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Land cover distribution in the peatlands of Peninsular Malaysia, Sumatra and Borneo in 2015 with changes since 1990

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ABSTRACT

Insular Southeast Asian peatlands have experienced rapid land cover changes over the past decades inducing a variety of environmental effects ranging from regional consequences on peatland ecology, biodiversity and hydrology to globally significant carbon emissions. In this paper we present the land cover and industrial plantation distribution in the peatlands of Peninsular Malaysia, Sumatra and Borneo in 2015 and analyse their changes since 1990. We create the 2015 maps by visual interpretation of 30 m resolution Landsat data and combine them with fully comparable and completed land cover maps of 1990 and 2007 (Miettinen and Liew, 2010). Our results reveal continued peatland deforestation and conversion into managed land cover types. In 2015, 29% (4.6 Mha) of the peatlands in the study area remain covered by peat swamp forest (vs. 41% or 6.4 Mha in 2007 and 76% or 11.9 Mha in 1990). Managed land cover types (industrial plantations and small-holder dominated areas) cover 50% (7.8 Mha) of all peatlands (vs. 33% 5.2 Mha in 2007 and 11% 1.7 Mha in 1990). Industrial plantations have nearly doubled their extent since 2007 (2.3 Mha; 15%) and cover 4.3 Mha (27%) of peatlands in 2015. The majority of these are oil palm plantations (73%; 3.1 Mha) while nearly all of the rest (26%; 1.1 Mha) are pulp wood plantations. We hope that the maps presented in this paper will enable improved evaluation of the magnitude of various regional to global level environmental effects of peatland conversion and that they will help decision makers to define sustainable peatland management policies for insular Southeast Asian peatlands.

1. Introduction

Insular Southeast Asia has faced rapid environmental changes over the past few decades and it is currently one of the global hotspot areas of deforestation, forest degradation, tropical peat fires and plantation development (Achard et al., 2002; Corlett, 2009; van der Werf et al., 2010; Miettinen et al., 2012a; Margono et al., 2014; Miettinen et al., 2014; Stibig et al., 2014). The intensity and rapidity of these changes, as well as the associated environmental problems, are perhaps best seen in the peatlands of the region (Miettinen et al., 2012b). Due to the difficult working conditions for heavy machinery, low agricultural potential and sufficient availability of land on mineral soils, the 25 Mha of peatlands in Southeast Asia (equal to 56% of all tropical peatland; Page et al., 2011) were left largely undeveloped until the 1980's. In their natural state, peat swamp forests form a carbon sink which has resulted in an immense carbon deposit (∼69 Gt) in the peatlands of the region

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(Page et al., 2011). In addition, peatlands support specialized flora and fauna, partially endemic to the region, play an essential role in hydrology by regulating the water flow and have significant societal values for local people (Giesen, 2004; Rieley and Page, 2005; Corlett, 2009).

However, since the 1980's the peatlands of insular Southeast Asia have been increasingly utilized (Silvius and Diemont, 2007), inducing significant ecological, hydrological and atmospheric effects. Extensive logging activities over the 1990's made peat swamp forests highly susceptible to fire (Siegert et al., 2001) and lead to catastrophic fire damage during the 1997–1998 El Niño season resulting in massive carbon emissions (Page et al., 2002). Due to very slow natural regeneration of burnt peat swamp forests, often hindered by dense ferns and recurrent fire activity (Langner and Siegert, 2009; Page et al., 2009; Blackham et al., 2014) the majority of the 1997–1998 burnt areas remained as degraded peatlands. Drainage and conversion of peatland areas to plantations and agriculture gained momentum over the first decade of the new millennium, leading to remarkable expansion of fire prone peatland areas with lowered water table levels. Aerobic conditions in the upper peat profile, often combined with change in vegetation cover and use of fertilizers, result in increased carbon emissions from peat oxidation (Hooijer et al., 2012, 2014; Jauhiainen et al., 2012, 2014; Hirano et al., 2014; Sakata et al., 2015) and make the top layers of peat vulnerable to fires (van der Werf et al., 2008; Gaveau et al., 2014). Carbon emissions associated with peatland drainage and cultivation (Couwenberg et al., 2010; Hooijer et al., 2010; Miettinen et al., 2012a) as well as with recurrent peat fires (Page et al., 2002; van der Werf et al., 2008, 2010; Gaveau et al., 2014) make Indonesia one of the top emitters of greenhouse gases in the world and directly affect global climate change.

Peatland deforestation, drainage and conversion to agriculture drastically changes peatland ecosystems and may jeopardize the existence of plant and animal species endemic to Southeast Asian peatlands (see e.g. Giam et al., 2012). The region is one of the biodiversity hotspots in the world but is currently experiencing high levels of extinctions (Myers, 1988; Wilcove et al., 2013). Peatlands serve increasingly as refuge for endangered animal species (e.g. orangutan, Sumatran tiger and Sumatran rhino) which are losing their habitats in mineral soils (Giesen, 2004; Morrogh-Bernard et al., 2003; Meijaard et al., 2012). Furthermore, peatland drainage causes fluvial runoff of carbon from the peat domes, easily leads to flooding in nearby areas and may have feedback effects on local and regional climate patterns due to changes in evapotranspiration (Rieley and Page, 2005; Evans et al., 2014).

By 2007, forest cover in the peatlands of Peninsular Malaysia, Sumatra and Borneo had decreased to 42% (Miettinen and Liew, 2010) and deforestation rates remained high (Miettinen et al., 2012b). Over a quarter of peatlands had been converted to managed land cover types (11% small-holder areas and 18% industrial plantations), with lowered water table levels, and further 23% of the peatland areas were covered by highly fire prone degraded fern, shrub and secondary regrowth (Miettinen and Liew, 2010). Deforestation and conversion to managed land cover types is expected to have continued since 2007 but the current land cover distribution in the peatlands of Southeast Asia is unknown.

Meanwhile, peatland deforestation and conversion taking place in insular Southeast Asia, and particularly the role of industrial plantation development in it, has become one of the most discussed topics in natural resource management and conservation (see e.g. Jewitt et al., 2014; Law et al., 2014 and Austin et al., 2015). Indonesia and Malaysia are constantly under international pressure to implement sustainable peatland management policies protecting the remaining peat swamp forests and improving management practices and rehabilitation efforts in deforested peatlands. Annual peatland fires with repeated transboundary haze episodes (see e.g. Gaveau et al., 2014) cause significant health problems and economic losses throughout the region, while the ecological, biodiversity and carbon emission effects of peatland conversion highlighted above have consequences in varying levels from local to global scale. Due to the broad and far reaching consequences of peatland management, current peatland policy discussion in Southeast Asia involves governmental, non-governmental and business stakeholders from all over the world with a common aim to find solutions to the pressing peatland management challenges in the region.

In order to provide information on the current status and recent change trends on peatlands to evaluate the effects of the changes and to support formulation and implementation of peatland management policies, we here present land cover and industrial plantation distribution in the peatlands of Peninsular Malaysia, Sumatra and Borneo in 2015. We analyse the 2015 maps together with fully comparable and completed land cover maps of 1990 and 2007 (Miettinen and Liew, 2010) as well as industrial plantation maps of 1990, 2000, 2007 and 2010 (Miettinen et al., 2012a). In our land cover change and industrial plantation expansion analyses we concentrate on previously unpublished changes since 2007 (and since 2010 for plantation extent) building on known peatland land cover change history 1990–2010.

2. Materials and methods

2.1. Study area

The study area covers 15.7 Mha of peatland (Fig. 1) as defined by the peatland maps used in the analysis. The peatland areas for Sumatra and Kalimantan (Indonesian part of Borneo Island), were extracted from the Wetlands International 1:700 000 peatland atlases (Wahyunto et al., 2003, 2004). For Malaysia, the European Digital Archive of Soil Maps (Selvaradjou et al., 2005) was used to outline peatland areas as described in Miettinen and Liew (2010). For Brunei, we could not find any existing maps of peatland extent. The peatlands in Brunei were manually digitized using the Landsat data described below, Shuttle Radar Topography Mission (SRTM) elevation product (Jarvis et al., 2006) and an image originally