Protected areas: an effective tool to reduce emissions from deforestation and forest degradation in developing countries?

Working Paper, revised 16th May 2008

16 May 2008

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Citation: Clark, S., Bolt, K., Campbell, A. (2008). *Protected areas: an effective tool to reduce emissions from deforestation and forest degradation in developing countries?* Working Paper, UNEP World Conservation Monitoring Centre, Cambridge, U.K.

Acknowledgements: UNEP-WCMC's work on the linkages between reducing emissions from deforestation, livelihoods and protected areas has been financially supported by the Department for International Development (UK), the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany), UNEP and WWF UK.

Many organisations and individuals provided ideas and input for this paper. We are particularly grateful for such input to the members of the Cambridge Conservation Forum. Our thanks too to Emily Brickell and Lera Miles for comments on the draft of this paper.

Contents

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Abstract

Successful implementation of REDD is likely to require the reduction of deforestation rates on a national scale. Designation of new protected areas and strengthening of the current protected area network could form one strategy for achieving this. This review aims to inform the debate through an assessment of the effects of forest designation and management on deforestation rates, and through consideration of the design and management-related factors that influence protected area effectiveness in reducing deforestation. The evidence suggests that protected areas are an effective tool for reducing deforestation within their boundaries. The extent to which this deforestation is displaced to surrounding areas is unclear. Protected areas designated under the more restrictive IUCN categories (I-II) seem to be more effective than those that may include a focus on sustainable use (V-VI). However, there are only a small number of studies on deforestation within category V-VI protected areas. In addition, studies rarely consider the forms of governance that exist within protected areas, or the level of community involvement. Some insight can be gained through analysis of deforestation rates in indigenous lands and community forestry areas, which have also been shown to be successful at reducing deforestation. The evidence suggests that the creation of a protected area network that incorporates all levels of protection, as appropriate for the situation at site level, could be a valuable component of a national REDD strategy. To better inform such planning decisions, further research is required into the factors that influence the effectiveness of protected areas in reducing deforestation; and in particular the interrelationship between protected area status, community involvement and governance.

Introduction

Forests play a key role in the global carbon cycle, absorbing and storing carbon in their biomass and soils. The UN Framework Convention on Climate Change (UNFCCC) discussions on reducing emissions from deforestation and degradation (REDD) in developing countries result from a recognition of the substantial greenhouse gas emissions resulting from deforestation, especially in the tropics. Depending on the method of forest clearing and the subsequent use of the felled trees and land, deforestation not only releases the carbon stored in the above ground biomass, but leads to decomposition of roots and mobilization of soil carbon. Global greenhouse gas emissions from changes in land use, including tropical deforestation, are estimated to make up around 20% of annual global emissions from all sources (IPCC 2007), though there is a high level of uncertainty attached to the precise figure. Forest fragmentation and degradation also increase the risk of forest fires, which release further carbon emissions and increase susceptibility to future fires (Cochrane & Schulze 1999). Retaining and restoring forested areas is therefore a crucial climate change mitigation strategy.

Discussions at the recent UNFCCC's 13th Conference of the Parties focussed on guidance for demonstration (pilot) REDD projects, potential policy mechanisms and incentives for developing countries. While the precise form of any future REDD mechanism as part of a post-2012 emissions reduction agreement is yet to be determined, this review aims to inform the debate by considering protected areas as a prior example of the effects of forest conservation interventions on deforestation rates. This review considers the designation and management-related factors influencing their effectiveness in achieving this.

Forested protected areas

Forested protected areas are established in order to conserve forest of biodiversity value from damaging processes, such as deforestation. Deforestation drivers vary by region and time as well as being mutually re-enforcing (Kaimowitz & Angelsen 1998), but most notably include the demand for timber, and for land for agriculture, settlements, and mining. Land areas with particular characteristics face differing risks of deforestation; altitude, proximity to roads and/or settlements, land gradient, rainfall and soil productivity have all been found to affect the rate of deforestation (Kaimowitz 1995, Cropper *et al.* 2001, Wilkie *et al.* 2001, Deininger & Minten 2002, Linkie *et al.* 2004, Mas 2005, Gaveau *et al.* 2007). It is clear that many factors need to be taken into consideration when assessing the causes of deforestation in or around a given protected area, and that no one management solution is applicable to all situations. This review aims to identify general patterns in the impact of an area's protection status and management on the rate of deforestation.

Broadly speaking, protected areas can be defined as areas of land or sea "dedicated to the protection and maintenance of biological diversity and of natural and associated cultural resources, managed through legal or other effective means" (IUCN 1994). The World Conservation Union (IUCN) describes six management categories (Table 1) for protected areas, according to the reason for establishment. The categories do not specifically determine protected area management and governance (Naughton-Treves *et al.* 2006), and this differs both within and between categories. In general, protected areas with a higher IUCN category (I-II) are more (and sometimes completely) restrictive of resource exploitation and land use change than the lower categories (V-VI).

Table 1 – IUCN management categories

Category	Description
Ia	Strict Nature Reserve: protected area managed mainly for science
Ib	Wilderness Area: protected area managed mainly for wilderness protection
II	National Park: protected area managed mainly for ecosystem protection and recreation
III	Natural Monument: protected area managed mainly for conservation of specific natural features
IV	Habitat/Species Management Area: protected area managed mainly for conservation through management intervention
V	Protected Landscape/Seascape: protected area managed mainly for landscape/seascape conservation and recreation
VI	Managed Resource Protected Area: protected area managed mainly for the sustainable use of natural ecosystems

Several global and regional conventions and agreements provide for the designation of internationally recognised protected areas. For example, World Heritage Sites and Biosphere Reserves are both designated through a process managed by the UN Educational, Scientific and Cultural Organization (UNESCO). World Heritage sites are areas of "outstanding universal value", either of a natural or cultural origin, following the definitions of the World Heritage Convention. Biosphere Reserves, designated under the Programme on Man and Biosphere, constitute areas with a core under protection and a buffer zone allowing human habitation (often tens of thousands of people) and sustainable development. Within the European Community, the Birds and Habitats Directives have ensured the designation of a network of Natura 2000 sites, recognised as of regional conservation importance. These international sites are not assigned an IUCN management category, but often share the boundaries of nationally-designated areas that do have a category.

The IUCN management categories are independent of the ownership of, or management responsibility for, the protected area. Additional distinctions can be made between protected areas in terms of 'governance' type, depending upon whether the area is government managed, co-managed, privately owned, or a community conserved area. Governance types vary within and between management categories. Community-managed forests are increasingly growing in importance as a method of forest conservation. Though they are not always formally designated as protected areas, their goals are often consistent with IUCN management category VI. Similarly, indigenous lands are not typically assigned an IUCN category, as they are not primarily designated for biodiversity protection. As governments accord them a high protection status, both community-managed and indigenous areas are reviewed here to assess their effectiveness in comparison to traditional protected areas.

Are protected areas effective in reducing tropical deforestation?

Protected areas

The evidence reviewed in this report indicates that there is less deforestation within formally protected areas than in the areas surrounding them (Sánchez-Azofeifa *et al.* 1999, 2003, Pelkey *et al.* 2000, Bruner *et al.* 2001, Deininger & Minten 2002, Helmer 2004, Curran *et al.* 2004, DeFries *et al.* 2005, Mas 2005, Naughton-Treves *et al.* 2005, 2006, Sommerville 2005, Bleher *et al.* 2006, Nepstad *et al.* 2006, Chowdhury 2007, Gaveau *et al.* 2007, Oliveira *et al.* 2007, Phua *et al.* 2007; Oliveira *et al.* 2007). A minority of studies report no significant impact on deforestation arising from protection status (Marizán 1994, Cropper *et al.* 2001, Rautner *et al.* 2005, Roman-Cuesta & Martinez-Vilalta 2006).

As deforestation rates are influenced by site-specific factors, it is useful to compare the situation across a range of protected areas. A questionnaire-based study of 93 protected areas in 22 tropical countries compared the rate of land clearing at the time of the protected area's establishment with that of the present day (Bruner *et al.* 2001). All protected areas were 'subject to significant land-use pressure', but it should be noted that the study was not specific to forested areas, and had a focus on biodiversity rather than forest loss. Nevertheless, land clearing is a useful indicator of success in reducing deforestation, and only 17 percent of protected areas had experienced net clearing since their establishment. 97 percent experienced less land clearing than did a surrounding 10 km belt; although the proportion of protected areas faring better than the surrounding areas fell to 80% when logging and fire were also considered. The study suggests that these protected areas are very effective at preventing land use change.

Deforestation studies have often been undertaken with the use of satellite data. In a study of 198 category I & II protected areas and the 50 km zones surrounding them, 500-m MODIS and 8km AVHRR satellite data were used to measure deforestation from 1980-2000 (DeFries *et al.* 2005). Overall, approximately 25% of protected areas experienced some forest loss; with 9% losing over 5% of the forest area. In comparison, there was some forest loss in the 50km surrounding zone of over 68% of the protected areas. The results were summarised by region (Table 2), indicating that Latin American protected areas have defended against deforestation more effectively than Asian or African protected areas, as has been reported elsewhere (Naughton-Treves *et al.* 2005). These figures do not show the absolute area lost by region, or take into account the differing deforestation pressures and management regimes acting upon these forests. It was concluded that protected areas are generally effective in reducing deforestation.

Table 2. Percentage of protected areas with land cover change from 1980-2000. Adapted from supplementary materials provided by Defries et al. (2005)

	1% or more of surrounding 50km zone was lost	1% or more of protected area was lost	5% or more of protected area was lost	Total number of protected areas
Latin America	41%	14%	3%	85
South and Southeast Asia	47%	20%	14%	95
Africa	47%	18%	12%	18

Similar work has been undertaken in Costa Rica. Sánchez-Azofeifa *et al.* (2003) studied deforestation from 1986 to 1997 in and around a network of National Protected areas, Biological Reserves and surrounding zones. Both aerial photography and maps derived from satellite data were used. Deforestation within these protected areas was negligible: 17 out of a sample of 27 protected areas lost less than 100ha, and the maximum loss measured was 324ha. Higher levels of deforestation were observed immediately around the protected areas, with deforestation rates increasing with distance from the parks; from an average of 0.32% per year in the 1 km surrounding zone to 1% per year in a 10 km zone. In some cases, deforestation reached right up to the park boundaries. This raises questions over the effectiveness of protected areas in implementing REDD, as it is difficult to establish the extent to which deforestation is merely displaced to other areas.

Case Study - Kinabalu Park (Phua *et al.* 2007)

Kinabalu National Park in Malaysia is a category II protected area in which only recreational, educational and scientific use is permitted. The park has been strictly managed by the state government since 1984, with substantial fines for encroachment. It has no formal buffer zone but local people are involved in maintaining boundaries and have other job opportunities. Using satellite data and change vector analysis, forest cover was measured in 1973, 1991 and 1996. Overall 1.3% of the park was deforested in this time; from 1973-1991, 2606 ha of forest was lost at a rate of 145 ha/yr; from 1991-1996 the deforestation rate was over three times slower, with 236 ha deforested. To measure the effectiveness of protections against encroachment, deforestation was measured within the 1 km zone inside the park's borders, and zones both 1 km and 10 km outside the park. Over the 23 years, 0.1% of the forest 1 km within the boundary was cleared compared to 1% in the 1 km outside and 1.6% in the 10 km surrounding zone, indicating that protection has been effective.

Of particular interest are studies that have accounted for differences in deforestation pressures inside and outside of protected areas, facilitating assessment of the impact of protection status alone. For example, Mas (2005) measured a deforestation rate of 0.3%/yr within the Calakmul Biosphere Reserve in Mexico, versus a rate of 1.3%/yr in the 10 km surrounding area. Within this surrounding zone, the deforestation rate was measured for the areas of land in which deforestation pressures matched those within the protected zone. The rate in this comparable land outside of the protected area was 0.6%/yr. This suggests that the protection status of the area halved the rate of deforestation relative to nearby land under similar pressures.

Various models have also been developed to measure or predict deforestation rates. Cropper *et al.* (2001) developed a bivariate probit model using land use data collected over a number of years in North Thailand, to predict the probability of deforestation for land with and without protection status. In this region, designation as a national protected area (category II)

did not have a statistically significant impact on forest clearing. This is consistent with other findings that protected areas are less effective in Southeast Asia than in other tropical regions (DeFries *et al.* 2005). Conversely, a model for Mexico that used data from digital maps and censuses to forecast deforested areas in 1990 from forest cover in 1980 found that protection had a statistically significant effect at reducing deforestation (Deininger & Minten 2002). Without protection, 43% of plots in protected areas would have been at high risk of being deforested, whilst with protection 'only' 9% of plots were deforested. The influence of the protected area status varied depending upon factors such as forest type and distance from roads.

Many studies have found that protected areas are effective at reducing forest loss related to roads (Wilkie *et al.* 2001, Deininger & Minten 2002, Mas 2005, Ankersen *et al.* 2006, Oliviera *et al.* 2007). In the Peruvian Amazon, 1.15% of the area under protection within 20 km of roads was deforested in a six year period, compared to 4.76% of unprotected forest (Oliveira *et al.* 2007).

Most studies discussed thus far have focused upon comparison of deforestation rates inside and outside protected areas. Whilst protected areas may reduce the rate of deforestation *relative to their surroundings*, forest may still be cleared at high rates. In an extreme example, Gunung Raya Wildlife Sanctuary in Sumatra lost nearly 81 percent of its forest cover between 1972 and 2002. The 2.74% per year deforestation rate was only 0.1 percent less than that in the surrounding unprotected area (Gaveau *et al.* 2007). Deforestation rates in excess of 3-6% within protected area borders have been reported by Linkie *et al.* (2004) and Achard *et al.* (2002). Therefore, although protected areas are generally successful at *reducing* deforestation rates, they may not eliminate deforestation and in some cases the total area of forest loss can still be very high.

Similarly, few studies have taken leakage into account, in which deforestation inside protected areas is simply displaced to surrounding areas. Whilst little information exists for leakage from protected areas, Oliviera *et al.* (2007) have assessed relative changes in and around sustainably managed timber concessions in Peru. Following the assignment of the concessions, deforestation rates in these areas halved while in surrounding areas, deforestation increased by several hundred percent. Overall the deforestation rate remained the same. This study has been cited as the best empirical evidence of the occurrence of leakage to date (Ewers & Rodrigues 2008). The local reduction in carbon emissions resulting from the success of a protected area may therefore be offset by an increase in deforestation outside of the area, indicating that unless a country's protected area network includes a high proportion of remaining forest, it can form only part of a successful strategy for REDD.

Indigenous lands

Within formally declared indigenous lands, local institutions typically govern the use and