

# Deforestation and timber production in Congo after implementation of sustainable forest management policy



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## ABSTRACT

Over 400 million hectares of tropical forests are managed for timber production, comprising more than half of the remaining global permanent tropical forest estate. A growing proportion of tropical production forests are managed under Sustainable Forest Management (SFM) principles. The objective of SFM is to achieve multiple benefits, including forest protection, biodiversity conservation and income enhancement. However, the outcomes resulting from the implementation of SFM in tropical forest ecosystems have seldom been examined rigorously. In this paper, we present a methodological approach to assess broad-scale impacts of SFM policy in tropical forest ecosystems. As a case study, we investigated deforestation and timber production in logging concessions in the Republic of Congo after the implementation of its SFM-based forestry law in 2000. Compliance with the forestry law was incomplete, allowing a unique opportunity to compare deforestation and legal timber production outcomes in concessions that implemented SFM-based policy compared to those that did not. Quasi-experimental matching analysis indicated that deforestation in matched parcels in compliant concessions was up to 2-times higher than matched parcels in non-compliant concessions, equivalent to 67 km<sup>2</sup> of forest loss for the period 2005–2010. Annual deforestation data demonstrated that deforestation was stable or increased in all six concessions following the respective date of compliance in each concession. Legal timber production increased (by 5%, from 0.18 to 0.19 CBM/ha/yr) and became more stable, in compliant compared to non-compliant concessions. Our results suggest that the presence of SFM in a concession does not immediately lead to less deforestation. Rather, SFM policy may be associated with higher deforestation, because SFM is also associated with higher legal timber production, foreign capital, and international timber demand. Our findings measure short-term associations between SFM and deforestation in the Congo, and underscore the need for empirical evaluation of long-term impacts of SFM in tropical forest ecosystems worldwide.

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## 1. Introduction

As human population and per-capita consumption grow, there is an increasing pressure on forests for timber, food and bio-fuels (Edwards et al., 2014; Foley et al., 2005; Laurance et al., 2014). Global demand for tropical timber is especially strong, as a result of growing timber markets in Asia and other developing economies (FAO and ITTO, 2011). This pressure is felt disproportionately in tropical forests of developing countries, as developed nations implement strong policies to limit exploitation of their own

remaining forests (Meyfroidt et al., 2010). However, those same countries contain the last remaining extensive tracts of intact tropical forests, which are essential for regulating global climate and hydrological cycles, and provide critical habitat for threatened biodiversity (Bradshaw et al., 2008). Thus, there is an urgent need to identify strategies that balance trade-offs between human needs and ecosystem integrity in tropical forests of developing countries (Lambin et al., 2014).

Sustainable Forest Management (SFM) – the process of managing permanent forest land for timber production without reducing inherent values and future productivity – is viewed as a key component of forest protection, biodiversity conservation and income enhancement in tropical forests. During the 1992 Rio Summit, SFM was identified as a key strategy for conservation and economic development in tropical forest regions worldwide (FAO and ITTO,

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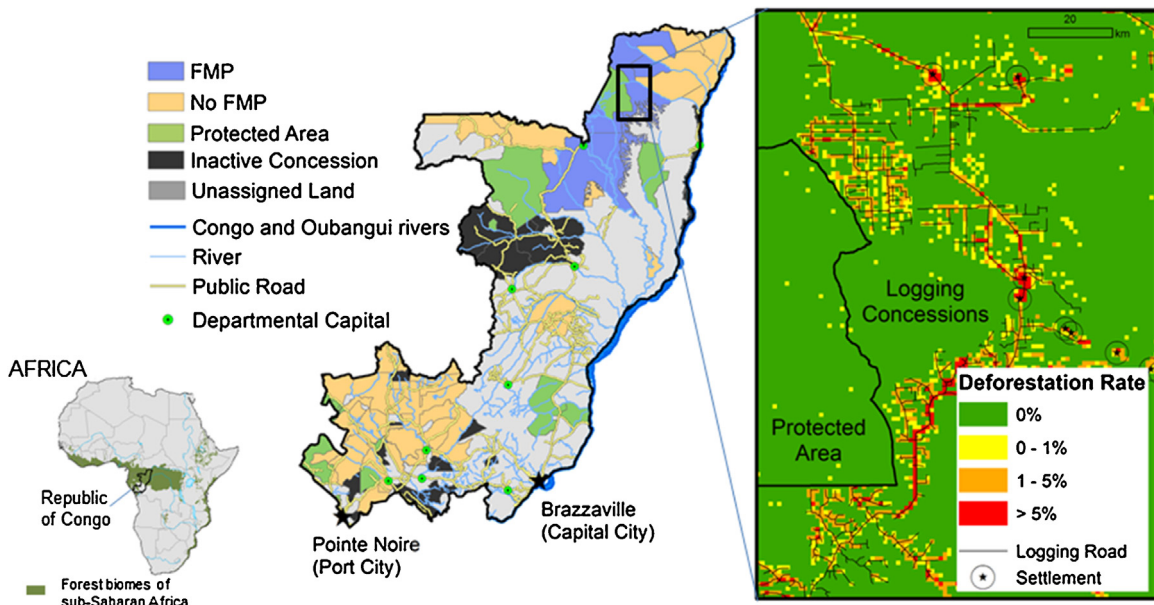


Fig. 1. Management regimes and deforestation patterns in Republic of Congo.

2011; Karsenty et al., 2008). Since Rio, SFM has been embraced by governments, production organizations, conservationists, consumers, and development NGOs alike (Amsallam et al., 2003; de Wasseige et al., 2012; Lambin et al., 2014; Putz et al., 2012). Over 400 million hectares of tropical forests are currently managed for timber production, encompassing more than half of the remaining global permanent tropical forest estate (Blaser et al., 2011). A growing proportion of those forests are operating under SFM principles.

There is broad consensus that Forest Management Plans (FMPs) are a critical first step toward achieving SFM in the tropics (FAO and ITTO, 2011). A FMP is a detailed plan for selective logging of a prescribed area for a specific amount of time, and is designed to ensure maximum harvest rates while at the same time ensuring adequate time for maturation of new harvestable specimens before the next logging cycle (Armitage, 1998). The FMP framework was developed in Germany in the 1700s in response to acute local timber scarcity, as a means to ensure long-term timber stocks (Holzl, 2010). Since the early 19th Century, FMPs have been attempted with varying implementation experiences for tropical forests (Agrawal, 2005; Nasi and Frost, 2009). The area of tropical forests managed through FMPs increased by 30% from 2005 to 2010, and now total 183 million hectares worldwide, or 46% of tropical production forests (Blaser et al., 2011).

In tropical forests, FMPs are considered a key tool for climate change mitigation and biodiversity conservation because, theoretically, they limit deforestation and forest degradation (Amsallam et al., 2003; Armitage, 1998; Blaser et al., 2011; FAO and ITTO, 2011). FMPs encourage selective timber harvests over large areas, thus preventing forest clearing associated with intensive logging (Putz et al., 2012). In addition, FMPs clearly define allowable cutting zones and timber volumes, enabling governments to monitor and regulate timber extraction, thus preventing forest clearing due to overexploitation or agricultural expansion (Bell et al., 2012; Ezzine de Blas and Perez, 2008). Finally, by safeguarding long-term timber stocks, land rents for sustainably-managed natural forests remain competitive with rents for alternative land uses in the future, thus preventing eventual conversion to agriculture, pasture, and plantation forests (Agrawal et al., 2008; Angelsen, 2010; Blaser et al., 2011; Karsenty et al., 2008; Phelps et al., 2013).

However, the selective logging required by FMPs may also have unintended consequences for tropical forest ecosystems. Selective logging can encourage a broader spatial strategy of logging companies, causing logging activities to extend into intact forests (Brandt et al., 2014; Edwards et al., 2014). Simulation models suggest that the highly-selective logging specified by FMPs may spread forest disturbance over large areas, leading to increased deforestation and fragmentation as logging roads penetrate deeper into interior forests (Bell et al., 2012; Fredericksen and Putz, 2003; Gullison and Hardner, 1993). Spreading logging out over large areas leads to negative impacts on biodiversity, compared to concentrating logging activities in smaller areas (Edwards et al., 2014). Thus, there is a critical need to empirically assess the impacts of logging policy on deforestation patterns and on timber production.

Examining impacts of natural resource policy is challenging in tropical regions of developing countries (Lambin et al., 2014; Milder et al., 2015). First, logging often occurs in vast, remote, inaccessible regions, and thus on-the-ground measurement of logging impacts is extremely difficult. While site-based investigation is important, in practice only a fraction of the area impacted can be investigated, leaving us uninformed about the universality of the observed impacts. As a result, governments, scientists, and international organizations are investing more and more in creating satellite-derived measurements of deforestation (Hansen et al., 2013; Xin et al., 2013). Satellite-derived measurements of forest change can be measured consistently over broad spatial and temporal scales, thereby providing an unbiased measure of the impacts of logging activities. Second, governance in developing countries is often weak, and thus the institutional structures necessary to monitor and enforce policies are often lacking. As a result, international organization and governments are increasingly investing in official record-keeping of compliance and timber production to promote transparency of logging operations (Blaser et al., 2011; FAO and ITTO, 2011).

Our objective here was to empirically determine outcomes of sustainable forest management implementation in tropical forest landscapes. We used publicly-available deforestation and timber production datasets to investigate impacts of logging policy on forest ecosystems and timber production in the Congo Basin. Simple comparisons of the outcomes of different management regimes can be vulnerable to bias, because certain management regimes may be

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