Agricultural land use change in the Brazilian Pampa Biome: The reduction of natural grasslands

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ARTICLE INFO

ABSTRACT

This manuscript analyzes the land use changes and its conjectural drivers in the Brazilian Pampa Biome. Therefore, land use changes in the municipalities of this biome were collected from the Brazilian Agricultural Censuses of 1975, 1985, 1995/1996 and 2006. To analyze the changes in the land use for natural pastures, pampa's microregions were compared in 10-year by a relative growth rate. There has been a 26% decrease in natural pastures in the Brazilian Pampa Biome since 1975, with a negative growth of −12.5% between 1975 and 1985. The activities with the highest growth were cultivated forests and temporary crops (1985–2005), and the increment of the area dedicated for those agricultural activities was related to the decrease in the area of natural pastures in the Pampa. Temporary crops (soy) and cultivated forests (forestry) began to integrate Pampa's landscape mainly between 1995 and 2005, changing the native configuration of the biome. Finally, sharing information on the Brazilian Pampa Biome phenomena will facilitate future dialogue among all stakeholders, and this manuscript is expected to contribute to the global debate on the conservation of natural landscapes, especially natural grasslands.

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1. Introduction

Land use changes related to the expansion of agricultural activities over natural ecosystems hinders biodiversity, and placed Brazil among the countries with most vulnerable areas (Rodrigues et al., 2009). In this context, cattle production is associated at the same time to the deforestation in the Amazon (Arima et al., 2014) and to the conservation of the natural pastures in the Pampa Biome (Nabinger et al., 2009). Therefore, considering the features of each biome is fundamental to formulate proper conservation strategies, suitable infrastructure, and to understand the impacts of food production and of land use changes in each environment (Bowman et al., 2012).

In addition, researches in land use changes are even more relevant in undervalued ecosystem, such as the Pampa's grasslands[1] (Brandon et al., 2005). In this region, cattle have been produced for over 300 years and is the central maintainer of Pampa's features (Overbeck et al., 2007). The Pampa Biome retain much of its original aspects, such as rich biodiversity and high potential for forage production (Rambo, 2005; Behling et al., 2009; Carvalho and Batello, 2009). The Brazilian Pampa represents 63% of the Rio Grande do Sul state's area, and was only considered a biome in 2004 (IBGE, 2004). Moreover, cattle production had influenced the economy and culture of this region (Boldrini, 2009), and cattle herd mainly consist

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[1] Southern grasslands represent all natural grasslands of the three States of Brazil's South Region present in the Atlantic Forest and in the Pampa Biomes. Pampa's grasslands are the part of the Southern grasslands specifically inside the Pampa.
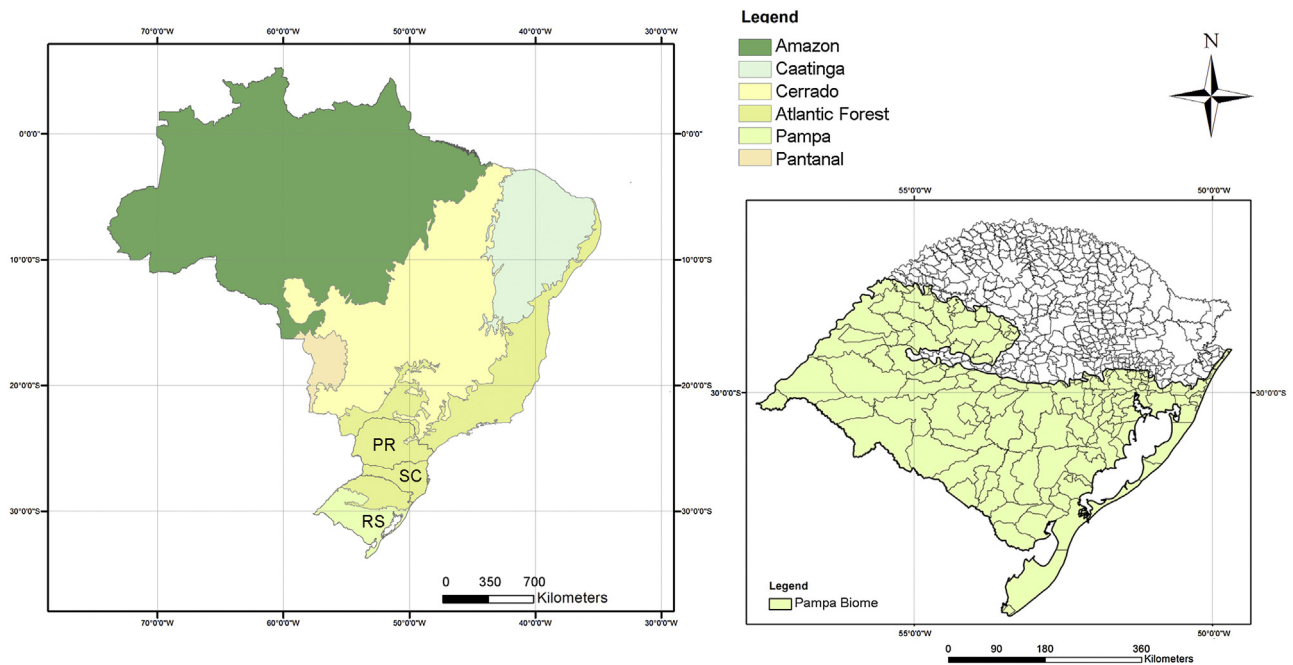
Fig. 1. Geographic location of the Brazilian biomes, with highlight for the Pampa Biome, along with the political boundaries of the municipalities of the Rio Grande do Sul state. The acronyms represent the states of Rio Grande do Sul (RS), Paraná (PR), and Santa Catarina (SC) in the Brazilian Southern Region.

of British breeds and crossbreeds with *Bos indicus*, more precocious than pure Nelore breed (SEAPA, 2014).

Despite the potential for cattle production, the efficiency should be higher (Barcellos et al., 2011), but farmers managed Pampa's grasslands with practices that caused overgrazing, low productivity, and low financial income (Nabinger et al., 2009). Moreover, although there are technological alternatives that could increase cattle productivity, technology[2] adoption is incipient, as well as its economic results (Dill et al., 2015). This scenario has contributed to the conversion of Pampa's grasslands into other agriculture activities. In addition, these land use changes and unsustainable use of Pampa's grasslands have caused landscape fragmentation, loss of biodiversity, invasion of exotic species and soil degradation (Boldrini, 2009; Carvalho and Batello, 2009).

Hence, researches dedicated to understand the drivers for land use changes in natural pastures should be encouraged and used as a foundation for the correct management of Pampa's grasslands. Nevertheless, the analyzes on this issue had been only estimations and perceptions, and so far, no research analyzed how much of the natural pastures were lost in the Brazilian Pampa Biome and what where the causes for its conversion into other land uses. Thus, this manuscript analyzes the land use changes in the Brazilian Pampa Biome and its conjectural drivers.

2. Material and methods

The Southern Brazilian region is composed of the Rio Grande do Sul, Paraná, and Santa Catarina states, and present a cattle herd of 27,634,241, almost half of which in the Rio Grande do Sul, especially in the Pampa Biome (IBGE, 2014) (Fig. 1).

Data were collected from Agricultural Censuses (1975, 1985, 1995, and 2005[3]), available as hardcopies and at SIDRA digital

Table 1
Agricultural land use categories according to the Brazilian Agricultural Census (IBGE, 2006).

Land use	Description
Permanent Crops	Planted area or area in preparation for planting long-term crops.
Temporary Crops	Planted areas or area in preparation for planting short-term crops (less than one year).
Natural Pastures	Area for cattle grazing mostly formed by non-planted pastures.
Cultivated Pastures	Area for cattle grazing mostly formed by planted pastures.
Natural Forest	Natural area used for product extraction or preserved as forest reserves.
Cultivated Forest	Planted area or area in preparation for planting forest species.

database from the Brazilian Institute of Geography and Statistics (IBGE). The variables collected were land use areas in the Pampa biome municipalities (Table 1).

In this research, special attention was given to the natural pastures located in the Brazilian Pampa Biome, and hereafter we will refer to it as Pampa's grasslands.

All data were grouped by microregion to avoid any bias of the municipalities' emancipation.[4] An exploratory analysis was performed considering the land use area of each category in the corresponding microregion. These values represented the variation of land use over the years through a relative growth rate (RG):

$$RG = \frac{(Area\ currently\ used - Area\ used\ in\ the\ previous\ period) \times 100}{Area\ used\ in\ the\ previous\ period}$$

The RG of natural pastures was plotted in ArcGis 10.2 (ESRI, 2015) to identify the critical areas for its reduction. To determine land use changes, the weighted values were compared in every 10 years by a repeated measures ANOVA adjusted by Greenhouse-Geisser

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[2] Some of the available technologies with low costs are economic management practices (Dill et al., 2015), management of the stock rate and improvement of the natural pastures (Borges et al., 2016).

[3] The Brazilian Agricultural Censuses of 1995 and 2005 were published in 1996 and 2006, respectively.

[4] Municipalities are autonomous units of lower hierarchy within Brazil's administrative political organization, and their creation, incorporation, or separation is done by state law (IBGE, 2001).