Chapter 2
Consequences of Deforestation and Climate Change on Biodiversity

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ABSTRACT

Ever since their evolution, forests have been interacting with the Earth's climate. Species diversity is particularly high in forests of stable moist tropical climates, but patterns of diversity differ among various taxa. Species richness typically implies high ecosystem resilience to ecosystem disturbances; many species are present to fill in newly created niches and facilitate regeneration. Species loss, on the other hand, often entails environmental degradation and erosion of essential ecosystem services. Until now species extinction rates have been highest on tropical islands which are characterized by a high degree of species endemism but comparatively low species richness (and therefore high vulnerability to invasive species). Deforestation and forest degradation in many countries has lead to forest fragmentation with similar effects on increasingly insularized and vulnerable forest habitat patches. If forest fragments are becoming too small to support important keystone species, further extinctions may occur in cascading ways, and the vegetation structure and composition may eventually collapse. Until now relatively few reported cases of species extinctions can be directly attributed to climate change. However, climate change in combination with habitat destruction, degradation, and fragmentation may lead to new waves of species extinctions in the near future as species are set on the move but are unable

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to reach cooler refuges due to altered, obstructing landscapes. To mitigate the future risks of extinctions as well as climate change, major efforts should be undertaken to protect intact large areas of forests and restore wildlife corridors. Carbon sequestration may be seen as just one of many other environmental services of forest biodiversity that deserve economic valuation as alternatives to conversion to often unsustainable agricultural uses.

1. FORESTS AND CLIMATES

The world's climates and forests are intimately interlinked. Dense communities of tree species can only grow in environments with sufficient soil water. Where mean annual precipitation is less than about one meter, continuous forests are commonly replaced by smaller woody vegetation (e.g. scrub forests, dry thickets), grasslands (e.g. savannas, steppes) or deserts. In these dry regions tree stands and forests may only be found in topographic depressions where water accumulates and is stored well into the dry season, e.g. along river beds and in periodic floodplains (Whittaker, 1975). Likewise, primary productivity in forests is principally related to rainfall as well as temperature, ranging from averages of about 2200 g m^{-2} yr^{-1} in lush tropical rainforests (trees of more than 30 m height and mean woody biomass of around 45 kg m^{-2}) to 800 g m^{-2} yr^{-1} in the northern taiga forests (stunted trees of less than 15 m height and woody biomass of around 20 kg m^{-2}; Gurevitch *et al.,* 2006). Seasonal weather patterns also influence tree physiology and determine the distribution of forest biomes, e.g. temperate deciduous forests occur in regions characterized by cold winters, whereas dry deciduous forests are widespread in parts of South and Southeast Asia that are influenced by the monsoon. The growing season of these vast deciduous northern forests is reflected as a small seasonal decrease in atmospheric carbon dioxide measured at weather stations around the northern hemisphere.

Ever since their evolution, forests have been influencing the gas composition in the atmosphere, which in turn influenced temperatures and weather patterns on planet Earth (Zachos *et al.,* 2001, Sigman & Boyle, 2000). The accumulation of oxygen in the atmosphere and the absorption of carbon dioxide into the biosphere and earth crust began with the evolution of photosynthesis in algae around 3500 million years ago. After the 'great oxygenation event' around 2400 million years ago plants began to spread and diversify on land (Anbar *et al.,* 2007, Dole, 1965). Carbon sequestration further increased when woody vascular plants started reaching for the sun in the middle Devonian (ca. 385 million years ago), and during the Carboniferous (ca. 359 million years ago) biomass accumulation reached a first climax in tropical peat swamp forests of Pangaea, which lead to the formation of large coal deposits (Ghazoul & Sheil, 2010).

Forests are still sequestering carbon at significant rates which can offset emissions from deforestation to some degree (Lewis *et al.,* 2009; Bunker *et al.,* 2005). South East Asian peat soils up to >20 m deep constitute probably the largest carbon stores of any living ecosystem (Phillips, 1998). Poor drainage, permanent waterlogging, high rainfall and substrate acidification are conditions in which plant materials accumulate faster than they decay (Brady, 1997). The average rate of carbon accumulation in pristine peat swamps in Indonesia has been estimated at 0.8-1.9 t ha^{-1} y^{-1} (Immirzi & Maltby in Rieley *et al.,* 1997), respectively 0.4-1.1 t ha^{-1} y^{-1} (Sorensen, 1993). South East Asian peat soils developed in coastal floodplains as early as 30'000 BP (Whitten *et al.,* 1997; Page *et al.,* 2004). On average these swamp forests may comprise about 200 t C ha^{-1} in the standing tree biomass and more than 2500

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