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The impact of commodity price and conservation policy scenarios on deforestation and agricultural land use in a frontier area within the Amazon

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ABSTRACT

Deforestation in the Amazon is caused by the complex interplay of different drivers. Price of commodities such as beef and soya, and incoming migration are paramount factors. Construction of new highways is a key aspect, as they enable a growing flow of people and economic activities, provoking an intensification of the conversion of forests into pasture and agricultural areas. The pavement of road BR-163 accelerates the expansion of the agricultural frontier from the state of Mato Grosso to Pará, inside the Amazon. Today, the Brazilian government applies two main kinds of policies to protect the environment. First by establishing conservation units (CUs) that include an array of reserve types from natural areas to indigenous lands, and second by enforcing the Forest Code (FC), a law that limits the occupation and use of forests. Legal reserve requirements for rural properties are 80% in the Amazon rainforest, 35% in the Cerrado shrublands and 20% in other regions. However, the effectiveness of these policies relies on a fragile institutional capacity, which causes a flawed monitoring, law enforcement and control. To assess the impact of effective conservation policies on land use and deforestation by 2020, we used the LUSMAPA model in combination with two scenarios, one that included different commodity price developments and migration rates and one on the assumption of the institutional strength to uphold the conservation policies. A revision of the FC from an average 80% policy target to 60% effective implementation and disregard borders of CUs by allowing 5% deforestation in CUs, that both corresponds to a 'weak' governmental enforcement, leads to additional deforestation of 41–57%, depending on the commodity price scenario. The results of the simulations are discussed in the light of recent policy changes in Brazil.

Introduction

The Amazon biome is the single largest continuous tropical rainforest, and one of the richest stocks of biodiversity on Earth. This area is highly threatened by deforestation, causing biodiversity loss and enhanced greenhouse gas emissions (Rodrigues-Filho et al., 2012). The states of Mato Grosso and Pará in Brazil are facing a conflict between agricultural expansion due to an increase in the international demand for commodities on one side and conservation of the Amazon rainforests, important for carbon storage and biodiversity conservation on the other side.

A strong correlation can be found between commodity markets, in particular beef and soybean, and deforestation (e.g., Morton et al., 2006; Laurance, 2007; Barona et al., 2010; Laurance et al., 2011). The international prices of commodities are regulated by the ratio stock/consumption worldwide, and historic incidents indicate the impact that these international prices have on regional development in Brazil. A devaluation of the Brazilian currency, in 1999, provoked an increase in the price of domestic beef, stimulating a growth of the herd in the Amazon. Size of cattle herds increased from 47 million in 2000 to 74 million in 2005, and accounted for 73% of the overall growth in that period in Brazil (MAPA Ministério da Agricultura, 2010).

Paving of several highways that cut through the Amazon biome is another important determinant of deforestation. Such paving, like BR-163 highway, is part of a project to integrate the Brazilian road system with those of other countries in South America with access to the Pacific ocean as well as to bridge the access to the Atlantic ocean through the Amazon river, shortening the distance traversed by the Brazilian products to European and Asian markets. Pavement of highway BR-163 in the north of Mato Grosso and the south of Pará provides better access to the international market for local soybean farmers, but is also causing an increasing migration into the area with deforestation, land grabbing and speculation as a result, provoking a fast and radical change in land use and intensifying social conflicts (Albernaz et al., 2006). By 2011,

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however still a large part of the road is not paved and the overall conditions (even of the paved tract) are precarious. Increasing trade in soybeans under the influence of liberalization of international food markets has made it attractive for the government to pave the still unpaved part of the highway BR-163. Therefore, highway BR 163 is the centre of a hot debate in which different lobbies of various stakeholders participate (for more information on this, see Rodrigues-Filho et al., 2012).

Forest conservation policies in Brazil focus on two instruments. First, the Forest Code (FC) policy, which is a progressive environmental legislation, was according to the existing regulations amended in 1965. Since 2000, 80% of a rural property in the Amazon region, which includes both the rain forest and Mesophyll forest in Mato Grosso, and 35% of the forest in the Cerrado region in the southern Amazonia and Central parts of Brazil, should be left intact as a legal reserve (Brazilian Forest Policy Code from year 1965). However, problems of surveillance in remote areas and corruption mean that illegal logging and deforestation are intense. Rural lobbies are pushing their representatives in the Parliament for reviewing the FC in order to reduce the share of rural properties to be preserved. The second instrument, the creation of protected areas, Law 9985, of July 18, 2000, instituted the National System of Nature Conservation Units (SNUC), providing criteria and regulations for the creation, implementation and management of the conservation units (CUs) in the country. SNUC has established two types of CUs: Integral Protection and Sustainable Use.

Preservation of the biodiversity and other natural characteristics of the territory is the main focus of integral protection areas. Economic use of natural resources is allowed in Sustainable Use units, while indigenous land has in practice played the role of a protected area. Brazil has allocated a large area of land to protected areas (11% of its territory). However, the borders of the majority of the country's 60 national parks are not respected (Fiueiredo, 2007).

The land use dynamics which include factors of cattle ranching and large and small scale agriculture in the area under the influence of BR-163 has been widely studied and discussed (Fearnside, 2007; Droulers and Le Tourneau, 2010; Nepstad et al., 2001; Soares-Filho et al., 2004). In order to understand the land use dynamics within the region, we studied the agricultural frontier alongside road BR-163 as a case study of the interplay between commodity prices and conservation policies on sustainable development in 2020. For this, we developed a land use simulation model, referred to as LUSMAPA (Land Use Simulator Mato Grosso-Pará). This model is based on dynamic simulation of land uses, driven by commodity prices, migration rates and road pavement, and follows a model structure comparable to (Portela and Rademacher, 2001). Our main objective was the evaluation of the drivers on deforestation and agricultural land use in the case study area up to 2020. The impacts of the altered FC-law and CU protection levels on deforestation and agricultural land use are studied in detail, using municipal land use data of 2009 as reference.

Methodology

Study area

The study area is located along highway BR-163 that connects Cuiabá in the state of Mato Grosso with Santarém in the state of Pará (Fig. 1). The municipalities along this road represent various stages of agricultural development. In Mato Grosso the municipalities of *Feliz Natal*, *Marcelândia*, *Sinop* and *Sorriso* represent a consolidated agricultural area, referred to as 'South'. Even though *Feliz Natal* and *Marcelândia* still have proportionally a large area of forest, they were included in a consolidated area because their land use are strongly influenced by dynamics in *Sorriso* and *Sinop*. In this area agriculture is well developed and the soya is expanding rapidly. In the most northern part of Mato Grosso, the municipalities *Alta Floresta*, *Guarantã do Norte* and *Novo Mundo* represent an intermediate agricultural stage; pasture area is well developed while the expansion of soya started in 2008. These three municipalities are referred to as 'Central'. In the southern part of the state of Pará the four municipalities *Itaituba*, *Novo Progresso*, *Rurópolis* and *Trairão* represent the pioneer stage of the agricultural frontier. Rainforest is still abundant and the main land use conversion is deforestation to pasture. This area is referred to as 'North'.

Data analysis

Various land uses and agricultural production data between 1995 and 2008 were assessed from IBGE (National Institute of Geography and Statistics) at the municipal level prior to the model development. While various data on types of crop area were available, pasture data are mostly lacking and various types of forest classes, like forest under protection of the Forest Code (FC), were also not available. For those land uses several post calculations had to be made.

Calculation of pasture area

Barona et al. (2010) also found missing pasture data and proposed an interpolation method based on cattle heads and cattle density. We followed the procedure of Barona et al. (2010) and used the yearly counts of cattle heads between 1995 and 2009 and the only available IBGE pasture data of 1995 and 2006 at municipal level. To estimate pasture areas between 1995 and 2009 cattle density was calculated for 1995 and 2006 separately, using the cattle head counts and pasture data in 1995 and 2006. For two municipalities, *Novo Mundo* in the Central area and *Feliz Natal* in the South area, no pasture data was available; for those municipalities the values of nearby municipalities were used, *Guarantã do Norte* in Central and *Marcelândia* in South. The linear interpolated cattle densities between 1995 and 2006 were used to obtain pasture areas of all years between 1995 and 2006, while linear extrapolations were used up to 2008. These data show linearly increasing cattle densities over time. For the assessment up to 2020 we used the calculated cattle densities of 2008 and assumed those to be constant up to 2020, since we had no reliable data to assume a change in such densities.

Calculation of crop data

Crop area in the IBGE database is split up into various crop types, including soya area. Since most of the main crops have two harvests per year, except soya, which has one harvest per year, we could not simply add up all different kinds of crop types to estimate the full crop area. While soya area could be directly assessed from the IBGE data we assumed another agricultural land use in the model, referred to as 'other crops' that constitutes a mixture of temporary crop types like rice, beans, manioc, corn and cotton and permanent crops like banana, coffee, rubber, cocoa and fruit trees. To assess the full area we used 'planted crop area' in the IBGE database, instead of 'harvest area', since the former better reflect the actual size of this combined land use.

Calculation of forest area and forest types

INPE (National Institute for Spatial Research) provides data on forest area at municipal level from 2000 onwards, and these data are based on remote sensing. However, from these data the conservation status of forest cannot be derived. Hence, additional