much easier to access for poachers and illegal loggers, and so species that are targets for these activities are unlikely to do well in highly fragmented forest unless extra protection is put in place, such as patrols.

to significant spillover effects, boosting the presence of forest species in the oil palm planted area, once they reach a few hundred ha in size.

Isolated fragments, even over 1000ha, may be too small to support resident populations of *at risk* species that need large ranges, such as orangutans, tigers and elephants: research by Marshall et al. (2009) indicates that areas of more than 50,000ha are needed to maintain viable orangutan populations. Yet these fragments might facilitate the movement of such species across the landscape between larger forest areas, which could be critical for maintaining viable populations of these species within human-modified landscapes.

The potential benefits of very small fragments as stepping stones for maintaining populations of vulnerable species has not been studied in depth, but research by Ancrenaz et al. (2015) indicates that orangutans make use of small habitat patches to enable them to utilize or move across the oil palm planted area and so this, and other *at risk* species may benefit. Research from temperate regions has shown that small fragments can be important for dispersal of insects (e.g. Slade et al. 2013).

Riparian Buffers are a type of forest fragment that are retained to protect water courses. They are subject to large edge effects because of their long thin shape but might be important for connectivity. The potential benefits of riparian buffers will be addressed in a separate science-for-policy paper. Research is underway at the SAFE project in Sabah that will inform on many aspects of fragmentation in oil palm landscapes (www.safeproject.net).

Newly prepared terraced oil palm plantations with intervening forest fragments, photo credit: Ch’ien C. Lee www.wildborneo.com

Other tree plantations

As well as investigating the conservation potential of oil palm, it was important to understand whether other long-rotation crops that could occur in the same landscape have a similar impact on primary forest species. We therefore examined other tree plantations including rubber, cacao, Albizia and Acacia.

Black and Red Broadbill, photo credit: Ch'ien C. Lee

Overall, these tree plantations retained an average of 50% of primary forest species (and around 70% of total biodiversity). The proportion of primary forest biodiversity that can be supported in tree plantations is dependent on the complexity of the habitat, and mixed species plantations or traditional systems such as jungle rubber and shade coffee and cocoa tend to support many more species than mono crops (e.g. Sheldon et al., 2010; Muhamad et al., 2013). Therefore complex tree crop systems within an oil palm dominated landscape could boost the conservation of primary forest species, and might be useful as buffers to protect the edges of natural forest fragments, or as connecting habitat, while retaining some economic outputs from the land. One study even suggests that proximity to tree plantations could increase oil palm yields although the reason for this pattern is not yet understood (Edwards et al. 2014a). More research is needed to understand how these different timber and agricultural systems could benefit biodiversity as part of a landscape containing oil palm plantations.

IUCN red listed species: Almost all Red List data available for tree plantations were for birds. Overall, the average percentage of primary forest red-listed species supported was around 45%, although for the subset of complex agroforestry systems (jungle rubber and shade cacao) that was analyzed, this proportion was much higher. Caution should be used in interpreting these results, however, as few data are available.

Conclusion

Current RSPO policy for sustainable oil palm development advocates retaining natural forests within the oil palm landscape to conserve areas with High Conservation Value (HCV).

Our findings show that there are important differences between impacts on primary forest species versus total numbers of species. The larger and less fragmented the remaining forest areas are, the more *at risk* species they will support. Larger and more connected forests are indicators of greater levels of biodiversity conservation. Conserving natural forest is likely to be the most effective means to support at *risk* species, but complex agroforestry systems could also support substantially more primary forest species than oil palm monocultures, and could be effective in connecting and buffering vital natural forest areas where there is a necessity to maintain economic outputs from the land. Increasing the complexity of oil palm plantations (for example by intercropping or encouraging native groundcover) might lead to a small increase in overall biodiversity and help some forest species to traverse the planted area, but is likely to have less benefit for forest specialists that are at greatest risk from expansion of oil palm agriculture.

The RSPO needs to measure its impact on avoiding biodiversity losses. On-the-ground sampling of species which are, by definition, rare is expensive, time-consuming, difficult and likely to miss those species that are not large and/or charismatic. The information in this report shows that measuring the level of avoided deforestation and the amount of forest cover retained within RSPO plantations would be a useful indicator of biodiversity levels. The total hectarage of forest is not the only important measure: the size, quality, shape and connectedness of individual forest patches is also vital for supporting *at risk* species in oil palm dominated landscapes.

Young regenerating forest, photo credit: Ch'ien C. Lee

Key knowledge gaps

1) There is very little quantitative information on the ability of **IUCN red-listed species** to persist in oil palm landscapes.

2) **Data are lacking for plant diversity** patterns across land cover types, but plants could be more adversely affected than animals since removal or replacement of vegetation is the focus of most human-modification activities.

3) So far there has been no quantitative assessment of **the effectiveness of HCV areas** in oil palm landscapes to support *at risk* species, particularly relating to **longer term** persistence of these species.

4) There has also been very little research to test whether or not **restoration or other management activities** are able to maintain or enhance the effectiveness of HCV areas for supporting *at risk* species.

5) Evidence has shown that larger, higher quality fragments are better for supporting primary forest species, but there is very little evidence to quantify the importance of **small forest patches for improving connectivity** or the benefit of enhanced connectivity for conserving populations of species in the landscape.

6) This study focused on land cover characteristics, but there are other important factors which determine the persistence of vulnerable species, especially in fragmented landscapes, such as **the impacts of hunting, wildlife conflict, illegal harvesting, and passing of disease between domestic animals and wildlife.** There is very little research available on these topics for oil palm landscapes.

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Appendix 1: Methods for data collation and analysis

Data were collated from published research and PhD/Msc theses where studies reported numbers of species in primary forest and in other land cover types, allowing us to compute changes in numbers of primary forest species following land cover change. We included studies if they were from Malaysia or Indonesia. Primary forest species were identified as those species that were recorded during sampling of primary forest sites within the same study. Thus the number of primary forest species was the total number of species in primary forest sites, but the number of primary forest species at sites with other land covers could be equal to or less than the total number of species in that land cover site. Studies were included only if sampling effort was the same in all land cover types, and if species lists for all land cover types were available. The necessity to include only sites with equal sampling effort was problematic for very small fragments where studies often had lower sampling effort due to the area available to sample, and so the biodiversity within fragmented forest could be overestimated because very small fragments were often excluded from the analysis.

A data point comprised the published number of primary forest species for a species group in a particular land-cover type; thus a single published paper or thesis could contribute more than one data point to our synthesis if it included several land cover types or several taxonomic groups (e.g. birds, ants etc.). We expressed each data point as the percentage of the number of primary forest species of a species group in a land-use type relative to primary forest. Generalized linear mixed models (GLMMs) were used to compare overall species richness in relation to that of primary forest and the percentage of primary forest species recorded for each taxon studied (n = 13 taxa) in each of our four modified land covers (logged forest, forest fragments, tree plantations and oil palm plantations). Land cover was modelled as a fixed effect and we also included the identity of each study as a random effect to account for pseudo-replication (e.g. >1 taxon in a single study). Analysis was carried out using the 'lmer' function with a Gaussian error distribution in the lme4 package for R3.2.0 (R Core Team, 2013). The models were checked for homogeneity of variances and normality of residuals, and effect sizes (log response ratios) of each model were deemed significant if the confidence intervals of the effect size did not cross zero (Faraway, 2006).

IUCN Red Listed species were identified by checking species lists in studies against the published IUCN Red Lists (www.iucnredlist.org) and species were scored independently of whether they had been recorded in primary forest. Few data points for a restricted number of taxa in most land cover types meant that quantitative analysis was not possible, but qualitative information was reported from the available literature.

There are slight differences in the total numbers of species (biodiversity) reported here compared with Lucey et al. (2015) because we include slightly fewer and different studies in this report due to the inclusion criteria, but the qualitative results reported in Lucey et al. (2015) have not changed.

Appendix 2:
Table showing the number of data points for each land-use and the number of studies contributing data.

	Primary forest species			IUCN red listed species		
	datapoints	taxa	studies	datapoints	taxa	studies
logged forest	65	13	28	22	3	12
fragments	24	5	7	13	2	2
tree plantation	21	6	11	10	2	7
oil palm	20	9	9	1	1	1

Three species groups (mammals/ birds/ beetles) have data for all four land cover types

Appendix 3: Explanation of confidence levels

The confidence levels in the Key Messages are assigned to estimates of the ability of different landcover types to support species of conservation concern. This level indicates the confidence in the scientific evidence, based on the amount of evidence (i.e. the number of published research studies), the variation in the evidence (i.e. how similar estimates are for a particular land-use), and the size of the difference in the conservation value compared with primary forest.

High confidence: the evidence is robust and provides a clear consensus: there is very little doubt about the number of species that a land-use supports.

Reasonable confidence: The evidence is generally in agreement as to the biodiversity value of a land-use, but there is a small amount of uncertainty, either because there is some variation among estimates, or because there are fewer data available.

Low confidence: The evidence is lacking and/or variation among estimates is very large and more research is needed.