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Economic and environmental impacts of PPCerrado policy using the Brazilian Land Use Model – BLUM

Leila Harfuch and Marcelo M. R. Moreira
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Abstract/Resumen

Deforestation in the Cerrado has occurred in 48% of the biome area, mostly due to the land's allocation to agricultural activities. The Brazilian federal government, seeking to reduce the deforestation rate, launched the "Action Plan for the Prevention and Control of Deforestation in the Cerrado" (PPCerrado) in 2009-2010, in order to achieve the goals laid out in the Climate Change National Plan (PNMC). The main instrument proposed in the plan is to create preserved areas (conservation units), targeting 10% of the biome area for preservation. This paper measured the environmental and socio-economic impacts of the creation of preserved areas in the Cerrado as indicated in the PPCerrado. We used the Brazilian Land Use Model (BLUM) and simulated three scenarios changing the available and suitable land for agricultural expansion based on the priority for conservation (restricting the available land that could be converted to agricultural use): the first one considering business as usual scenario, BAU; the second one considering only the areas considered as extremely high priority for conservation, LPR1; the third one summing all the areas classified as high, very high and extremely high priority for conservation according to the PPCerrado, LRP2. Both scenarios simulated using land availability restrictions (excluding areas with priority for conservation) presented the following impacts, compared to the baseline scenario in 2020: decreased total cropland, high level of pasture intensification, higher commodity prices, and increased deforestation in other biomes, especially the Amazon region.

Keywords: Cerrado, deforestation, Brazilian agriculture, land use, PPCerrado policy, BLUM, environmental policy, Climate Change National Plan, Amazon.

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1. Introduction

The Cerrado biome is located mainly in the Central Brazilian region and occupies, approximately, 204 million hectares, which represents 25% of total Brazilian territory. According to the Brazilian Environmental Ministry, almost 48% (97.6 million ha) of the Cerrado biome is deforested. In addition, public protected areas represent only 3.1% of the biome (or 6.3 million hectares).

Traditionally, and more intensively since the 1970s, public policy for the Cerrado biome has been devoted to colonization and territory occupation. During the establishment of the region's occupation, the soil was considered unsuitable for agriculture, especially for grains. However, the correction of soil characteristics and the development of other technologies suitable for the region created the opportunity to implement highly productive tracts of land for crops and pasture productions (Rezende, 2003). Since then, the Cerrado has become the most dynamic agricultural region in Brazil, especially for pasture, soybeans, corn and cotton. According to the 2006 Agricultural Census, the Brazilian Center-West region, where most of the Cerrado biome area is located, accounted for 33% of total agricultural area in Brazil (IBGE, 2009).

Ferreira et al. (2009) affirm that the deforestation rate in the Cerrado biome varies from 0.21 to 0.86% per year. Part of this area was converted to agricultural activities and tends to increase over time. In light of the increase in total agricultural area, mostly at the expense of natural vegetation, public policy interests have been changing. One instance of this is the recently launched an action plan named the "Action Plan for the Prevention and Control of Deforestation in the Cerrado" (PPCerrado), published in September 2009 (MMA, 2009) and revised in 2010 (MMA, 2010); its purpose is to reconcile environmental and economic interests in a sustainable development framework. PPCerrado was launched to fulfill three important national laws: the National Biodiversity Policy, the Water Resources Act, and the Climate Change National Plan

However, it is not evident if, and, to what extent, such an important plan will succeed in achieving its goals. Deforestation may be reallocated to other areas but the new restrictions may significantly diminish agricultural production and local well-being. In this sense, this paper aims to answer the following questions: Will the recently launched PPCerrado be successful regarding the objective of protecting natural vegetation in the Cerrado? If so, do the instruments used (establishment of protected areas in the Cerrado) really prevent and reduce overall deforestation? Is it possible to simultaneously prevent deforestation and fulfill the growing need for agricultural products such as food, fiber and energy?

The methodology used was an improved version of the Brazilian Land Use Model (BLUM), which was adapted and prepared to simulate scenarios incorporating restrictions on land available and suitable for agricultural expansion until 2020. Based on PPCerrado policy, we simulated a baseline scenario (or BAU – business as usual); one scenario considering areas indicated in the policy as “extremely high” priority for conservation (LRP1); and one considering all the areas classified as important for conservation (“extremely high”, “very high” and “high” priority for conservation).

2. Methodological Approach

2.1. The Brazilian Land Use Model – BLUM

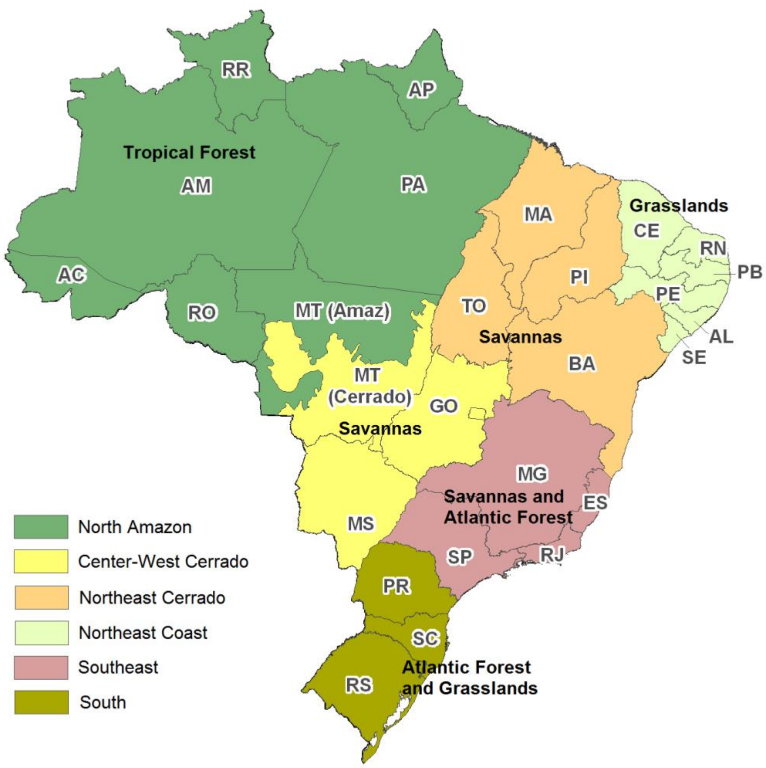
BLUM is a one-country, multi-regional, multi-market, dynamic, partial equilibrium economic model for the Brazilian agricultural sector, which is comprised of two sections: *supply and demand* and *land use*. The model includes the following products: soybeans, corn (first and second crop), cotton, rice, dry beans (first and second crop), sugarcane, wheat, barley, dairy, and livestock (beef, poultry, eggs and pork). Commercial forests are exogenous projections in the model. Combined, these activities were responsible for 95% of the total area used for agricultural production in 2008, including pastures. Although second and winter crops, such as corn, dry beans, barley and wheat do not generate an additional need for land (they are smaller and planted in the same place as summer season crops, in double cropping areas), their production is accounted for in the national supply.

2.1.1 The supply and demand section

In the supply and demand section in BLUM, the demand is projected at the national level and is formed by domestic demand, net trade (exports minus imports) and final stocks (which are not considered for sugarcane, and dairy and livestock sectors), all of which depend on prices and on exogenous variables such as gross domestic product (GDP), population and exchange rate. The supply is formed by national production (which is regionally projected) and beginning stocks (again, only refers to grains and final sugarcane-based products). The supply depends on expected profitability of each commodity, which are formed by costs, prices and yields.

Land allocation for agriculture and pasture is calculated for six regions[1] (see Figure 1).

Figure 1 - Regions considered in the Brazilian Land Use Model



Source: ICONE.

National supply and demand and regional land use of each product respond to prices. Consequently, for a given year, equilibrium is obtained by finding a vector of prices that clears all markets simultaneously. Year by year, a sequence of price vectors is found, which allows the

[1] The main criteria for identifying the regions were agricultural production, homogeneity, and individualization of biomes, with special relevance for conservation.

market trajectory to be followed through time. The outputs of the model are: regional land use and change, national production, prices, consumption and net trade.

Annual production in each region comes from the product of allocated land and yields. National production is the sum of all regions' production, in addition to beginning stocks. This relationship guarantees the interaction between the land use and supply and demand sections of the model, given that that the following identity must be satisfied:

Beginning Stock + *Production* + *Imports* = *Ending Stock* + *Consumption* + *Exports*

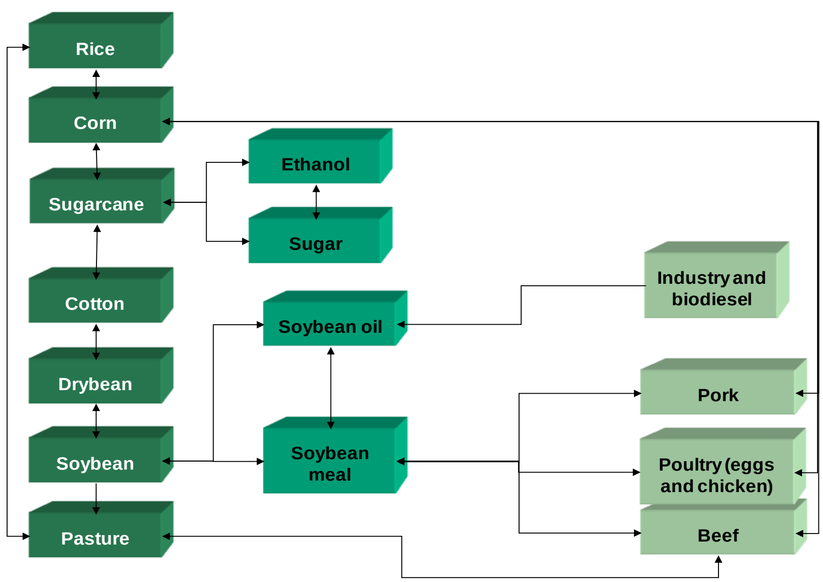
or, given that *Net Trade* = *Exports* - *Imports*:

Beginning Stock + *Production* = *Ending Stock* + *Domestic Consumption* + *Net Trade*

BLUM also takes into account interactions among the sectors analyzed, and between one product and its derived products. For example, the interaction between the grain and livestock sectors is the feed consumption (basically corn and soybean meal) that comes from the supply of meat, milk and eggs, which is one component that comprises the domestic demand for corn and soybeans. In the case of the soybean complex, the components soybean meal and soybean oil are parts of the domestic demand for soybeans and are determined by the industry demand. Similarly, ethanol and sugar are the components of sugarcane demand (

Figure 1).

Figure 1 - Interactions between BLUM sectors



Source: ICONE

2.1.2. The land use section

Land use dynamics are divided in two effects: *competition* and *scale*. Intrinsically, the competition effect represents how the different activities compete for a given amount of available land, and the scale effect refers to the way that the competition among different activities generates the need for additional land. This need is accommodated by the expansion of total agricultural area over natural vegetation. In BLUM, total agricultural area is endogenously determined in the scale effect.

The competition effect follows the methodology proposed by Holt (1999), and consists of a system of equations that allocates a share of agricultural area to each crop and pasture in each region as a function of its own and "cross" price-profitability. It establishes that, for a given amount of agricultural land, an increase in its own profitability of one activity will increase the share of area dedicated to this activity. On the other hand, an increase in profitability of a competing activity reduces the share of area of the competitors. The regularity conditions (homogeneity, symmetry and adding up) are imposed so that the elasticity matrices (and associated coefficients) are theoretically consistent. For any set of these coefficients we calculate own and cross impacts and competition among activities. Then, using this structure, simulations in BLUM allow us to calculate not only land allocation, but also land use changes. In other words, the conditions allow the identification of the exchanged area for each activity, given the amount of total allocated agricultural area.

In order to guarantee coherence of the above-mentioned conditions, pasture area is regionally and endogenously determined, modeled as a determinant of each crop and of total agricultural land and calculated as the difference between of total agricultural area minus crop area. In the context of Brazilian agriculture, it is particularly relevant to project pastureland both endogenously and regionally, since it represents around 77% of total land used for agricultural production.

Although the competition effect may only represent the dynamic of the consolidated regions where the agricultural area is stable and approaching its available potential, Brazil still has regions in which the total land allocated to agriculture is expanding, a fact that leads to the conversion of native vegetation (as can be seen in Nassar et al., 2010a). This effect is captured in the scale section of the BLUM. The combination of competition and scale effects and the accurate definition of their strength in each region are essential to enable the model to represent the reality of Brazilian agricultural land use dynamics.

The scale effect refers to the equations that define how the returns of agricultural activities determine the total land allocated to agricultural production. More precisely, total land allocated to agriculture is a share of total area available for agriculture, and this share responds to changes in the average return of agriculture regionally.

Scale and competition effects are not independent. Together, they are the two components of the own return elasticities of each activity. Considering a *ceteris paribus* condition, the increase in profitability of one activity has three effects: first, an increase in total agricultural area (through average return); second, an increase in its own share of agricultural area; and, therefore, third, a reduction in the share of agricultural area of other activities. For competing crops, cross effects of profitability on area are negative.

As mentioned previously, the own elasticities of each crop are the sum of competition and scale elasticities. At the same time, regional elasticity of land use with respect to total agricultural returns (agricultural land supply elasticity) is the sum of the scale elasticities of each activity. Therefore, competition elasticities can be calculated directly from agricultural land supply elasticity while total own elasticities were obtained through econometric analysis and literature review. The option to estimate area response to return, instead of price, is supported by several studies, as mentioned in Barr et al. (2011).

In order to accomplish the main objective we simulate scenarios incorporating the PPCerrado policy in the BLUM. Firstly, we worked with a GIS expert in order to estimate the priority level and the areas to be conserved in the policy. Secondly, we used that information to shock the variable land availability in the BLUM and compare results.

Land availability is an exogenous restriction in the BLUM. The amount of land allocated to agricultural production is conditional upon the total land available and suitable for agriculture.

In the BLUM land use section, the area a of crop i of each region l (l=1,…,6) in year t is defined by the following equation:

$$a_{ilt} = A_l^T * m_{lt} * s_{ilt} \quad (1)$$

A^T is the total area available for agricultural production; m_{lt} is the share of A_l^T that is currently used for agricultural production (all crops and pasture), and s_{ilt} is the share of the area used by agriculture that is dedicated to crop i. A^T is an exogenous variable and is the shock variable in this study.

The variable m_{lt} is endogenous to the model and responds to the average agricultural market return (profitability) index of region l (r_{lt}), so the share of area allocated to agriculture can be defined as:

$$m_{lt} = \frac{A_{lt}}{A_l^T} = k r_{lt}^{\alpha_{lt} \varepsilon_{r_l}^{A_l}} \quad (2)$$

where k is a constant parameter; $\varepsilon_{r_l}^{Al}$ is the land supply elasticity (with respect to the average return) for region l[2]. The parameter α_{lt} is positive, higher or lower than one, defined as:

$$\alpha_{lt} = 1 - \frac{A_{lt} - A_{l0}}{A_l^T} \quad (3)$$

Where A_{l0} is the land used for agriculture in a defined base period. When the amount of agricultural land in period t is close to that in the base period α_{lt} is close to 1 and it does not affect $\varepsilon_{r_l}^{Al}$. However if agricultural land in t is larger than the base period, than the parameter α_{lt} is smaller than one and reduces the effect of $\varepsilon_{r_l}^{Al}$. The opposite occurs when current agricultural land is smaller than (A_{lo}).

The average return of region l, r_{lt}, is calibrated based on evidences that indicate which activities most expand in the agricultural frontier.

$$r_{lt} = \sum_{i=1}^{n} r_{it} * d_{li} \quad (4)$$

Remote sensing information would provide a vector D with the respective deforestation rate caused by each agricultural activity. We can then calculate the weighting vector d_{li} as follows:

[2] For a detailed explanation of the model, see Nassar et. al (2011). Available at: http://www.iconeBrazil.org.br/arquivos/noticia/2258.pdf

$$d_{li} = \frac{D_{li}}{D_l^T}; \text{where } D_l^T = \sum_{i=1}^{n} D_{li} \quad (5)$$

It should be noticed that there is no subscript *t* since the vector does not change over time.

3. The PPCerrado Policy and Simulations

The PPCerrado is a strategic action plan associated with Brazil's national policies as articulated in the National Plan of Biodiversity, the National Plan of Hydro Resources and the Climate Change National Plan (PNMC).

In regards to national Decree 7.390, announced in December of 2010 (Brazil, 2010), Brazil aims to reduce Green House Gas (GHG) emissions mainly through targeting deforestation rates in the Amazon and Cerrado biomes by 2020. The PPCerrado is an action plan to prevent and control deforestation as regulated in the Climate Change National Policy (Low n. 12.187/2009). In order to preserve the remaining natural vegetation in the Cerrado, the action plan aims to create conservation units (fully protected and for sustainable use) by targeting 10% of the total biome area, as recommended by the International Union for Conservation of Nature (IUCN) and by the National Biodiversity Commission (Conabio).

The action plan presents the following measures: control and monitoring; protected areas and territory ordering; and incentives for sustainable activities. According to the PNMC, the Cerrado biome needs to reduce the deforestation rate by 40% from the baseline (average annual deforestation rate from 1999 to 2008) by 2020.

For the purpose of this paper we will focus on the impacts of creating new protected areas in the Cerrado. According to MMA (2010), creating conservation units is one of the most important actions to prevent and control deforestation in the Cerrado biome. The MMA identified 431 locations as priorities areas for conservation, which means creating 250 new areas compared to the 181 extant. Agricultural expansion is the main driver of deforestation in the Cerrado biome, especially for soybeans and pasture-based livestock production. Pig iron mining is also an important driver of deforestation (MMA, 2010).

In order to measure environmental and socio-economic impacts of the PPCerrado policy in terms of the creation of conservation units, we performed three simulations in BLUM:

i. BAU scenario: the business-as-usual scenario with current land availability;
ii. LRP1: land availability restriction considering areas in the Cerrado biome defined as “extremely high” priority for conservation in PPCerrado policy;
iii. LRP2: land availability restriction considering areas in the Cerrado biome defined as “extremely high,” “very high” and “high” priority for conservation in PPCerrado policy.

The next section shows the results found in this study.

Figure 2 shows the areas with priority for conservation in the PPCerrado. Agricultural expansion is the main driver of deforestation in the Cerrado biome, especially for soybeans and pasture-based livestock production. Pig iron mining is also an important driver of deforestation (MMA, 2010).

In order to measure environmental and socio-economic impacts of the PPCerrado policy in terms of the creation of conservation units, we performed three simulations in BLUM:

iv. BAU scenario: the business-as-usual scenario with current land availability;
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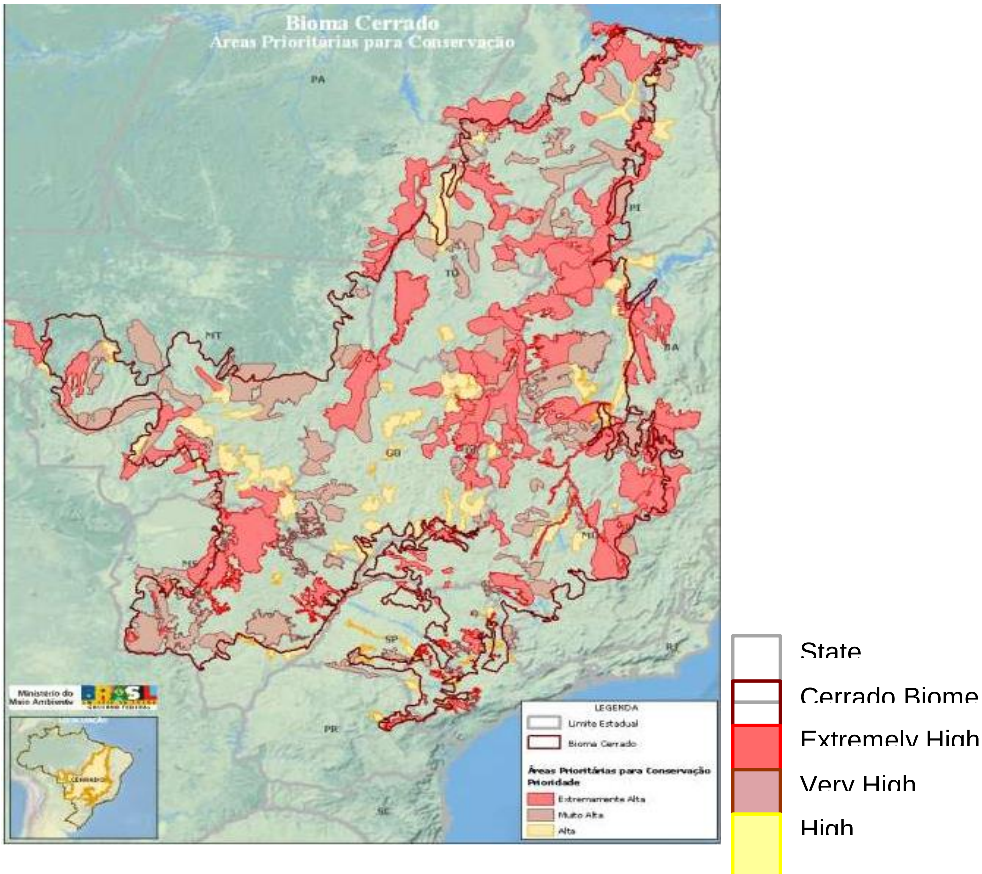
vi. LRP2: land availability restriction considering areas in the Cerrado biome defined as “extremely high,” “very high” and “high” priority for conservation in PPCerrado policy.

The next section shows the results found in this study.

Figure 2- Areas with priority for conservation according to the PPCerrado action plan



Source: MMA (2010)

4. Results

Having estimated, through GIS techniques, the land that might be protected - as defined in PPCerrado policy (Step One) and shown in

Table 1 - the researchers calculated the land available and suitable for agriculture by taking into consideration current Brazilian environmental law as well as the original database for land available and suitable for agriculture.

Table 1 – Land availability and suitable for agricultural production for different scenarios (1,000 ha)

	BAU Scenario	LRP1 Scenario	LRP2 Scenario
South	2,081	2,056	2,048
Southeast	4,324	-48	-2,261
Center-West Cerrado	8,872	4,884	-9,021

North Amazon	16,108	14,605	14,605
Northeast Coast	68	68	68
Northeast Cerrado	12,066	5,590	-2,103
Brazil	43,519	27,156	3,335

Source: Sparovek et al. (not published)

According to the PPCerrado, there are approximately 93 million hectares defined as areas with high, very high and extremely high priority for conservation. This represents 45% of the total area in the Cerrado biome. However, one should note that the policy is not intended to transform all these areas into Conservation Units (as parks, for example) absent of any economic use whatsoever. The objective of the policy is to have part of this area protected, targeting 10% of the total Cerrado area for non-economic use (as defined in the Biological Diversity Convention cited in MMA, 2010).

Since we estimated two scenarios for the policy, two database sets were calculated. The first one included only the areas thought to have "extremely high" priority for conservation (for scenario LRP1). The second used the total area considered as priority for conservation (scenario LRP2). Based on the way that we calculated these areas, the LPR1 scenario approximately reflects the 10% target for Unit Conservation creation. The LRP2 scenario can be considered an alternative to the LRP1. The following criteria were considered in each calculation: environmental law (Legal Reserve requirements[3]) and suitability for agriculture (slopes, climate, water availability, etc.) using Sparovek et al. (2010).

The results were delivered by the Cerrado biome's multiple municipalities, but for use in BLUM they were aggregated according to the model's six macro regions, as shown in **Table 2**.

[3] Legal Reserve requirement refers to a percentage of the total farm area that might be conserved as natural vegetation. In the case of Cerrado, the regions that are out of the "Legal Amazon" (states that abut the frontier of the Amazon region) have 35% of this requirement and the others have 20%.

Table 2 – Land availability and suitability for agricultural production for different scenarios (1,000 ha)

	BAU Scenario	LRP1 Scenario	LRP2 Scenario
South	2,081	2,056	2,048
Southeast	4,324	-48	-2,261
Center-West Cerrado	8,872	4,884	-9,021
North Amazon	16,108	14,605	14,605
Northeast Coast	68	68	68
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Brazil	43,519	27,156	3,335

Source: Sparovek et al. (not published) and results of the study

It can be noted that there are some negative areas as land available for agricultural production. This fact indicates that the current area in economic use must be reduced in these regions. For the model's simulation, in the case of negative areas, the reduction was introduced year by year linearly, from 2012 to 2020. For example, in the Center-West Cerrado, area reduction was 1,988 hectares per year (LPR2 scenario). The idea is to have the creation of protected areas for an extended period of time, until 2020.

There are several results from the simulations that are of ripe for analysis. However, for the purpose of this study, we will focus on the effects in terms of cropland[4] (Table 3), pasture intensification (Table 4), production for simulated products (

[4] BLUM simulates the following crops: rice, dry beans, cotton, soybeans, corn and sugarcane.

Table 5) and commodity prices (
Table **6**).

Table 3 – Land use results for the simulated scenarios (1st summer crops), 1,000 ha

	2010	BAU 2020	LRP1 2020	LRP2 2020	LRP1-BAU	LRP2-BAU	LRP1/BAU	LRP2/BAU
South	13,986	15,017	15,290	15,888	272	870	2%	6%
Southeast	9,926	11,693	10,869	10,643	-824	-1,050	-7%	-9%
Center-West Cerrado	11,289	14,368	14,152	12,366	-217	-2,002	-2%	-14%
North Amazon	3,082	3,697	3,829	4,099	131	401	4%	11%
Northeast Coast	3,229	4,042	4,112	4,206	70	163	2%	4%
Northeast Cerrado	5,177	7,149	6,680	6,214	-470	-936	-7%	-13%
Brazil	46,689	55,968	54,931	53,415	-1,036	-2,553	-2%	-5%

Source: Results of the study

According to Table 3, Brazil had 46.7 million hectares of cropland for the simulated products in 2010. For the BAU scenario, cropland is expected to occupy 55.9 million hectares in 2020. For the shock scenarios simulated, however, with the reduction of land availability for agricultural expansion, cropland will occupy 54.9 and 53.5 million hectares for the LRP1 and LRP2 scenarios, which represents a 2% and a 5% reduction relative to the BAU scenario, respectively. Also, cropland increase in these scenarios as compared to the BAU displaced mostly pasture areas.

However, the leakage effects are of the most interest for analysis. Because the land availability reduction will occur only in the Cerrado biome, prices will increase and other biomes with higher land availability for agricultural expansion may increase cropland. Since the South is a traditional crop producer, it will respond more effectively to other regions' cropland reduction, especially in the more restrictive land scenario (LRP2). As shown in Table 3, the North Amazon region will increase 131 and 401 thousand hectares in 2020 for both scenarios respectively, relative to the BAU scenario. The Northeast Coast region had less impact due to more restricted land availability, will also respond positively to cropland expansion.

Table 4 shows pasture area for the regions analyzed. The interesting point is that most of the cropland expansion was over pasture areas, thereby inducing intensification of livestock production.

It could be noted that almost all cropland expansion in the Southern region was over pasture areas in both LRP1 and LRP2 scenarios, compared to the BAU one. On the other hand, the North Amazon region increased pasture area, increasing to even greater degree the land allocated to agriculture when considering cropland expansion.

Table 4 – Pasture area results for the simulated scenarios, 1,000 ha

	2010	BAU 2020	LRP1 2020	LRP2 2020	LRP1-BAU	LRP2-BAU	LRP1/BAU	LRP2/BAU
South	15,143	14,162	13,891	13,298	-271	-864	-2%	-6%
Southeast	27,287	25,312	22,817	21,378	-2,496	-3,934	-10%	-16%
Center-West Cerrado	47,175	45,039	42,466	33,788	-2,573	-11,251	-6%	-25%
North Amazon	48,443	50,729	51,122	52,035	393	1,305	1%	3%
Northeast Coast	10,886	10,574	10,563	10,543	-11	-31	0%	0%
Northeast Cerrado	30,640	29,478	26,576	22,908	-2,902	-6,569	-10%	-22%
Brazil	179,574	175,295	167,435	153,951	-7,860	-21,344	-4%	-12%

Source: Results of the study

Table 5 - Brazilian production for the simulated products and scenarios

	2010	2020 BAU	LRP1 Scenario	LRP2 Scenario	LRP1-BAU	LRP2-BAU	LRP1/BAU	LRP2/BAU
Corn (total)	56,018	69,157	68,507	67,515	-650	-1,642	-1%	-2%
Soybeans	68,688	92,702	92,438	91,830	-264	-872	0%	-1%
Cotton	3,037	4,626	4,587	4,497	-39	-129	-1%	-3%
Rice	11,661	14,661	14,513	14,254	-148	-407	-1%	-3%
Dry Beans (total)	3,323	4,344	4,322	4,294	-22	-50	-1%	-1%
Sugarcane	736,595	1,089,010	1,059,765	1,032,062	-29,245	-56,948	-3%	-5%
Soybean Oil	6,973	8,306	8,262	8,162	-44	-144	-1%	-2%
Soybean Meal	27,154	32,685	32,513	32,118	-173	-567	-1%	-2%
Sugar	38,542	48,781	48,097	47,268	-683	-1,513	-1%	-3%
Ethanol	26,976	52,429	50,750	49,053	-1,679	-3,377	-3%	-6%
Beef	9,994	13,076	13,042	12,923	-33	-153	0%	-1%
Swine Meat	3,237	4,458	4,450	4,445	-8	-13	0%	0%
Broiler Meat	12,230	15,605	15,567	15,537	-38	-68	0%	0%

Note: all products are in thousand metric tons, except for ethanol, which is in 1,000 m3 (or million liters).

Source: Results of the study

In terms of Brazilian production, all products were affected negatively in both shock scenarios, as compared to the BAU one. Sugarcane is the most affected crop in both LRP1 and LRP2 scenarios. As a result, ethanol and sugar production decreases 6% and 3%, respectively, in the LRP2 scenario. Although pasture decreases in both scenarios, beef production decreases by a much smaller amount.

The production reduction is a result of the demand decrease, due to the increase in commodity prices, as shown in

Table **6**. It is important to note that real sugar and ethanol prices in the BAU scenario are lower than 2010 real prices. Due to this fact, land restriction scenarios LRP1 and LRP2 presented much higher prices for both products in 2020. Since consumers are more elastic with regard to ethanol than to food products, the effect on demand was higher than for other products. As a result, sugar prices will also increase in order to compete with ethanol for the feedstock (sugarcane).

Table 4 also shows that despite the fact that beef production did not change much in both scenarios, lower availability of land for pasture increased prices by 5% and 21%, respectively, for the simulations LRP1 and LRP2. In other words, livestock production with higher intensification of pasture will only happen with higher beef prices, when crop feed becomes more competitive than before. In addition, it is important to mention that beef production will increase in the North Amazon, which would partly compensate for the reduction in the Cerrado biome region.

Table 6– Commodity prices in local currency (R$), deflated by 2000 prices

	Unity	2010	2020 BAU	2020 LRP1 Scenario	2020 LRP2 Scenario	LRP1/BAU	LRP2/BAU
Corn	R$/ton	131	168	177	191	5%	13%
Soybeans	R$/ton	290	343	359	398	5%	16%
Cotton	R$/ton	685	714	739	795	3%	11%
Rice	R$/ton	260	215	223	237	4%	10%
Dry Beans	R$/ton	639	508	535	571	5%	12%
Soybean Oil	R$/ton	923	1,104	1,138	1,216	3%	10%
Soybean Meal	R$/ton	252	314	321	341	2%	9%
Sugar	R$/ton	382	244	278	318	14%	30%
Ethanol	R$/liter	0.50	0.40	0.46	0.52	13%	28%
Beef	R$/Kg	2.63	3.05	3.21	3.68	5%	21%
Pork	R$/Kg	1.01	1.30	1.34	1.42	3%	10%
Poultry	R$/Kg	0.69	0.85	0.88	0.93	3%	9%

Note: Crop and meat prices are producer prices; ethanol, sugar, soybean meal and soybean oil are wholesale prices.

Source: Results of the study

5. Policy Implications and Recommendations

The main objective of the PPCerrado policy is to reduce deforestation in the Cerrado biome. The Brazilian NAMAs were implemented by Decree 7.390 from December 9th, 2010. The targets are:

- Legal Amazon: 80% reduction by 2020 from the baseline (average annual deforestation rate from 1996 to 2005) reaching 390,702 hectares;
- Cerrado Biome: 40% reduction by 2020 from the baseline (average annual deforestation rate from 1999 to 2008) reaching 942,000 hectares.

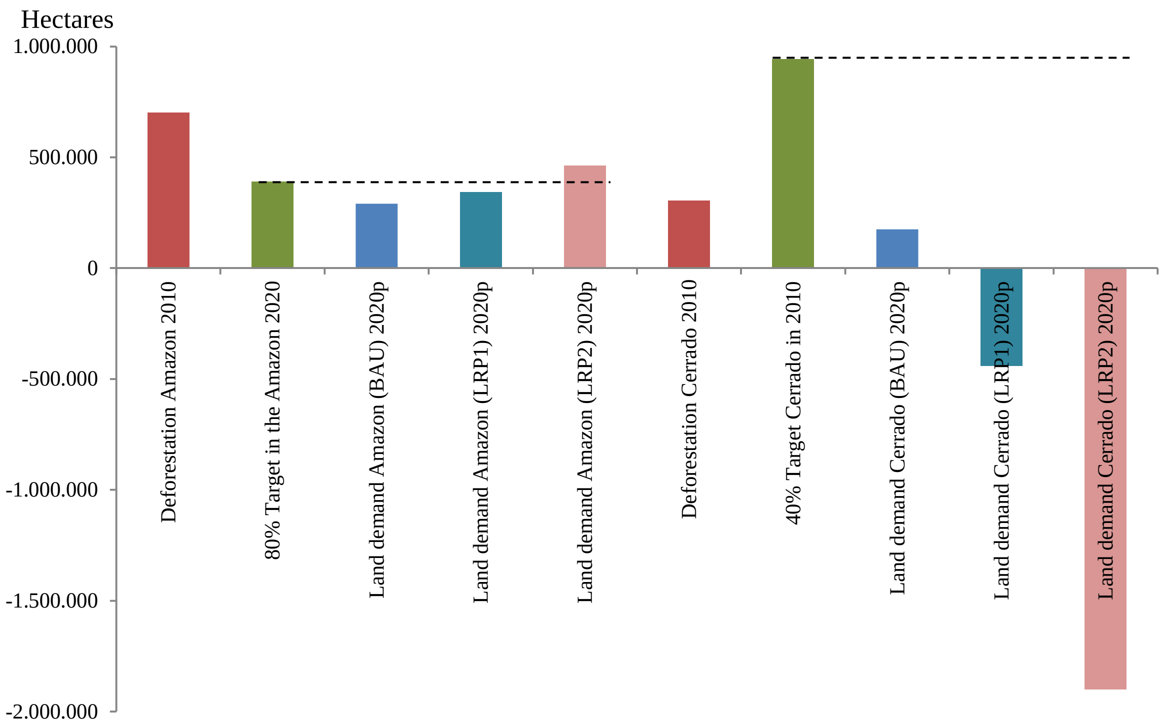
Compared to the current deforestation rates (2010 for Legal Amazon and for Cerrado Biome), the 2020 targets imply a 44% reduction for the Legal Amazon and a hypothetical growth of three times the observed deforestation of 2010 for the Cerrado Biome. Deforestation rates are decreasing at the same pace in both regions.

We compared the results for land demand for agricultural expansion until 2020 from the three scenarios simulated to the deforestation target in 2020 and the observed deforestation rate in 2010 for both the Legal Amazon and Cerrado biome, as shown in For the baseline scenario, until 2020 the year average deforestation rate for both Legal Amazon and Cerrado biome will comply with the deforestation reduction target. In the Legal Amazon the deforestation rate is expected to decrease to 290.1 thousand hectares in 2020, 26% lower than the target. In the case of the Cerrado biome, the deforestation rate is expected to be 175.4 thousand hectares in 2020, 81% lower than the target and also 42% lower than the currently observed deforestation. In other words, if no protection policies are implemented until 2020, agricultural land demand will be lower than the deforestation target in both biomes analyzed.

Figure 3).

For the baseline scenario, until 2020 the year average deforestation rate for both Legal Amazon and Cerrado biome will comply with the deforestation reduction target. In the Legal Amazon the deforestation rate is expected to decrease to 290.1 thousand hectares in 2020, 26% lower than the target. In the case of the Cerrado biome, the deforestation rate is expected to be 175.4 thousand hectares in 2020, 81% lower than the target and also 42% lower than the currently observed deforestation. In other words, if no protection policies are implemented until 2020, agricultural land demand will be lower than the deforestation target in both biomes analyzed.

Figure 3– Deforestation rate in 2010, land demand and deforestation target in 2020



Note: Deforestation targets are 80% reduction in the Amazon Biome and 40% reduction in the Cerrado Biome

Sources: LAPIG, INPE, ICONE, Decree 7.390

Pasture intensification is essential to evaluate land use dynamics in Brazil. In order to reduce deforestation rates in the Amazon and Cerrado, a reduction in pasture area by 3.3 million hectares is expected in the Cerrado biome in 2020, as compared to 2010. Since cattle-raising is the main activity in the Amazon, pasture will continue to increase until 2020 in the baseline scenario by 2.3 million hectares, as compared to 2010.

For the LRP1 scenario, reducing land demand in the Cerrado causes a leakage effect over the deforestation in the Legal Amazon. In this region, the deforestation rate will increase 18% compared to the baseline scenario. However, the deforestation target will still be complied in this scenario, reaching only 342.6 thousand hectares in 2020, 12% lower than the target.

It is important to note that, in order to minimize the impacts on crop production in the LRP1 scenario, pasture will decrease 8.8 million hectares in the Cerrado biome from 2010 to 2020,

increasing the intensification rate of beef production. On the other hand, pasture will increase in the Amazon by 2.7 million hectares, 400 thousand hectares more than in the baseline scenario.
In the case of LRP2 scenario, when protected areas are created in the Cerrado biome, the leakage effect in the Amazon has important negative implications. Deforestation in the Legal Amazon in 2020 will be 18% higher than the target, implying non-compliance with the law.

Pasture intensification will be even more important in LRP2 scenario. In the Center-West Cerrado region, pasture area needs to decrease by 13.4 million hectares in order to increase 1.1 million hectares of cropland and to allow the creation of protected areas. The Northeast Cerrado will need to reduce pasture area in 7.7 million hectares from 2010 to 2020 to accommodate higher cropland (1 million hectares) and the creation of protected areas. The Amazon is expected to accommodate part of the reduction in pasture areas in the Cerrado, increasing by 3.6 million hectares from 2010 to 2020. This means that, in this scenario, pasture in the Amazon will be 1.3 million hectares higher than in the baseline one.

Considering that livestock profitability is an opportunity cost for intensification, through multiplying the BAU scenario livestock profitability by pasture reduction, the total “opportunity cost” of intensification is found to be between R$ 1 billion and R$ 3 billion, respectively, for LRP1 and LRP2 scenarios. They also represent 5.5% and 16.3% of the total BAU scenario livestock profitability.

Policymakers must, therefore, balance these effects to make rational decisions and avoid segmented and sub-optimal policies. Creating protected areas can conserve the Cerrado biome but can also generate negative impacts for carbon-richer regions, such as the Legal Amazon. We suggest that policymakers balance carbon emissions reduction in the Cerrado and take into account the increase in [what?] in the Amazon, as they consider the agricultural dynamics in Brazil and its regions, as well as the main objective of the policy to reduce deforestation, i.e the reduction of total Brazilian GHG emissions.

In addition to the environmental impacts, policymakers must consider the socio-economic impacts of the PPCerrado policy. Commodity prices will be higher in the shock scenarios as compared to the baseline. On the other hand, total production of crops and meat will be lower in both simulated scenarios. Finally, investments in pasture intensification are essential for reducing deforestation, reducing natural vegetation and releasing area for cropland.

6. Final Considerations

The simulation reported in this study shows that the creation of conservation areas in the Cerrado biome leads to a re-allocation of production for both crops and livestock in 2020, decreasing in the Cerrado biome and increasing in the Atlantic Forest (basically in the South), the Amazon biome (North Amazon) and the Caatinga biome (Northeast Coast). In addition, the proposed policy has negative socio-economic impacts, increasing commodity prices and reducing the production of all products simulated. On the other hand, land use will require higher technology, especially for livestock production. Intensification of pastureland is expected to some degree, which allows a less negative impact on crop production due to the substitution of pasture by cropland.

It is also important to note that the amount of protected areas is essential for measuring the impacts. The negative effects on prices and production increase as the area allocated to conservation increases. Policymakers should consider all these effects when analyzing the PPCerrado policy, since the Cerrado biome is the most important region for agricultural expansion in the future. More importantly, leakage effects should be taken into account. The Cerrado biome has much lower carbon stocks than the Atlantic Forest and the Amazon, so maybe it would be rational to have more agricultural expansion in this biome rather than in others in order to reduce carbon emissions from land use changes.

The results above have clearly shown that higher levels of protection areas in the Cerrado lead to non-intentional, but nevertheless relevant socioeconomic and environmental impacts. An increase in agricultural prices and reductions in agricultural output (and rural income) are a cost for Brazilian and world citizens. Deforestation shifting is another relevant indirect effect of this policy, particularly because it can generate deforestation in more carbon rich regions, [thereby] leading to higher GHG emissions.

There are three key analyses to be considered for policymaking. The first one is the leakage effect over carbon richer biomes such as the Amazon, the effect of which is the reallocation of agricultural production as a result of creating protected areas in the Cerrado. The second is the high amount of investments for beef production intensification, which will only happen with agricultural subsidies and policy incentives. Finally, in addition to the environmental impacts of PPCerrado policy, socio-economic impacts might also be taken into account. Both alternative scenarios presented production reduction in all commodities analyzed, together with higher level of prices compared to BAU scenario. Macroeconomic impact policies, such as inflation, also need to be considered by policymakers.

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