



The drivers of sugarcane expansion in Goiás, Brazil



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ABSTRACT

Between 2003 and 2013, sugarcane area expanded six-fold, from 142,000 ha to 847,000 ha, in Goiás State and the Federal District, Brazil. And while there has been much research on land-use dynamics of sugarcane expansion in established sugarcane growing regions, little is known about the dynamics associated with its expansion in sugarcane frontiers like Goiás. Understanding these dynamics provides critical information for environmental, economic, and political decisions. Here, we investigate the agricultural land-use change dynamics associated with sugarcane production in Goiás and interrogate the relationship between biophysical, institutional, and logistical factors associated with sugarcane expansion. Our results demonstrate that pasture is seven times more likely to be converted to sugarcane than soy, and most new sugarcane area was not sourced in native Cerrado vegetation. Although there exist few biophysical limitations to sugarcane expansion, capital, infrastructure, and institutions constrain production. Lastly, we show that areas where soy is currently cultivated may be converted to sugarcane in the future given the expansion of transportation and sugarcane infrastructure. Thus, we suggest incentivizing the cultivation of sugarcane on degraded pastures and supporting increased pasture stocking rates to ensure continued protection of both natural vegetation and food production while supporting the expansion of sugarcane in the state.

1. Introduction

Sugarcane production in Brazil has been markedly expanding since the early 2000s. Although, São Paulo currently produces over half of the country's sugarcane, rising land prices are spurring investors and farmers to look elsewhere for ample, cheap land with less environmental regulation. Consequently, the Center-West region of Brazil has become an epicenter for sugarcane expansion. And while the socio-economic and environmental drivers and consequences of sugarcane production in historic sugarcane regions, like São Paulo, are well-documented (Sparovek et al., 2007; Fischer et al., 2008; Martinelli and Filoso 2008; Egeskog et al., 2014), little is known about the land-use change dynamics in these new sugarcane frontiers. Is new land being cleared for sugarcane production? Have areas cultivated with food crops been converted to sugarcane? What factors are associated with where sugarcane expands in these frontiers? Understanding the biophysical, institution, and logistical variables associated with new lands being brought into sugarcane will help predict where it may expand in the future, and assist in devising policy that encourages sustainable agricultural development. Here, we focus on documenting the dynamics

and local- and regional-scale drivers of sugarcane expansion in the Center-West state of Goiás (Fig. 1), where planted sugarcane area increased almost six-fold from 142,000 ha to 847,000 ha between 2003 and 2013.

Brazil leads the world in sugar production and exports, and falls behind only the United States in ethanol production and exports (USDA, 2016). Sugarcane has been cultivated in Brazil since the arrival of Europeans in the 16th century and has been blended with gasoline since the 1930s (Hira and Oliveira 2009). Sugarcane production expanded in the 1970s after the first global oil crisis. No longer wanting to be reliant on oil imports, the Brazilian government began the ProAlcool program, which subsidized infrastructure and technology for the production of sugarcane-based ethanol on the large scale. More recently, access to global markets, high global sugar prices, renewable energy policies in Brazil and other countries, and the advent of the flex-fuel vehicle (a car that can run on both pure ethanol and blended gasoline) in 2003 have increased demand for sugarcane production. Between 2003 and 2011, Brazil's National Bank for Social and Economic Development (BNDES) distributed over \$28.3 billion in loans to ethanol plant owners (Mendonça et al., 2013). Since 2008, the global recession, problematic

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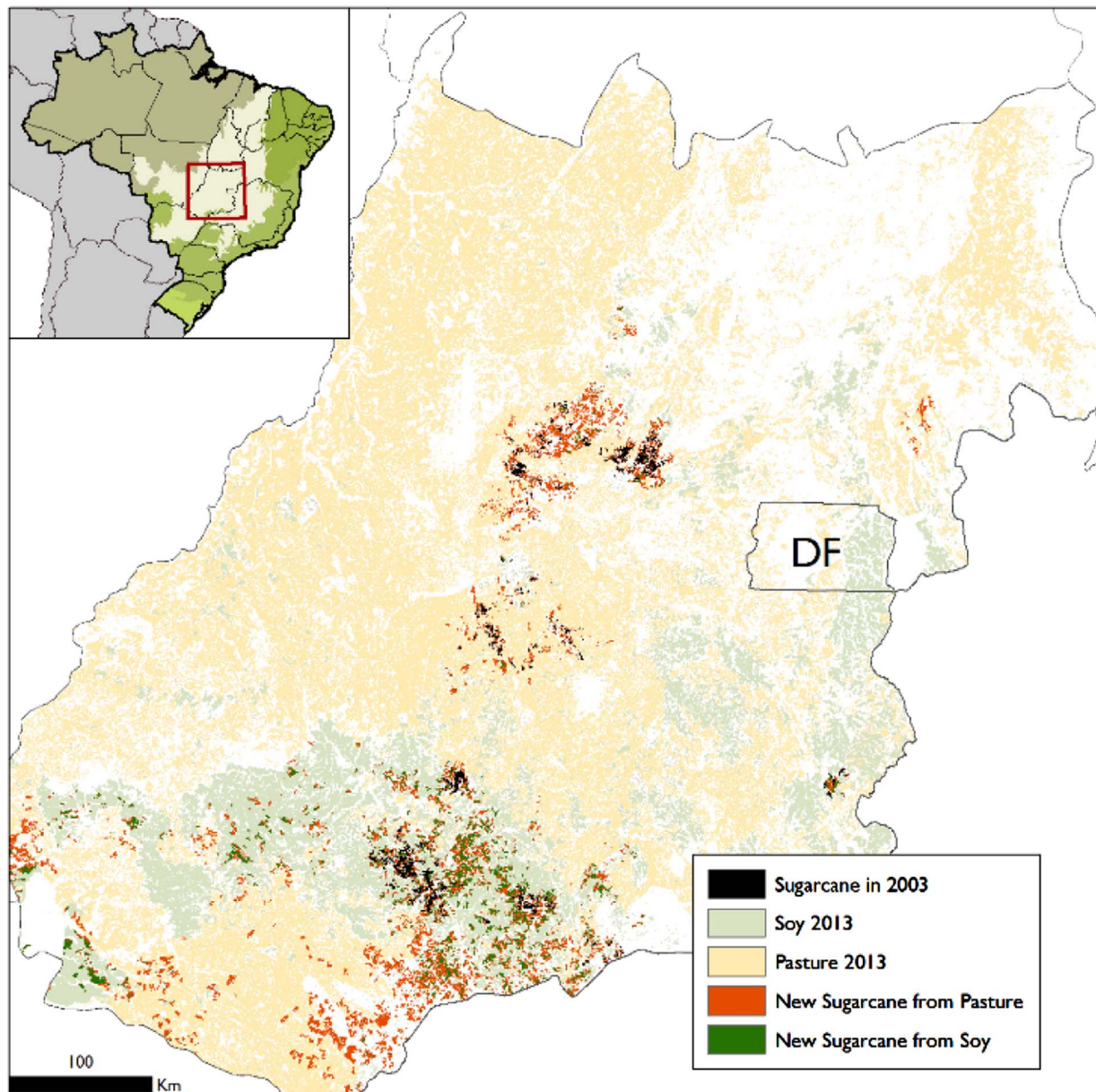


Fig. 1. Study area. Land covers in Goiás State in 2013. The yellow areas are pasture and the light green areas are soy. The black areas represent land that was sugarcane in 2003 and has remained such through 2013. The orange and darker green areas indicate land converted to sugarcane from pasture and soy, respectively, during our study period. The Federal District (DF), home to Brasília, is also highlighted. Inset: Brazil and its biomes. The Cerrado biome, in which Goiás and the Federal District fall, is highlighted in red. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

weather during harvesting, and the Brazilian government's decision to regulate gas prices to keep them intentionally lower have made sugarcane production for ethanol slightly less attractive. And between 2008 and 2013, the amount of sugarcane converted to ethanol versus raw sugar decreased steadily from 60% to 50%. However, sugarcane area in the country continues to rise. We recommend [Hira and Oliveira \(2009\)](#) for a comprehensive history of sugarcane production in Brazil.

Understanding the current socioeconomic and environmental drivers of sugarcane expansion are crucial to managing its expansion in the future. These dynamics have been well documented in São Paulo State, Brazil's established leader in sugarcane production. Biophysical characteristics associated with land most preferential for sugarcane expansion include reliability of precipitation, cool minimum temperatures, slope, and soil type ([Scarpari and de Beauclair 2004](#); [Jasinski et al., 2005](#); [Vera-Díaz et al., 2008](#)). Successful sugarcane production requires stable and consistent wet and dry seasons, the former for the initial growth of the crop, and the latter which ensures high sugar

content ([Sparovek et al., 2007](#)). Sugarcane also must be cultivated within 50–100 km of a sugarcane mill, because the sugarcane quality degrades with time ([Sparovek et al., 2007](#); [Zuurbier and van de Vooren 2008](#); [Nagavarapu 2010](#); [Gilio et al., 2016](#)). In São Paulo, intact Cerrado land is usually not cleared for sugarcane: instead, the crop expands onto land previously cultivated with pasture grasses or crops ([Sparovek et al., 2007](#); [Martinelli and Filoso 2008](#); [Egeskog et al., 2014](#)). Traditionally, pasturelands – not croplands – are converted to sugarcane: livestock production in São Paulo has markedly decreased as sugarcane has expanded ([Sparovek et al., 2007](#); [Sparovek et al., 2009](#); [Novo et al., 2010](#)). Between 2004 and 2008, however, about half of the land converted to sugarcane in São Paulo was sourced in cropland ([Egeskog et al., 2014](#)).

When land is converted to sugarcane, the farmers who own the land either sell it to the sugarcane manufacturers, lease their land, or convert their pasture or cropland to sugarcane and become sugarcane producers themselves. Whether a farmer leases their land or becomes a sugarcane

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