Is oil palm agriculture really destroying tropical biodiversity?

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Abstract

Oil palm is one of the world's most rapidly expanding equatorial crops. The two largest oil palm-producing countries—Indonesia and Malaysia—are located in Southeast Asia, a region with numerous endemic, forest-dwelling species. Oil palm producers have asserted that forests are not being cleared to grow oil palm. Our analysis of land-cover data compiled by the United Nations Food and Agriculture Organization suggests that during the period 1990–2005, 55%–59% of oil palm expansion in Malaysia, and at least 56% of that in Indonesia occurred at the expense of forests. Using data on bird and butterfly diversity in Malaysia's forests and croplands, we argue that conversion of either primary or secondary (logged) forests to oil palm may result in significant biodiversity losses, whereas conversion of pre-existing cropland (rubber) to oil palm results in fewer losses. To safeguard the biodiversity in oil palm-producing countries, more fine-scale and spatially explicit data on land-use change need to be collected and analyzed to determine the extent and nature of any further conversion of forests to oil palm; secondary forests should be protected against conversion to oil palm; and any future expansion of oil palm agriculture should be restricted to pre-existing cropland or degraded habitats.

Introduction

Over the next 50 years, rapid and widespread agricultural expansion will pose a serious threat to natural ecosystems worldwide (Tilman *et al*. 2001). During the past few decades, the oil palm (*Elaeis guineensis*) has become one of the most rapidly expanding equatorial crops in the world. The global extent of oil palm cultivation increased from 3.6 million ha in 1961 to 13.2 million ha in 2006 (FAO 2007). Today, oil palm is grown in 43 countries with a total cultivated area accounting for nearly one-tenth of the world's permanent cropland (Figure 1; FAO 2007; WRI 2007). The two largest oil palm-producing countries—Indonesia (4.1 million ha) and Malaysia (3.6 million ha)—are located in Southeast Asia (FAO 2007). Coincidentally, this region also contains 11% of the world's remaining tropical forests (Iremonger *et al*. 1997), and harbors numerous endemic or rare species, many of which are restricted to forest habitats (Mittermeier *et al*. 2004; Sodhi *et al*. 2004; Koh 2007). As such, the potential impacts of oil palm expansion on tropical forests and biodiversity in the region are a major conservation concern (Koh & Wilcove 2007; Scharlemann & Laurance 2008). The European Commission, whose member nations import palm oil as a biofuel feedstock, is drafting a law to ban the import of fuel crops grown on certain kinds of land, including tropical forests (Kanter 2008). To address growing concerns from European government agencies, environmentalists and consumers of oil palm products, the oil palm industry in Southeast Asia has argued both that oil palm plantations are beneficial to biodiversity (MPOC 2008a), and that expansion of oil palm cultivation has not come at the expense of forests (MPOC 2008b).

In this article, we use national land-use data compiled by the Food and Agriculture Organization of the United Nations (FAO) to determine what types of land have been converted to oil palm in Malaysia and Indonesia. We then present a framework for assessing the impact of oil palm agriculture on biodiversity by determining the relative impacts to biodiversity of converting different land uses to oil palm. While it has generally

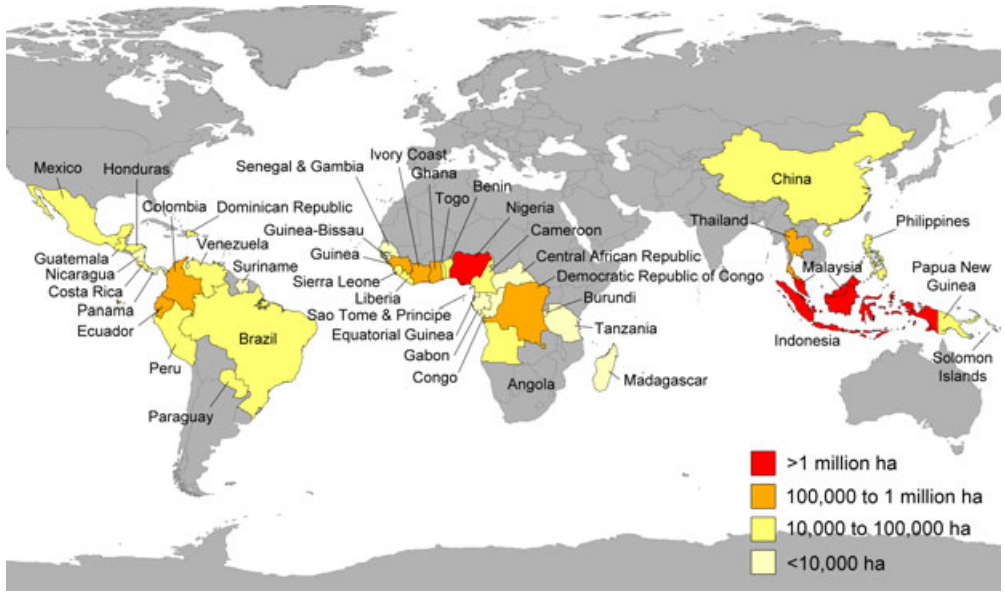

Figure 1 Map showing the extent of oil palm cultivation in 43 oil palm-producing countries in 2006 (FAO 2007).

been acknowledged that oil palm plantations in Malaysia and Indonesia have been created from pre-existing cropland (e.g., rubber) and forests (Casson 2000; Corley & Tinker 2003), the relative contributions of these two land uses to oil palm expansion have not been investigated. Furthermore, logged-over forests often are regarded by governments as degraded habitats and allowed to be cleared for agriculture. This has encouraged the conversion of secondary (logged) forests to oil palm plantations in Malaysia and Indonesia (Casson 2000; McMorrow & Talip 2001). As such, from both the policy and scientific perspectives, the relative biodiversity values of primary forests, secondary forests, pre-existing cropland, and oil palm plantations must be assessed to evaluate the impact of changes in land use.

We based our analysis on national statistics of cropland area (FAO 2007) and forest area (FAO 2006) compiled and published by the FAO. A major shortcoming of the FAO forest area data is that no independent remote-sensing survey was carried out to validate the data at the time they were compiled (FAO 2006). Nevertheless, a recent study has shown that these FAO statistics for Malaysia and Indonesia correspond well to estimates of cropland and forest areas generated from a remote-sensing analysis using Landsat TM satellite imagery (Stibig *et al*. 2007). FAO and Landsat-based estimates for Malaysia's total forest area in 2000 differed by only 46,000 ha (0.2%). Although the FAO gathered these forest area data through fully referenced country reports, which underwent detailed reviews to ensure completeness and correct application of definitions and methods, the fact that these data were self-reported make them liable to potential biases. If, for example, countries are under-reporting forest losses to the FAO, our analysis may underestimate the extent to which forests are being cleared to grow oil palm.

During the period 1990–2005, oil palm in Malaysia expanded by a total of 1,874,000 ha (FAO 2007). To estimate the minimum and maximum areas of pre-existing cropland and forests that were converted to oil palm plantations, we considered two scenarios. Under the first scenario, the aggregate decrease in area of all commercial crops that declined in cultivated area between 1990 and 2005 was taken to be the maximum cropland area converted to oil palm plantations (834,000 ha; FAO 2007; see supplementary material); this accounted for only 45% of oil palm expansion during this period. The remaining unaccounted increase in oil palm-cultivated area (1,040,000 ha; 55%) was taken to be the minimum forest area converted to oil palm plantations. Under the second scenario, the total decline in forest area (including primary, secondary, and plantation forests; but excluding rubber plantations) in Malaysia during the period 1990–2005 was taken to be the maximum forest area converted to oil palm plantations (1,109,000 ha; FAO 2006), which accounted for 59% of oil palm expansion. The remaining unaccounted increase in oil palm-cultivated area (765,000 ha; 41%) was taken to be the minimum cropland area converted to oil palm agriculture. As such, our analysis indicates that during the period 1990–2005, between 55% and 59% of oil palm expansion in Malaysia can be attributed

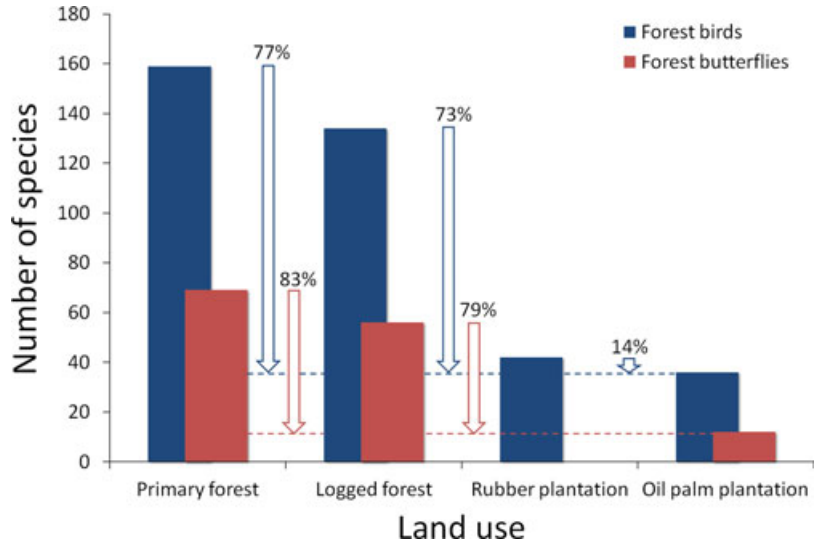

Figure 2 Total number of species of forest birds (dark grey bars) and forest butterflies (light grey bars) recorded from different land-use types in southern Peninsular Malaysia and Borneo, respectively (Hamer *et al*. 2003; Dumbrell & Hill 2005; Peh *et al*. 2005, 2006; L. P. Koh, unpublished work; see supplementary material). Forest birds and butterflies are species that depend extensively or exclusively on lowland evergreen rainforests.

to conversion of forests, and between 41% and 45% of oil palm expansion was likely due to conversion from pre-existing cropland (including rubber plantations). Although Malaysia reported no loss of primary forests during this period (FAO 2006), substantial amounts of secondary or plantation forests likely were converted to oil palm plantations.

A similar analysis was conducted for Indonesia. Between 1990 and 2005, oil palm-cultivated area in Indonesia increased by 3,017,000 ha (FAO 2007). The maximum cropland area converted to oil palm plantations (aggregate decrease in area of all declining commercial crops) was estimated to be 1,313,000 ha (FAO 2007), which accounted for 44% of oil palm expansion in the country. The minimum forest area converted to oil palm plantations (remaining unaccounted increase in oil palm-cultivated area) was estimated to be 1,704,000 ha, which represented 56% of oil palm expansion. During this period, the total forest area in Indonesia decreased by 28,072,000 ha (FAO 2006), which was larger than the total extent of oil palm expansion. Therefore, the maximum forest area converted to oil palm plantations was taken to be 100% of the extent of oil palm expansion. Our analysis suggests that during the period 1990–2005, at least 56% of oil palm expansion in Indonesia may be attributed to the conversion of primary, secondary, or plantation forests.

One caveat of our analysis is that oil palm plantations could have been created from land devoted to uses other than forest or cropland (e.g., grassland or urban area) (FAO 2006). However, because these unclassified land-uses (grouped under category of "Other land"; FAO 2006) represent less than one-fifth of the total land area in both Malaysia and Indonesia (FAO 2006, 2007; WRI 2007), they do not detract from the main conclusions of our study.

Our analysis indicates that oil palm plantations in Malaysia and Indonesia have replaced forests and, to a lesser extent, pre-existing cropland. The remaining critical question is whether these conversions are likely to have had a significant impact on the region's biodiversity. We investigate this question using existing data for birds and butterflies. Recently, Peh *et al*. (2005, 2006) conducted a comparative study of the relative conservation values of different land uses in southern Peninsular Malaysia for forest birds (i.e., species that depend extensively or exclusively on lowland evergreen rainforests). They sampled the species richness of forest birds in primary forests, secondary (logged) forests, rubber plantations, and oil palm plantations by performing a total of 720 point count surveys over a 5-month period. The data they collected indicate that 30 years after selective logging, forests can recover 84% of their original forest bird community (Figure 2; see supplementary material). More importantly, their study reveals that the conversion of primary forests and logged forests to oil palm plantations decreases the species richness of forest birds by 77% and 73%, respectively, whereas the conversion of rubber plantations to oil palm plantations results in only a 14% decline in species richness of the remaining forest birds. Similar patterns hold for forest butterflies in Borneo. Hamer *et al*. (2003) and Dumbrell & Hill (2005) sampled forest butterflies in primary forests and logged forests in the Danum Valley Field Centre and the Ulu Segama Forest Reserve in Sabah, using banana-baited traps. Using the same trapping method, we

sampled butterflies from 98 sites in two oil palm complexes in Sabah in 2006 (L. P. Koh, unpublished work; see supplementary material). We used data from these three studies and compared the species richness of forest butterflies among primary forests, logged forests, and oil palm plantations. Our analysis suggests that the conversion of primary forests and logged forests to oil palm plantations decreases species richness of forest butterflies by 83% and 79%, respectively (Figure 2). Further studies of other groups of species clearly are needed to assess fully the biodiversity impacts of oil palm agriculture compared to other land uses in Southeast Asia. In particular, more empirical research is needed to quantify the biodiversity value of oil palm plantations relative to primary and secondary forests, as has been conducted in other tropical regions (e.g., Barlow *et al*. 2007a, 2007b, 2007c; Gardner *et al*. 2007). Nevertheless, our findings strongly suggest that the conversion of either primary forests or secondary forests to oil palm plantations has detrimental impacts on Southeast Asia's biodiversity.

Policy recommendations

Southeast Asia has the highest relative rate of deforestation in the humid tropics (Achard *et al*. 2002). If present levels of deforestation were to continue unabated, the region could lose up to three-quarters of its original forest cover by 2100 which, according to recent studies, could lead to the loss of 13%–42% of regional populations of all species, at least half of which would represent global species extinctions (Brook *et al*. 2003, 2006; Sodhi *et al*. 2004). International demand for oil palm products will likely continue to drive expansion of oil palm agriculture in Southeast Asia and exacerbate the rates of forest loss and degradation in the region. We highlight weaknesses in land management research that need to be addressed to safeguard the biodiversity in oil palm-producing countries and propose several policy recommendations: (1) more fine-scale and spatially explicit data on land-use change need to be collected and analyzed by governments, nongovernmental organizations, and independent scientists to identify accurately the extent and nature of any future conversions of forests (primary and secondary) to oil palm and other agricultural uses; (2) secondary (logged) forests should also be protected against conversion to agricultural uses such as rubber plantations and oil palm plantations. The notion that such forests are unimportant for biodiversity is contradicted by the data on birds and butterflies; (3) to gauge more precisely the importance of secondary forests relative to primary forests, rubber plantations and other croplands, it would be useful to have similar survey data for other taxa; and (4) ideally, any future expansion of oil palm agriculture should be restricted to pre-existing cropland or other degraded habitats (e.g., nonnatural grasslands). Given the powerful economic and social forces that are driving the expansion of the oil palm business, implementing these steps will not be easy, but they are likely to be essential to the long-term conservation of this region's unique flora and fauna.

Supplementary Material

The following supplementary material is available for this article:

Appendix S1: Changes in area of all major commercial crops cultivated in Malaysia between 1990 and 2005 (FAO 2007).

Appendix S2: Changes in area of all major commercial crops cultivated in Indonesia between 1990 and 2005 (FAO 2007).

Appendix S3: Species list of forest birds recorded from primary forests, logged forests, rubber plantations and oil palm plantations in southern Peninsular Malaysia by Peh *et al*. (2005, 2006).

Appendix S4: Species list of forest butterflies recorded from primary forests, logged forests and oil palm plantations in Borneo by Hamer *et al*. (2003), Dumbrell & Hill (2005) and L.P. Koh (unpublished)

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