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Protecting Biodiversity outside Natural Forests: Environmental-friendly Oil Palm Plantations as an Off-reserve Strategy in Peninsular Malaysia

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ABSTRACT

Malaysian palm oil industry has been associated with tropical deforestation and faunal biodiversity loss. Despite the numerous forest reserves and protected areas, biodiversity conservation should be extended into agricultural areas including commercial oil palm. Scientific studies have clearly demonstrated that oil palm monocultures are poor substitute to natural forests. However, those studies have also indicated that oil palm-dominated landscapes support substantial biodiversity including forest species. With respect to ecological services, some species are known to be important in controlling pest outbreaks in oil palm plantations. Previous studies have shown that oil palm cultivations are effective carbon sinks. The central remaining knowledge gap of how palm oil-producing countries should conserve biodiversity within the existing oil palm plantations and smallholdings is addressed in this study. Thus, thematic review process that was organized around a topic of interest was used. In more specific, 53 journal articles investigating or highlighting the impacts of commodity crops cultivation on biodiversity were reviewed. It was proposed that oil palm-dominated landscapes be managed for conservation outcomes similar to that have been implemented in forest reserves and protected areas.

Keywords: Biodiversity, oil palm, conservation, plantations, smallholdings, ecological services, carbon sinks, off-reserve strategy

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INTRODUCTION

In some developing countries, commercial agricultural areas, including those in exotic oil palm (*Elaies guineensis*) plantations, are established at the expense of natural forests (Donald, 2004; Koh & Wilcove, 2008; Koh *et al*., 2011). In return, massive forest conversion and fragmentation through clear-cutting has caused unprecedented biodiversity loss (Fitzherbert *et al*., 2008; Wilcove & Koh, 2010). Most of the affected natural forests include those areas that are already designated as forest reserves or protected areas. However, in some producer countries such as Malaysia, oil palm plantations were converted from other commodity crop plantations (e.g. coconut and rubber) (Basiron, 2007; Koh & Wilcove, 2008).

Oil palm crop has contributed significantly to the economic revenues of Malaysia (Basiron, 2007; Hardter *et al*., 1997). Similarly, Malaysian palm oil industry has also created job opportunities for poor people in the rural areas and improved their standard of living (Basiron, 2007). Their substantial contributions in the socio-economic development may prolong upstream plantation business in this country. Unfortunately, this may create conflict between palm oil-producing countries and environmental activists in developed countries. Due to some controversial issues, palm oil-based products are currently boycotted by environmental NGOs in those countries (Nantha & Tisdell, 2009; Tan *et al*., 2009). Some issues of concern with oil palm plantations are deforestation, species extinction, and environmental pollutions.

As consumer countries (e.g. the United States and European Union countries) are becoming increasingly concerned with environmental issues, palm oil stakeholders (e.g. government agencies, smallholders, and plantation companies) should implement conservation measures within oil palm-dominated landscapes. Environmental-friendly crops have become a trend and are currently in great demand. For example, some coffee and cacao plantations in developing countries are currently being certified as bird-friendly. This has opened a new and greater market for such coffee and cacao products in developed countries with environmental concerns. Furthermore, there have been many ecological studies to support conservation schemes or practices on fauna implemented in those commodity crop plantations (Clough *et al*., 2009; Greenberg *et al*., 1997a, 1997b; Philpott *et al*., 2008).

JUSTIFICATIONS FOR ENVIRONMENTAL-FRIENDLY OIL PALM AGRICULTURE

To date, environmental management practices have been implemented to transform agricultural areas into environmental-friendly plantations (e.g. zero burning technique prior to replanting and bio-control programs to suppress pest organisms). However, those practices may be insufficient to protect biodiversity effectively. Palm oil stakeholders should be praised to carry out such conservation measures but they also need to be motivated to do more to conserve farmland biodiversity.

Neglecting biodiversity conservation within oil palm plantations is a counterproductive because of several reasons: (1) biodiversity resources can be found in oil palm-dominated landscapes. Planted oil palm areas cover more than 4,000,000 ha of oil palm plantation estates and more than 700,000 ha of semi-traditional smallholdings in Malaysia (MPOB, 2011), (2) most protected areas and forest reserves are surrounded by oil palm plantations and smallholdings (e.g. Taman Negara, Krau Wildlife Reserve, and Endau Rompin National Park), (3) the application of agrochemicals such as pesticides and herbicides in oil palm-dominated landscapes, if uncontrolled, may harm wildlife or kill non-target fauna, (4) high conservation value species (e.g. elephants, tigers, and pangolins) may be persecuted or illegally hunted within oil palm-dominated landscapes, (5) the palm oil industry, through its downstream operations (processing factories), has caused environmental pollution (e.g. water quality) which may further degrade wildlife habitat, and (6) limited data on the number of ecological studies conducted in oil palm-dominated landscapes worldwide for supporting biodiversity conservation in industrial plantations.

This review paper discusses the possibility of transforming conventional oil palm agriculture into environmental-friendly cultivation areas. We reviewed 53 relevant research papers written in the past three decades that thematically investigated the ecological impacts of various commodity crops (e.g. oil palm, rubber, and coffee) on biodiversity. Those papers provide evidence to justify the move to incorporate agricultural areas such as oil palm into an off-reserve protection strategy. We argue that the existing oil palm-dominated landscapes can be equally important as protected areas in terms of biodiversity conservation. This can be justified by the amount of biodiversity that the oil palm-dominated landscapes can sustain.

INDUSTRIAL OIL PALM EXPANSION

Introduced from tropical Africa, oil palm (*E. guineensis*) has been successfully established in industrial plantation estates and semi-traditional smallholdings in many Southeast Asia countries (Williams & Hsu, 1970; Turner & Gillbanks, 1974; Hardter *et al.*, 1997; Basiron, 2007; Tan *et al.*, 2009). The growing demand from the domestic and international market has turned oil palm cultivation into a profitable business for palm oil-producing countries. Palm oil has become one of the major exports in Malaysia, Indonesia, Papua New Guinea, and Thailand, surpassing other commodity crops.

Thus, the palm oil industry is an important economic tool for developing countries to combat hardcore poverty, as demonstrated by successful palm oil producers like Malaysia and Indonesia (Koh & Wilcove, 2007; Lam *et al.*, 2009; Tan *et al.*, 2009). These countries, however, also support a high concentration of tropical biodiversity in the region. Industrial oil palm expansion has been associated with the decline of charismatic fauna such as the Orang utans (*Pongo spp.*) and their habitat in Borneo and Sumatra (Gaveau *et al*., 2009; Nantha & Tisdell, 2009). To date, scientific evidence has indicated that oil palm plantations support lower biodiversity than natural forests (Koh, 2007; Fitzherbert *et al*., 2008; Danielsen *et al*., 2009; Wilcove & Koh, 2010).

Oil palm monocultures have replaced lowland tropical rainforest directly and indirectly (Lambert & Collar, 2002; Danielsen *et al*., 2009; Yule, 2010). Direct conversion of lowland tropical rainforest to oil palm cultivation areas occurred when forested lands were clear felled primarily for the purpose of oil palm planting. Indirect conversion occurred when forested lands were clear felled for the planting of other commodity crops but later converted into oil palm cultivation areas. However, by either direct or indirect conversion, commercial logging usually precedes agricultural expansion in many cases. This particular scenario is very common in the present-day Malaysia, and has been the case since the British-colonial days (Kumar, 1986; Berger, 1990). A high profile Malaysian government sponsored, large-scale oil palm cultivation scheme, the Federal Land Development Authority (FELDA) has received financial support from the World Bank to open up vast tracts of primary rainforest in the interior of Peninsular Malaysia since the 1950s (Berger, 1990; Basiron, 2007). As a consequence, much of the remaining pristine or undisturbed tropical rainforest of the peninsula is located in the highlands, far from the coastal areas, where oil palm plantations have been established.

CURRENT OIL PALM MANAGEMENT

Commercial oil palm monocultures are established in industrial plantations, but some are planted in smallholdings. These plantations cover more than 50 ha of planted oil palm areas. Workers, mostly foreign labourers, are employed to harvest oil palm fruit bunches manually. In order to ensure maximum harvest, the application of agrochemicals such as fertilizers and pesticides is common in oil palm plantations. To date, their effects on human, ecosystem, or wildlife are almost unknown. However, Integrated Pest Management (IPM) has been implemented to reduce the dependency on pesticides in oil palm plantations. For example, barn owls (*Tyto alba*) have been used to control rat populations (Wood & Chung, 2003). In addition, tree planting has been used as a tool for reforestation and wildlife corridor within oil palm plantations. Plantations are protected from harvest theft and wildlife poachers by security guards, trenches, and boundary fences.

Environmental-friendly plantations are defined as those managed by companies which have been recognized by the Roundtable on Sustainable Palm Oil Organization (www.rspo.org) as being sustainable palm oil producers. This is in contrast to conventional plantations that were not operated according to biodiversityfriendly guidelines and did not necessarily comply with the minimum environmental standards (e.g. zero burning of oil palm biomass). Semi-traditional smallholdings can be defined as oil palm cultivation areas that were less than four ha and owned by independent farmers or government-funded land-scheme settlers (e.g. FELDA settlements). These smallholdings usually comprised more than one age class of oil palms intercropped with commercial crops (e.g. bananas, coconuts, cassavas, coffee, pineapples) or indigenous fruit trees (e.g. durians and rambutans).

PALM OIL CERTIFICATIONS AND BIODIVERSITY STUDIES

Palm oil certification standards, such the Roundtable on Sustainable Palm Oil (RSPO) aimed for sustainability indicators for palm oil production, have been judged to be inadequate by environmental NGOs and conservation scientists (Bhagwat & Willis, 2008; Fitzherbert *et al*., 2008; Groom *et al*., 2008; Laurance *et al*., 2010). The Principles and Criteria of RSPO have been promoted by palm oil industry stakeholders and the World Wildlife Fund for Nature (WWF). Unfortunately, the standards were not supported by any scientific evidence.

Under Criterion 5.2 of the Principles and Criteria of RSPO; "the status of rare, threatened or endangered species and high conservation value habitats, if any, that exist in the plantation or that could be affected by plantation or mill management, shall be identified and their conservation taken into account in management plans and operation". We argue that this criterion gives greater priority to protected species but it does not seriously consider the conservation of the majority of non-protected species. In addition, there are very few protected species that can be found in oil palm plantations (Donald, 2004; Koh, 2008; Azhar *et al*., 2011). Large-sized mammals rarely inhabit oil palm plantations. However, these wild animals may pass through plantations to move between protected areas (Ickes, 2001; Kawanishi & Sunquist, 2004; Linkie *et al*., 2007).

Hence, participation by palm oil stakeholders is needed in order to increase more scientific work that can enhance biodiversity conservation. Their involvement is critical, and very costly to ignore, because without ecological considerations in their management policies, more species (especially endemic ones) and their natural habitats are likely to be lost. Therefore, oil palm dominated landscapes should be managed not only for profits but also to conserve farmland biodiversity. This suggestion needs to be supported by scientific work, which will provide detailed information across management regimes (Donald, 2004; Groom *et al*., 2008). We believe that previous studies are inadequate because most researchers have surveyed only plantations but not smallholdings (Aratrakorn *et al*., 2006; Peh *et al*., 2006; Koh, 2008; Edwards *et al*., 2010; Sheldon *et al*., 2010). In addition, those studies, particularly on birds, also did not take into account of wetlands or migratory species in the assessment of the biota in oil palm plantations.

To the best of our collective knowledge, only a handful of studies have been undertaken to investigate faunal diversity in oil palm-dominated landscapes, particularly in vertebrate animals. The ecological impacts of the palm oil industry on biodiversity are perceived as being highly predictable, causing ecologists to lack the motivation to research on this issue (Danielsen *et al*., 2009). Meanwhile, negative campaigns by environmental NGOs portray oil palm-dominated landscapes as 'green dessert' devoid of wild flora and fauna. This perception is as bad as the one espoused by some stakeholders of the palm oil industry that oil palm-dominated landscapes are solely established for crop production, and not for conservation.

BIODIVERSITY LOSS IN ESTABLISHED PLANTATIONS AND SMALLHOLDINGS

Conservation scientists have used forest birds in their snap-shot survey in oil palm-dominated landscapes. They have analyzed species occurrence and/or population abundance. Their findings suggested that the values for bird species richness was lower in oil palm plantations than in natural forests (Aratrakorn *et al.,* 2006; Peh *et al.,* 2006; Koh *et al.,* 2008; Edwards *et al.,* 2010; Azhar *et al.,* 2011). In particular, Azhar *et al.* (2011) reported that oil palm-dominated landscapes supported 42% of total bird species found in logged peat swamp forest (Table 1). In contrast, some studies have suggested certain individual species, for example, Red Junglefowl (*Gallus gallus*) was abundant in oil palm plantations than in natural forests (Azhar *et al*., 2008). With respect to oil palm management regimes, smallholdings supported higher bird species richness than plantations (Azhar *et al.,* 2011).

A few studies have investigated forest mammals in oil palm-dominated landscapes. These studies showed similar poorer values for mammal species diversity in commercial plantations than in natural forests (Bernard *et al*., 2009; Maddox *et al.,* 2007; Normua *et al*., 2004). Likewise, studies on forest arthropods in oil palm plantations have indicated similar results (Turner *et al*., 2009; Fayle *et al*., 2010). Overall, those published research papers have shown that oil palm-dominated landscapes, irrespective of the management regimes, are not totally inhospitable to some faunal groups. This finding supports the implementation of conservation measures within oil palm-dominated landscapes.

Biodiversity resources found in commercial plantations may not be similar to natural forests with respect to species richness and composition. Rare species may be completely absent in agricultural areas, but these areas may support hundreds of common species including forest fauna. Some forest species may come to commercial plantations from time to time. These may include migratory and wetland species (Azhar *et al*., 2011). Moreover, some species may even inhabit plantations for good. Oil palm-dominated landscapes may offer habitat heterogeneity to wildlife. Eco-tones (i.e. two or more intersectional

TABLE 1
Birds (82 species) recorded in oil palm-dominated landscapes (plantations and/or smallholdings) as well as in logged peat swamp forest in Peninsular Malaysia

Species	Detection site
Oriental Pied Hornbill, *Anthracoceros albirostris*	Plantations and smallholdings
Rhinoceros Hornbill, *Buceros rhinoceros*	Plantations and smallholdings
Blue-crowned Hanging Parrot, *Loriculus galgulus*	Plantations and smallholdings
Long-tailed Parakeet, *Psittacula longicauda*	Plantations and smallholdings
Blue-eared Barbet, *Megalaima australis*	Plantations and smallholdings
Coppersmith Barbet, *Megalaima haemacephala*	Plantations and smallholdings
Lineated Barbet, *Megalaima lineata*	Plantations
Scarlet-backed Flowerpecker,*Dicaeum cruentatum*	Plantations
Common Iora, *Aegithina tiphia*	Plantations and smallholdings
Green Imperial Pigeon, *Ducula aenea*	Plantations
Peaceful Dove, *Geopelia striata*	Plantations and smallholdings
Spotted Dove, *Streptopelia chinensis*	Plantations and smallholdings
Thick-billed Pigeon, *Treron curvirostra*	Plantations
Pink-necked Pigeon, *Treron vernans*	Plantations and smallholdings
Striped Tit-babbler, *Macronous gularis*	Plantations
Dark-necked Tailorbird, *Orthotomus atrogularis*	Plantations and smallholdings
Ashy Tailorbird, *Orthotomus sepium*	Plantations and smallholdings
Rufous-tailed Tailorbird, *Orthotomus sericeus*	Plantations and smallholdings
Common Tailorbird, *Orthotomus sutorius*	Plantations and smallholdings
Yellow-bellied Prinia, *Prinia flaviventris*	Plantations and smallholdings
Rufescent Prinia, *Prinia rufescens*	Plantations
Rufous Woodpecker, *Celeus brachyurus*	Plantations
Common Flameback, *Dinopium javanense*	Plantations and smallholdings
Red-eyed Bulbul, *Pycnonotus brunneus*	Plantations
Yellow-vented Bulbul, *Pycnonotus goaivier*	Plantations and smallholdings
Olive-winged Bulbul, *Pycnonotus plumosus*	Plantations and smallholdings
Cream-vented Bulbul, *Pycnonotus simplex*	Plantations
Little Spiderhunter, *Arachnothera longirostra*	Plantations and smallholdings
Crested Goshwak, *Accipiter trivirgatus*	Plantations
Black Baza, *Aviceda leuphotes*	Plantations
Black-shouldered Kite, *Elanus caeruleus*	Plantations and smallholdings
White-bellied Sea-Eagle, *Haliaeetus leucogaster*	Plantations
Brahminy Kite, *Haliastur indus*	Plantations
Black-thighed Falconet, *Microhierax fringillarius*	Plantations
Crested Serpent Eagle, *Spilornis cheela*	Plantations and smallholdings
Changeable Hawk Eagle, *Spizaetus cirrhatus*	Plantations and smallholdings

cont'd Table 1

Species	Detection site
Dusky Eagle Owl, *Bubo coromandus*	Smallholdings
Buffy Fish-owl, *Ketupa ketupu*	Plantations
Spotted Wood-owl, *Strix seloputo*	Plantations
Large-tailed Nightjar, *Caprimulgus macrurus*	Plantations and smallholdings
Red Junglefowl, *Gallus gallus*	Plantations and smallholdings
Barred Buttonquail, *Turnix suscitator*	Plantations
Plaintive Cuckoo, *Cacomantis merulinus*	Plantations
Lesser Coucal, *Centropus bengalensis*	Plantations and smallholdings
Greater Coucal, *Centropus sinensis*	Plantations and smallholdings
Common Koel, *Eudynamys scolopacea*	Plantations and smallholdings
Stork-billed Kingfisher, *Halcyon capensis*	Plantations
White-throated Kingfisher, *Halcyon smyrnensis*	Plantations and smallholdings
Red-throated Flycatcher, *Ficedula parva*	Plantations
Asian Brown Flycatcher, *Muscicapa dauurica*	Plantations
Asian Paradise Flycatcher, *Terpsiphone paradisi*	Smallholdings
Pied Faintail, *Rhipidura javanica*	Plantations and smallholdings
Forest Wagtail, *Dendronanthus indicus*	Plantations
Richard's Pipit, *Anthus novaeseelandiae*	Plantations and smallholdings
Blue-tailed Bee-eater, *Merops philippinus*	Plantations and smallholdings
Blue-throated Bee-eater, *Merops viridis*	Plantations
Dollarbird, *Eurystomus orientalis*	Plantations and smallholdings
Ashy Drongo, *Dicrurus leucophaeus*	Plantations
Slender-billed Crow, *Corvus enca*	Plantations and smallholdings
Large-billed Crow, *Corvus macrorhynchos*	Plantations
Black-naped Oriole, *Oriolus chinensis*	Plantations and smallholdings
Oriental Magpie Robin, *Copsychus saularis*	Plantations and smallholdings
Flyeater, *Gerygone sulphurea*	Plantations
Brown Shrike, *Lanius cristatus*	Plantations and smallholdings
Tiger Shrike, *Lanius tigrinus*	Plantations
Baya Weaver, *Ploceus philippinus*	Plantations and smallholdings
White-headed Munia, *Lonchura maja*	Plantations and smallholdings
Black-headed Munia, *Lonchura malacca*	Plantations
Scaly-breasted Munia, *Lonchura punctulata*	Plantations and smallholdings
Asian Glossy Starling, *Aplonis panayensis*	Plantations and smallholdings
Jungle Myna, *Acridotheres fuscus*	Plantations and smallholdings
White-vented Myna, *Acridotheres javanicus*	Plantations and smallholdings
Hill Myna, *Gracula religiosa*	Plantations and smallholdings
Edible-nest Swiftlet, *Aerodramus fuciphaga*	Plantations and smallholdings

cont'd Table 1

Species	Detection site
Pacific Swallow, *Hirundo tahitica*	Plantations and smallholdings
Purple Heron, *Ardea purpurea*	Plantations and smallholdings
Chinese Pond Heron, *Ardeola bacchus*	Plantations
Little Egret, *Egretta garzetta*	Plantations
Cinnamon Bittern, *Dupetor flavicollis*	Plantations
Yellow-bittern, *Ixobrychus sinensis*	Plantations
White-breasted Waterhen, *Amaurornis phoenicurus*	Plantations and smallholdings
Red Wattled-lapwing, *Vanellus indicus*	Plantations and smallholdings

Source: Azhar *et al.* (2011)

habitat edges) may provide different micro-habitats to various species. Hence, we propose oil palm plantations, together with smallholdings, be considered as an off-reserve strategy that can complement forest reserves and protected areas.

ECOLOGICAL SERVICES IN OIL PALM AGRICULTURE

Studies have also shown insect defoliators of oil palm such as bagworms and nettle caterpillars, beetles are being regulated by natural enemies that include pathogens, parasitoids and predators (Sankaran & Syed, 1972; Cheong *et al*., 2010). These natural enemies collectively maintain the pest population in a relatively stable equilibrium below the economic threshold. However, anything destabilizing the regulatory mechanisms provided by those natural enemies would likely to cause serious pest outbreaks (Dutcher, 2007). The effectiveness of natural enemies in maintaining the pest population can be enhanced through conservation and habitat manipulation.

Natural enemies can be conserved through reducing the effects of pesticides on them. Their numbers and activity can be improved through the provision of food, often nectar and pollen sources, permanent habitats or refuges, and alternate prey or hosts. One of the practices in providing these resources is through manipulating vegetation diversity of the ecosystem. This practice has been adopted in oil palm plantations where nectariferous plants, like *Euphorbia heterophylla*, *Cassia cobanensis*, *Antigonon leptopus* and *Turnera subulata*, are planted to attract beneficial insects, particularly parasitoids (Basri *et al*., 1995). These parasitoids feed on nectar and extra-floral secretions and parasitize phytophagous insect pests. Thus, a conservation effort towards maintaining these natural enemies should be part of the management practices for all oil palm plantations and smallholdings.

MITIGATING CLIMATE CHANGE

Commodity crop plantations such as oil palm are the most effective carbon sink for absorbing atmospheric CO_2 in terrestrial ecosystems. Hence, such plantations can mitigate man-made global warming (Anderson, 2008). Surprisingly, oil palm, *E. guineensis,* has proven to be effective in reducing CO_2 concentration due to its photosynthetic efficiency compared to other tropical vascular plant species. Durrene and Saugier (1993) noted that light saturated rate of net CO_2 assimilation in oil palm was 20 µmol CO_2 m^{-2} s^{-1} at PAR (Photosynthetic Active Radiation) compared to some other fast growing plant species such as *Acacia mangium* (10-14 µmol CO_2 m^{-2} s^{-1}), *Acacia aulacocarpa* (7-8 µmol CO_2 m^{-2} s^{-1}), *Tectona grandis* (14.5 µmol CO_2 m^{-2} s^{-1}), and *Macaranga gigantea* (8-11 µmol CO_2 m^{-2} s^{-1}), *Dyera costulata* (10-12 µmol CO_2 m^{-2} s^{-1}) and *Shorea leprosula* (6 µmol CO_2 m^{-2} s^{-1}) (Sapari, 2008; Shida *et al*., 1999; Rajendrudu & Naidu, 1997; Ishida *et al*., 1996; Zipperlen & Press, 1996). As a C3 type plant, *E. guineensis* is able to tolerate high levels of CO_2. In a nutshell, the species is able to tolerate twice the amount CO_2 in comparison to other plant species (Ibrahim *et al*., 2010). Even though oil palm-dominated landscapes may promise a high carbon sink value, this does not warrant future oil palm expansion into natural forests, for the amount of biodiversity loss may be greater.

FUTURE DIRECTIONS

Tropical deforestation should never be allowed to make way for new commercial plantations in the future because of dramatic biodiversity loss. For example, 48 – 60% of bird species will be lost due to forest conversion to oil palm cultivation (Azhar *et al.,* 2011). The expansion of oil palm monocultures should only be implemented in replace of other croplands. Biodiversity found within oil palm plantations outside natural forests should also be protected.

We suggest that the palm oil industry in Malaysia embrace the transformation of the conventional plantations into environmental-friendly ones. Then, these environmental-friendly plantations could be implemented as an off-reserve protection strategy in addition to crop production. Another proximate solution would be palm oil stakeholders maximize harvest yield per ha from the established plantations. This solution will remove the pressure to open new sites for plantations from the remaining primary and secondary forests.

In addition, palm oil companies should be encouraged to maintain forest patches within their oil palm plantations. Wildlife in those forest patches will not be susceptible to poaching if hunters are not allowed to access those oil palm plantations. Meanwhile, the surrounding forest reserves or protected areas may as well be better protected from hunters if these areas are buffered by such plantations. In contrast, Edwards *et al*. (2010) suggested that conservation investment be diverted from the retention of forests patches within oil palm-dominated landscapes to the protection of contiguous forests.

RECOMMENDATIONS AND CONCLUSION

The existing oil palm plantations and smallholdings should be managed for conservation outcomes as well as for economic purpose. Scientifically, oil palm plantations are poorer in terms of biodiversity than natural forests (Donald, 2004). For example, bird diversity in established plantations is only a fraction of the ones that were found in natural forests. However, this should not discourage palm oil stakeholders from implementing conservation measures in oil palm-dominated landscapes. Some conservation scientists have supported the implementation of conservation measures in the existing plantations and smallholdings (Koh, 2008; Najera & Simonetti, 2010; Azhar *et al*., 2011; Foster *et al*., 2011; Jambari *et al*., 2012).

Farmland biodiversity, including forest species, may stand better chances if stakeholders can transform conventional oil palm agriculture into environmental-friendly plantations. Palm oil stakeholders may have to be open to implementing new conservation practices that have been successfully applied elsewhere or in other commodity production areas. These practices may need to be supported by scientific evidence-based studies (Foster *et al*., 2011). Hence, long-term studies will be important to assess some of the recommended practices. We recommend that palm oil stakeholders implement the following practices in environmental-friendly plantations:

1. Set-a-side areas or patches of native vegetation for biodiversity conservation (Fischer *et al*., 2006; Wilson *et al*., 2009). These areas may include fragmented forests and/or rehabilitated forest corridors (achieved by tree planting) within oil palm plantations. This measure may increase landscape connectivity between sub-populations. Additional tree planting will enhance the capability of commercial plantations to absorb atmospheric CO_2.
2. Unpolluted aquatic habitats may include man-made ponds, irrigation canals, and flood-control drains (Czech & Parsons, 2002). Water-birds would benefit greatly from the creation of such aquatic habitats.
3. Bio-control applications including barn owl and predatory insects (Wood & Chung, 2003). This measure may reduce the use of hazardous pesticides and adverse effects of agro-chemicals on non-target fauna.
4. Prescriptive grazing to control unwanted vegetations (Dennis *et al*., 2001). This measure may reduce the use of hazardous herbicides and provide organic fertilizers into soils.
5. Prevent illegal hunting by providing security guards (e.g. auxiliary police force and CCTVs) and physical barriers (e.g. perimeter fencing and trenches) (Hayward & Kerley, 2009).
6. Removal of introduced predators (e.g. feral dogs and cats) from plantations

and smallholdings (Nogales *et al*., 2004). These predators may gradually exterminate local birds and small mammals.

Commercial oil palm agriculture in Peninsular Malaysia should not increase at the expense of natural forests, but conversion from other agricultural land uses should continue. In the existing oil palm plantations and smallholdings, biodiversity loss should be mitigated through the implementation of conservation measures. In order to conserve biodiversity, stakeholders in the palm oil industry should work together with conservation scientists to manage commercial plantations. Natural forests will be better protected from poaching and illegal logging if they are surrounded by neighbouring environmental-friendly oil palm plantations.

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