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Deforestation scenarios for the Bolivian lowlands

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ABSTRACT

Tropical forests in South America play a key role in the provision of ecosystem services such as carbon sinks, biodiversity conservation, and global climate regulation. In previous decades, Bolivian forests have mainly been deforested by the expansion of agricultural frontier development, driven by the growing demands for beef and other productions. In the mid-2000s the Movimiento al Socialismo (MAS) party rose to power in Bolivia with the promise of promoting an alternative development model that would respect the environment. The party passed the world's first laws granting rights to the environment, which they termed Mother Earth (Law No. 300 of 2012), and proposed an innovative framework that was expected to develop radical new conservation policies. The MAS conservationist discourse, policies, and productive practices, however, have since been in permanent tension. The government continues to guarantee food production through neo-extractivist methods by promoting the notion to expand agriculture from 3 to 13 million ha, risking the tropical forests and their ecosystem services. These actions raise major environmental and social concerns, as the potential impacts of such interventions are still unknown. The objective of this study is to explore an innovative land use modeling approach to simulate how the growing demand for land could affect future deforestation trends in Bolivia. We use the LuccME framework to create a spatially-explicit land cover change model and run it under three different deforestation scenarios, spanning from the present–2050. In the *Sustainability* scenario, deforestation reaches 17,703,786 ha, notably in previously deforested or degraded areas, while leaving forest extensions intact. In the *Middle of the road* scenario, deforestation and degradation move toward new or paved roads spreading across 25,698,327 ha in 2050, while intact forests are located in Protected Areas (PAs). In the *Fragmentation* scenario, deforestation expands to almost all Bolivian lowlands reaching 37,944,434 ha and leaves small forest patches in a few PAs. These deforestation scenarios are not meant to predict the future but to show how current and future decisions carried out by the neo-extractivist practices of MAS government could affect deforestation and carbon emission trends. In this perspective, recognizing land use systems as open and dynamic systems is a central challenge in designing efficient land use policies and managing a transition towards sustainable land use.

1. Introduction

Tropical forests in South America play a key role in the provision of ecosystem services (ES) such as carbon sinks, biodiversity conservation, and climate regulation at local, regional, and global scales (Nobre, 2014). However, these unique forests and their services have been threatened by complex, interconnected driving forces such as agricultural expansion, climate variability, and forest degradation (Davidson et al., 2012; Malhi et al., 2008). Bolivia, for example, is listed among the countries with the highest net forest loss during 2000–2010 (FAO, 2010), with 50% of its territory now covered by lowland forests (Killeen et al., 2007).

Bolivian lowlands experienced intense colonization from the 1950s to the 1970s due to the migration of peasants from the Andean region (Pacheco, 2006). In the mid-1980s, the agro-industrial corporations engaged in large-scale deforestations mainly in the southwestern portion of the Bolivian Amazon, in Santa Cruz, where current deforestation converted 75% of the land for agricultural purposes (Killeen et al., 2008). More recently, international driving forces, such as the growing demand for agricultural products (mainly soybeans and beef), have been the major cause of deforestation in Bolivia as well as in other Amazonian countries (Dalla-Nora et al., 2014; Müller et al., 2012; Pacheco et al., 2010).

In the mid-2000s the Movimiento al Socialismo (MAS) party

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rose to power in Bolivia with the promise of promoting an alternative development model that is more respectful of the environment. The MAS party enacted the Mother Earth Law, (No. 300, of 2012), which recognizes Mother Earth's rights and the State's obligations to ensure these rights. This law also introduced a new non-market based mechanism for forest conservation, the "Joint Mitigation and Adaptation Mechanism for the Integrated and Sustainable Management of Forests and Mother Earth" (Decree 1696 of 2013). This mechanism seeks to ensure sustainable forest management through the knowledge and rights of indigenous people and to become an alternative to dominant market-based mechanisms like Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries (REDD+) (Müller et al., 2014b).

MAS conservationist and production policies in Bolivia, however, have been experiencing continuous tension. The lack of governance, land tenure conflicts, and conceptual gaps limit the application of laws and regulations regarding deforestation. Thus, despite the innovative environmental and legal framework, little progress has been made in this direction (Müller et al., 2014b, 2013; Pacheco et al., 2010). Moreover, the application of some environmental laws and regulations contradicts the government's aim to guarantee food production and exportation, which is increasing the expansion of the agricultural lands from 3 to 13 million ha in the next 10 years with the "13 Pillars of the Patriotic Agenda 2025" (Bolivia, 2013; Chumacero, 2012; Hoiby and Zenteno-Hopp, 2014; IBCE, 2013). A further contradiction is the construction of roads and oil exploration in protected areas (PA) and indigenous territories (IT) (Chumacero et al., 2010; Jiménez, 2013).

Understanding the deforestation processes occurring in Bolivian lowland forests, as in the rest of the world, is a challenging task. It deserves a multidisciplinary approach, as seen in the work by Aguiar (2006), Aguiar et al. (2014) and Folhes et al. (2015), that takes into account the multi-dimensional nature of this topic. Few studies have addressed the issue of deforestation in Bolivia through time and space (i.e., Mertens et al., 2004; Müller et al., 2014a, 2012; Sangermano et al., 2012). The lack of pertinent information such as multi-temporal land cover change (LCC) data limits the efforts in this issue because many LCC datasets have only been available since 2012.

The aim of this study is to explore an innovative modeling approach for Bolivian lowlands to simulate how the growing demand for agricultural land and different land use policies could affect future deforestation trends. This study also discusses the social and environmental implications related to different land use change scenarios based on deforestation rates and spatial pattern analyses. Ultimately, we seek to assist in the discussion of broader land use policies regarding the sustainable development of agriculture in the Bolivian forests.

2. Materials and methods

2.1. Study area

In Bolivia, the physiography and altitude determine significant gradients in temperature, precipitation (Fig. 2), and consequently, the rich biodiversity (Ibisch and Merida, 2004). Three main physiographic regions can be distinguished: Andean, Sub-Andean, and Lowlands. The Andean region is located at 3000 m.a.s.l. between the Western Range (Cordillera Occidental) and Central Range (Cordillera Central) and is characterized by the Altiplano (high plateau) and high peaks (Navarro and Maldonado, 2002). The Sub-Andean region, located in the transition zone between the highlands and

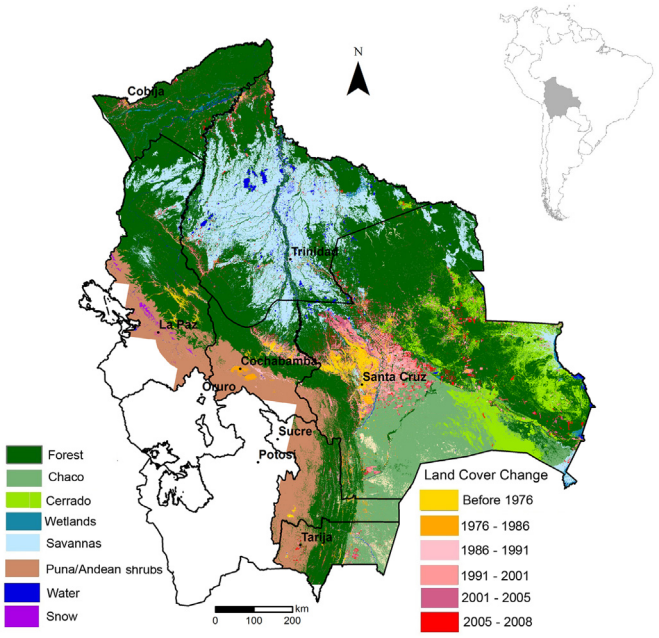

Fig. 1. Study area in the eastern lowlands of Bolivia below the natural montane tree line (~3000 m). Land cover change (LCC) data from Killeen et al. (2012).

lowlands, is comprised of valleys and piedmont regions. The study area is the Bolivian lowlands, a territory located approximately 3000 m below the natural montane tree line (Killeen et al., 2008, 2007) (Fig. 1). This area covers almost 70% of the national territory, including the whole Amazon Basin and portions of La Plata Basin. Although the lowlands are the most extensive physiographic area in Bolivia, they account for only 31% of the country's population, especially in the department of Santa Cruz (26%), followed by Beni (4%) and Pando (1%) (Fig. 2a) (INE, 2014).

The increasing process of deforestation in the Bolivian lowlands occurs in several stages and is promoted by national development policies. First, after the National Revolution of 1952, both the State and international development agencies channelled capital to encourage the development of large-scale cash crop agriculture in the lowlands. Agriculture for domestic consumption was the main driver of deforestation during this period. In parallel, the central government promoted a program to colonize the lowlands called "March to the East" (Sivila, 1977). This program sought to stimulate the migration of spontaneous colonists from the Andean highlands to the lower lands, with the purpose of extending agricultural and supplementing the need for cheap labor in the rising agro-industry (Zeballos, 2006). These migrants settled mainly in the northwestern area of Santa Cruz (Yapacani), north Cochabamba (Chapare) and to the north of La Paz (Yungas) (Pacheco, 2006). Second, in the middle of the 1980s, the agro-industrial corporations, Santa Cruz farmers, and foreign colonies (Menonites and Japanese) engaged in large-scale deforestation to enable agricultural production (75% of current Bolivian deforestation) in Santa Cruz (Killeen et al., 2008). Third, this process continued in the 1990s with the support of the government and the World Bank through the Eastern Lowlands Project (WB, 1997); the support included investments in silos, processing facilities, highways, and infrastructure. Finally, during the 2000s, mechanized agriculture (mainly soybean, which was influenced by local and international markets), cattle ranching, and small-scale agriculture were the main drivers of deforestation (Müller et al., 2011; Pacheco, 2006). Periodic soy booms fuelled by international markets have played an important role in the expansion of agro-industrial corporations, which were further triggered by leading foreign producers and their transnational capital (Medeiros, 2008).