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Tropical peatland fires in Southeast Asia

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9.1 ABSTRACT

Extensive tropical peatlands are located in the Malaysian and Indonesian lowlands, particularly in Borneo, Sumatra, West Papua, and Peninsular Malaysia. In an undisturbed condition, these peatlands make a significant contribution to terrestrial carbon storage, both in terms of their aboveground biomass (peat swamp forest) and thick deposits of peat. Occasional forest fires, including peatland fires, have occurred in Southeast Asia over several millennia but, in recent years, they have become a more regular feature. The most severe fires have been linked with the El Niño phase of ENSO which causes extended periods of drought, particularly across the peatland areas of southern Sumatra and southern Kalimantan. During the last 20 years, rapid land use change, exacerbated by climatic variability, has led to an increase in fire frequency, as the remaining peat swamp forests come under pressure from increased illegal logging, development for plantations and agriculture-based settlement, and, where economic development has failed, land abandonment. A case study of fire occurrence in Borneo illustrates that peat swamp forests are much more prone to fire than any other forest type, largely as a result of the high pressure being put on these last remaining forested lands. From studies in central Kalimantan (southern Borneo), we demonstrate the relationships between peat drainage, vegetation change, and increased fire frequency, including the role that peat combustion and subsidence play in an increased incidence of surface flooding. Tropical peatland fires, and the changes in vegetation that they bring about, have significant impacts on the atmosphere, the carbon cycle, and various ecosystem services; they also cause wide-ranging social and economic impacts. Fires on peatlands usually affect both the surface vegetation and the underlying peat layer and, as a result, they release much larger amounts of CO₂ into the atmosphere than forest fires on mineral soils. In 1997, peatland fires in Indonesia resulted in the release of between 0.81 Gt and 2.57 Gt of carbon into the atmosphere, equivalent to 13% to 40% of mean annual global carbon emissions from

fossil fuels, and over the last ten years a conservative estimate of total carbon emissions from peatland fires in Southeast Asia is of the order of 2 Gt to 3 Gt. Future climate changes may place further pressure on the tropical peatland ecosystem and are likely to lead to enhanced carbon emissions from both peat degradation and fire.

9.2 INTRODUCTION

Fire is a critical ecosystem disturbance factor that has a major ecological impact on species composition and vegetation structure, as well as on soils, water, and the atmosphere. In recent decades tropical forest fires have become more frequent, intensive, and extensive, mostly as a consequence of increased levels of human activity, notably deforestation and logging, which have resulted in conditions conducive to fire (Cannon *et al.*, 1998; Nepstad *et al.*, 1999; Chazdon 2003). During 1997–1998, for example, large-scale wildfires occurred throughout the tropical forest biome, particularly in Amazonia and Southeast Asia, where they were linked to recent changes in land use, exacerbated by regional climatic variability, especially an extended dry season (Cochrane, 2001; Page *et al.*, 2002).

Tropical forests represent around 50% of the global forest area and are estimated to contain 40% of terrestrial carbon (Malhi and Grace, 2000; Nightingale *et al.*, 2004). Even relatively small perturbations within these ecosystems can produce significant changes in global carbon flux, estimates of which are highly variable. Most take account of the uncertainties involved in estimating the loss of forest area, but not in the amount of carbon in different ecosystem compartments (e.g., vegetation and soils) or site-specific effects. Both deforestation and fire lead to reductions in soil organic carbon stocks and changes in cycling patterns, and the carbon pool in tropical forest soils responds very rapidly to land use change. Decomposition of soil organic matter may contribute up to 25% of carbon losses arising from deforestation (Detwiler, 1986; Melillo *et al.*, 1996), but in regions with carbon-rich substrates (e.g., peatlands), these losses can be considerable. A recent study estimated carbon losses of 97 Mt C to 238 Mt C yr⁻¹ from deforested and drained peatlands in Southeast Asia (Hooijer *et al.*, 2006). These values for deforestation and land drainage exclude carbon losses from fires, which are much higher (Page *et al.*, 2002).

The Southeast Asian region has experienced occasional wildfires over several millennia (Goldammer, 1992), but, in recent years, they have become a more regular feature, with some of the most extensive fires located in peatland areas (Page *et al.*, 2002; Langner *et al.*, 2007). Peat fires result in rapid loss of both aboveground and belowground carbon stocks and a wide range of environmental, social, and economic impacts (Schweithelm, 1999). In this chapter we demonstrate the role that recent land use and land cover changes have played in the increased frequency and intensity of peatland fires in Southeast Asia. We focus on the principal drivers of fire, their ecological consequences, using case studies from Borneo and Sumatra, and consider future scenarios for these increasingly fire-prone landscapes.