



Original research article

# Political shifts and changing forests: Effects of armed conflict on forest conservation in Rwanda



Elsa M. Ordway\*

Department of Ecology, Evolution, and Environmental Biology, Columbia University, New York, NY 10027, USA

## HIGHLIGHTS

- Aspects of conflict can have very different impacts on forest cover.
- Theoretical framework distinguishes armed conflict activity impacts from conflict settlements.
- Forest transitions in NW Rwanda indicated more spatially concentrated loss during conflict.
- 96% of forest loss during conflict across the landscape occurred in protected areas.
- Results underscore heavy dependence on forest resources during conflicts.

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## ABSTRACT

Most armed conflicts in recent history occurred in biodiversity hotspots. Yet, studies examining impacts of warfare on forests yield contradictory results. This study provides a theoretical framework articulating different hypothetical relationships between conflict and forest transitions. Landsat TM and ETM+ data were analyzed to examine forest transitions in Rwanda during conflict and post conflict periods. Net trends showed little difference between periods, with a rate of 1.6% annual gain during conflict years, and 2.5% following the conflict. Closer inspection revealed spatially concentrated forest loss during conflict years; 96% occurred in protected areas with the most loss in Gishwati Forest Reserve at a rate of −6.1%. Trends were explored with spatially explicit conflict data that distinguished armed conflict activity from conflict induced settlements. Impacts of conflict on forests in Rwanda appear to be influenced by natural resource use near settlements. Massive migrations of people into settlements during the conflict, who had previously been scattered across the landscape, resulted in a redistribution of pressures. Reduced pressure elsewhere supports this inference. Results underscore the vulnerability of protected areas and the spatial dynamics of forest resource dependence during conflicts. This work demonstrates the value of distinguishing conflict activities to assess their varied environmental effects.

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## 1. Introduction

Many disciplines are devoted to understanding the ethical, sociopolitical and economic ramifications of conflict. Less attention has been devoted to understanding how warfare can impact the environment. Yet, armed conflict has long occurred in areas of conservation priority with considerable implications for the environment (Dudley et al., 2002). In the last several decades, 80% of armed conflicts occurred directly in biodiversity hotspots, many of which are tropical forest regions

\* Correspondence to: Department of Environmental Earth System Science, Stanford University, Stanford, CA 94305, USA. Tel.: +1 616 443 9141.  
E-mail address: [eordway@stanford.edu](mailto:eordway@stanford.edu).

(Hanson et al., 2009). Given such high spatial correlation and the urgency of conservation efforts, further examination of the relationships between warfare and the environment is needed.

Warfare and post conflict development may interact with land use activities to influence the transformation of the landscape and severity of forest conversion. Land use has contributed to recent overwhelming declines in biodiversity through habitat fragmentation, modification, and loss, resulting in degraded ecosystems and environmental services (DeFries et al., 2004; Foley et al., 2005). The growing body of literature that addresses various direct and indirect impacts of armed conflict on the environment has put forth a range of hypotheses (Black, 1994; Cairns, 2003; Dudley et al., 2002; Jarrett, 2003; Loucks et al., 2009; Machlis and Hanson, 2008; McNeely, 2003; Omar et al., 2009). Studies have shown that conflict and warfare can either drive deforestation or favor forest recovery (Alvarez, 2003; Biswas and Tortajadaquiroz, 1996; Dávalos, 2001; Dudley et al., 2002; Glew and Hudson, 2007; Hecht and Saatchi, 2007; Kim, 1997; Kreike, 2003; Lodhi et al., 1998; McNeely, 2003; Westing, 1996). Deforestation and reforestation could theoretically occur simultaneously in the same region as a function of the geographic concentration of activities related to different aspects of conflict. For example, heavy military activity could impede access to some forested areas with a concomitant increased dependency on forest resources from refugee camps in other regions. Rustad et al. (2008) emphasize the lack of rigorous methods used to test these hypotheses. Spatial analysis tools offer a method for evaluating these processes and patterns. This paper reviews existing research on the subject of armed conflict and forest transitions and offers a theoretical framework for future investigation. Results from a spatial analysis of forest dynamics in Rwanda during and after a period of conflict are also discussed to more explicitly understand the various ways in which conflict can impact the environment.

### 1.1. A framework for understanding the impacts of conflict

Effects of conflict on forests can be broadly summarized as three distinct processes (McNeely, 2003). First, conflict may lead to the active exclusion of activities from certain geographic regions, referred to as war zone refugia or “gunpoint conservation” (Alvarez, 2003; Dávalos, 2001; Fjeldsået al., 2005). Refugia zones can arise from impeded access to geographic regions owing to heavy violence, hostile areas, and wartime restrictions. As a result, natural resource use and related impacts to biodiversity may decline in the immediate area. Research has illustrated this process in Mozambique (Biswas and Tortajadaquiroz, 1996), the demilitarized zone between North and South Korea (Kim, 1997), and via the prevention of commercial and private exploitation of areas in South Sudan (Aveling et al., 2010). Forest recovery has also been associated with more complex social and economic shifts tied to civil war and global trade in El Salvador (Hecht and Saatchi, 2007).

The second relationship involves resource or land use changes driven by increased or inefficient natural resource use during conflict, such as increased timber and fuelwood consumption in close proximity to refugee camps (Formoli, 1995; Lodhi et al., 1998; Pech, 1995). Nackoney and others (2014) provided evidence of human populations moving deeper into interior forests in the Democratic Republic of the Congo (DRC) to escape conflict, and explored the validity of reports of increased human reliance on bushmeat leading to wildlife population declines. Land use practices provide critical natural resources and environmental services, and simultaneously reshape the systems on which these services depend (DeFries et al., 2004). Research indicates that one of the primary causes of global environmental change resulting from land use activities is tropical deforestation (NRC, 1999). Land use occurs at the local scale, although it is becoming a force of global importance at the interface of coupled issues of human needs and the conservation of biodiversity and ecosystems (DeFries et al., 2004). It should be noted that tropical deforestation is driven by causal factor synergies that often involve complex interactions between climatic, economic, social and political perturbations (Geist and Lambin, 2002; Lambin et al., 2003; Scholes and vanBreemen, 1997; Uriarte et al., 2010).

A third process by which armed conflict may impact forest use and conservation is through the collapse of institutional frameworks (McNeely, 2003). National parks in Madagascar experienced a rise in illegal logging that was attributed to political instability following the 2009 coup d'état (Allnutt et al., 2013). Warfare in Nepal led to infrastructure damage, the collapse of protected areas (PAs), and the killing of park staff (Baral and Heinen, 2005). de Merode et al. (2007) tested the efficacy of PAs in Central Africa during a period of conflict, concluding that PAs play an important role in biodiversity conservation throughout periods of violence, but increased patrols, monitoring, and funds are required to compensate for increased illegal activities and use of resources. Additional studies have highlighted the importance of PAs as a source of stimulation for social and economic development in post conflict periods (Johnson et al., 2012; Scherl and Emerton, 2008).

A review of the literature reveals that myriad theories exist to describe the impacts of armed conflict on the environment. However, a basic framework for comparing and evaluating theory through empirical validation is lacking. More rigorous standardization of methods and concepts and terminology can greatly improve our ability to understand these relationships and build on previous research more effectively. The complexities of social-ecological systems require careful consideration of uncertainty and unpredictability, dynamic processes, and an ability to simply describe the system without yielding to oversimplification (Holling, 2001). Relationships between forest transitions and conflict are fraught with complexity and idiosyncrasies. A synthesis of the literature indicates that this research area can benefit from a theoretical framework that outlines different aspects of conflict and the variation in their impacts, both spatially and temporally. This study presents a framework for understanding the hypothetical relationships between changes in forest cover and two different aspects of conflict: armed conflict activity and conflict induced settlement (Fig. 1). By differentiating between these two features of conflict, we can begin to understand ways in which armed conflict can exhibit very different impacts on forests.

Forest transitions can be generally categorized as either gain or loss. The war zone refugia hypothesis illustrates the potential for a gain in forest cover near areas of heavy armed conflict. A sigmoidal logistic function can be used to

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