Review

Mitigating the biodiversity impacts of oil palm development

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Abstract

Impacts of oil palm plantation agriculture on biodiversity have proven severe, leading to increased human–wildlife conflict, homogenization of structurally and species diverse ecosystems, and destruction of habitat for globally threatened species. Growing international demand is likely to drive further expansion of this strategic commodity in producer countries. In response, a diverse set of tools and approaches with significant potential to mitigate future impacts have been developed and are being widely applied throughout Southeast Asia, the global centre of palm oil production. This paper aims to profile these mitigation tools, beginning first with a brief review of the documented biodiversity impacts of oil palm, followed by a description of conceptual frameworks for mitigation, and a critique of five emerging mitigation tools: (1) the High Conservation Value (HCV) approach, (2) land-use advocacy, (3) carbon offsets (4), biodiversity banking and (5) enhanced regulation and enforcement. A feature shared by all is the essential role played by civil society in the development and successful implementation of these tools. We conclude by highlighting further research needs and/or activist efforts most likely to yield lasting positive impacts to redirect the location, size and shape of the oil palm 'biodiversity footprint'.

Keywords: Biodiversity banking, Biofuel, Carbon offsets, *Elaeis guineensis*, Forest, High conservation value, Land-use planning

Review Methodology: For the recent literature regarding oil palm impacts on biodiversity, we searched CAB Abstracts and ISI Web of Science using the keyword search terms 'oil palm' and 'biodiversity', and used the references within these articles to check for additional relevant material. Much of the work pertaining to management and mitigation methods is ongoing and not published in peer-reviewed literature. We therefore used our collective knowledge of this field, and used international meetings as opportunities to discuss current and emerging mitigation approaches with experts from the oil palm industry, practitioners in consultancy companies and environmental non-governmental organizations (NGOs), as well as academia.

Introduction

Agricultural expansion is recognized as the leading cause of biodiversity loss [1]. This has led to growing international concern regarding the environmental impact of oil palm (*Elaeis* spp.), as production continues to expand across the tropics [2–4]. Oil palm has the highest yields and largest market share of all oilseed crops and is currently one of the most extensively cultivated biodiesel feedstocks in the world. Though its origins lie in West Africa, it has already expanded across 43 tropical countries in Africa, Latin America and particularly Southeast Asia, where two countries, Indonesia and Malaysia, contribute ~80% of global production [5]. Expansion is driven by large companies and smallholders responding to global demand for cheap vegetable oil (mainly from Indonesia, India and China), and the growing biofuel markets of the European Union.

Oil palm grows best in low-lying tropical areas with high rainfall [6], a zone naturally occupied by moist tropical rainforests, the Earth's most biologically rich and endangered terrestrial ecosystems [7]. In some regions, particularly in Southeast Asia, oil palm cultivation is the latest driver of land-use change following industrial logging and clearance for plantations of other commodities such as rubber and cocoa [8]. Despite unsubstantiated claims to the contrary (see discussion in [9, 10]), oil palm production has been a substantial, albeit recent, driver of deforestation. Between 1990 and 2005 at least 56% of oil palm expansion in Indonesia and 55–59% of that in Malaysia is estimated to have been at the expense of forests [4]. Thus, with unprecedented demand for oil palm products, and biodiversity-rich land suitable for its cultivation, environmentalists are rightly concerned about the impact that unregulated oil palm expansion could have on biodiversity [2].

Efforts to mitigate these impacts are emerging as a result of civil society's push for environmental responsibility, third-party certification and corporate social responsibility (CSR). This demands biodiversity protection among other concerns for social welfare and environmental and economic sustainability. Parts of the oil palm industry are making efforts to address biodiversity issues amidst wider concerns of sustainability via a certification initiative, the Roundtable of Sustainable Palm Oil (RSPO; www.rspo.org). The RSPO is a global, multi-stakeholder initiative that seeks to promote the production and use of sustainable palm oil through a membership of industry, social and environmental NGOs, and financing institutions. Sustainable palm oil production is 'comprised of legal, economically viable, environmentally appropriate and socially beneficial management and operations', which are described in the RSPO's 8 principles and 39 criteria [11]. Membership is open to those who pay their annual membership fee (€2000/year, in 2009) and are working towards RPSO certification where applicable. Certification is obtained once an accredited certification body verifies compliance with the RSPO standard. However, a disproportionate representation of industry members has raised concern over possible asymmetries in power within the organization and commitment to sustainability [12]. As of November 2009, the RSPO's membership included 81 growers and 121 processors and traders, compared with 21 social and environmental organizations (http://www.rspo.org).

The objectives of this paper are to (i) briefly review the ecological literature describing the impacts of oil palm growing on biodiversity (ii) describe three broad conceptual frameworks to fulfil biodiversity conservation objectives; (iii) critique the strengths and weaknesses of five mitigation strategies that are proposed or underway in the oil palm industry, following dialogue between the private sector, non-governmental organizations (NGOs), governments and academia; and (iv) highlight areas where further research and/or activist effort is most likely to yield lasting positive impacts to redirect and reform the location, size and shape of the oil palm 'biodiversity footprint'. The geographic scope of this paper is global, but in practice draws heavily on examples from Malaysia and Indonesia, where most oil palm is produced and trialling of mitigation efforts is most active.

Impacts of Oil Palm Growing on Biodiversity

Attempts to mitigate the environmental impacts of agriculture require an understanding of the levels of biodiversity plantations can support relative to pre-existing or alternative, land-cover. Studies concerning biodiversity constitute less than 1% of all peer-reviewed publications concerning oil palm [13], yet there is an emerging synthesis that plantations are biologically depauperate compared with other natural and plantation habitats. Comparisons to natural forests are appropriate since there is large overlap between oil-palm-growing and forested areas, and oil palm cultivation has been linked to deforestation [4, 8].

Species vary in their dependence on habitat features and hence their sensitivity and response to environmental change. Generalist species respond positively and may thrive in secondary habitats or managed plantations, while specialists decline and might become locally extinct. The net response, determined according to taxonomic group or over all species studied, depends upon the extent to which natural habitat features are retained or replicated in the post-disturbance environment. The loss of virtually all forest vegetation during conversion to oil palm therefore lays the foundation for impacts on faunal groups.

Intensive management of any agricultural system precludes regeneration of native vegetation, which, in the tropics, results in forest trees, lianas, epiphytic orchids, and indigenous palms being completely absent from most plantations. Oil palm plots appear to support more species of pteridophytes (i.e. non-flowering plants such as mosses and ferns) than old growth dipterocarp forest, but few forest specialists persist and dominant species are typical of regrowth on disturbed ground [14]. Oil palm monoculture as a potential habitat therefore contrasts greatly with that provided by natural forest: plantations have a much less complex structure, with a uniform tree age structure, lower canopy, sparse undergrowth, less stable microclimate, greater human disturbance, and are cleared and replanted on a 25–30-year rotation [6].

In a recent meta-analysis of biodiversity responses to conversion of forest to oil palm plantation, a mean of only 15% of forest species across 22 comparisons were present in oil palm (Figure 1) – 85% of natural forest species were shown to be lost in conversion [14]. All vertebrate groups so far studied (primates, bats, small mammals, carnivores, birds and reptiles) suffer species losses in oil palm: the total number of species in plantations was less than half (38%) that of natural forest, and only 22% of vertebrate species were shared by forests and plantations (Figure 1).

Invertebrates exhibit more variation in their response to oil palm conversion than vertebrates. Of 16

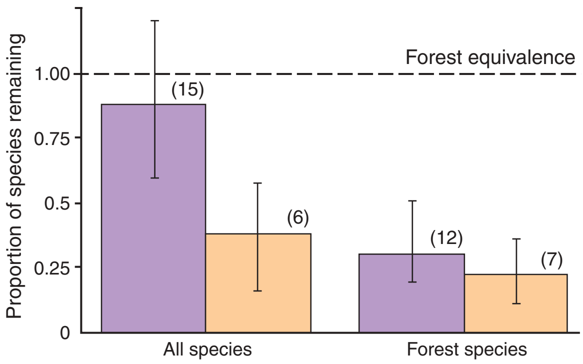

Figure 1 The impact of replacing forest with oil palm on the number of animal species (species richness). Bars represent the mean number of animal species recorded in oil palm as a proportion of those recorded in forest, with all species recorded in oil palm and only those present in both oil palm and forest ('shared species'). Data are presented as mean proportions and confidence limits for invertebrates (light grey) and for mammals, birds and reptiles combined (dark grey). Meta-analysis sample sizes are provided in parentheses. The figure is reproduced from Danielsen *et al.* [14], where the analysis is described in full

independent comparisons, nine revealed declines in plantations [14]. In studies of ants, bees and moths, comparisons between oil palm and forest revealed an increase in species numbers in particular components of invertebrate communities, but declines in others. For example, one study of bees found more species in oil palm than in forest, but honey bees (Apidae) were notably absent, with important implications for forest regeneration [15].

Converting forest to oil palm therefore leads to a significantly impoverished wildlife community. Most forest species are lost and replaced by smaller numbers of largely non-forest species resulting in simpler, species-poor communities. The species that are lost tend to include taxa that rely on habitat features not found in plantations (e.g. dead wood, or large trees for cavity-dwelling species), those with the most specialized diets (e.g. frugivores), and those with the smallest range sizes and highest conservation concern [16–18]. Dominant species in plantations are typically invasive (non-native) species and pests. While any conversion of natural forest is inevitably damaging to biodiversity, studies comparing several land-cover types reveal that oil palm plantations support even fewer forest species than plantations of other tree commodity products such as rubber, cocoa and *Acacia* [2]. Although more studies have been published since this meta-analysis was undertaken (e.g. [19–21]), the overwhelming message is that oil palm plantations have little biodiversity value.

Can Biodiversity-friendly Plantations Exist?

It is unlikely that oil palm management practices could be improved enough to significantly increase the biodiversity value of plantations. This is because the main cause of massive biodiversity losses in oil palm areas is reduction of habitat complexity, and there are only limited opportunities to improve that while maintaining agricultural productivity. Retaining epiphytes or undergrowth in plantations only marginally increases the number of bird and butterfly species, and planting non-native plants to attract beneficial insects does not significantly improve the biodiversity value [22]. Of much greater biodiversity value is the protection of forest fragments and corridors within plantations, including riverside buffers and remnants on slopes. However, there are natural ecological limits to this approach: tens of thousands of hectares of forest are required to support viable populations of most rainforest species [23]. This suggests that avoiding oil palm development on forested land in the first place is the best option for biodiversity.

Indirect Threats via Forest Fragmentation, Access and Displacement

Further threats to biological communities arise from indirect, often off-site, effects of agricultural expansion. Oil palm agriculture is becoming a significant driver of forest fragmentation [24], a process that describes the conversion of formerly continuous habitat into smaller, more isolated patches. Given that oil palm and other tree crops are unsuitable habitats for most forest species, plantations may act as a barrier to animal movements [25, 26]. Studies of forest fragments surrounded by oil palm in Malaysia show that small fragments support lower species diversity than larger fragments [25, 27, 28]. This implies that maintaining remnants of natural forest in plantations might increase the biodiversity value of estates, but most benefits will only result from retaining larger patches. Edge effects, such as increased vulnerability to wind, desiccation and fire [29], are likely to exacerbate this situation, and result in forest fragments degrading over time together with the wildlife they support. The strength of these effects might be lower in mature, tall-growth plantations, which could buffer adjoining forests from abiotic changes, but increased tree sapling mortality as a result of elevated pig densities near plantations [30] could have negative implications for forest regeneration.

Other externalities relevant to mitigation measures include the impacts of pollution and sedimentation, as well as factors such as infrastructure development that influence access or encroachment of areas of high conservation value (HCV) adjoining plantations. Agricultural expansion on the scale currently observed for oil palm displaces local people from their native lands [31, 32]. This can involve further encroachment into lands adjoining an oil palm estate and increase human–wildlife conflict, particularly for large vertebrates (e.g. elephants, orangutans and tigers) which are frequently harmed or hunted [26, 33]. For mitigation measures to be successful in the long term,

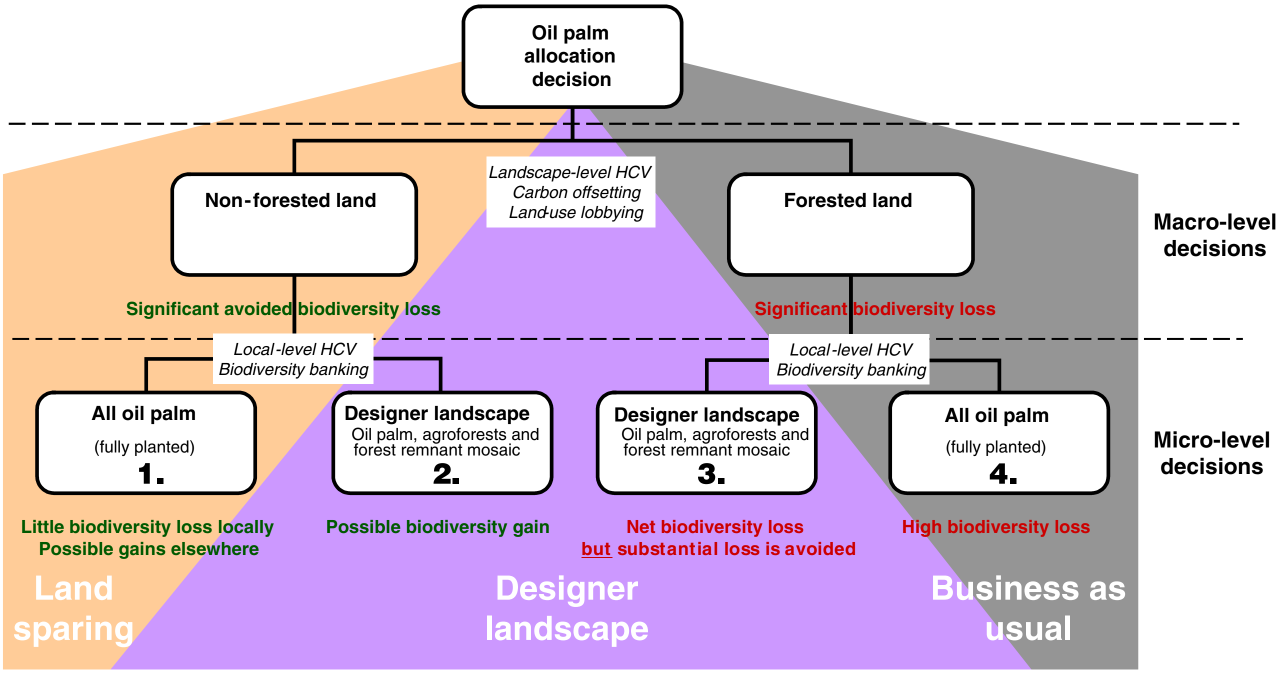

Figure 2 Possible management scenarios, biodiversity outcomes and mitigation options for industrial oil palm landscapes under three conservation strategies. Determining where oil palm licenses shall be issued, a macro-level decision undertaken by governments, has over-riding conservation importance than concession, or micro-level, decisions undertaken by companies wishing to implement biodiversity objectives. Ideally, land-use lobbying, equipped with landscape-level application of the HCV concept and competitive markets for carbon offsetting, could promote oil palm intensification combined with forest protection (i.e. 'land sparing' [35]), resulting in licenses issued on degraded non-forest land to be fully planted with oil palm estate – Scenario 1. The 'designer landscape'/agroforestry approach proposed by Koh *et al*. [34] could promote net positive or negative biodiversity impacts depending on whether designer estates replace non-forest (net positive, Scenario 2) or forest (net negative, Scenario 3) habitats, but because of lower yields, could encourage overall expansion in plantation area. Efforts to keep oil palm licenses out of forested areas, especially those with HCVs, will have the largest net positive impact on biodiversity and facilitate compliance with the RSPO certification standards, which prohibit conversion of areas deemed necessary to maintain or enhance one or more these values. However, this may prove unfeasible in some growing areas, in which local-level application of HCV serves to ameliorate concession-level impacts under the current RSPO framework, and, if used with biodiversity banking, presents an emerging opportunity to further mitigate the environmental impacts of oil palm development. Crucial to all conservation actions in all oil palm growing countries is the need for enhanced regulation and enforcement and public activism. Similar principles would apply to other biofuel systems

management must include these local communities, whether native or displaced, as stakeholders [34].

Conceptual Frameworks for Biodiversity Conservation in Oil Palm

Although there is still much to learn, the environmental impacts of oil palm production are sufficiently well documented to conclude that unregulated expansion poses a major threat to biodiversity. In response, several land management strategies have been proposed to influence the size, location and/or shape of the industry's biodiversity footprint (Figure 2):

1. *Improved land-use planning*: maximization of natural habitat cover and connectivity at a macro-scale by directing plantation development onto degraded land. This aims to avoid conversion of forested areas with high biodiversity value and/or forests that provide connectivity (preventing habitat fragmentation). If coupled with efforts to increase productivity via improved management (intensification), this should reduce overall land requirements, and hence minimize the size of the oil palm footprint – the land-sparing option of Green *et al.* [35]. For this strategy to be effective, however, forest cover and degraded lands need to be better defined, identified and mapped. There are substantial barriers to implementation, not least are the political and financial incentives to clear forests in producer countries, a finite area of degraded lands and practical burden of reclaiming them for agricultural production, and complicated ethical issues of land ownership [34, 36–38].
2. *'Wildlife-friendly' production* (*sensu* Green *et al.* [35]): enhancement of biodiversity in existing plantations by reducing chemical input and retaining natural habitat features, while maintaining yields. The use of

agroforestry (practices that integrate trees/woody perennials into farming) is one way of coupling biodiversity interests in plantations with the economic needs of local people within estates [34, 39], but it is not without its limitations. Not least of these are that oil palm is deemed unsuitable for high-yield agroforestry [40], and that agroforests could encourage access and hence disturbance to already-sensitive adjoining habitats [36]. Wildlife-friendly production is perhaps the easiest strategy to implement, and is the only conservation option in many existing plantations, but it has the least potential for overall net biodiversity gain [40].

3. *Landscape design* (*sensu* Koh *et al.* [34]): a combination of the above principles to design landscapes that accommodate natural habitats, smallholders and their agroforestry systems; specifically, to place agroforestry (wildlife-friendly production) zones between forested areas and intensive (land-sparing) oil palm plantations. The resulting landscape mosaic is one that serves the needs of companies, local communities and conservation within areas already slated for oil palm development, but, like wildlife-friendly production, is not without its limitations [34, 36, 37] (Figure 2). This approach is in contrast to a purely oil palm-forest matrix that excludes people and offers only protected zones which few can access, appreciate and benefit from. It also recognizes the reality that governments in many oil-palm-producing countries likely will not rescind decisions to allocate forested land for oil palm development.

Mitigation Tools and Approaches

Here we review five mitigation tools and approaches being pursued to offset the impacts of oil palm plantations on biodiversity. For each, we describe examples and prevalence of their use, roles of different stakeholders involved, and strengths and limitations.

High Conservation Value (HCV) Approach

The HCV concept was developed in 1999 by the Forest Stewardship Council (FSC) as Principle 9 of a certification standard for responsible forestry [41]. Fundamental to HCV is the notion that, while all natural areas have value, some areas support exceptionally important biodiversity, environmental or socio-cultural attributes that merit special management attention. These attributes are defined as six *High Conservation Values*, three of which apply specifically to biodiversity: HCV 1, concentrations of biodiversity; HCV 2, large landscape-level forests; and HCV 3, rare or endangered ecosystems. If a production area is found to support one or more HCVs, operations may still take place, but a management system adequate to maintain or enhance the HCV must be implemented. This may include protection of 'no development' zones within the production matrix, or simple modification to existing operational procedures. The practice of HCV is guided via an international multi-stakeholder HCV Resource Network (www.hcnnetwork.org), with a Global Toolkit defining general concepts [42] and more detailed national interpretations based thereupon (e.g. [43]).

Though originally intended for use in production forestry, HCV has proven a versatile concept and is increasingly applied to other sectors such as mining and agriculture [44]. In the oil palm sector, it is now widely promoted, and in 2005, the RSPO adopted HCV, making it a cornerstone of their sustainability standard. All RSPO members with oil palm plantations developed after November 2005 are required to conduct HCV assessment prior to vegetation clearance and to avoid converting areas deemed necessary for management to maintain or enhance HCVs present [45]. This task is frequently outsourced to external consultants and should ideally be peer-reviewed by another party.

Proper application of the HCV concept has the potential to influence the percentage of area converted (size), which areas are retained (shape), or even whether the estate will be developed at all (location). For example, according to the Indonesian application of HCV, a proposed estate found to maintain viable populations of protected or globally threatened species (HCV1) is required to maintain and protect sufficient habitat within the estate and surrounding landscape for these populations to persist [43]. Depending on the species concerned and the land-cover types involved, managing HCV1 might lead to retention of all remnant natural forest (reducing footprint size), delineation of forest corridors to retain connectivity with protected areas nearby (reshaping the footprint), or under extreme conditions, voluntary cancellation of the license by the grower (relocating the footprint).

Strengths of the HCV approach lie in its ability to identify areas important for the maintenance of key biodiversity, ecosystem services and social and cultural values all under one integrated assessment tool. Assessment and development of management plans require consultation and endorsement by local and other stakeholders, a transparency which typically contrasts greatly with government-mandated environmental and/or social impact assessments.

There are, however, several weaknesses inherent to the HCV approach in an oil palm setting [46]. Since HCV is not required by government, RSPO non-members do not use it, thereby limiting the area of new plantations where HCV will be applied. Biodiversity and water quality provisions, for example, often require management of the wider landscape extending beyond the borders of an oil palm estate. Consequently, HCV management efforts of an exemplary RSPO company may be thwarted by the impacts of its neighbours. Undertaking quality HCV assessments is also a challenge. While the approach aspires to be scientific, quality still rests with the practitioner, so greater transparency in reporting and more critical review by RSPO or an independent organization is necessary. Implementing HCV management recommendations can also be very challenging, requiring skills and traditions often lacking in oil palm companies. Successful management therefore depends on a company's commitment to build human resources needed to tackle the social, environmental and political issues evident in oil palm landscapes, which require inter-disciplinary solutions.

Land-use Advocacy

Efforts to influence land-use planning for oil palm development are most active in Indonesia. Here, advocating for rational land-use planning is especially important at the district level, where oil palm licenses are issued (a macro-level decision – Figure 2). Simulations of land-use change involving oil palm have been developed to inform district government of the consequences of various land-use options available to them [47]. This is a major step forward in protecting biodiversity from threats arising from non-RSPO members or other industrial actors, but it is not without its limitations: ultimately, effectiveness of this type of approach depends on the willingness of government to revise, implement and enforce land-use plans given the strong influence of counter-lobbyists [48].

Land-use lobbying works more effectively if 'no-go' areas are mapped over large spatial areas that include multiple provinces or even countries. While forest cover maps exist for many oil-palm-producing countries [49–51], they have varying levels of precision, and can quickly become outdated. Landscape-level mapping of HCVs and other support tools such as IBAT (http://ibatforbusiness.org/ibat) can be used to influence the zonation of legally convertible areas and location of oil palm plantations in order to maintain forest area and connectivity. Notably, such efforts also seek to map degraded areas where oil palm could be promoted. This approach is mainly being driven by conservation NGOs, which, in Indonesia include the Worldwide Fund for Nature (WWF), which has a project to map landscape HCV areas deserving protection and non-forest degraded lands suitable for oil palm, as well as by The Nature Conservancy (TNC) and Fauna and Flora International (FFI). Large-scale forest/non-forest maps should ideally be available in the public domain so that they can be used not only to influence government planning but also to support RSPO compliance, especially if adopted by the RSPO as documented no-go zones for its membership. Overall, land-use advocacy holds great potential for mitigating oil palm impacts, because it does not rely on voluntary commitment, and makes the company and local government liable under Indonesian law for violations of the government land-use plan.

Carbon Offsets

Reducing Emissions from Deforestation and Forest Degradation (REDD) is a financial mechanism that aims to compensate land users, land owners, corporations and governments for the value of carbon stored in forests that would otherwise be released into the atmosphere through deforestation. As of 2009, carbon credits generated from REDD schemes can only be traded in voluntary markets or be paid for using designated carbon finance funds. However, it is widely anticipated that REDD will be adopted in a post-2012 climate change mitigation policy (post-Kyoto treaty). This would allow REDD credits generated from forest conservation projects in developing countries to be traded in carbon (compliance) markets that supply carbon credits for industrialized nations to offset their carbon footprints.

Indonesia has more than 24 carbon offset projects at some stage of development [52]. In relation to oil palm, there are examples of projects working with and against the industry. For example, the NGO FFI is facilitating partnerships between investors, oil palm companies, governments and local communities, with the aim of compensating the company for maintaining forested areas and associated carbon biomass within its operational license. Sale of the carbon credits would in turn cover the substantial opportunity costs of forfeited oil palm revenues, land taxes and management of these retained forests [38, 53]. In other cases, NGOs and investors are working to displace oil palm, funding forest conservation projects on land slated for oil palm through outside funding from carbon project developers to produce carbon credits sellable to the global market (for example, InfiniteEarth's Rimba Raya Project adjacent to Tanjung Puting National Park in Indonesian Borneo, www.infinite-earth.com).

Carbon offsets have the potential to provide standing forests with the economic value they need to withstand current economic incentives to clear them [38, 54]. Yet, markets are still voluntary and realization of market potential may rely on REDD being adopted into the post-Kyoto treaty; without this, carbon prices will be too low, leaving standing forests without the economic edge needed to encourage their conservation [14, 55, 56]. On the other hand, the full opportunity costs of REDD implementation need to be considered. These costs would be incurred at several societal levels and expressed as both the relatively obvious direct cost (of foregone economic potential) and less obvious indirect and less tangible costs including impacts on employment, tax revenues, societal and governmental perspectives on financial investments in REDD regions [57].

Biodiversity Banking

Biodiversity banking, 'habitat banking', or 'bio-credits' are another emerging trading mechanism that seeks to mitigate net biodiversity impacts of resource-extractive industries [58]. These schemes often involve an offsetting component to allow resource-extracting companies to compensate for biodiversity losses at one site by improving conservation outcomes of an equal or greater magnitude elsewhere. Recently, they have been discussed by various oil palm stakeholders as a potential means for offsetting HCV losses created by member companies during the pilot phase of the RSPO standard from 2005 to 2007.

The goal of biodiversity offsets 'is to achieve no net loss and preferably a net gain of biodiversity on the ground with respect to species composition, habitat structure, ecosystem function and people's use and cultural values associated with biodiversity' [59]. Offsetting is commonly determined by land area, though compensation need not necessarily be restricted to this. For example, resources allocated to identify and resolve underlying causes of biodiversity loss, strengthen or safeguard protected areas, or to establish corridors or buffer zones to enhance existing conservation areas, can all be considered valid forms of ecological compensation.

One strength of biodiversity banking is the potential to mobilize funding to areas where conservation efforts are needed most. Oil palm license areas located in degraded landscapes typically support fewer biodiversity values than areas of larger contiguous natural habitat. In such cases, mitigation resources might be better used to strengthen the conservation status of these larger habitats with greater long-term ecological viability, and hence increasing the magnitude and permanence of conservation benefits (Figure 2). However, unlike carbon, biodiversity is not fungible; there is no simple way to commodify species and habitats into an interchangeable currency [60]. This therefore raises legitimate scientific and ethical questions about the final justification for offsets. Nevertheless, there are situations where limited resources may be better used to support ongoing conservation efforts of larger areas than protecting isolated habitats patches within an oil palm matrix with questionable long-term ecological viability.

A number of practical and ethical factors limiting the ability of biodiversity banking to mitigate oil palm impacts must be addressed. Foremost is the scientific challenge of quantifying biodiversity losses and gains, and defining like-for-like in practical ecological terms. Numerous procedures have been proposed (e.g. [59, 61–63]), but none yet have been successfully demonstrated in an oil palm context. The main challenge for the oil palm industry will be to establish banking and offsetting methodology that accommodates biological and socio-political realities on the ground. For example, how much must a company contribute to enhance management of a nearby protected area to justify clearing smaller degraded patches in its own estate?

A further limitation is that if mitigating biodiversity impacts remains voluntary, the use of biodiversity banking will be limited to only a few companies. For example, at the time of writing, the first banking scheme operational in the tropics has struggled to sell biodiversity credits, with sales limited to logging companies because of the voluntary nature of offsets [64] and the fact that the procedure has yet to be endorsed by the RSPO. If formally adopted by the RSPO, then offset applications may expand, but the greatest potential for offsets will lie in producer-country governments making biodiversity mitigation mandatory, with offsets one allowable approach. Finally, for offsets to be successful, government and NGOs will need to develop the capacity to oversee, support and approve them [59].

Enhanced Regulation and Enforcement

Sound regulations and their enforcement are central to successful biodiversity conservation in development scenarios [65]. For oil palm, weak regulation and enforcement in three areas severely encumber ongoing biodiversity conservation efforts: the RSPO, government and producers.

The RSPO holds serious potential to influence biodiversity impacts of oil palm, but in its current form lacks ability to regulate member activities and strictly enforce its own member code of conduct [12]. The RSPO lacks a rigorous system for monitoring non-compliance of members or progress towards achieving certification. On the regulation side, of particular concern to environmentalists is that the RSPO does not require strict avoidance of peat forests or other endangered ecosystems, choosing instead to leave such decisions open to interpretation of HCV assessors evaluating RSPO Criterion 7.3 of the standard. Efforts to rectify these problems are underway, with civil society groups lobbying for a ban on clearance of any natural forest by RSPO members [12, 66], and non-compliance reporting by watchdog groups leading to RSPO investigations of members alleged to violate the code of conduct [67]. On a hopeful note, the RSPO itself has convened a working group on new plantings to develop a system for verifying member compliance with biodiversity provisions prior to clearance of new areas. Implementing measures to improve RSPO member conduct through tightened regulations and improved enforcement will be required for the RSPO to counter criticisms of 'greenwashing' and to deliver on its potential for mitigating biodiversity impacts.

In many tropical countries, large areas of land are strongly controlled by a single government sector, which hinders the formulation of cross-sectoral policies promoting sustainability. Governments of some oil palm producing countries also have weak regulation of land-use planning and plantation licensing. In Indonesia for example, the district government head has authority to issue new plantation licences in accordance with national land-use plans, but the geographic limits of this authority are poorly defined. In many cases, district governments have issued licences in accordance with more flexible local plans but in conflict with those of central government. Recent improvements to the legal code in Indonesia have eliminated some of this ambiguity by making it a criminal offence to violate land-use plans, indicating progress toward better enforcement. A further problem, however, is that even when oil palm licenses are issued on lands legally permitted for conversion, such land might support substantial forest cover that should be conserved, whereas nearby, legally designated 'conservation forest' may have long since been deforested. A full 7.5 million ha of forest in Indonesian Borneo is currently classified as legally convertible to non-forest [68].

Enforcement problems notwithstanding, oil palm producers have the ability to control much of their own biodiversity footprint by making wise choices in license acquisition and development. Establishing internal company regulations that guide acquisition and development based on biodiversity requirements (staying away from forested areas) would significantly contribute to conservation, and set the way forward for other companies. Companies can also mitigate off-site impacts via enhanced on-site regulations and enforcement. A company's ability to restrict illegal forest access via company roads, and implement strict hunting bans for their workers can provide a significant contribution to biodiversity conservation in a given area [26]. Dialogue with government and local stakeholders is crucial. A recent example in Indonesia Borneo whereby two oil palm companies and the district government formally agreed to disallow encroachment into a neighbouring orangutan conservation area [69] is encouraging.

The Role of Civil Society

Civil society activism via watchdog groups, NGO lead campaigns and consumer-driven market pressure has stimulated development of, and given profile to, most of the mitigation approaches discussed above. Such activism plays an extremely important role at the interface of biodiversity and oil palm, and has already led to policy formulation in consumer countries, such as the biofuels sustainability scheme of the European Union. The interests of civil society will doubtlessly play an increasingly important role in determining the ultimate shape of agro-industrial landscapes in the tropics.

The RSPO and its third-party certification programme emerged from demands placed on the industry by activist groups seeking a higher degree of corporate social responsibility. As an organization with voluntary membership, however, the RSPO does not have an enforcement mandate and relies heavily on civil society to monitor compliance of its members and use a grievance procedure to evaluate claims of non-compliance. Even outside of this formal procedure, local advocacy groups in countries with weak governance are bringing international attention to non-compliance of oil palm companies with environmental regulations (e.g. [70]). As RSPO membership and oil palm operations expand, this watchdog role should grow, helping to keep RSPO members' performance in the public arena. A recent decision by the World Bank to suspend lending to palm oil companies amidst environmental concerns [71], should also serve as massive incentive for the RSPO to improve its mandate.

A separate but related form of civil society involvement is engagement of scientists via publications in peer-reviewed journals and collective resolutions of academic societies. Such 'academic activism' has provided the scientific basis for conservationists to combat industry-sponsored claims that oil palm is a wildlife-friendly crop and counteract pseudo-scientific propaganda that oil palm impacts on biodiversity have been wildly overstated (e.g. [9, 10]). The Association of Tropical Biology and Conservation has also recently distributed a resolution calling upon improved international efforts to oppose conversion of tropical forests to biofuel plantations, and support for certification initiatives [72].

Conclusion

Limiting biodiversity impacts on the oil palm frontier will no doubt require integration and coordination among all the tools and approaches discussed above. Yet a few items would appear crucial to such progress and merit emphasis. Civil society has been and will likely remain the primary driver of mitigation efforts. Its watchdog role must remain strong to drive further progress, and its willingness to experiment with new solutions will be vital to drive innovation. Weak regulation and enforcement of one or more facet of all the tools described above will remain one of the greatest challenges to overcome. In this regard, RSPO must set stricter regulations on forest clearance and more robust monitoring systems to ensure progress of its members and thus public acceptance of, and the sustainability of, the initiative. Earnest commitment by responsible RSPO producers has the ability to make unprecedented gains on the biodiversity conservation front; continued non-compliance by less committed producers will risk eventual collapse of the RSPO as a grand form of 'greenwashing' [73].

Scientific research is also needed in a number of areas to strengthen biodiversity conservation in oil palm landscapes. High-priority topics include:

(1) mapping of remaining forests and degraded lands;
(2) development of authoritative HCV area maps designating 'no-go' areas for use by certification bodies, including the RSPO and its members;
(3) assessment of the ecological dimensions of fragmentation and landscape design, in particular, to better

understand the composition, shape and arrangement of matrix elements required to maintain viability of target attributes, as well as to evaluate the conservation potential of a site prior to investment of human and other limited resources;
(4) socio-economic analysis of the optimal configuration of oil palm landscapes, and also the costs of carrying out habitat conservation policy in this context; and
(5) defining biodiversity offsets in an oil palm context.

Civil society's activist efforts should focus on improving standards/regulation, accountability and enforcement of RSPO, government and producers. For RSPO, this means:

(1) pressuring RSPO to adopt a clear policy of forest clearance and a map of HCV 'no-go' areas;
(2) broadening RSPO membership, particularly into China and India as major importers of palm oil (currently represented by five processor/trader members – http://www.rspo.org), and Indonesia as a major exporter (currently represented by 61 members);
(3) strengthening compliance and monitoring mechanisms; and
(4) increasing the market for certified palm oil.

Only through RSPO does civil society currently have a mechanism to hold oil palm companies that are not violating government laws responsible for biodiversity conservation. With government, energy is best spent working with the administration to adjust land-use plans for biodiversity conservation (Figure 2), increase enforcement of these plans and explore the possibility of mandatory biodiversity offsets. Many biodiversity conservation opportunities are also provided working with companies; developing capacity to manage biodiversity, creating collaborative agreements across estate borders and near protected areas, and financing of conservation initiatives. Civil society should peruse these opportunities, while some civil society groups remain in the watchdog role, pushing companies and all other stakeholders to strive for greater biodiversity outcomes in an expanding oil palm landscape.

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