1. INTRODUCTION

Agribusiness plays an important role in the Brazilian economy, accounting for 21% of the national GDP in 2015 (CEPEA, 2016). For the beef industry, it is estimated that from 2010 to 2013, the area allocated to pastures occupied 19% to 23% of the entire national territory, which represents between 164 to 198 million hectares, depending on the source considered.

In 2014, according to Brazilian Beef Exporters Association – ABIEC (2015), beef cattle production reached 10.1 million of carcass equivalent tons (TEC), out of which 2.1 million (20%) was for exports. In the study "Long-term vision for the Brazilian beef industry: implementation of the Forest Code and reduction of deforestation," the 2035 baseline scenario indicates that pasture areas will need to be reduced by 18 million hectares compared to 2010, together with an increase of beef cattle production by 44%. That is, the beef industry should increase its production per hectare by 58% in 25 years.

Given this scenario, the intensification of cattle ranching represents a unique opportunity for the release of pasture areas for other uses, deforestation and GHG emissions and increase in beef cattle productivity, ensuring food security and conservation of natural resources.

This study aims to present an economic analysis of cattle ranching intensification from the farmer’s point of view, comparing several combinations of technologies and possibilities for expansion of the agricultural frontier. These analysis also show in which conditions (size of the property, technology migration, biome) intensification is economically feasible; if the intensification of pastures in already cleared areas is more advantageous than clearing new areas of native vegetation; what is the implication of land appreciation in the profitability of the activity; and if it is possible to envisage the development of cattle ranching with environmental conservation.
2. METHODOLOGY

In order to assess the economic feasibility of cattle ranching intensification in the Amazon, Cerrado and Atlantic Forest biomes, four hypothetical scenarios were considered:

**SCENARIO 1**
Cattle ranching intensification, considering only the production area of a hypothetical property.

**SCENARIO 2**
Cattle ranching intensification in the production area of the property and cattle ranching expansion over own vegetation area (over Legal Reserve surplus).

**SCENARIO 3**
Cattle ranching intensification in the production area of the property and cattle ranching expansion over purchased native vegetation area (expansion over remaining vegetation in purchased property).

**SCENARIO 4**
Cattle ranching expansion over purchased vegetation area.

For the Atlantic Forest biome only scenario 1 was considered, since territorial expansion is not allowed due to the deforestation restriction in the biome (Law 11.428/2006).

For all of these scenarios, hypothetical complete cycle (breeding, raising and fattening) farms were considered, which correspond to 50% of the national herd, with production areas of 3 thousand hectare (large) and 300 hectare (small). The productivity levels (live weight per hectare per year) adopted were: extractivist (productivity of 0-3@/ha/year), low (3-6@/ha/year), medium (6-12@/ha/year) and growing (12-18@/ha/year).

Several sources of data on investments, costs and revenues were combined. The financial rates applied in the analysis were 5.85% p.a. for the inflation rate and 8.5% p.a. for the interest rate (average considered for 20 year period), resulting in a real interest rate of 2.5% p.a.. The investments were distributed in four years and the costs and revenues also proportional to the farm’s productivity gains over the same period. The main business revenue was the sale of animals after each production cycle.

The return on investment calculation for cattle ranching was based on the value of investments made for production intensification (technology migration to higher levels of productivity), depreciation and profit (revenue minus cost). On the other hand, the appreciation of the land was included in the calculation of return on investment considering the price of pasture area over the area of the property. For both cattle ranching and land appreciation, the results were adjusted to present value considering the inflation and interest rates in a period of 20 years and classified according to the Net Present Value (NPV), Internal Rate of Return (IRR) and Payback (or period for the recovery of invested capital).

2 Considering that 1@=15kg of live weight.
3. RESULTS

The results were presented by biome and size of production property and detailed in the complete report and summarized in below.

### TABLE 1. Results per biome and size of production area of the hypothetical properties

<table>
<thead>
<tr>
<th>SCENARIO 1 (intensification with use of 100% of productive area)</th>
<th>CERRADO</th>
<th>AMAZON</th>
<th>ATLANTIC FOREST</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,000 ha</td>
<td>All technology levels are economically feasible. The most profitable (highest relative NPV) and resulting in highest IRR to the cattle activity (22%) being the medium to growing technology.</td>
<td>3,000 ha</td>
<td>All technology levels are economically feasible. The highest return per ha was the migration from low to growing technology. However, the highest IRR in cattle activity (17.6%) occurs in the migration from medium to growing technology.</td>
</tr>
<tr>
<td>300 ha</td>
<td>Cattle activity feasible for the migration from low and medium to growing technology. The most profitable and with highest IRR being the migration from medium to growing technology with IRR about 13.4% for the total project.</td>
<td>300 ha</td>
<td>The most profitable level being the migration from low and medium to growing technology in the expansion area with IRR about 12% for the total project.</td>
</tr>
<tr>
<td>300 ha</td>
<td>Economically feasible</td>
<td>300 ha</td>
<td>Economically feasible</td>
</tr>
</tbody>
</table>

### SCENARIO 2 (intensification of initial area + expansion in own area, representing 50% of final productive area)

| 3,000 ha | Feasibility in the migration from low and medium to growing technology, the most profitable being the migration from medium to growing with extractivist production in expansion area with IRR about 9.2% to the cattle activity. | 3,000 ha | The most profitable level being the migration from low to growing and extractivist technology in the expansion area with IRR about 13.4% for the total project only due to the land price valuation. | 3,000 ha | Expansion not allowed in the biome due to Law 11.428/2006. |
| 300 ha | Economically unfeasible | 300 ha | Economically unfeasible | 300 ha | Economically unfeasible |

### SCENARIO 3 (intensification of initial area + expansion in acquired area representing 50% of final productive area)

| 3,000 ha | It is economically feasible in a few combination of technologies, but only due to land price valuation. Medium to growing technology migration and expanding using low technology has IRR about 7.6%. | 3,000 ha | It is economically feasible in a few combination of technologies, but only due to land price valuation. Low to growing technology migration and expanding using growing technology has IRR about 7%. | 3,000 ha | Expansion not allowed in the biome due to Law 11.428/2006. |
| 300 ha | Economically unfeasible (highest IRR about 2.7%) | 300 ha | Economically unfeasible (highest IRR about 5.0%) | 300 ha | Economically unfeasible (highest IRR about 5.0%) |

### SCENARIO 4 (expansion in acquired area representing 100% of productive area)

| 3,000 ha | Economically unfeasible (highest IRR about 4.5%) | 3,000 ha | Economically unfeasible (highest IRR about 5.2%) | 3,000 ha | Expansion not allowed in the biome due to Law 11.428/2006. |
| 300 ha | Economically unfeasible (highest IRR about 3.2%) | 300 ha | Economically unfeasible (highest IRR about 4.6%) | 300 ha | Economically unfeasible (highest IRR about 4.6%) |

**TABLE 1.** Results per biome and size of production area of the hypothetical properties
3.1. Results for Cerrado biome

SCENARIO 1

For this biome, scenario 1 (intensification of cattle ranching in the production area of the property) showed the highest profitability (relative NPV) in the highest intensification level (12-18@/ha/year), with a higher IRR (at constant 2014 prices, reaching up to 22%) and lower discounted payback, both for properties with 300 and 3 thousand hectare, with a 5 year payback period.

The large farms (with 3 thousand hectare of production area) showed economic feasibility in all cases, with the IRR above the Minimum Attractive Rate of Return (MARR) considered (8.5%). However, the lower the initial productivity level of the farm (as in the cases of properties of up to 6@/ha/year of live weight gain), the lower the IRR and the higher the payback period.

The small farms (with 300 hectare of production area) showed better economic feasibility in the scenarios that start with medium (6 to 12@/ha/year) to growing (12 to 18@/ha/year) productivity.

SCENARIO 2

The Scenario 2 in a large farm showed the best economic return migrating from the initial medium productivity (6-12@/ha/year) to growing (12-18@/ha/year), using extractivist production in the expansion area (up to 3@/ha/year), (considering productivity gains in 1,500 hectare, besides from cattle ranching expansion over own vegetation area and considering that the property has a native vegetation surplus that can be legally converted into production area in 1,500 hectare). In this case, the IRR was of 13.1% with a payback period of 10 years. However, the best profitability (relative NPV) occurred in the growing technology level (12-18@/ha/year) in the expansion area.

SCENARIO 3

In scenario 3 (intensification of cattle ranching in production area and expansion in purchased area) for a large farm, the two projects with the highest economic return but with IRR below the MARR considered (8.5%) were those in low (3-6@/ha/year) and medium (6-12@/ha/year) to growing (12-18@/ha/year) production intensification level, associated to expansion in purchased area using growing and low production technology levels, respectively. That is, implementing a cattle ranching intensification project (in 1,500 hectare) combined with the purchase of new area for expansion of the activity (in the additional 1,500 hectare) has low or null economic feasibility in the simulated scenario.

In the analysis of the farms with 300 hectare, no combination of cattle ranching intensification and production expansion was economically feasible in the simulated scenarios 2 and 3, with negative project results in almost all cases, even incorporating land appreciation.
SCENARIO 4

For scenario 4, considering only the implementation of cattle ranching over purchased native vegetation area, with different production technologies, it was possible to observe profitability behavior as in the previous scenarios. That is, cattle ranching intensification leading to increasing returns on investments made for large properties (exclusively due to land appreciation), not being economically feasible in small properties.

In general, for the expansion of productive areas projects in a 3,000 hectares property, the land appreciation linked to the expansion over native vegetation areas has greater weight in the return on investment project than the profitability of cattle ranching itself, regardless of the productivity. Otherwise, in the intensification projects in the same area, cattle ranching has greater impact on the return of the project than the appreciation of the land, being crescent with the productivity levels considered.

3.2. Results for Amazon biome

SCENARIO 1

In scenario 1 (considering only cattle ranching intensification without expansion of the production area), in production area with 3 thousand hectare, the highest profitability (relative NPV) occurs when migrating from low (6@/ha/year) to growing (12-18@/ha/year) productivity, in contrast to the Cerrado, where the most profitable would be to increase productivity from medium to growing level. However, the highest economic return (highest IRR) occurs in the migration of medium to growing technology. In this scenario, the IRR of projects varies from 14% to 20% in 20 years, with payback of 11 years to 6 years, respectively. Even not considering land appreciation, technology migration is profitable for all levels of productivity evaluated.

SCENARIO 2

The results from scenario 2 that combines production intensification and cattle ranching expansion over own native vegetation (over Legal Reserve surplus), in the case of large properties, the project with highest profitability (relative NPV) was the one with productivity intensification migrating from low (3-6@/ha/year) to growing level (12-18@/ha/year), with expansion in own area with growing (12-18@/ha/year) technology. However, the IRR is of 11.1% and the payback period of 19 years, lower than in the case of intensification with medium (6-12@/ha/year) to growing (12-18@/ha/year) initial productivity and expanding over vegetation with extractivist technology (up to 3@/ha/year). The IRR in the last case reaches 13.4% and payback period is of 13 years.

The small farms (with 300 hectare of production area) only showed economic feasibility in the transition from medium (6-12@/ha/year) to growing (12-18@/ha/year) productivity level. In the other cases, the positive returns were exclusively due to land appreciation, and negative profitability for the small properties.
SCENARIO 3

The results in scenario 3 were very similar to those of scenario 2, since the only difference is the purchase of vegetation area for cattle ranching expansion, besides from production intensification in the property. The financial results, however, were worse than in scenario 2, and there was no case where the IRR was higher than the MARR, considering the total return on investment of the project (with land appreciation and production intensification).

SCENARIO 4

Similarly, in scenario 4, which considers only production expansion over purchased vegetation area, none of the projects was considered economically feasible.

3.3. Results for Atlantic Forest biome

SCENARIO 1

In the case of Atlantic Forest (only scenario 1 was considered), the projects with greatest profitability, both for large and small properties, were those with more technology migration, that is, when passing from medium (6-12@/ha/year) to growing (12-18@/ha/year) level, resulting in an IRR of 31.6% and 20.9%, respectively. It is important to highlight that the return on investment is explained mainly by cattle ranching intensification, and with lower impact of land appreciation in the project’s NPV compared to the Cerrado and Amazon biomes. The payback period is also lower in this biome, varying from 4 to 7 years in the case of large properties and 6 to 12 years in small properties.

This result is different from the Amazon and Cerrado biomes, especially due to the differences in logistics and infrastructure surrounding the properties. Additionally, the variations in the prices of land with pasture are lower in the Atlantic Forest relative to other biomes, resulting in lower impact on the return of the investment project.

Unlike the Cerrado and Amazon biomes, all farms with up to 300 hectare proved to be economically feasible for production intensification, especially in cases where the technology migration reaches 12 to 18@/ha/year. There are few properties with an area above 2,500 hectare, which is in line with the profile of the properties in this region.

Compared to other regions, the intensification projects in this biome have the highest rate of returns on investment for all productivity levels considered, reaching up to 32%. This result is mainly explained due to the greater proximity of this region to beef consumer centers and better access to inputs for intensification.

Even altering the price of cattle, the impact result is too small compared to the relative IRR and NPV.

4 Even altering the price of cattle, the impact result is too small compared to the relative IRR and NPV.
4. FINAL REMARKS

Based on this analysis, it is possible to conclude that, due to economies of scale in cattle ranching, larger properties are able to achieve better economic returns through intensification compared to smaller properties. Cattle ranching intensification in all scenarios for properties with up to 300 hectare is only economically feasible in the Atlantic Forest biome, due to the higher return per hectare of the activity in this region, compared to the other analyzed biomes.

Economic feasibility was higher in cattle ranching intensification projects in already cleared areas compared to projects that include expansion over native vegetation, both in the case of own area (Legal Reserve surplus) and purchased area, for different levels of productivity.

The projects which include expansion over purchased native vegetation show that the return on investment is determined, exclusively, by real estate appreciation due to the low prices of land with vegetation compared to those of land with pastures.

Thus, note that it is possible to envisage cattle ranching with environmental conservation. Nevertheless, in the agricultural frontier regions, deforestation is still attractive from the real estate appreciation perspective – a decisive factor in the farmer’s decision process (considering that it is economically preferable to expand in new vegetation areas rather than through pasture recovery techniques). In this context, command and control policies are necessary in order to contain deforestation, in addition to private policies, such as restrictions on purchase of cattle from illegal deforestation areas; as well as policies to promote the adoption of Good Agricultural Practices (GAP), differentiated prices for quality of the carcass and greater inclusion of cattle ranchers in the formal beef market.

Moreover, two important factors should be considered in order to boost production intensification without expansion over new areas of native vegetation. The first is the investment in recovery and renovation of pastures within properties, especially those in agricultural frontier regions, considering the need to produce more without increasing pasture areas. In this sense, what is found is the existence of several technologies and management practices that are already available for producers. However the greatest challenge is dissemination, large scale adoption, technical assistance to the producer and necessity of capital injections.

The second is the necessity of rural extension and technical assistance, essential in order to implement sustainable intensification projects in the properties. This is one of the gaps faced by producers, who often need to better understand the investments (and returns) and the necessary techniques, which can make them less reticent to the process. According to case studies and pilot projects (IIS/ICV, 2015, GTPS, 2014) these are some of the main barriers to be overcome to ensure that cattle ranching intensification is widespread in Brazil.
ABOUT INPUT

The Land Use Initiative (INPUT - Iniciativa para o Uso da Terra) brings together Agroicone with Climate Policy Initiative (CPI) in Brazil. It counts on a dedicated team of leading economists, lawyers, mathematicians, geographers and agronomists who work at the forefront of how to increase environmental protection and food production.

INPUT engages stakeholders in Brazil’s public and private sectors and maps the challenges for a better management of its natural resources. Also, it mobilizes agents of the productive chains in order to promote compliance with the new Forest Code. In addition, the project aims at analyzing and influencing the creation of a next generation of low-carbon economy policies in Brazil.

In this project, Agroicone is responsible for generating information about the alternatives to native vegetation restoration, as well as the areas of compensation for Legal Reserves and engaging the private sector in discussing the challenges of regulation and create industry solutions that enable large-scale adaptation.

For more information on the project, visit: www.inputbrasil.org