Carbon emissions from forest loss in protected areas

A report commissioned by The Nature Conservancy as part of the PACT 2020 Innovation Initiative in collaboration with UNEP-WCMC and the IUCN World Commission on Protected Areas

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This report was commissioned by The Nature Conservancy as a contribution to understanding the role of protected areas in responses to climate change. Under the auspices of IUCN, a number of partners including UNEP-WCMC and The Nature Conservancy are promoting an initiative known as PACT 2020 (Protected Areas and Climate Turnaround) to make the case for protected areas to be an integral component of responses to both climate change mitigation and adaptation. This report is an element of the foundational phase of this initiative that will be further developed as an IUCN Innovation Fund programme.

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Executive summary

Forest clearance contributes 20% of total global emissions of carbon dioxide (CO_2) to the atmosphere (IPCC 2007). Reducing forest loss is therefore of utmost importance for climate change mitigation. As formally protected areas are one potential tool for achieving these emissions reductions, it is important to understand the extent to which protected areas are in fact subject to land use change, and whether improving the effectiveness of their management could contribute to reducing emissions from deforestation and forest degradation.

This study combines the best available data on carbon stocks and deforestation with protected area data to estimate the area of forest loss within the protected area network of the humid tropical forest biome during 2000-2005. Carbon emissions resulting from deforestation are estimated according to four scenarios of land use following clearance; ranging from complete loss of biomass to pasture, crop, or oil palm development on a regional basis. Regions where protected areas are simultaneously rich in carbon and under pressure from land cover change are identified.

We examined the distribution of an estimated 21 million hectares of humid tropical forest loss between 2000 and 2005 (representing a 2% reduction in forest cover). The largest forest area loss was observed in the Neotropics. Rates of deforestation were similarly high in the Neotropics and Tropical Asia, 2.39 and 2.17% respectively. During the same period, over 1.7 million ha were estimated to have been cleared within protected areas in the humid tropics (0.81% of the forest they contained). Tropical Asia had the highest rates of deforestation within protected areas (1.33%). Despite low deforestation rates in protected areas in the Neotropics (0.79%), more than half the global total loss of humid tropical forest from within protected areas occurred in this region because of the large amount of forest protected there. Globally, more strictly protected areas (IUCN management categories I-II) had lower rates of humid tropical forest loss (0.53%) than the protected area network as a whole.

Protected areas of the humid tropical forest biome contained an estimated 70Gt of carbon in 2000, over half of which was in the Neotropics. We estimate that forest loss from within protected areas between 2000 and 2005 resulted in 822 - 990 Mt of CO_2 equivalent emissions. This accounted for around 3 % of total annual emissions from tropical deforestation during that period (IPCC 2007). Approximately 75% of total emissions from deforestation in protected areas were from the Neotropics with up to 15% coming from Tropical Asia. In both of these regions reducing deforestation in protected areas could provide significant emissions reduction benefits.

Improving the effectiveness of protected area networks, particularly in regions like the Neotropics and Tropical Asia that have large carbon stocks subject to high deforestation pressures, could be an important strategy for reducing emissions from deforestation and degradation.

Introduction

In addition to containing as much as 90% of terrestrial biodiversity (Brooks *et al.* 2006), tropical forests store more than 320 billion tonnes of carbon (Gibbs *et al.* 2007). Clearing these forests results in large emissions of carbon dioxide (CO_2) to the atmosphere; the annual emissions from current tropical deforestation have been estimated at ~1 – 2 gigatonnes (Gt; Ramankutty *et al.* 2007) or 20% of total global CO_2 emissions (IPCC, 2007). Reducing forest loss is therefore of utmost importance for climate change mitigation, and this is reflected in the commitment to include reduced emissions from deforestation and degradation (REDD) in the post-2012 agreements of the UNFCCC.

Achieving these emissions reductions will require effective strategies for reducing land cover change, in which formally protected areas are one promising tool. Protected areas, which are by definition designated with the primary aim of conserving biodiversity, generally constitute legal restrictions on land use change, and potentially play an important role in maintaining terrestrial carbon stocks. It has been estimated that globally, ecosystems within protected areas store over 312 Gt carbon or 15% of the terrestrial carbon stock (Campbell *et al.* 2008).

Despite their legal status, designation of protected areas does not in itself guarantee protection of the ecosystems they contain. Recent research indicates that whilst protected areas generally reduce deforestation relative to unprotected areas, they do not entirely eliminate land use change within them (Clark *et al.* 2008). Therefore, it is important to understand the extent to which protected areas are in fact subject to land use change, and the degree to which improving the effectiveness of existing protected areas could make an effective contribution to reducing emissions from deforestation and forest degradation

This study uses an analysis of new data on deforestation in the humid tropics to estimate deforestation within protected areas between 2000 and 2005. These estimates are used in combination with analysis of data on carbon stocks to identify regions where protected areas are simultaneously rich in carbon and under pressure from land cover change.

The principal reasons for tropical deforestation are conversion to cropland and pasture at both small and large scales (Geist & Lambin 2002, Lambin *et al.* 2001). However, the causes of deforestation differ among tropical regions (Rudel 2007). Pasture expansion is a major cause of deforestation (Chomitz *et al.* 2006, Steinfeld *et al.* 2006), especially in Latin America, where it has been the most important cause of forest loss over the last decade (Kaimowitz *et al.* 2004, Laurance *et al.* 2004, Nepstad *et al.* 2006a, Soares-Filho *et al.* 2006, Nepstad *et al.* 2008). Recently soybean production has become one of the most important contributors to deforestation in the Brazilian Amazon (Cerri *et al.* 2007). It has been estimated that by 2015, approximately 60% of the newly deforested area in the Brazilian Amazon will be used for soybean cultivation (Cerri *et al.* 2007), though much of that land will first have passed through a phase of use as cattle pasture (Morton *et al.* 2006). Rapid growth in consumption of vegetable oils both for food and biodiesel (OECD, FAO 2007) is driving rapid expansion of oil palm plantations. The total oil palm area in Indonesia expanded by more than an order of magnitude between 1967 and 2000, from less than 2000 km^2 to over 30,000 km^2 (FWI/GFW 2002), with much of this area derived from deforestation.

These different land uses all have different implications for estimating the amount of carbon emissions resulting from deforestation, which must include the release of carbon stored in the above ground biomass, decomposition of roots and mobilization of soil carbon, and must take account of carbon stored in subsequent land use. This study has applied some simple scenarios of likely regional land use changes to estimate the range of carbon emissions that may have resulted from deforestation in protected areas in different parts of the humid tropics.

These estimates can be used to make an initial identification of regions where improved investment in protected area networks would contribute to the UN Framework Convention on Climate Change (UNFCCC) goal to reduce emissions from deforestation and forest degradation.

Quantifying the emissions from deforestation also makes it possible to estimate the financial value of the carbon loss from protected areas within the humid tropical forest biome between 2000 and 2005, based on current market values. This may provide some indication of the scale of financial resources that could potentially be generated by including emissions from protected areas in a mechanism aiming to reduce emissions from tropical deforestation.

Protected areas are likely to make up just part of a national REDD strategy, and the role of the existing protected area network within a REDD mechanism is still subject to debate. However, carbon has a value on the international market place, and reducing deforestation within vulnerable protected areas could contribute towards national commitments on biodiversity conservation as well as on greenhouse gas emissions. As deforestation is already illegal in most protected areas, action can often be taken quickly without further legislation.

This study illustrates the potential role of protected areas in climate change mitigation and will be a useful input to current discussions on a mechanism for reducing emissions from deforestation (REDD) under the UNFCCC, which has also been raised within the UN Convention on Biological Diversity (CBD).

Methods

Study area

All analyses were restricted to the humid tropical forest biome, defined as all WWF ecoregions with humid tropical forests (Olson *et al.* 2001). Land clearing in the humid tropical forest biome results in a large loss of carbon stock, and includes highly biodiverse terrestrial ecosystems (Hansen *et al.* 2008).

Datasets

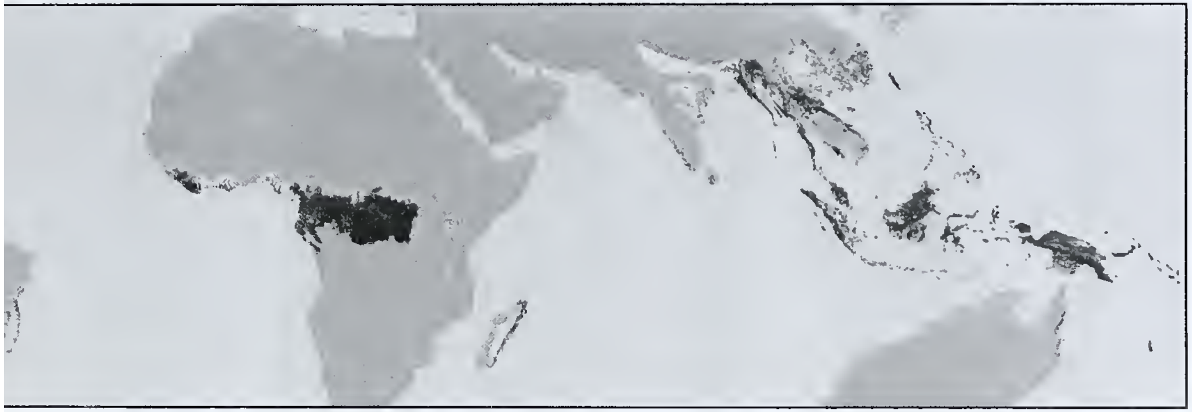
We estimated carbon loss within protected areas, and its financial value, by combining spatial datasets on forest area, forest area loss from 2000 to 2005, carbon stock, protected areas and a dataset of carbon market prices.

Forest area

We calculated forest area for the year 2000 from the Vegetation Continuous Field (VCF) tree cover data gathered by the MODerate Resolution Imaging Spectroradiometer (MODIS) at 500m resolution (Hansen *et al.* 2003, 2006). MODIS provides the best available cloud-free observations at near daily repeat frequency globally. MODIS-derived VCF data provide information on percent tree canopy density per 500m pixel, which we converted to percent forest cover by dividing VCF by 0.8 to account for the fact that VCF observations are of tree canopy cover and not forest cover (completely forested pixels are recorded as 80% VCF canopy cover; Hansen *et al.* 2003). Further, to exclude non-forested pixels with some canopy cover (such as shrublands), we defined forest as pixels with ≥ 25% forest cover (Figure 1). We calculated forest area by multiplying the proportion of forest cover by the pixel area (21.47 ha; although notionally 500m resolution, each MODIS pixel is 463.3127 m squared).

Forest area loss 2000-2005

We estimated forest area loss between 2000 and 2005 from MODIS-derived change probability maps provided by Hansen and colleagues (Hansen *et al.* 2008). Hansen *et al.* employed a classification tree bagging algorithm to produce a 5-year change probability map at 500m resolution, based on 32-day MODIS composites of 7 spectral bands each (blue, green, red, near infrared and three mid infrared bands) and MODIS Land Surface Temperature. The classification tree algorithm related forest cover loss training data to the MODIS inputs and resulted in a per 500m pixel 5-year change probability map (Figure 2). We calculated the gross forest area loss by multiplying the change probability and the forest area within each 500m pixel (Figure 3).



e humid tropical forest biome in the year 2000, derived from MODIS Vegetation Continuous Field data at 500m
l. (2008) shown in MODIS Integerized Sinusoidal projection. .