

# Soybean expansion and its impact on Livestock in the Brazilian Pampa

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## Abstract

Due to productivity gains and international demand, soybean has been advancing into territories characteristic of other agricultural activities, such as the Brazilian Pampa biome. In this sense, the present study aimed to analyze the expansion of soy in the Pampa biome and its impact on the livestock systems of the region. The research had a quantitative, descriptive approach, using the survey method. The data analysis techniques used were descriptive statistics and linear regression. The results showed an advance of soybean crops over the Pampa, having a growth of planted area, on average, of 6.57% per year in the period from 2000 to 2019. The estimated regression model made it possible to verify that for every increase of 100 hectares cultivated with soy in the Brazilian Pampa biome results in an average reduction of 76 head of cattle, demonstrating the impact of the advance of crop production on traditional forms of livestock farming.

**Keywords:** Agricultural economics, beef cattle, ecosystem services, pampa, soybean expansion, sustainability.

## Introduction

Brazil is the world's largest producer of soybeans, reaching 38.5 million hectares of planted area, with a record production in 2020 of 135.5 million tons. For the year 2021, in Rio Grande do Sul (RS), Brazil's southernmost state, there was a forecast production of 42.7 million tons, which corresponds to an increase of 21.1% over the previous year (CONAB, 2021). In addition to oil production for human consumption Soybean has emerged as important feed for livestock including pig in all over world (Tedtova et al 2020).

Among the biomes where soy production has advanced, the Pampa biome stands out. The Pampa biome represents the largest extension of natural pastures in the world, covering the state of Rio Grande do Sul in Brazil, Uruguay and Argentina. In Rio Grande do Sul, the biome occupies 63% of the state's area, totaling approximately 17 million hectares. In addition, there are an estimated 3000 species of plants with a great variety of grasses, as well as 500 species of birds and more than 100 species of land mammals. In addition to this natural and genetic heritage, it also has a rich social and cultural patrimony, due to its history of agrarian occupation and social reproduction of the "gaucho", a social type linked to extensive livestock farming in the native grasslands of the biome (MMA, 2019). According to Litre (2010), livestock production in the Pampa relates in complete harmony with the biodiversity and unique characteristics present in the region, thus conserving its environmental peculiarities. However, in recent years, the conservation of landscapes and characteristics of the region has been changing as a result of the advance of soybeans and other monocultures.

According to Silveira et al. (2017), the increase in the price of soybeans, which started in the 2000s, encouraged the expansion of soybean and rice cultivation in the Brazilian Pampa, transforming much of the region's known native pastures into agricultural land. This scenario caused a restructuring of the local productive spaces, previously dedicated almost exclusively to beef cattle raising.

The research is justified by the fact that the Pampa, as well as livestock production, are elements that form the economy and society of the territory, thus giving a local identity to the people who live in the region. Furthermore, according to Oliveira et al. (2017), the Pampa is one of the Brazilian biomes with less geographical coverage in conservation units and the responsibility for environmental preservation falls mostly on livestock farms in the region. With this scenario, the present study aimed to analyze the expansion of soybeans in the Brazilian Pampa biome and its impact on the livestock production in the region. As specific objectives, we seek to verify the advance of the area planted to soy in the biome and to analyze the relationship between the increase in soy production and the amount of cattle in the Pampa.

## Material and Methods

The study area is the Pampa biome in state of Rio Grande do Sul, Brazil (Fig 1). Thus, the aim is to verify the advance of soy in the Brazilian Pampa, the region most affected by the advance of agriculture over livestock areas.

The research presented a quantitative approach, of descriptive character, using the survey method. The data collection technique used was the survey of secondary data. For each specific objective, secondary data from public agencies was examined, delimiting the variables of research analysis according to Table 1.

Rio Grande do Sul has two biomes: the Atlantic Forest biome in the north of the state and the Pampa biome in the south of the state. Thus, data on soybean planted area, and cattle herd were collected for all municipalities in Rio Grande do Sul and subsequently segmented into two biome groups. (IBGE, 2019; SEAPDR, 2020). The variables of the Pampa and Atlantic Forest biomes contemplated data from 116 and 381 municipalities of the state, respectively.

For the presentation of the results, descriptive statistics was used as a technique of data analysis, by means of graphical representations. Furthermore, with the purpose of understanding the evolution of the variables, the logarithmic regression technique was used to obtain the growth rates of the area planted with soybeans from 2000 to 2019 in the Pampa biome. The logarithmic regression, also known as the log-linear method, measures the elasticity of the dependent variable (planted area) as a function of the independent variable (time). Finally, to verify the influence of the area planted with soy on the amount of cattle herd in the Pampa biome, the simple linear regression method was used, according to equation 1.

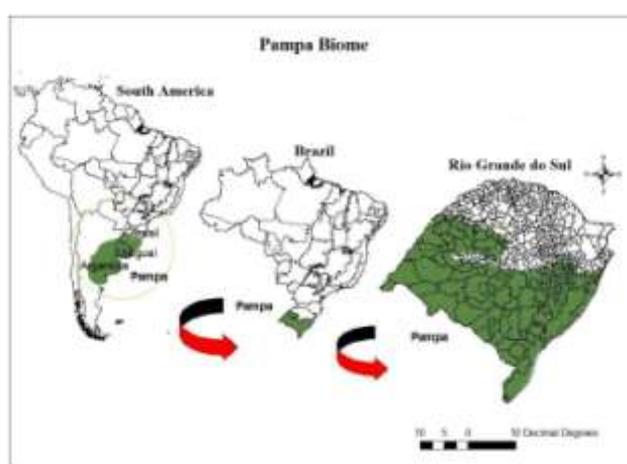
$$Y_{Herd} = \alpha + \beta X_{Area} + \varepsilon \quad (1)$$

Where: Y = cattle herd in the Pampa biome (in heads) from 2010 to 2020;  $\alpha$  = intercept;  $\beta$  = angular coefficient; X = soybean crop area (in hectares) in the Pampa biome from 2009 to 2019;  $\varepsilon$  = residue.

The model was estimated by the Ordinary Least Squares Method. The overall significance of the model was tested by means of Analysis of Variance (ANOVA) at a maximum significance level of 5%.

**Table 1** - Objectives, research variables, data sources, and analysis techniques applied in the research.

Objectives	Research variables	Data sources	Analysis techniques
Verify the advance of soybean planted area in the Pampa biome	Soybean planted area in the municipalities belonging to the Pampa biome and Atlantic Forest biome in Rio Grande do Sul - 2000 to 2019.	Municipal Agricultural Research of the Brazilian Institute of Geography and Statistics (IBGE)	Descriptive Statistics
Analyze the relationship between the increase in the area planted with soy and the amount of cattle herd in the Pampa biome	- Soybean planted Area (2009 - 2019) and Cattle Herd (2010 - 2020) in municipalities belonging to the Pampa biome.	Secretary of Agriculture, Livestock and Rural Development - RS, Brazil	Descriptive Statistics Linear Regression

**Fig 1** - Location of the Pampa biome in South America and Brazil Source: Adapted from Azevedo (2013).

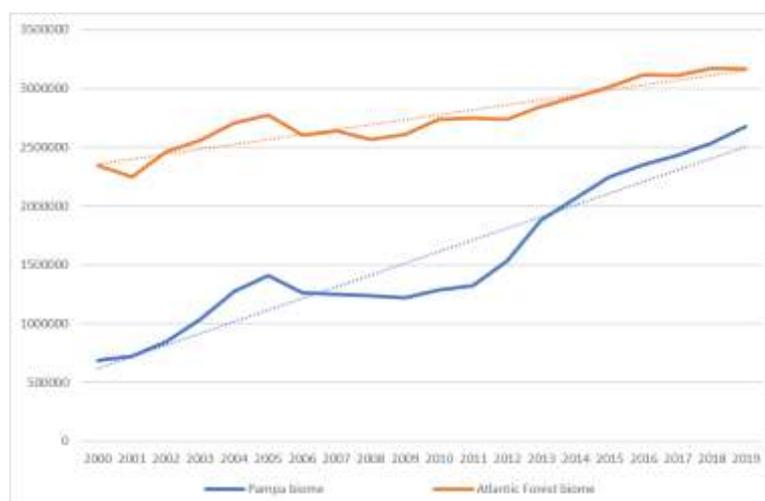
## Results and Discussion

To analyze the advance of soybean cultivation in the Pampa biome of Brazil, the evolution of the area planted with soybeans in Rio Grande do Sul was first verified, comparing the two biomes in the period from 2000 to 2019, as shown in Figure 2. From the analysis of growth rates, it was found that in the period from 2000 to 2019 the Atlantic Forest biome showed a growth of soybean plant area of 1.53% per year, while in the Pampa biome the growth reached 6.57% per year. Thus, it could be concluded that, in the period analyzed, soybean growth in the Pampa was 429% higher than in the Atlantic Forest biome, typical region of oleaginous crop cultivation.

In 2000, the Pampa biome represented only 22.6% of soybean cultivation in Rio Grande do Sul. In turn, in 2019, this percentage increased to 45.8%, close to the percentage present in the traditional region of cultivation - the Atlantic Forest biome. Also, between the years 2000 and 2019, it was possible to verify that 70.8% of the advance in the area planted with soybeans in the state of Rio Grande do Sul occurred within the Pampa biome. Thus, the results indicate a strong expansion of soybean cultivation in the Brazilian Pampa biome in the last 20 years. This has changed the pattern of agricultural crops in the Brazilian Pampa, previously focused predominantly on rice cultivation, unlike the Atlantic Forest biome, which historically had soybean production as the main agricultural crop.

This transformation came along with the reduction of the cattle herd in both biomes. In the pampa biome, the cattle herd decreased from 9.5 million to 7.9 million head from 2010 to 2020, a reduction of 16.8%. In the Atlantic Forest biome, the bovine herd decreased from 2010 to 2020, from 4.1 million to 3.7 million heads, a reduction of 9.7% (SEAPDR, 2020).

These results strengthen the concern of researchers with the characteristics of the biome, as well as with the lifestyle of farmers. As Litre (2010) argues, the trend and proportion of the growth of these monocultures, such as soybeans, means that not only the livestock farmer's lifestyle is threatened, but also the fauna, flora and the fundamental characteristics for the biome to remain preserved.



**Fig 2** - Evolution of the planted area (in hectares) of soybeans in the Pampa and Atlantic Forest biomes of Rio Grande do Sul.

**Table 2** - Estimated parameters of the regression model

Model				R Square (R <sup>2</sup> )	ANOVA	
					F	p-value
	Coefficients	t	p-value	49.60%	8.85	0.015
Intercept	10591906	20.36	0.000			
Soybean planted area	-0.7642	-2.97	0.015			

The probable reasons for a higher soybean advance in the Brazilian Pampas are: a) the demand for more accessible land; b) the development of cultivars adapted to the region; c) the substitution of land ownership from the cattle raising model to the land leasing model; and d) the emergence of new players determined to invest in this new agricultural frontier (Pizzato, 2013; Silveira et al., 2017).

Table 2 presents the parameters of the regression model estimated to verify the influence of the area planted with soy on the cattle herd of the Pampa biome in Brazil from 2010 to 2020. By analyzing Table 2, it is evident, from the ANOVA, the validity of the model. That is, it can be seen that the variable planted area has a significant linear relationship with the cattle herd of the Pampa biome in the period 2010 to 2020 ( $p < 0.05$ ). According to the result of the coefficient of determination ( $R^2$ ), it is possible to see that the variation in the area planted with soybean explains 49.60% of the variations in the amount of cattle herd in the Pampa biome from 2010 to 2020.

When analyzing the individual coefficients, it appears that each increase of one hectare of planted area in the Pampa biome results in a reduction of, on average, 0.76 head of cattle, maintaining the other factors constant. Therefore, it can be stated that in the last ten years, each 100 hectares increase in the area of soybean plantation in the biome has resulted in an average reduction of 76 head of cattle. Crawshaw et. al. (2007) report that the coexistence of livestock farms with the Pampa biome, when well managed, is one of the few examples worldwide of an economically viable and sustainable activity in relation to the conservation of biological and social diversity of the territory. However, the results of the research indicate that this coexistence has been altered in recent years due to the advance of areas for soybean cultivation in the biome. In this sense, Viana et al. (2021) highlight the need to reflect on the development of public policies that understand the Pampa as a "common good". This strategy allows mountain cattle ranching to be environmentally Sustainable, while being able to generate income for families and maintain productive activity, thus boosting local economies.

### Conclusion

Among the two biomes present in the state of Rio Grande do Sul, we observed that the growth of the area planted with soybeans over the last 20 years was more accelerated in the Pampa biome, with a growth rate of 6.57% per year. The research also identified an influence of the advance of the area planted with soy on the reduction of the cattle herd in the biome.

Attention is drawn to the lack of public policies that value the ecosystem services of livestock in natural areas and that seek to stimulate sustainable exploitation and conservation of the Pampa. A region that, as important as other Brazilian biomes, is fundamental for the preservation of cultural, social, and environmental aspects of Brazil.

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