

A Review on Land Use in the Malaysian State of Sarawak, Borneo and Recommendations for Wildlife Conservation Inside Production Forest Environment

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ABSTRACT

The Malaysian state of Sarawak, which lies in the island of Borneo, is rich in plant and animal diversity, and forms one of the global biodiversity hotspots. The major land uses include logging, agriculture and forest plantations. Deforestation and degradation of forests are occurring at a rate of 0.64% annually, largely due to expansion of oil palm plantations which increases at an average rate of 10.2% annually. More areas are being converted into forest plantations, which accounts for 3.25% of the total forested area. On the other hand, protected areas remain small, representing only 6.64% of total forested area or 4.23% of the total land area, and are located far apart. The bulk of forests are subjected to logging and many areas may be converted in the future to other land use such as agriculture. Furthermore, logging has been a major economic activity, and will continue to be so in the future. Hence, the network of production forests become crucial for wildlife and working with logging companies in this aspect is a realistic approach towards wildlife conservation. Some measures proposed include encouraging collaborative research in production forests; making sustainable forest management practices mandatory; creating buffer zones in areas adjacent to protected areas; and maintaining maximum connectivity of habitat for wildlife.

Keywords: Forestry, land use, Sarawak, wildlife conservation

INTRODUCTION

Tropical forest lies within the equatorial zone between the Tropics of Cancer and Tropics of Capricorn and has very high species abundance and species endemism than any other regions of the world (Myers, 1988). There are over 185,000 species of flowering plants (Prance, 1995), of which around 37,000 species are trees (Odegaard, 2000), with many more remained undescribed (Ghazoul & Sheil, 2010). Within the tropical forest region, Southeast Asia forms one of the global biodiversity hotspots, home to 20-25% of the world's plant and animal species (Myers *et al.*, 2000; Mittermeier *et al.*, 2005, 2011; Woodruff, 2010). The Sundaland is one of the four bioregions in Southeast Asia, and contains over 25,000 species of plants including 15,000 endemics, and 1,800 vertebrate species of

which 701 are endemics (Brooks *et al.*, 2002; Myers *et al.*, 2000; Mittermeier *et al.*, 2011). Within this bioregion is the island of Borneo, which has the richest tree diversity of between 10,000 to 15,000 species (Wikramanayake *et al.*, 2001; MacKinnon *et al.*, 1996). Borneo is the distribution centre for the Dipterocarpacea family, comprising 291 species or 75% of the family, and is a dominant and important commercial timber species in Southeast Asia (Soepadmo & Wong, 1995; Ashton, 1982, 2004). The richness of a single tree family i.e. Dipterocarpacea, growing in one place is not matched by anywhere else in the world (Whitmore, 1988).

However, habitat destruction and over exploitation are threatening the biodiversity and subsequently the ecological services provided by them (Sodhi & Brook, 2006). Land cover is changing at very fast rate, whereby natural ecosystems and forests are converted to other land uses such as large scale plantations and small-holder dominated farming areas (Koh & Wilcove, 2008; Wilcove

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& Koh, 2010); or became degraded due to fire and logging (Achard *et al.*, 2002; Langner *et al.*, 2007; Miettinen *et al.*, 2011). Tropical forests in Southeast Asia experience the highest rate of loss and degradation, resulting in less than half its original forest cover remaining (Corlett & Primack, 2008; Achard *et al.*, 2002). In 2000, forest cover declined from 51% to 49%, and is projected to reduce to 46% in 2020 (FAO, 2011). In Malaysia alone, forest cover decreased by 8.58% from 22.4 Mha in 1990 to 20.5 Mha in 2010, and is projected to decrease further to 20.0 Mha in 2020, largely due to pressures from conversion to agriculture coupled by the slowness in increasing coverage of permanent forest reserves (FAO, 2011). Logged over tropical forest have always been under tremendous pressure to be converted to other more profitable land use (Laurance, 2007), unless they are granted perpetual protection status. In cases where protected areas are already in place, most of them are underfunded and under protected (Corlett & Primack, 2008). Sadly, many of the existing protected areas are fragmented and may not hold bright prospects as they are constantly encroached (Curran *et al.*, 2004), and lack the manpower to manage them properly (Tisen & Bennett, 2002).

This paper provides a review on the status of land use and changes in the Malaysian state of Sarawak, which is situated in Borneo, and examines the importance of forestry as one of the major economic activities. Arguments on land use and management policies especially pertaining to forestry and recommendations to address the conservation of wildlife, in tandem with sustainable development and forest management are discussed.

MATERIALS & METHODS

Study area

The study area is the state of Sarawak, which lies between 0° 50' - 5° 0'N and 109° 36' - 115° 40'E in the island of Borneo, and forms part of the Federation of Malaysia. It covers an area of 12.32 Mha and has a population of 2.47 million. Sarawak experiences a hot and humid equatorial monsoon climate, with a mean annual rainfall of over 3,800 mm and daily temperature range of 22°C to 33°C. The gross domestic production was RM83.8 billion and export was valued at RM76.2 billion in 2010,

the bulk from petroleum and gas, followed by oil palm and timber products (DOS, 2011). The major types of lowland vegetation include peat swamp forest, mixed dipterocarp forests and heath forest.

Statistical data and maps

We conducted extensive literature reviews and sourced data from the Department of Statistics Malaysia, which publishes annual data on key statistics of Sarawak and keeps historical records of various publications from other government agencies (DOS, 2011). We reviewed both published and unpublished reports of relevant agencies (e.g. Forestry Department of Sarawak, Sarawak Forestry Corporation, Department of Agriculture), and digitised the map of protected areas of Sarawak (SFC, 2012). The base map for land use was sourced from Miettinen *et al.* (2012).

RESULTS & DISCUSSION

Forest cover and land use changes

In 2010, it was reported that the total forested area in Sarawak was 7.85 Mha or 63.76% of land area (DOS, 2011) and agricultural land was 1.35 Mha (10.96%) (DOA, 2011). Historically, the first agricultural activity to have significant impact on forests of Sarawak was rubber (*Hevea brasiliensis*), which was introduced in 1881, followed by large scale planting in 1905 mostly in the form of smallholders (Aiken & Leigh, 1992), a situation which remains until today (DOS, 2010). By 1964, rubber was replaced by timber as the main export when large scale logging begun in the late 1940s mostly along the coastal peat swamp forest (Aiken & Leigh, 1992). Forestry intensified during the 1970s, when hill logging technology improved (Wong, 1992) and this accelerated the exploitation of interior forests (Aiken & Leigh, 1992). The mixed dipterocarp forest, which contained large and tall standing species such as *Dryobalanops lanceolata*, *Shorea superba* and *Dipterocarpus caudiferus*, were the first to be logged and subsequently converted into agriculture (Ashton, 1995).

Forestry is governed by the Forest (Amendment) Ordinance which specifically spells out the requirement for a permit to remove forest produce (Government of Sarawak, 2001). The Forest Department of

Sarawak (FDS) is entrusted with this obligation of overseeing the management of permanent forests, including national parks and wildlife sanctuaries (Government of Sarawak, 1998a; 1998b) and has control over land use especially regulating logging by issuing licenses or permits for such activities. There are three main categories of forests, supposedly to remain under forest cover in perpetuity and are classified as Permanent Forest (PF). PF consists of: (i) Forest Reserves (FR), which are generally production forests; (ii) Protected Forests, which are constituted for the primary purposes of protection of soils and waters where intensive production of forest crops is unlikely to be practicable; and (iii) Communal Forests, which are areas used by the community concerned. The administrative term of Permanent Forest Estates (PFE) is used for PF. According to international definition, production forests are forested area designated for production and extraction of both wood and non-wood products (FAO, 2004).

In Sarawak, PF covers 57.71% of the forested area and are mostly dedicated to production forestry. The total area already licensed out for timber extraction is not known, with expert analyses and guesses putting the figure at about 8.8 Mha in the early 1990s (GTZ, 1992). If this figure was taken to be accurate, the total area approximately matched the entire PF category, meaning to say that all available forests have already been licensed out and have been logged, are being logged and are potentially to be logged in the near future. Jomo *et al.* (2004) noted that over 90% of forest in Sarawak is available for logging, a figure which is almost the same as the total PF category. Only a small percentage of forested area, i.e. 6.64% has legal protection status as national parks, nature reserves or wildlife sanctuaries. On the other hand, State Land has more extensive coverage, with the least protection status, and can be potentially alienated and converted to other uses, including timber harvesting. In more recent years, forest plantations were established, and forms part of the permanent forests i.e. they are classified as PF (Government of Sarawak, 2001). As most of the species planted are non-native, forest plantations may be constituted as 'farms' rather than 'forests'. If this definition is used, the total forested area in Sarawak may

even be much lower than commonly reported.

The greatest impact from land conversion in Sarawak is oil palm (*Elaeis guineensis*), accelerated by the exhaustion of land bank in Peninsular Malaysia. Malaysia has been a top palm oil producing country since 1970s, and together with Indonesia, account for more than 85% of the world's production (FAO, 2012a). Under the Third National Agriculture Policy (1998-2010), more land in Sarawak was designated for planting oil palm (MOA, 1998) and since then, an average annual increment of 10.5% in planted area was achieved since 2002, the highest for all states in Malaysia. Direct calculation based on yearly increment of oil palm planted area against the total land area, shows a minimum average annual conversion rate of 0.42% since 2002 (Table 1), largely converted from peat swamp forests (Tsuyuki *et al.*, 2011). Deforestation in Sarawak, which occurred at an average rate of 0.64% per year, whereby intact inland forest experienced a loss of about 0.5 Mha within two decades since 1990, was mostly attributed to large scale expansion of oil palm plantations (Tsuyuki *et al.*, 2011).

The loss of forest cover has also been attributed to shifting agriculture practices. Historically in Sarawak and prior to independence, conversion of forest to large scale agriculture plantations for economic development was never strongly advocated because of issues related with the complexity of native customary rights land and ownership of land; and the physical characteristics of the soil conditions both in the lowland and interior that did not favour agricultural development (Jomo *et al.*, 2004). Instead, logging has been blamed for the rapid degradation of forests since large scale commercial forestry started in the 1960s (Aiken & Leigh, 1992) of which in less than two decades from 1980, the loss was 12% (Jomo *et al.*, 2004). By itself, shifting agriculture by natives is unlikely to have contributed to such large scale forest damage at such pace (Ichikawa, 2007). A study conducted in northern Sarawak in Lambir indicated that land use changes, especially native land, accelerated when accessibility by road increased, which in turn also affected the economy of the area that were created by demands generated from the expansion of

Table 1. Oil palm planted areas in top producing states in Malaysia.

Year	Planted area (ha)				Annual rate of increase (%)				Annual change in Sarawak	
	Sarawak	Sabah	Johor	Pahang	Sarawak	Sabah	Johor	Pahang	Area (ha)	Percentage of land (%)
2001	374,828	1,027,329	636,782	532,500						
2002	414,260	1,068,973	664,059	584,482	10.5	4.1	4.3	9.8	39,432	0.32
2003	464,774	1,135,100	659,639	583,276	12.2	6.2	-0.7	-0.2	50,514	0.41
2004	508,309	1,165,412	666,368	578,848	9.4	2.7	1.0	-0.8	43,535	0.35
2005	543,398	1,209,368	667,872	606,821	6.9	3.8	0.2	4.8	35,089	0.28
2006	591,471	1,239,497	671,425	623,290	8.8	2.5	0.5	2.7	48,073	0.39
2007	664,612	1,278,244	670,641	641,451	12.4	3.1	-0.1	2.9	73,141	0.59
2008	744,372	1,333,567	687,907	647,879	12.0	4.3	2.6	1.0	79,760	0.64
2009	N/A	N/A	N/A	N/A	12.8	-	-	-		
2010	N/A	N/A	N/A	N/A	9.5	-	-	-		
2011	1,021,587	1,431,762	721,145	694,801	11.0	-	-	-		

Data source: Malaysia Palm Oil Board (MPOB, 2012); N/A = data not available.

logging and plantation activities in the surrounding State Land (Ichikawa, 2007). Therefore, it could be implied that logging and plantation activities may have accelerated the expansion of shifting agriculture areas, the former occurring at faster pace in the lesser regulated government owned State Land, resulting in major land use changes.

Economy of forestry

Historical data showed that up to the late 1970s, some 76% of Sarawak was under forest cover, of which 90% was under logging concession, but between 1963 and 1986, an estimated 30% or more of forest area was logged (Blaser *et al.*, 2011). Log production picked up momentum in the late 1970s, climbing steadily and peaked in 1991 with over 19 Mm³ harvested before it started to decline (Figure 1). The International Tropical Timber Organisation (ITTO) (1990) made the recommendation to limit production to 9.2 Mm³ in order to be sustainable in the long term, on conditions that silviculture treatments are applied with restrictions on logging in State Land and steep slopes. Economically, the timber industry contributed RM22.5 billion to

Malaysia's export and employed over 300,000 people in 2008 (Government of Malaysia, 2011), making the country one of the top exporter of tropical timber products in the world. In Sarawak alone, the number of workers employed in the timber industry such as sawmilling and wood processing, but not including logging, reached 193,011 in 2005 (Government of Malaysia, 2011). The role of Malaysia, and particularly Sarawak, in the global economy of tropical timber, is significant. In 2009, Sarawak collected RM 4.563 billion in forest revenues (DOS, 2011), of which the direct revenue from the collection of premia, royalties and tariffs amounted to RM 412 million or 9.03% of the total revenue (Table 2) (FDS, 2009).

Expansion of forest plantations – a more recent activity

In more recent time, forest plantations are expanding, resulting in significant land use changes in Sarawak. In 2008, the total forest plantation area in Sarawak was 207,502 ha, about a quarter of the total 863,296 ha throughout Malaysia (STA, 2012). By 2009, the total planted area in Sarawak increased by

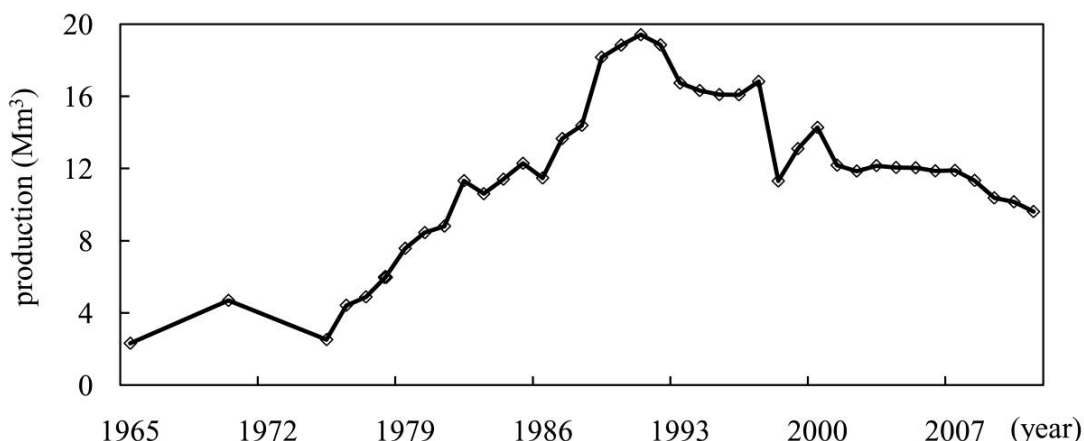


Figure 1. Production of logs from Sarawak since 1965, showing marked increase from the 1970s to 1990, before experiencing a constant decline after that.

Table 2. Revenues collected by Forest Department of Sarawak from forests related activities.

Category	Value (RM)	Percentage (%)	Percentage of state's revenue (%) #
Premia, royalties, tariffs	411,974,677.32	95.5	9.03
Licence and permits	13,257,275.00	3.1	0.29
National Park fees	2,658,532.00	0.6	0.06
Others, including compounds	3,348,924.27	0.8	0.07
Total	431,239,408.59	100	

The total revenue for Sarawak was RM 4,563,280,000 in 2009 (Source: FDS, 2009).

22.8% to 254,903 ha (FDS, 2009), which is equivalent to 2.07% of the total land area and 3.25% of the total forested area in Sarawak (Figure 2). Non-native species such as acacia (*Acacia mangium*) and eucalyptus (*Eucalyptus* spp.) were mostly planted, which accounted for 75.46% and 6.72% respectively of the total area of forest plantations, while native species such as kelampayan (*Neolamarkia cadamba*) and albizia (*Paraserianthes falcataria*) representing only 6.84% and 8.87% respectively. Up to October 2010, the total

gross area licensed out for forest plantation was 2.8 Mha (Mohd Bohari, 2010). Acacia is highly preferred because of its outstanding growth performance with mean growth annual increment of 28 m³ha⁻¹ and are harvestable after seven years (Appanah & Abdul Razak, 1998), shorter than the 25-year cycle in natural forests. The expansion of forest plantations is highly encouraged and Sarawak expects to reach the target of planted area of 1 Mha by 2020 (Borneo Post, 2011a), similar to an average increment of 13.2%yr⁻¹.

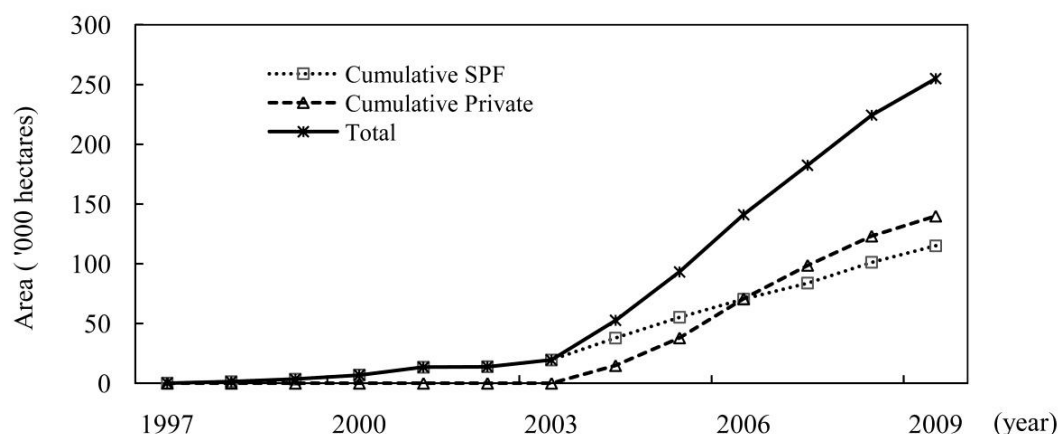


Figure 2. Cumulative area of commercial planted forests in the Sarawak.

Coverage and distribution of protected areas

On the other hand, the coverage of protected areas in Sarawak remains very low. To date, there are 23 national parks, five nature reserves and four wildlife sanctuaries, with an accumulative area of 521,562.5 ha, or 4.23%

of the total land area or 6.64% of the total forested land (Table 3). The existing protected areas are not well connected and are located far apart, many of which are isolated. They are clustered into two main regions i.e. the southwestern and northern regions of Sarawak (Figure 3).

Table 3. Land classification showing the main categories of forested areas in Sarawak, and total coverage of totally protected and protected areas.

Land classification	Size (ha)	Percentage of cover in Sarawak (%)	Percentage of cover over forested areas in Sarawak (%)
Total land area	12,315,600	100	
Other lands	4,462,800	36.24	
Forested area	7,852,800	63.76	100
<i>Forest Classification</i>			
<i>State land</i>	2,824,200	22.93	35.97
<i>Permanent Forest Estates (Forest Reserves, Communal Forests, Protected Forests)#</i>	4,507,038	36.60	57.39
<i>Totally Protected Areas* (National Park, Nature Reserve)</i>	329,327	2.67	4.19
<i>Protected Areas* (Wildlife Sanctuary)</i>	192,235	1.56	2.45

Source: (DOS, 2011); # revised figure after deducting updated figure of *, based on subjective assumption by the authors and acknowledging further clarification needed, that * are gazetted from PFE.

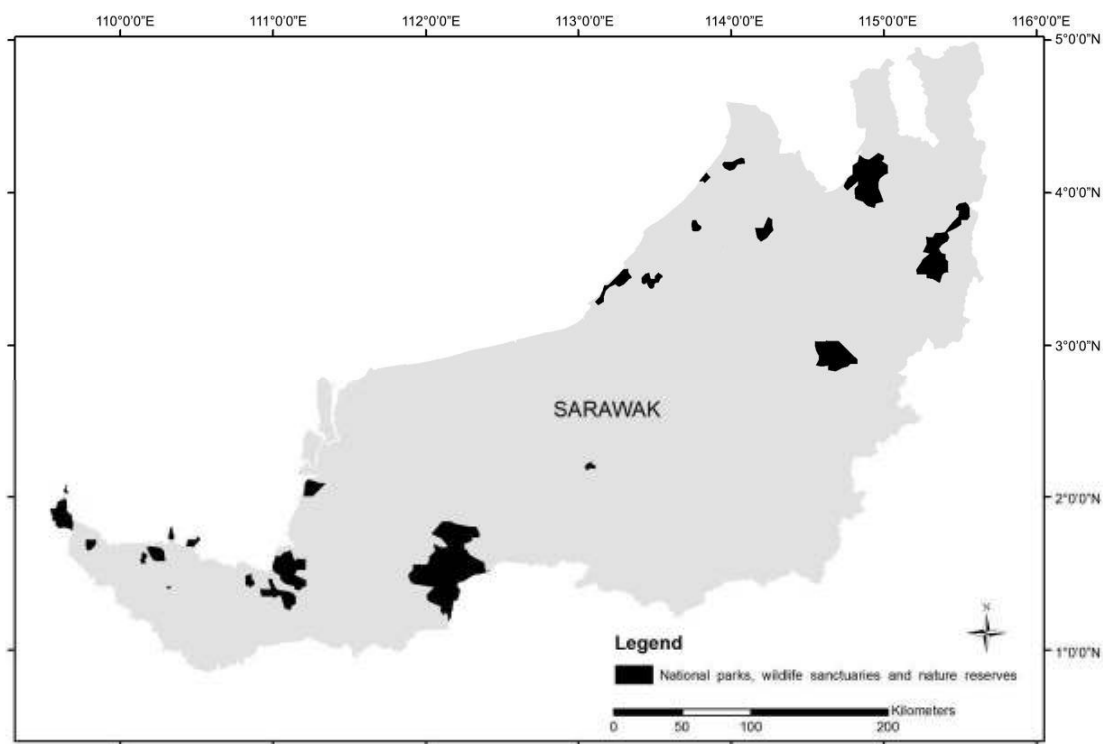


Figure 3. Distribution of protected areas (national parks, wildlife sanctuaries and nature reserves) in Sarawak.

Protected areas in Sarawak increased at an average rate of $4.9\% \text{ yr}^{-1}$ from 2002 to 2011, much lower than the rate of increase for oil palm planted area. The first national park gazetted was Bako in 1957, covering an area of 2,727 ha. Since then, there has been a gradual but slow increase in the area and number of protected areas. Sarawak aims to protect at least 10% of its land area (SFC, 2012), based on the target outlined in the Convention on Biological Diversity Conference of Parties Decision (CBD CoP7) (CBD, 2004). The existing figure of 4.23% is still below the status of global protected terrestrial areas, which stood at 12.2% in 2009 (UNEP, 2009). Furthermore, the proposed coverage would still be inadequate to preserve the full range of biological diversity (ITTO, 1990). Some of the existing protected areas are far apart or are situated next to other forms of land uses, threatening their long term integrity. For instance, Similajau National Park (NP) is situated next to the expanding agriculture areas that have been developed for oil palm; and Lambir Hills NP is divided by a public

road and is exposed to threats such as hunting, illegal felling of trees or land encroachment by agriculture. Ironically, the protected area network in Sarawak itself requires more protection.

Recommendations for conservation of wildlife in production forests

Forestry is an important economic activity and occupies a large area of existing forested land in Sarawak. In terms of wildlife conservation, the existing spatial network of protected areas is inadequate, coupled by the slow process in gazetting more areas for protection as compared to other land use changes. The role of wildlife conservation should not and cannot rest upon protected areas only. On the other hand, production forests that are sustainably managed can provide complementary role in wildlife conservation (Fimbel *et al.*, 2001). Thus, in Sarawak, which shares the astounding biological richness of Borneo, the best option at this point of time for effective wildlife conservation is to influence how logging is carried out.

Encourage Sustainable Forest Management

In all production forests in Sarawak, Sustainable Forest Management (SFM) practices should be encouraged and implemented whereby forest resources and forest lands are sustainably managed to meet social, economic, ecological, cultural and spiritual needs of present and future generations (FAO, 2012b; United Nations, 2000). The Forest Stewardship Council (FSC) and Programme for the Endorsement of Forest Certification (PEFC) are examples of forest certification schemes in the world, the latter adopted by the Malaysian Standard of Malaysian Timber Certification Scheme (MTCS). Although the state agencies have pledged to promote SFM, both in natural and planted forests (Borneo Post, 2012), indicating the government's effort to sustain the forestry industry in the long run (Borneo Post, 2011b), the progress has been slow and unconvincing, as evident from the very low number of sites currently certified under any SFM certification scheme. Certification is a voluntary process in Sarawak. Prior to 2010, there were two sites i.e. Selaan-Linau FMU and Anap-Muput FMU, which had undergone certification activities under the old Malaysian standards certification scheme. Anap-Muput FMU has since 2012 pursued the newly revised MTCS and was successfully certified under the Malaysian Criteria and Indicators (Natural Forest) in 2013.

The onset of expansion of forest plantations in Sarawak was due to the declining stocks of timber in natural forests. Other factor is attributed to the higher production yield (Vanclay, 1996), largely because of the homogeneity of tree species that can be clear felled upon maturity, generating a constant supply of timber. However, one may argue that it is the poor management of natural forests i.e. lack of SFM implementation that has resulted in over-exploitation and decreasing timber stocks. Whether increasing the area of forest plantations presents a solution to the decreasing naturally forested area and timber production is not proven as the original land use before conversion, in many instances, is not known. Clearing natural forest prior to replanting with non-native species would actually compromise the quality of forest cover. Instead, forest plantations should be

encouraged in degraded forest types, so that forest cover can be restored upon the maturity of these planted trees.

In terms of wildlife conservation, all is not lost as large scale forest plantations may still hold some hope; at least the impact is not as severe as compared to full conversion to mono-agricultural plantations. Diversity may be partially preserved in a managed forest environment but totally lost if converted (ITTO, 1990). For instance, the implementation of reduced impact logging methods in tropical forests may result in biodiversity enhancement over the long term (Edwards *et al.*, 2012). Therefore, it is crucial to engage in wildlife conservation activities in line with SFM inside production forests, of which it is heartening to note the commitment of FDS to work together with timber licensees in this aspect (Tisen & Bennett, 2002). After all, most of the existing protected areas are not large enough and are situated far apart (Bennett & Shebli, 1999), hence forests in between protected areas, largely under logging operations in natural or planted forest types, may connect protected habitat for wildlife and function as wildlife corridors. One commendable achievement is the implementation of the Master Plan for Wildlife (WCS, 1996), which is the only comprehensive, cross-sectoral master plan for wildlife (Gumal *et al.*, 2007), but a full revision is timely, considering the extent of land use changes that have happened since this document was prepared. Undeniably, more forests have become part of intensely managed landscape mosaics that still contain substantial biodiversity (Zagt *et al.*, 2010). Apart from production forests, the revision should also incorporate the roles of agricultural land, which is increasing and replacing forested areas at a very fast rate. Furthermore, the slack in implementing SFM at the policy level is a stumbling block in addressing the need for a more prudent management of the production forests in Sarawak.

Collaborative research in production forests

The conditions of many remaining forests are at the perils of impending land use and changes largely due to the slow pace in gazetting more protected areas. Larger protected areas are also needed to support wide ranging species

(Mohd-Azlan & Lawes, 2011). Furthermore, existing protected areas are isolated habitat islands, and may not be favourable for some wide ranging species such as the bearded pig (*Sus barbatus*), which has been reported to migrate over a range of 1 Mha (Caldecott & Caldecott, 1985) or flying foxes (*Pteropus vampyrus*), with a diurnal home-range of 1,120 ha (Gumal, 2004). The distribution of production forests surrounding protected areas can thus become equally important for the conservation of wildlife. This entails working together with timber companies in managing their habitat and wildlife species that occur within the concession areas by taking a holistic landscape management approach. The documentation of the Bornean endemic bay cat (*Catopuma badia*) (Hon, 2011) and Hose's civet (*Diplogale hosei*) (Mathai *et al.*, 2010), both inside production forests showed that the approach to engage with production forests in wildlife conservation is a workable partnership. As Meijaard & Sheil (2008) noted, working with production forests currently offers the only realistic way to maintain large scale forest landscapes in Borneo. Production forests should be integrated with protected areas as one large unit in order to maximize forest connectivity in order to create a network of pristine forests intertwined and connected by sub-optimal yet relevant habitat in production forests environment.

Create buffer zones around existing protected areas

The state of some protected areas in Malaysia during an assessment in 1997 showed many areas to be in degraded conditions and were not effectively protected because they were isolated (MacKinnon, 1997). Much of the forests outside protected areas are being converted to other agricultural uses or licensed out for logging activities, putting more pressure on existing protected areas. Logging is not only prevalent in Sarawak, but over the entire Borneo. The lowland rainforests are degraded and being lost at an alarming rate, due to clearing and conversion for timber, agricultural and development uses (Meijaard & Sheil, 2008). While this situation warrants greater protection in existing forests that are still intact, unfortunately, even protected areas are not spared from being destroyed or degraded, whereby the rate of forest cover

loss inside protected areas is faster than outside in certain parts of Indonesian Borneo (Curran *et al.*, 2004). Ideally, a protected area should consist of a 'core area' and surrounded by a 'buffer zone'. Beyond the buffer zone is usually a 'transition area', which is not strictly delineated and allows for development activities (WRI, IUCN, & UNEP, 1992). A protected area without any buffer zone is subjected to land use changes surrounding it, reducing its conservation capacity and exposing it to the various threats. Logging for instance, improves access to forests that were once not accessible, which subsequently results in increased hunting activities (Bennett & Gumal, 2011). The creation of a buffer zone may be able to reduce incidences of encroachment and illegal activities inside a protected area. In many cases, protected areas in Sarawak share boundaries with production forests or agricultural land, and have minimal or almost no buffers between them. A buffer zone allows management strategy to be put in place to regulate and restrict land use surrounding a protected area. For instance, the width of a buffer zone can be fixed (Peres & Terborgh, 1995) or changes based on quantitative assessment of the relationship between the buffer zone and surrounding factors (Li *et al.*, 1999). The implementation of a buffer zone concept could effectively increase the effective size of protection areas. The effect is more pronounced for very small area and will reduce the issues associated with edge effects. Thus, co-operation with logging companies is vital, where logging intensity is reduced at buffer zones, although a total ban is preferred. The indirect impacts associated with logging such as increased hunting due to increased access, can be suppressed if construction of roads inside the buffer zone is prohibited, an easy measure that can be implemented through the regulation of harvesting plan.

Maintain connectivity of wildlife habitat

With the onset of large scale land use changes, mostly from the expansions of agriculture and forest plantations, urgent consideration is needed to formulate a policy on managing wildlife at a wider landscape scale. The government should consider implementing measures to create and maintain wildlife

corridors and enhance habitat connectivity. For agriculture and forest plantations, a viable option is to set aside corridors for wildlife by not clearing existing forest during the initial land preparation stage. Older plantations should consider creating new wildlife corridors through replanting exercise or restoring damaged buffers, especially along rivers. Wildlife corridors inside older plantations can be created by delineating and leaving behind mature trees from being harvested, or by limiting any further access to a particular area to allow succession to natural forest to occur. Alternatively, restoration planting of indigenous species, interspersed with the mature non-native trees, can be introduced. Staggered harvesting instead of clear cutting should be applied, where certain portions of the area are left unlogged over a specific amount of time, preferably between one to two years, to allow for wildlife within to move out of the cutting zone. These unlogged areas act as temporary corridors which then connect to permanent wildlife corridors or conservation area.

As of now, many areas of forest plantations are near maturity, with some ready to be harvested. Within these plantations, a diverse assemblage of wildlife communities has also been recorded (Giman *et al.*, 2007), suggesting that forest plantations can support substantial populations of wildlife, although the communities do not resemble those of natural forests or its original state. Nevertheless, forest plantations have roles in conservation of wildlife. Therefore, we need to ensure that there are connectivity of wildlife habitat between forest plantations and the adjacent natural forests and protected areas.

CONCLUSION

Logging and agriculture are two of the major land use types in Sarawak. Land use changes are happening at very fast pace. Sarawak's spatial network of production forests, which accounts for majority of the forested land area, play important and complementary roles in biodiversity conservation. Therefore, policies inside these production forests must include conservation and management prescriptions for wildlife. Operations in tandem with criteria for forest certification ought to be made

compulsory, with strong governmental support and endorsement for companies engaging in SFM and certification processes. In production forests, the mandatory requirement for a certification scheme would partly address the issue pertaining to the conservation of wildlife and its habitat, but relying on this alone is grossly inadequate. The timber market is driven by environmentally conscious consumers who demand timber that is procured legally from sound forestry practices that reduces destruction to the environment and wildlife. In view of this, more research is encouraged and should be carried out inside production forests so as to affect how SFM can be effectively implemented in Sarawak.

Acknowledgements

This project is supported by the Environmental Management Leader Programme & Graduate School of Global Environmental Studies, Kyoto University and is part of the Planted Forest in Equatorial Southeast Asia: Human-nature Interactions in High Biomass Society Project, which is funded by the Grant-in-Aid for Scientific Research(S) by the Japan Society for the Promotion of Science. The authors would like to thank John Mathai and two anonymous reviewers for their comments, which helped improve the paper.

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