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Cover Page Footnote
Wallace M. (Marty) Meyer III is the Director of the Robert J. Bernard Field Station (BFS) and Assistant Professor of Biology at Pomona College in Claremont CA USA. He has research interests in conservation biology, invasion biology, biogeography, and ecology, including aspects of population, community and ecosystem ecology. Enviro-Lab Asia has provided him with an opportunity to explore how human modifications are influencing biodiversity and ecosystem functions in tropical Asia expanding his perspective on Anthropocene.

Re-envisioning sustainable oil-palm in SE Asia

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Abstract: In Southeast Asia, expansion of oil-palm agriculture, in combination with other industries (logging, fiber, and mega-dams), is transforming significant portions of the landscape threatening biodiversity, key ecosystem services, and human cultural diversity. While transformative answers to these multifaceted environmental issues seem daunting, the conservation biology literature provides a road map for effective techniques to mitigate environmental degradation while allowing for thoughtful, well-planned economic growth. I suggest that the lack of strict operational definitions and a holistic approach to sustainability are the two most critical factors hindering development of sustainable oil-palm agriculture. The task for environmental practitioners is to succinctly define quantifiable long-term sustainability practices and persuade governments and industries that it is in their best interest not to dismiss environmental concerns. If adopted, oil-palm and other industries in SE Asia could become a sustainable model for the world by preserving diverse biological and human communities while expanding economic interests.

Impact of oil-palm agriculture and other extractive industries in SE Asia

Oil-palm (*Elaeis guineensis*) agriculture has received increased attention in the recent decade because its expansion threatens tropical forests, the diverse flora and fauna these forests harbor, and the critical ecosystem services these forests support (Fitzherbert et al. 2008). Particular focus has centered on Malaysia and Indonesia, as they are the two largest oil-palm producing countries, Indonesia (4.1 Mha) and Malaysia (3.6 Mha) (Koh and Wilcove 2008), and they harbor 80% of SE Asia's remaining primary forests (FAO 2010). However, focusing on just oil-palm ignores the many varied and interconnected ecological challenges the region is currently facing. For example, logging and fiber concessions (areas of forests that are converted to monocultures of pulp-producing trees) account for more forest loss than oil-palm concessions (Abrood et al. 2015). These industries along with others (e.g., mining and mixed concessions) are linked to oil-palm expansion because, once land is logged or mined, it is considered degraded and additional concessions may be provided to allow for oil-palm agriculture (Koh and Wilcove 2008).

Combined, these industries have contributed to significant loss of tropical forests in the region. Estimates of net deforestation, which incorporates gross deforestation and forest regeneration, indicate that deforestation rates in SE Asia have been between 1.44 and 1.78 M ha $^{yr\text{-}1}$ for the

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past two decades (Achard et al. 2014, Table 1). To provide context to these numbers, 1.78 M ha is equivalent to area of both Rhode Island and Connecticut combined and these estimates suggest that forest loss in SE Asia have declined by this amount each year.

If current levels of deforestation continue, three quarters of the forests in SE Asia may be lost and estimates suggest that 13-42% of the regional biological populations will be expatriated, half representing the loss of species found nowhere else in the world (Brook et al. 2003, 2006, Sodhi et al. 2004). While such estimates of loss can be found globally in areas with intensive land use practice, it is important to remember that forests in SE Asia are located within biodiversity hotspots and contain a far greater diversity of species, many of which are endemic (found only within that one location) than do forests in most temperate-zone countries (Myers et al. 2000, Sodhi et al. 2004). For example, on just northern Borneo Island, plant-species richness is estimated at 11,000 species (Davis et al. 1986). A ten ha area of forest in this region can have over 700 tree species, more tree species than that found in North America (Aston 1977).

All conversions from primary forest negatively impact biodiversity. For example, conversion from primary forests to logged forest or oil-palm results in decreased butterfly species richness of 83% and 79%, respectively (Hamer et al. 2003, Dumbrell and Hill 2005, Koh and Wilcove 2008). Yue et al. (2015) found significant declines in mammal diversity from ~ 14 species at the forest/plantation edge to just one mammal species at distances of 2 km from the edge in the middle of an oil-palm plantation. A cross taxa meta-analysis examining lizards, birds, bats, primates, ants, bees, mosquitos, beetles, moths, forest butterflies and isopods (e.g., the available data) showed that across taxa, only 15% of the species recorded in primary forests were also found in oil-palm plantations (Fitzherbert et al. 2008). In this study, Fitzherbert et al. (2008) found that plantation assemblages were dominated by generalists, nonnatives and pest species.

It is also important to consider the long-term conservation importance of these habitats following such a disturbance. While oil-palm, rubber or fiber plantations have little conservation value (Peh et al. 2005, 2006, Yue et al. 2015), secondary forests can recover significant proportion of the biodiversity if given enough time. For example, Peh et al. (2005, 2006) show declines of 77% and 73% in species richness in rubber and oil-palm plantations, respectively relative to both primary and secondary forests. Even so, 30 years after selective logging, forests can recover 84% of their original bird community (Peh et al. 2005, 2006). As such, policies that consider secondary forests degraded and allow for additional agricultural expansion further exacerbate biodiversity decline.

Forest loss and degradation also results in significant declines in critical ecosystem services, or benefits that humans derive from ecosystems. The Millennium Ecosystem Assessment (2005) grouped ecosystem services into four categories: (1) provisioning, production of food and water, (2) regulating, control of climate and disease populations, (3) supporting, enhancing crop pollination and nutrient concentrations, and (4) cultural, which incorporates spiritual and recreational benefits. Loss of forests in SE Asia certainly impact services associated with each category. The regulating category that has received the most attention globally as significant carbon emissions are associated with forest loss. Forest degradation accounts for 10% of annual global greenhouse gas emissions (IPCC 2013). Carbon loss estimates are typicallyderived by multiplying forest area losses by estimates of above ground biomass (Houghton 2005). Carbon

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emissions associated with other compartments of the ecosystem (below ground, litter, and soil) have not well studied, suggesting that reported losses are likely underestimates. Reported estimates for carbon loss in Peat Forests, forests with significant underground carbon stores, typically account for carbon associated with oxidation of the peat and or burning of the peat biomass (Murdiyarso et al. 2010). Estimates of annual carbon losses range from 110 to 367 10^6 tC yr^{-1} (FAO 2010, Archard et al. 2014). Deviations among estimates of carbon loss are associated with model assumptions and methodological approach.

Most studies examining how landscape transformations influence carbon stocks were conducted in Indonesia. Currently, oil-palm accounts for ~ 28% of the gross carbon dioxide levels associated with deforestation from industrial concessions, while only fiber concession account for more carbon dioxide emissions, ~ 35% (Abood et al. 2015). Existing concessions contain approximately 15,929-28,489 Mt CO_2, or 28-38% of carbon stalk from all forests in Indonesia (Abood et al. 2015). Unfortunately, oil-palm growth on plantations contributes little carbon offsets through carbon sequestration (Carlson et al. 2012). In addition, ~ 20% of fiber and oil-palm concessions are located over Peat Swamp which stores significantly higher carbon concentrations relative to other tropical forest types (Couwenberg et al. 2010, Murdiyarso et al. 2010). Half of the concessions of these industries are in Peat Swamp or deep peat lands (Peat areas > 3 m in depth). It is uncertain to what extent these areas will be developed, as Indonesian law prohibits deforestation, drainage and development of deep peat (Wich et al. 2012).

One difficultly for conservation practitioners throughout the region seems to be predicting how future deforestation will be distributed across the landscape. In May 2010, the national government of Indonesia announced a moratorium prohibiting district governments from providing new concession licenses (Purnomo 2012; Busch et al. 2015). It went into effect in 2011 and was extended for two years in May 2013 (Government of Indonesia 2013). While this moratorium suggests that we should be able to accurately predict where future deforestation will occur, significant deforestation occurs outside concessions. Of the 14.7 Mha of forest lost on five Indonesian islands between 2000 and 2010, only 6.6 Mha were within concessions (Abood et al. 2015). In addition, 34.6% of the 26.8 Mha of Indonesia's remaining forests are located within existing concessions (Abood et al. 2015), suggesting that significant loss of forests would occur even if forest loss was restricted to existing concessions.

It is difficult to determine what is meant by the term "protected area" in the region. Forrest et al. (2015) argue that many "protected forests" are not static in that they may become unprotected, a phenomenon called Protected Area Downgrading, Downsizing and Degazettement (PADDD). Malaysia has experienced at least 121 PADDD events since 1990, most (110) were on Peninsular Malaysia, and loss represents ~ 5% of Malaysia's potential protected area estate and 0.1 % of Malaysia's land mass (Forrest et al. 2015)

Observations during a visit to Sarawak, Malaysia and Singapore

In January 2016, I traveled to Sarawak, Malaysia and Singapore with a diverse group of students and faculty from the Claremont Colleges and Yale-NUS. My objective was to provide context to my perceptions derived from conducting a review of the ecological literature, gain new information to augment what I had learned prior to the trip, and spend time learning from the

people that inhabit the area. My focus prior to the trip was on oil-palm and other extractive industries, but since our guides were focused on preventing the construction of the Baram Dam, one of many proposed mega-dams in the region, my scope expanded to include the ecological and cultural impacts of dam construction in the region.

Witnessing how extensive habitat modification and resource extraction is in developing SE Asian countries is critical. Our minds are poorly prepared to interpret the significance of 1.44 million hectares per year of forest loss, or especially annual carbon losses of 110 to 367 10^6 tC yr^{-1}. However, when you are on the ground, the significance of the transformation becomes apparent. The first two hours in Miri, our guide drove us outside the city in the lower elevation areas of northern Borneo. For those two hours, I saw nothing but oil-palm plantation and small towns. After lunch, we visited a blockade where native people were preventing an oil-palm producer access because with legal permission from the government but without consultation of the native people an oil-palm producer had removed native forest and planted oil-palm on their land. After this visit, we drove another two hours to higher elevations to the Baram dam blockade. The whole drive and the following two days, we witnessed heavy logging activity. I inquired about the logging and our guide informed me that all the forest that we were seeing were logged on 20-year rotations, a timeframe that was continually provided by various other people I spoke with. Unfortunately, this rate of rotation is a decade less than Peh et al. (2005, 2006) demonstrated is required for logged forests to recover 84% of their original bird community.

At the end of my first day, I was contemplating what I had seen and reflecting on forest recovery, when I made the observation that I had not seen many birds that day. I thought this was just because I had not focused on avian life. I became determined to superficially test if there were diverse bird assemblages that I just missed. For the next two days, while I was in the forests and rural areas of Miri, I took time to scan the sky, examine the ground and trees for birds, and asked my guides to point out any birds they saw. Despite my efforts, I saw a total of three birds. While I would be the first to argue that this is not a systematic survey and I am not a trained bird surveyor, three birds was shockingly low. I have seen 20 bird species a day without trying in other tropical areas I have visited (northeastern Australia, Belize and Guatemala, and Palau to name a few). This observation really solidified that what I was experiencing, while I was experiencing a beautiful and diverse secondary forest, the fauna was heavily influenced by humans and the impact of humans were extremely widespread (see Figure 1 for a representation of how widespread the impact of humans are in the region).

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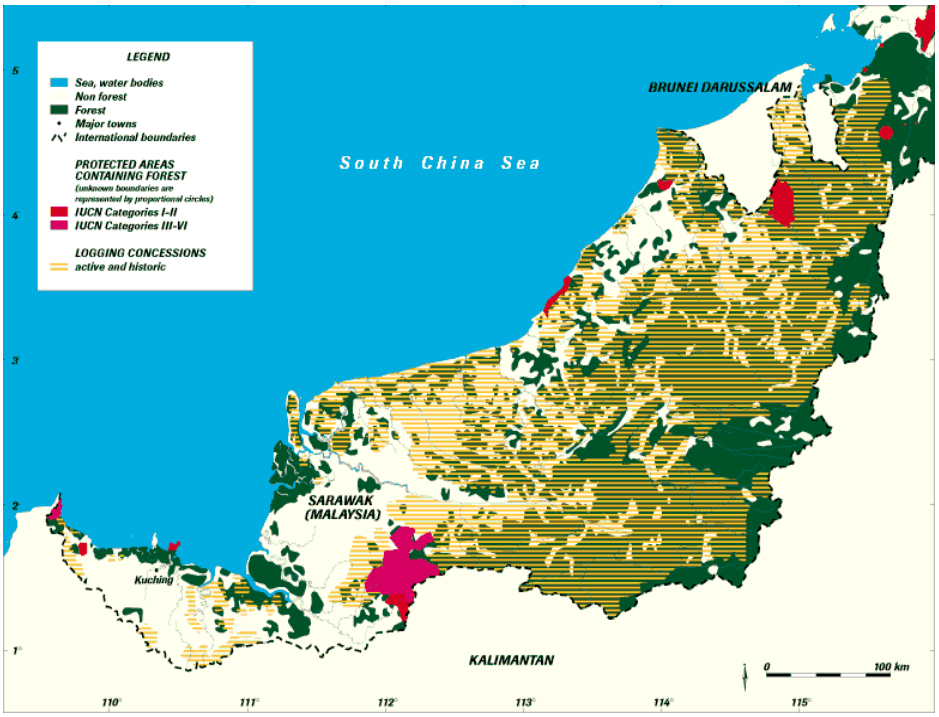

Figure 1. Figure of land use in Sarawak Malaysia with a focus on the distribution of logging concessions in the region (figure provided by the Borneo Project).

Most of the next few days in Sarawack focused on issues associated with the potential building of the Baram dam. We visited various Dyack villages that would be flooded if the dam was built and spoke to them about various issues and learned their customs. Because we spent so much time focused on the Baram Dam, we did not interact with many non-Dyack people or with middle-aged Dyack people, since they were currently living in the towns. A broader survey of people of Sararwak is certainly needed to determine a complete picture of perceptions associated with dam building in the region. While this limited perspective is unfortunate, the perspective provided was illuminating. It became clear that indigenous land rights are ignored by the government and various industries in the region and should be foci of conservation efforts. It was deeply moving to witness the passion, community strength and organizational effort of the native people as they tried to preserve their native homelands. The risk and rewards of fighting against dam construction are significant. If they oppose dam construction, it may be built and they may receive no reparations. However, losing their culture, which is concretely tied to place, was clearly such a bad option for those involved that no reparation was being considered. I am happy to report that since our visit the government has revoked the permit to build the dam.

Following our trip to Miri, our group traveled to Singapore and met with NGOs and Wilmar Inc., a corporate producer of oil-palm. It was interesting to compare my perceptions to those of the various people with whom we spoke. Occasionally, my perceptions differed. The most important way my perception differed was that many of the NGO representatives had extremely negative views on impacts of native people. While native people forage for bush meat, they have done this for centuries. Additionally, the younger generation is mostly in cities working, potentially reducing the impacts of foraging. On peninsular Malaysia, poaching of some animals like

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pangolins for export to China for food and medicine is also blamed on native people. Poaching is a significant threat to many animal populations/species (Burton 2009, Challender 2011). While I do not doubt that some native people are associated with the trade, I imagine other people are certainly involved since economic gains are significant. As I tried never to classify a person by some grouping since within most groups there is significant variation in their opinions, actions and motives, I was struck how often this was done within the country by all groups involved. Bush meat harvesting and poaching receive significant attention, but wide-scale landscape disturbances and modifications are certainly playing a significant role, but receiving less of the blame.

A meeting with Wilmar sustainability representatives was the most interesting event of the trip. I was excited to really delve into the question about what constitutes sustainable oil-palm. To Wilmar's credit, they had a dedicated staff working on this question, and were extremely transparent about their goals. Superficially, it seemed that they are dedicated to confirming that sustainable oil-palm does not result in the loss of primary forests. To achieve this, they have set up a tracking system that allows them to identify and better track the origin of oil-palm production, a tremendously difficult endeavor. While this is a clear first step in being able to identify if oil-palm is produced following deforestation, there are a few fatal flaws. Any forest that has been logged is considered degraded and prime for conversion to sustainable oil-palm agriculture and would still be considered sustainable. Consider the proportion of land under logging concessions (Figure 1). If forests cannot regenerate, what does that mean for species endemic to the region? In addition, if producers cut primary forest in the past, but agree not to do it in the future, those plantations that are currently grown on primary forests would be considered sustainable. Following this meeting, I had no idea how sustainable oil-palm prevents forest loss, their main goal? Also, it became clear that sustainable oil-palm has nothing to do with pesticide or herbicide use, potential pollution or sediment run off into streams, fuel use associated with transport of refining of the oil, and limited considerations for the humans that work in the industry. Because of this, I am perplexed that conservation organizations have lauded Wilmar and the Roundtable on Sustainable Palm Oil (RSPO) for their efforts. I will admit that I may be missing something, but there appears to be nothing sustainable about sustainable oil-palm. A quick look at the RSPOs Impact website (http://www.rspo.org/about/impacts) underscores my skepticism. It highlights acreage certified, production amounts, and members, but nothing about forests saved. As such, I think this ties into a broader conversation about what is sustainability – or sustainable development, how does the definition differ among people, how do consumers perceive the term, and how might have corporations adopted this term for their benefit?

What is sustainable development?

Sustainability and sustainable development have many varied definitions. Unfortunately, few definitions provide metrics that would allow someone to test if an action was "sustainable" (Kates et al. 2005). When they do, often metrics are focused solely on one or a few resources. Without strict operational definitions and a holistic approach, the term "sustainable" has no meaning, allowing this term to be easily co-opted by corporations, as I believe is being done by the oil-palm industry.

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Sustainable development was initially defined as actions that satisfy the needs and aspirations of the current generation without diminishing the needs and aspirations of future generations (Brundtland and Khalid 1987). While this definition sends a clear ethical message, this definition has two significant limitations. First, there is no operational definition that allows one to measure and objectively determine if development is "sustainable" (Kates et al. 2005). The difficultly of determining the needs and aspirations of the current generation is eclipsed by the impossibility of addressing the second component of the definition, which is to somehow predict the needs and aspirations of future generations. As such, it seems likely that the desires of the current generation, and predominantly that of the powerful and the rich, are going to drive present activities (Kates et al. 2005), a problem known as a social trap, e.g., when shorter-term interests are inconsistent with longer-term interests (Costanza 1987). The second limitation is that the definition of sustainability above is entirely human centric. It does not address our impact on other species or ecosystems. Despite the fact that it indirectly suggests that we should not destroy the environmental systems that support life, it does not imply that we have any moral obligation to mitigate the catastrophic loss of species (Wilson 2016). While Kates et al. (2005) highlight that this initial definition has elicited significant conversations about what is sustainable development, many subsequent definitions face similar flaws – all are human centric and difficult to quantify.

To alleviate the current limitations of most sustainability definitions, I argue that the environmental community must define exactly what it is we expect, e.g., what must plantations do to produce sustainable oil-palm. So what should we expect from a product labeled as sustainable oil-palm? While an intriguing question, it is also an extremely difficult question to answer as it has to apply to individual plantation owners and corporations. The goals associated with sustainability are large-scale involving the entire landscape. As such, I suggest that a sustainable oil-palm industry must be one with significant collaborations among partners. With significant collaborations where each partner can be expected to contribute to the cause, I propose that sustainable oil-palm be defined as a product produced by an industry that can provide evidence that it does not negatively impact biodiversity or any ecosystem service. This definition differs from previous definitions in two key ways. First, while this definition is human focused by incorporation of ecosystem services, it elevates the importance of biodiversity and changes the focus from human needs to specifically the things humans' need, ecosystem services and the species that provide them. Second, this definition includes an evidence-based component that involves monitoring biodiversity and ecosystem components highlighting that environmental metrics need to be measured and thresholds must be set. This sets the scene for a discussion of what specifically will be measured and thresholds that cannot be crossed in order to be certified as sustainable. This is where environmental leaders, not the industry, will need to define the criteria. It also provides transparency to assess positive aspects and weaknesses of current approaches and flexibility to adjust priorities to meet objectives. Once preservation of both biodiversity and ecosystem functions and a defined monitoring program to ensure this are in place, then industry members should be allowed to celebrate their efforts. The environmental community wants to support positive growth associated with industries that make the planet a better place.

Impediments to action

Koh and Wilcove (2008) suggest that aggressive public relations campaigns from the oil-palm industry have helped promote public acceptance of palm oil and provide unsupported information to dismiss the concerns of conservation biologists and environmentalists. In this paper, I will not respond to the many unsupported claims that have been propagated by the industry, like "oil-palm expansion does not threaten biodiversity" that have already been well debunked in this paper. Instead, I want to address the main theoretical question that seems to inhibit or slow people from other countries from engaging in environmental discourse associated with this region.

Do developing countries have the moral authority to interfere with countries that are trying to become developed themselves? This is argument is usually couched as either (1) because many developed countries have destroyed more of their original forest cover than either Malaysia or Indonesia, these nations lack the moral authority to interfere with oil-palm development in Southeast Asia (Koh and Wilcove 2008). Or, (2) why interfere with oil-palm development in SE Asia considering deforestation rates in SE Asia are consistent or lower than deforestation rates in other regions with tropical forests? A higher proportion of forests in developed temperate countries has been destroyed or converted for various uses, and deforestation rates in SE Asia are significantly different that other tropical forest areas. Estimates of net deforestation in tropical forests which incorporates both gross deforestation and forest regeneration suggest that deforestation rates are higher in Central/South America then in SE Asia or tropical Africa (Table 1). However, I am not sure how such facts justify widespread development in the absence of mitigating biodiversity loss or protections to ecosystem services.

Table 1. Estimates of net deforestation rates (millions ha year^{-1}) in tropical forests for SE Asia, tropical Americas, and tropical Africa from 1990-2000 and 2000-2010 (Achard et al. 2014)

Decade	SE Asia	Africa	South/Central America
1990-2000	1.78	1.42	2.85
2000-2010	1.44	1.65	2.84

To respond, I would argue that all citizens of the world have the moral authority to interfere with any environmental injustice. Again, it is important to remember that forests in SE Asia are located within biodiversity hotspots. Hotspots are small areas of the world designated because of unique importance for the conservation of plant and animal biodiversity. To qualify, they must have lost at least 70% of their original native vegetation (by area), and harbor at least 1500 endemic (regionally unique) plant species (Myers et al. 2000). As such, SE Asian forests contain a far greater diversity of species than do forests in most temperate-zone countries (Myers et al. 2000, Sodhi et al. 2004). Therefore, proportional losses in species account for significantly more species lost. Second, the effects of these landscape transformations have global ramifications. Estimates of annual greenhouse gas emissions from deforestation in Indonesia range from 0.32 to 1.91 $GTCO_2$ relative to a global total of 40-49 $GTCO^2$ (Ministry of Forestry 2008, DNPI 2010, Harris et al. 2012, Busch et al. 2012, Abood et al. 20014, IPCC 2014, WRI 2014), indicating that

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this small milti-island country may be contributing up to 5% of the CO^2 admission associated with forest loss. Currently, reductions in greenhouse gas emissions are required to preserve temperature and precipitation regimes that support life across the globe (IPCC 2013). Third, oil-palm demand is increasing and if we intend to preserve global biodiversity and ecosystem function within the tropics, this industry will need to have significant guidelines. Because it is a global industry, there are many loopholes that may allow both governments and industries to present an environmentally friendly front, while continuing extractive policies. For example, while the Malaysian government announced that it would ban the conversion of protected forests to oil-palm plantations (see above discussion on PADDD), they were purchasing land in other tropical nations for oil-palm development (Koh and Wicove 2008). A unified coalition is required to prevent governments and industries from dismissing environmental concerns, succinctly define and adopt quantifiable long-term sustainability practices, and transform public relation efforts to mask environmental degradation to ones that highlight their genuine efforts to support health ecosystems for humans.

Ecological solutions

The conservation biology literature provides a road map for effective techniques to mitigate environmental degradation while allowing for thoughtful well-planned economic growth. If adopted these developing counties/industries could become the model of sustainable development for the world. In addition, these countries/industries could utilize this structure to secure fiscal gains through an increasing market of carbon credits. In fact, Norway has already begun investing in forests of Indonesia in efforts to preserve carbon stalks, but these programs would benefit from strong landscape planning (Busch et al. 2015). This is not an easy transformation, as it does not fit our current economic models, yet these models come with extreme environmental costs, which are typically not included in calculations or: are not accounted for. This is unfortunate as financial estimates comparing global ecosystem services to gross national products demonstrate that services from natural systems are more valuable (Costanza et al. 1997).

What follows is a brief outline of how a landscape approach using foundations in conservation biology could effectively mitigate loss of biodiversity and ecosystem services. First, for preservation of biodiversity, it is critical to secure protection of remnant primary forests with a focus on securing the largest fragments first. Many protected forests are not static in that they may become unprotected (Forrest et al. 2015). Small isolated forest fragments harbor fewer species, than larger and less isolated fragments (Brühl et al. 2003; Benedick et al. 2006). In addition, large areas are required for the survival of large emblematic species, like the orangutan and Asian tiger (Maddox et al. 2007, Wich et al. 2012). Focusing on mammal species is a critical first step to obtain support for programs, and because these species require large areas, they can act as umbrella species, e.g., species chosen for conservation programs because protection of these species indirectly conserves a wealth of other species in the biological community. However, keeping populations in isolated fragments increases the risk of extinction and other deleterious factors such as increased probability of inbreeding. Plantations are barriers for dispersal for ground-dwelling species (tigers, see: Maddox et al. 2007) and even species that can fly (bats, see: Struebig et al. 2008). As such, creating corridors to facilitate species movements between preserved patches becomes the next critical step.

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This is where changing the deforestation narrative to focus on the importance of secondary forests is key. Koh and Wilcove (2008) advocated that a prohibition on transformation of secondary forests to oil-palm is needed if we are to stem biodiversity loss. However, its effect may be minimal if logging rotations continue at their current rates of every 20 years. Better, might be allocating portions of logging concessions to oil-palm production, but protecting portions for corridors to connect remaining forest remnants. Upon changing concession type, agreements should be made to eliminate logging in these corridors to allow the forest to develop and recover biodiversity. Such agreements would also increase the value of this land as the forest develops it should be more valuable from a carbon credit perspective. A holistic approach to the placement of these corridors would be critical as placement may be able to preserve additional ecosystem services. For example, if corridors were near rivers, they could minimize sediment runoff in streams that is currently impacting fish populations and limiting transportation in the rivers. Placement of corridors could also be used to secure native people's villages and sacred sites, as many are near rivers. By taking this approach, it should allow for both oil-palm production, environmental, and some cultural concerns to be addressed.

The most difficult ecosystem service to mitigate for will certainly be that associated with regulating climate. Transformations from forest to plantation certainly will come at a cost of reduced carbon storage and probably initial releases during the initial transformation process. Growth of oil-palm on plantations contributes little carbon offsets through carbon sequestration in comparison to forest recovery (Carlson et al. 2012). However, initiating conversations about how to minimize these impacts will significantly benefit global efforts to reduce greenhouse gas emissions. Preserving portions of secondary forests for corridors will provide new areas for long-term carbon storage and prohibition on loss of Peat forests is a prerequisite for preventing significant carbon loss. Requiring that the oil-palm industry include carbon costs associated with transportation and processing the oil into its land-use practices would also be an essential feature of reducing carbon emissions.

Conclusion

As an ecologist, this experience has opened my eyes to the importance of advocating for conservation in Southeast Asia. I am convinced that environmental preservation and economic development can happen at the same time, but economic growth will need to use a different model of expansion. The stakes are high, and my hope is that by highlighting the necessary adjustments that the region needs to make quickly, it can minimize extensive biodiversity loss and degradation to key ecosystem services. The future and well-being of our species depends on these changes as well as the future of thousands of other species. Adopting the changes I have proposed, soliciting further advice from ecological experts and landscape planners, and initiating in-depth conversations regarding a holistic approach to sustainability can make these countries and industries the model for the world and in the process preserve the diverse biological and human communities that make these areas of the world unique.

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