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PEAT SWAMP FORESTS AND CARBON STOTAGE IN RIAU BIOSPHERE RESERVE: WITH INITIAL RESULT FROM RESTORATION EXPERIMENTS

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SUMMARY

The Riau Biosphere Reserve covers a total area of 698,663 ha and was established in 2009 as an effort to conserve tropical peatlands and promote sustainable development. This study highlights remaining natural peat swamp forest have distinct forest type formations, high biodiversity and stores a huge amount of above-below carbon need to be conserved. Above-ground biomass and carbon storage are highly influenced by forest cover. Below ground stored carbon is different in each land use, even if these land use have already changed from forest to agriculture. Multipurpose tree species was used in restoration. All methods of propagation were applied to ensure continuous supply of seedlings such as wildings, cuttings, and seeds. In general, survival rate of seedlings decrease after ten month planted. We planted tree species which have both economic values (i.e. timber and non-timber forest products) and ecosystem services values such as *Dyera lowii, Tetramerista glabra, Callophylum lowii, Palaquium sumatranum, Palaquium burckii, and Cratoxylon arborescens*. More than their potential to generate income from carbon storage and other ecosystem services.

Key words: Biosphere reserve, biodiversity, carbon storage, peat swamp forest, rehabilitation

INTRODUCTION

In Sumatra, 4.04 Mha of peatland in Riau Province categorized as the Sumatran peat swamp forest ecoregion are recommended to be protected. An ecoregion is defined as a large area of land or water that contains a geographically distinct assemblage of natural communities (WWF 2008). The peat swamp forests are located on five remaining large forest blocks in Riau province. One of these blocks is in the Giam Siak Kecil-Bukit Batu, which is known as Riau's Biosphere Reserve (WWF 2008, MAB Indonesia 2008, Jarvie *et al.* 2003).

Peat swamp forests are both fragile and unique ecosystems that are both peat-forming wetlands and tropical rainforests. Water, peat and vegetation are strongly interconnected such that removing any one of these components or disturbing the balance between them may fundamentally change the nature of peatland ecosystem (Wetlands International 2007, GEC 2012).

One of the serious problems in sustainably managing peat swamp forests is their current state of severe degradation. In the Biosphere Reserve, land conversion and poor management had caused the loss of around 300,000 ha of natural peat swamp forest within the past 17 years. In addition to companies, local villagers also converted lands along Bukit Batu river basin for rubber jungle garden. The villagers used to only plant jungle rubber as marking for their own land but nowadays, younger villagers extend and convert more natural forest to establish wider land of rubber jungle cultivation.

As a result of these land conversions and loss of drainage, forest fires occur annually, especially during dry season further worsening land degradation. Meanwhile, the remaining peat swamp forest in the core area of the Biosphere Reserve is subject to illegal logging activities. Local people used to gather timber and non timber forest products such as seeds of *Palaquium sumatranum* to produce oil for cooking, white latex from *Dyera lowii* and *Payena lerii*, and bark of *Alseodaphne ceratoxylon* used as mosquito repellant. Other trees provide medicine and fruits. Nowadays, however, these forest products have gradually decreased with the deforestation and degradation of natural peat swamp forests.

Moreover, Bukit Batu forest block was declared a conservation area in 1999 by the Central Government through the Forestry Department. This move demarcated conservation area boundaries separating areas claimed by villagers where jungle rubber garden exist. An intensified conflict between the government and villagers has emerged and without appropriate forest conservation and management measures that address the livelihoods of the villagers, conservation will not succeed as forest degradation will continue.

The establishment of zones is clearly not sufficient or effective in managing the Biosphere Reserve since this does not sufficiently address sustainable rural livelihoods and the maintenance of ecosystem services. There is still continued fire and illegal logging activities in some part of biosphere reserve even now. Moreover, the establishment of industrial oil palm and acacia

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plantations in the buffer and transition area threaten the sustainable livelihoods of local community. The large scale development of peatland without sufficient management of hydrology has been the major cause of fire and land degradation in the Biosphere Reserve.

Owing to the massive areas of degraded peat swamp forest in the biosphere reserve, preserving the forest remnants becomes more important. Consequently, it is necessary to study the vegetation in order to elucidate the characteristics of the remaining peat swamp forest. The study results was are important to determine management direction on conservation efforts of remaining peat swamp forest in the Biosphere Reserve. Estimation amount of remaining carbon resources in various land use cover of the biosphere reserve. These results will be useful in developing the baseline data of carbon storage in biosphere reserve. In the last it will demonstrated results progress of rehabilitation study in secondary logged over forest including improvement of method of preparing seedlings stock and vegetation rehabilitation techniques and clarification the amount of carbon storage after ten months vegetation rehabilitation done and by natural regeneration. Local participation was discussed as well.

Study areas

The area of study is located at Riau Biosphere Reserve, Riau Province in the coastal east of Sumatra Island. Riau province covers an area of about 9 Mha. Having the largest peatland area in Sumatra, Riau province plays a very significant role to the local environment as well as global environment. The strategic position of Riau province in relation with other ASEAN countries makes its environmental role in the region even more important, especially regarding transboundary haze pollution and illegal logging.

This biosphere is unique such that it has a vast landscape with unique hydrological network of small lakes and streams and still has remaining natural peat swamp forest. The dominant natural ecosystems are peat swamp forests surrounded by different types of land use, such as production forests, degraded/abandoned lands, industrial plantations (timber and oil palm), agricultural lands, and settlements.

Results and Discussion

Mixed Peat Swamp Forest and Bintangur Forest - and details their distinct dominant species, floristic composition, diversity, and local environment characteristics (Table 1).

Table 1. Forest types and their characteristics.

Forest Types	Characteristics of forests	Density (# stems ha^{-1})	Basal area (m^2 ha^{-1})
Mixed Forest	Much water on the forest floor, 50–100m from river, peat depth >6m, *Pandanus* spp. Present	1,228	18.33
Mixed Forest	100–150m from the river, peat depth >6 m, dense *Pandanus* spp.	1,274	18.49
Mixed Forest	Little or no surface water, relatively flat micro- topography, 50–100m from the river, peat depth >6m, asam paya (*Salacca conferta*) present	1,406	25.61
Mixed Forest	Ten years after selective logging, 150–1000m from the river, peat depth >6.5m. In the rainy season, water present 150m from the river, asam paya (*Salacca conferta*) present	2,492	19.61
Bintangur Forest	Wind and indirect fire disturbance, surrounded by drainage canals and pulpwood plantation, approximately 23 km from the river, peat depth >10m, *Calophyllum lowii* the dominant species	1,280	11.57
Bintangur Forest	Approximately 23 km from the river, wind and indirect fire disturbance, surrounded by drainage canals and pulpwood plantations, peat depth >10m	662	6.68

It was also important in the conduct of the succeeding below and above ground biomass and carbon storage were measured for each selected land cover. Generally, it was shown that the remaining natural peat swamp forests store huge above and below carbon, even higher than in other peat swamp forests. The results highlight the uniqueness of the Biosphere Reserve and especially its importance in worldwide efforts to reduce forest carbon emissions.

The comparison in the amount of above and below ground carbon in various land uses is shown in Table 2. The amount of carbon is generally much higher belowground in all land uses.

Tabel 2. Above and below ground carbon storage in different land use

Land Uses Cover	Above Ground Carbon Storage (Mg C ha^{-1})	Below Ground Carbon Storage (Mg C ha^{-1})	ercentage of Carbon	Bulk Density (gr/cc)	Peat depth (Meter)
Natural Forest	94.25	4200	0.56	0.125	6
Logged Over Forest	71.5	5981	0.55	0.145	7.5
Disturbed Forest	26.75	4731	0.57	0.083	10
Rubber Garden	68*	4032	0.56	0.16	4.5
Acacia Plantation	42.57*	5460	0.56	0.15	6.5
Oil palm Plantation	42.3*	3960	0.55	0.12	6.5

*Sources: Above ground of carbon storage of rubber (Palm *et al*.2004); Acacia (Kehutanan 2010); oil palm (Murdiyarso *et al*. 2010).

The above comparison of amount of carbon stored in peatlands highlights the importance of peat swamp forest ecosystem in carbon storage, and not just the carbon stored in trees. This should be taken into consideration when evaluating for management option in the Biosphere reserve. The largest amount of below-ground carbon of 5981 Mg C ha^{-1} is found in logged-forest areas, followed by peatlands under acacia plantations with 5775 Mg C ha^{-1}. The lowest belowground carbon is in oil palm plantation of around 3960 Mg C ha^{-1}.

Natural forest has the highest amount of above-ground carbon followed by logged over forest. The lowest is wind-disturbed forest. In developed peatlands, the highest amount of carbon was measured under rubber trees having 68 Mg C ha^{-1} compared to *Acacia crassicarpa* with 42.57 Mg C ha^{-1} and *Elaeis guineensis* with 42.3 Mg C ha^{-1}. These differences could be useful information in the management of these plantations or in choosing land uses in relation to concerns to maintain carbon storage on the peatland ecosystem.

The percentage of carbon composition is similar in either forested areas or developed peatland areas. On the other hand, bulk density shows highest in rubber garden compared to other sampling plots. This is followed by acacia plantation and the lowest bulk density is in disturbed forest areas. The values of bulk density could be determined in degree of decomposition . The generally low bulk density values indicate low decomposition in peat. Our results found that rubber garden had highest values of bulk density; this is because peat had decomposed in advance compared to other sampling plot areas.

We propose three ways to improve their current status: conservation and stopping further forest conversion, natural regeneration and rehabilitation. The stopping of further forest conversion implies the need to designate boundaries and enforce them. There is a conflict between the government and some villagers who wanted to utilize designated conservation areas. This conflict needs to be resolved through the preparation of a management plan that addresses both integrity of the forest as well as the livelihoods of the villagers. Natural regeneration is an option for a faster recovery of forest vegetation after any disturbance. In the case of canopy species that could hardly undergo natural regeneration, some form of human-assisted regeneration is needed. Rehabilitation targets the areas that could hardly undergo natural regeneration and would need human intervention such as planting.

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Conclusions

1. Conservation of peat swamp forests in the Biosphere Reserve depends upon, firstly, protection of the remaining natural forests and, secondly, restoration efforts of degraded secondary forests, degraded or waste peatland.
2. The improvement of management of remaining peat swamp forests and rehabilitation should consider their unique ecological characteristics particularly the dominant tree species, fast growing species as well as below ground peat characteristics.
3. The remaining peat swamp forests should be kept in their natural conditions in order to provide continuously ecosystem services. Given their unique biodiversity characteristics and high amount of stored carbon, protection could be enhanced by adding incentives to local communities including monetary incentives from biodiversity and climate change mitigation funds.
4. The current rehabilitation of degraded peat swamp forests and peatland areas should be extended and should involve wider community participation. Given the high cost, financing is crucial and a way forward is to optimize various sources and means of domestic funding (e.g., GERHAN= The Indonesian Movement of Forest and Land Rehabilitation) and even international (e.g. REDD+ and PES). All support should help establish a management model that the local community could do and support continuously.

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