Property size drives differences in forest code compliance in the Brazilian Cerrado

Mauricio Stefanes[a,b,*], Fabio de Oliveira Roque[b,d], Reinaldo Lourival[b,e], Isabel Melo[b],
Pierre Cyril Renaud[f], Jose Manuel Ochoa Quintero[b,c]

[a] Faculdade de Ciências Biológicas e Ambientais, UFGD, Dourados, MS, 79.804-970, Brazil
[b] Programa de Pós-Graduação em Ecologia e Conservação, UFMS, Campo Grande, MS, 79070-900, Brazil
[c] Instituto de Investigaciones de Recursos Biológicos Alexander von Humboldt, Avenida Paseo Bolivar (Circunvalar) 16-20, Bogotá, D.C., Colombia
[d] Centre for Tropical Environmental and Sustainability Science, College of Science and Engineering, James Cook University, Cairns, Queensland 4878, Australia
[e] Nature and Culture International, Brasilia DF, 71680385, Brazil
[f] UMR CNRS 6554 LETG-Angers, UFR sciences, University of Angers, France

ARTICLE INFO

ABSTRACT

The Rural Environmental Registry (CAR) dataset opens a new window for spatially explicit studies of the rural landscape of Brazil, enabling analysis with an accurate representation of land use and land cover change dynamics at the property level. Here, we evaluated farm compliance with the Brazilian Forest Code (revised in 2012) in Mato Grosso do Sul state, where agribusiness activities have already converted more than 70% of native vegetation, Cerrado. We analysed the most recent version of the CAR dataset, using geographic information system analytical tools. We observed a positive relationship between compliance with the 20% compulsory Legal Reserves and farm size class. We showed that larger, rather than smaller, farms have important effects on biodiversity conservation at the landscape scale. Large farms (> than 1000 ha), comprising 74.2% of the study area, tended to show better compliance levels (51%) than smaller properties (33%). At the same time, they contain huge amount of land with native vegetation that lies outside Legal Reserves, and so may pose a risk for legal deforestation of near 2 million ha. We argue that a portfolio of socioeconomic incentives for restoration, protected areas, and no-net-loss components in agricultural programmes, are essential measures to increase compliance and halt deforestation in the Cerrado of Central Brazil. Moreover, we argue that considering property size improves the likelihood of success of such initiatives. Although acknowledging that landscape management can help address socioeconomic conflicts and improve food production, it must be accompanied by a strong "anti-deforestation" policy to guarantee the maintenance of existing native vegetation remnants. We also highlight the importance of investigating the role of property size in maintaining remaining vegetation in this region, instead of merely focused on the number of compliant farms.

1. Introduction

Land use changes have shown a contagion-like pattern when spreading across the Neotropical region, affected by factors such as economic growth, property size, and accessibility (Etter et al., 2006; Rosa et al., 2013). Recent implementation of robust and large-scale command and control policies in Brazil is consistently decelerating the deforestation rates and helping to decouple deforestation from economic growth (Boucher et al., 2013; Stickler et al., 2013). This process, although well-documented for forested areas in the Brazilian Amazon (Michalski et al., 2010; Godar et al., 2014), is still not well-studied in non-forest ecosystems such as the Cerrado, Caatinga and Pantanal

(Overbeck et al., 2015).

The Cerrado biodiversity hotspot encompasses a large variety of native vegetation types, ranging from dense woody vegetation (forests), woodland-parkland, and riparian (gallery) forests to scrublands, forested savannahs, and savannahs (see the details in Oliveira and Marquis, 2002). In Brazil, the Cerrado biome has lost more than 50% of its original native vegetation coverage to agribusiness expansion during the twentieth century (Myers et al., 2000; Klink and Machado, 2005). In the State of Mato Grosso do Sul (MS), where Cerrado accounts for more than half the total area (61%), overall native vegetation loss had exceeded 70% by 2014. Soares-Filho et al. (2014) raised concerns about how the Brazilian Forest Code (FC/2012) could lead to rapid, human-
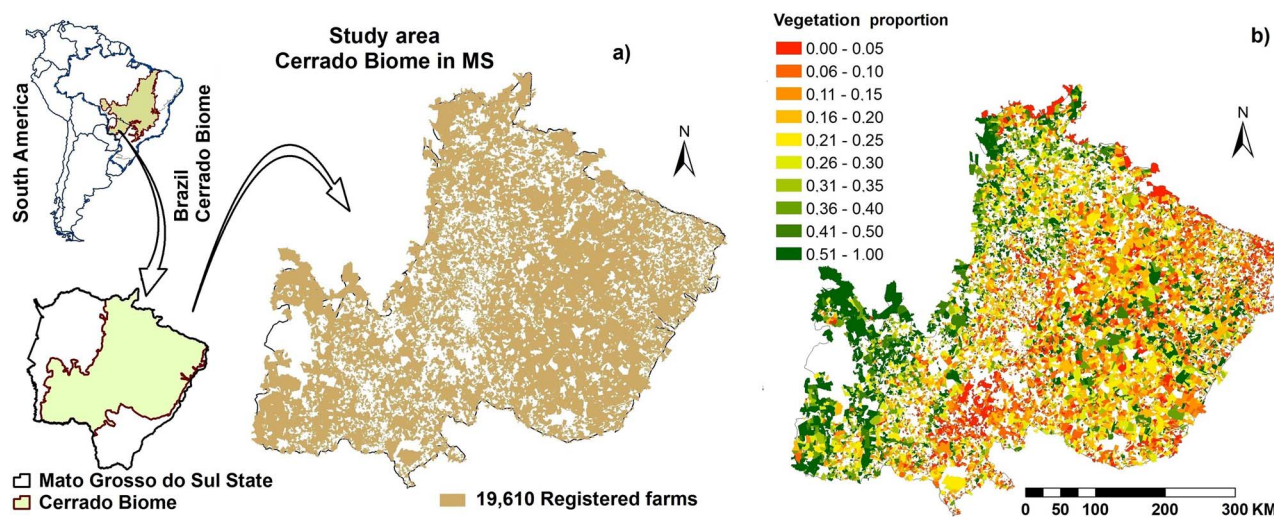
Fig. 1. a) Study area: rural properties registered in the Rural Environmental Registry- CAR dataset from the Cerrado biome in the central region of Mato Grosso do Sul State. b) Proportion of remaining native vegetation per farm size within the farms in study area.

induced transformation in the Cerrado and Caatinga biomes, high-lighting the need to understand and model land cover change patterns in the Brazilian savannahs. Uncertainties about how the key drivers of land use change operate in non-forested ecosystems raise questions about the main agents shaping land cover changes and their relationship with economic and socio-political factors. Answering these questions could lead to a better understanding of the vegetation loss processes and their drivers, and so provide the necessary tools to guide public policy and environmental conservation efforts. Therefore, it is urgent that these factors are addressed, so that agricultural production and environmental sustainability may be reconciled (Boucher et al., 2013).

Brazilian rural land distribution differs between biomes due to the effects of the historical and socioeconomic context (Moran, 1993; Oliveira and Marquis, 2002). Such differences are evident in the Forest Code and are reflected in the mandatory percentages of native vegetation set-asides on farms as Legal Reserves (LR) and Permanent Preservation Areas (PPAs). To give one example, farms located within the Amazon biome should retain 80% tropical forest and 50% savannah, while other savannahs in Brazil outside the Amazon should maintain 20% of native vegetation. This can also vary within a biome, depending on property size (Brazil, Forest Code 12,651, May 2012). For example, the new Forest Code establishes a variation in the areas adjacent to rivers that must be protected according to fiscal modules (property sizes that depend on the municipalities) and river widths (for more details see Soares-Filho et al., 2014).

Property size drives forest retention patterns in the deforestation frontier of the Amazon basin (Michalski et al., 2010). According to Michalski et al. (2010) small properties are less compliant with legislation than larger farms because small properties tend to have lower profitability. Given that large farms are more susceptible to international market pressures and government enforcement measures, they may be more effective in reducing deforestation rates in the Amazon and other areas less affected by spatial constraints on their economic feasibility (Godar et al., 2014).

Given the relevance of property size in determining native vegetation conservation, our aim is to understand, classify, and evaluate the relationship between farm size and compliance with FC/2012 in the Cerrado biodiversity hotspot of Mato Grosso do Sul State, capitalizing on the opportunity potentiated by the availability of digital files of rural properties limits data from the Rural Environmental Registry System (acronym in Portuguese, CAR). We processed and analysed the CAR dataset from Mato Grosso do Sul using a geographic information system. According to the FC/2012, all landowners in Brazil must have

registered with CAR by December 2017. That is, each landowner must go through a self-declaratory electronic licencing procedure that includes a spatial compliance report on the property's land use. Easily and readily available, the CAR database is a good and inexpensive way to assess whether properties comply with legislative provisions (Garcia et al., 2013).

Mato Grosso do Sul provides a good model with which to evaluate the relevance of property size in determining native vegetation conservation, since i) the intensification and expansion of land use and conversion is recent (50 years); ii) it has one of the largest Brazilian agricultural economies (Chaplin-Kramer et al., 2015); and iii) the State has one of the largest land distribution imbalances in Brazil (IBGE, 2016), characterized by recent dramatic conflicts between indigenous people, agribusiness and land for conservation (Sullivan, 2013). Assuming that farm size is a proxy for financial and managerial success (Michalski et al., 2010), we expected that large farms would have better geographical and financial conditions, and better access to information (Godar et al., 2014) than small farms. These characteristics should make them more likely to comply with FC/2012. Conversely, because small farms have less land, they have less economic flexibility to devote part of their productive land to a Legal Reserve.

2. Methods

2.1. Study area

The Cerrado of Mato Grosso do Sul represents 10% of the Brazilian Cerrado biome (Fig. 1), and until the mid-twentieth century it was mostly devoted to cattle ranching (Myers et al., 2000). However, the technological development of the "green revolution" enabled a shift to croplands with productivity comparable to the best global agricultural lands (Garrett et al., 2013). By the 1960s, due to governmental subsidies to large landholders, the Cerrado became the frontier and the engine of a national economy based on export-oriented agriculture (e.g. soy, cellulose, corn, beef, and sugarcane).

2.2. Dataset

The CAR dataset is managed by each state's environmental agency, which are integrated into the National Environmental Agency (IBAMA), enabling a comprehensive analysis of rural properties through the SICAR (spatial database).

The number of CAR registered proprieties in our study area represented 82% of the total Cerrado in Mato Grosso do Sul. We identified