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Conservation and conflict in the Democratic Republic of Congo: The impacts of warfare, mining, and protected areas on deforestation

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ABSTRACT

Tropical forests provide critical ecosystem services worldwide. Nonetheless, ongoing agricultural expansion, timber extraction, and mining continue to jeopardize important forest resources. In addition, many tropical forests reside in countries that have experienced violent conflict in recent decades, posing an additional, yet poorly understood threat. Conflict may decrease or increase deforestation depending on the relationship between conflict and other causes of land use change, such as mining expansion or protected area establishment. The Democratic Republic of Congo (DRC), home of the second largest tropical forest in the world, has experienced 20 years of violent conflict, resulting in the death of over 100,000 combatants and up to 5 million civilians. Expanding mining concessions also threaten the DRC's forest, even though nearly 12% of it is under some form of protection. In this study, we used spatially-explicit data on conflict, mining, and protected areas, along with a host of control variables, to estimate the impacts of these factors on forest cover loss from 1990 to 2010. Through a panel instrumental variables approach we found that: i) conflict increased forest cover loss, ii) mining concessions increased forest cover loss, but in times of conflict this impact was lessened, and iii) protected areas reduced forest cover loss, even in high conflict regions. Our results thus suggest that policy interventions designed to reduce violent conflict may have the co-benefit of reducing deforestation, especially in areas with low mining potential. Likewise, protected areas can be effective even in times of war.

1. Introduction

Tropical forests cover 6% of the Earth's surface, yet contain over two thirds of all terrestrial plant and animal species, store massive amounts of carbon, and provide livelihoods to millions of people (Bradshaw et al., 2009; Sunderlin et al., 2008). These forests are threatened by deforestation and forest degradation (Gibbs et al., 2010; Lambin and Meyfroidt, 2011), driven by a range of proximate drivers, including agricultural expansion (Phalan et al., 2013), urban sprawl (Seto et al., 2012), mining (Hirons, 2011), and timber harvest (Asner et al., 2010). As global demand for food, timber, and minerals continues to soar, the pressure on tropical forests increases. At the same time, the ecosystem services provided by tropical forests are becoming more valuable (Hansen et al., 2010; Shearman et al., 2012). Combined, these dynamics make conserving tropical forests one of the greatest conservation challenges of the 21st century (Laurance et al., 2012).

While tropical deforestation has decreased in some areas, forest loss continues unabated in much of the world (Ernst et al., 2013; Hansen et al., 2013). Payment for ecosystem services programs, such as REDD+, has become increasingly common in many tropical forests (Nepstad et al., 2011). Nonetheless, establishing protected areas is still the most widespread policy to safeguard tropical forests. Globally, approximately 27% of tropical forests have some form of protection (Nelson and Chomitz, 2011). However, the effectiveness of this protection is questionable, especially in areas with poor economic conditions and weak governance (Andam et al., 2008; Irland, 2008).

A less well understood driver of deforestation is violent conflict (Machlis and Hanson, 2008), which is unfortunately common in tropical forests worldwide (Beyers et al., 2011; Hecht and Saatchi, 2007). Empirical studies suggest a complex relationship between conflict and forest conservation (Draulans and Van Krunkelsven, 2002; Gorsevski et al., 2012; Rustad et al., 2008). Direct impacts of conflict include road building, defoliation and unsustainable use of forest resources (Machlis and Hanson, 2008). Indirect impacts may include decreased economic activity during times of conflict, which could reduce forest cover loss, and changing discount rates, which could increase the propensity to harvest forest resources (Stevens et al., 2011). These effects have been shown to remain well after conflict ends (Nackoney et al., 2014). Nonetheless, empirical studies suggest that conflict may

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have both negative and positive outcomes in terms of conservation (Rustad et al., 2008) even within small geographic areas (Gorsevski et al., 2013). Likewise, the efficacy of protected areas in times of conflict also varies over space and time (de Merode et al., 2007; Glew and Hudson, 2007).

Analyzing the effect of conflict on deforestation is particularly challenging due to the endogenous nature of forest loss in this setting. Conflict may be the result or the cause of deforestation, implying an endogenous empirical relationship. Neglecting this endogeneity bias in models of deforestation can lead to biased coefficients and standard errors, thereby inhibiting our ability to understand the causal mechanisms between conflict and deforestation in a statistical framework (Blackman, 2013). In the social sciences, an instrumental variables (IV) approach is commonly used to model such endogenous relationships, and is a standard practice in the recent conflict literature (Miguel et al., 2004) and in the deforestation literature (Chomitz and Gray, 1996; Sims, 2010). Limited use of this technique, however, has restricted our understanding of how violent conflict impacts tropical deforestation. One of the primary contributions of this study, therefore, is to understand potential causal relationships between conflicts, mining, protected areas and deforestation by implementing the IV technique.

Starting in 1996 and continuing in various forms until today, one of the deadliest conflicts since World War II has raged in the Democratic Republic of Congo (DRC), with over 100,000 combatant fatalities and up to 5 million more deaths of civilians from malnourishment and preventable diseases (Coghlan et al., 2006; Tollefsen et al., 2012). Much of this conflict occurred in the Congo Basin forests — one of the world's most biodiverse regions (Mittermeier et al., 1999), which provides habitat to the critically endangered mountain gorilla (*Gorilla beringei beringei*), okapi (*Okapia johnstoni*), bonobo (*Pan paniscus*) and forest elephant (*Loxodonta cyclotis*), among other species (IUCN, 2012). In addition, these forests store vast amounts of carbon (Saatchi et al., 2011), of which large volumes are released every year through deforestation (Tyukavina et al., 2013), and also contain some of the most valuable mineral deposits in the world (The World Bank, 2008). Mining contributes nearly 25% to DRC's GDP (The World Bank, 2008), but threatens forests in the Congo Basin — approximately 12% of which are currently protected (UNEP, 2009). Together, biodiversity, minerals, and conflict make the tropical rainforest of the DRC one of the most valuable and vulnerable in the world.

We contribute to the growing literature on conflict and conservation by compiling and analyzing a long-term (1990–2010) large-scale (the majority of the DRC) database on deforestation, conflict, mining concessions and protected areas in the DRC. Using this dataset, along with the instrumental variables approach combined with policy simulations, we address four questions about deforestation in the DRC: (1) does conflict increase deforestation, (2) do mining concessions increase deforestation, (3) do protected areas reduce deforestation, and (4) does conflict interact with mining and protected areas to jointly impact deforestation?

2. Methods

2.1. Study area

The DRC extends from the Atlantic Ocean in the west to the Great Lakes region in the east, covering an area of over 2,345,409 km^2 (Central Inteligence Agency, 2013). Our study area contained all of the DRC that is part of the Congo Basin – the second largest tropical rainforest in the world – and is based on the extent of previously published forest change maps (Hansen et al., 2008; Potapov et al., 2012) (Fig. 1), which includes 559 out of 685 secteurs (similar to a U.S. county).

The conflict in the DRC has been termed "Africa's World War" and its complexity compared to that of Europe's thirty years of war (Prunier, 2008). As the Congo Basin contains some of the world's most valuable mineral deposits, the conflict is usually viewed through the lens of the "resource curse" (Matti, 2010) and has been described as "economics by other means" (Jackson, 2002; Keen, 1998; Reno, 1998). Furthermore, the DRC is surrounded by politically unstable countries: Angola, Sudan, the Central African Republic and Rwanda. With cross-cutting ethnic solidarities and lack of resources to patrol them, national borders are porous, facilitating cross-border raids, ethnic insurgencies and occasionally "proxy wars" (Prunier, 2004, 2008). Altogether, this has led to frequent bouts of violence, particularly in the eastern portion of the DRC.

Since the official end of the war, the country has been plagued by fighting between local rival militias (Marriage, 2013). Where the state does not provide public services or security, people often turn to warlords and rebels for protection, generally mobilizing along ethnic lines, often leading to organized ethnic conflict. Power struggles over territory

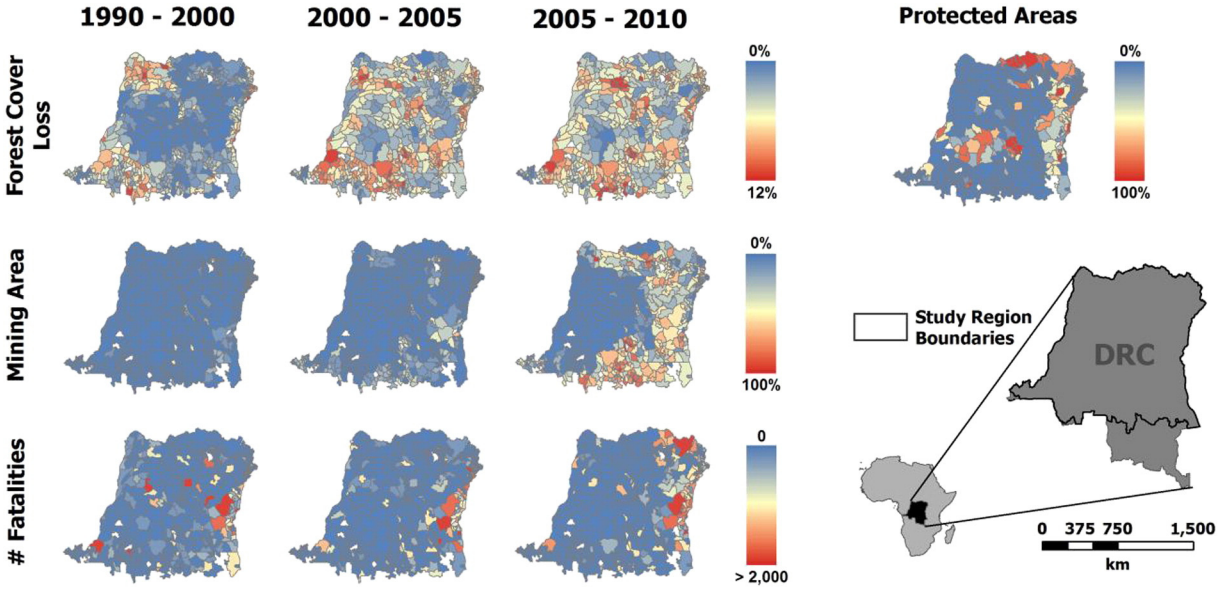

Fig. 1. Percentage of forest cover loss, number of fatalities, and mining concessions 1990–2010; percent protected area.