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THESIS PROJECT

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Forest Credits to Foster Reforestation in the Brazilian Atlantic Forest

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Preface

The reduction of native vegetation habitats is posing increasing pressure on biodiversity and is presenting constant challenges to those governments, agencies and individuals who devolve their efforts to protect the environment. In this context, creatine and innovative tools are necessary to maintain habitats and possibly, reverse the negative trends. The employment of financial incentives to foster conservation relies on the appeal of economic gain, the same reasons behind unsustainable exploitation of the environment. If planned carefully, these incentive schemes can target groups of the human population which are more in need and channel the economic gain towards those categories.

This research aims to add to the body of literature that studies ways in which incentive schemes, finalized to environmental restoration and conservation, can improve the most unfortunate social contexts.

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Summary

The Atlantic Forest is a Brazilian biome that has been heavily impacted by deforestation. To encourage reforestation, Brazilian institutions have regulated to protection of the vegetation located on private properties by introducing the Legal Reserves (LR), areas that land-owners must maintain covered in forest. LR can be established anywhere on a property and their size is 20% of the property area, in the Atlantic Forest.

In order to increase compliance, the Brazilian government created the Environmental Reserve Quota (CRA). For land-owners who do not wish to reforest their land, the CRA program allows to comply with the LR requirement by purchasing forest credits (CRA). CRA can be sold by land-owners whose property houses a surplus area of forest. The offsetting can only occur by purchasing CRA issued from the Atlantic Forest.

Depending on the way it is implemented, the CRA scheme could be promising regarding compliance and reforestation. CRA price depends on the opportunity cost of the land. As land-owners aim to purchase the cheapest CRA, a larger market entails a more varied option of CRA prices. Instead, in a more restricted market, the land is less heterogenous and thus, the CRA price varies less. Hence, the size of the CRA market plays an important role.

The potential of the CRA scheme depends also on the land-owners: as the size of the market determines availability of differently-priced CRA, land-owners influence the CRA price by shaping demand and supply of credits. However, not all land-owners have the possibility to join the CRA scheme, due to factors such as lack of education.

In this study, the CRA market is analyzed by implementing an Agent-Based Model (ABM) that simulates the role of the land-owners acting in the CRA scheme. The model will depict the heterogeneity of land-owners' strategies in the CRA market and portrays the resulting forest cover.

Three scenarios where explored: one characterized by a CRA market restricted to the state level; one where the market is national; one, where the market is national and that includes the participation of land-owners previously excluded by the CRA scheme.

The results show that the largest forest area is accomplished in the state-level market, where the price of the CRA are also higher compared to the other scenarios. In the national scenarios, most of the forest cover is located in areas of lower opportunity cost, where CRA are cheaper. Between the two national market scenarios, the one that resulted in higher forest cover is the more inclusive.

Introduction

The Atlantic Forest & the Brazilian legislation

The Atlantic Forest is one of the 6 biomes that constitute the native vegetation of Brazil (Fig.1). This biome is of great relevance for Brazilian economy as it houses 70% of the population, intensive govern-subsided agriculture (Galindo-Leal et al., 2003) and major urban centers such as Rio de Janeiro and Sao Paulo (Rezende et al., 2018). From the environmental perspective, the vegetation of the Atlantic Forest is one of the oldest in the world, as it appears to host species existing in Gondwana (FAO, 2012). Furthermore, 50% of tree species are believed to be endemic of this Brazilian biome (FAO, 2012). Due to the increasing pressure of agriculture, industrialization and urbanization, the Atlantic Forest has been victim to intense deforestation that started as early as the 16th century (Coudel et al., 2012). By the year 2016, according to the Brazilian National Institute for Space Research (INPE), the remaining portion of the biome amounted to approximately 13% of the original extent (Hirota, 2017; Wagner et al., 2020)

Figure 1: The country of Brazil, divided into 26 states and the Atlantic Forest biome (in darker green). Maps were obtained from the Brazilian Institute of Geography and Statistics (IBGE) and modified using ArcGis.

The environmental legislature appointed to regulate land practices in private lands in Brazil was first instituted in 1934 under the name of Forest Code, and has been revised and supplemented over the years (Fig. 2) (Brancalion et al., 2016). Among other measures, the Code introduced protected areas and instituted the first Legal Reserves (LR), which are portions of private land that must be maintained covered in native vegetation (Rylands & Brandon, 2005; Santiago et al., 2017). Renewed in 1965, the FC establishes the Areas of Permanent Protection (APP), which are areas of special importance due to their location mostly close to water resources (Metzger et al., 2019; Rezende et al., 2018), together with the Special Reserves of Natural Heritage (RPPNs), forested lands voluntary set-aside by the land-owner (Pegas & Castley, 2016).

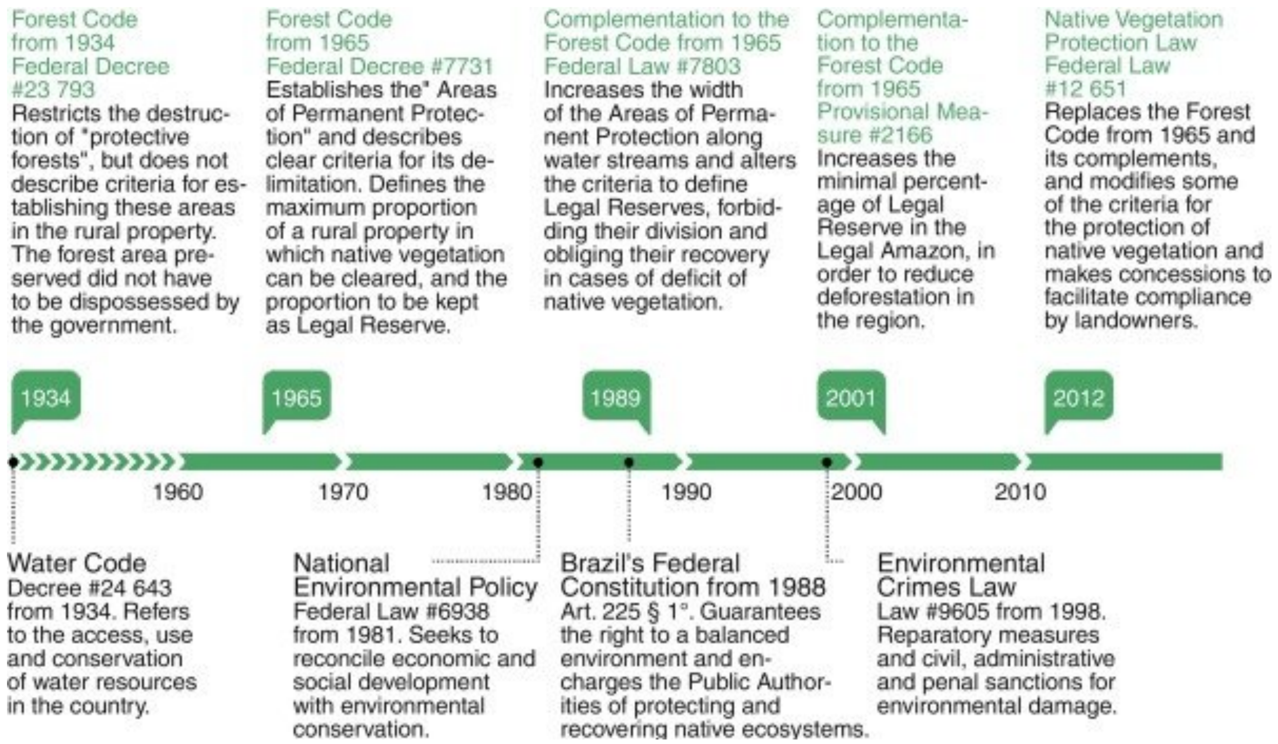

Figure 2: Evolution of the Brazilian body of law concerning land use and forest protection. Image retrieved from Brancalion et al., 2016.

As shown in Fig.3, APPs are instituted on private land close to water bodies, hill tops and steep slopes, with the aim to protect such areas. The presence of APPs depends on the characteristics of the territory and so there is no required portion of land to reserve for APPs. On the contrary, LRs (Fig.3) do not protect a specific feature of the landscape and so they can be placed anywhere on a private property. In 2000, the introduction of the National System of Conservation Units (SNUC) divided protected areas between fully protected and of sustainable use: in the first category are included APPs and only a few activities are allowed, such as research and ecotourism; on the other hand, the LRs were considered areas of sustainable use, where logging and grazing are permitted (Brancalion et al., 2016). In order to reduce deforestation, the Forest Code increased, in 2001, the set-aside area requested as LR, establishing a different requirement per each biome: 80% in the Amazon, 35% In the Cerrado and 20% in the rest of the biomes, including the Atlantic Forest (Coudel et al., 2012).

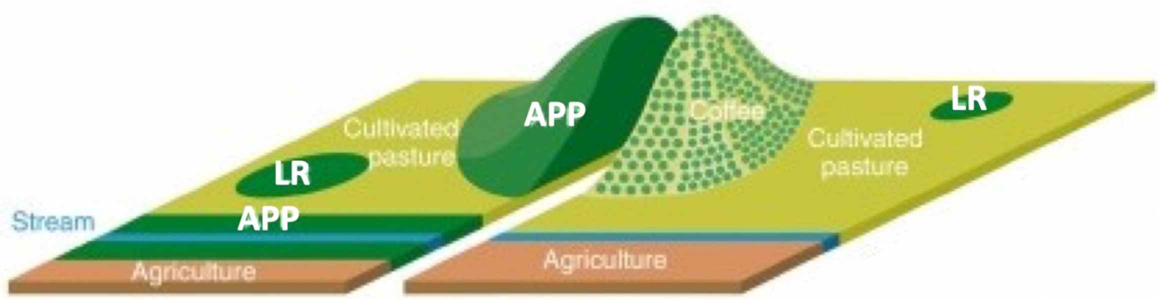

Figure 3: Differences between APP and LR. LR can be located everywhere and need to be present in a specific portion that varies across biomes; APPs are located on steep slopes, hilly tops and adjacent to water bodies. The property on the left side of the picture complies with the law, the one on the right, does not. Image retrieved from (Brancalion et al., 2016a).

This measure was largely unpopular among land-owners. Indeed, while they recognized the importance of APP to guarantee ecosystem services, LR were considered inconsistent with land-owning rights (Muhar et al., 2018) and detrimental to agricultural activity (Winter & May, 2001).

Thus, after decades of scarce compliance (Muhar et al., 2018), the Forest Code was replaced, in 2012, by the Native Vegetation Protection Law (NVPL) (Rezende et al., 2018). The NVPL was designed to enhance compliance and control. To that end, tools were introduced, such as the Environmental Rural Registry (CAR), a voluntary national cadastral for agricultural establishments, that provides the authorities information regarding law fulfilment, and the Environmental Reserve Quotas program, which allows to compensate a LR deficit by purchasing forest credits (CRA) (Brancalion et al., 2016; Coudel et al., 2012). The increased flexibility of the law, however, came with a price, as the NVPL pardons illegal deforestation that occurred before 2008 (Soares-Filho et al., 2016). Furthermore, the measure introduced by NVPL reduce the reforestation requirements by approximately 60%, due to reconsideration of the criteria that protected hilltops, exclusion of intermitted springs (whose water does not flux constantly) from APPs, reduction of APPs around lentic waterbodies and decrease of protection of the buffer area adjacent to springs (Brancalion et al., 2016).

The implementation of the NVPL, however, had positive effects on law enforcement. Before the NVPL, the low level of enforcement had created a sense of impunity that was only contained in 1998, with the introduction of the Environmental Crimes Law, that punish non-compliance with the FC with sanctions and obligation to correct wrong actions (Brancalion et al., 2016). With the NVPL, especially the introduction of the CAR was beneficial as the availability of geospatial data increased the resources of enforcing agents (Brancalion et al., 2016)

CRA - Environmental Reserve Quotas

The CRA system is a new form of Payment for Ecosystem Services (PES) that aims to both increase forestation and grant a land-owner the option to comply with LR requirement not only through reforestation of their own property, but also by purchasing someone else's native vegetation (Vieira et al., 2018). The CRA are credits that can be issued for a private area, that is covered in native vegetation and not registered as LR or APP. The CRA issued from such area can be sold by a landowner with an excess of vegetation to one who has a deficit. In order for the LR debt to be completely offset, the purchaser needs to buy in CRA an amount of land corresponding to their debt and said land needs to be in the same biome (de Freitas et al., 2017; Muhar et al., 2018).

The performance of an economic tool such as the CRA depends on the socioeconomic and ecological context of the country where it is implemented. In Brazil, where only a small portion of landowners voluntarily comply with the environmental law (Muhar et al., 2018), several authors suggest that the introduction of a financial tool could encourage compliance, if carefully designed (Brito, 2017; Soares-Filho et al., 2016; Vieira et al., 2018). Indeed, the CRA scheme would result in a forest increase only under specific conditions mostly based on the borders of the CRA market, i.e. the area within which it is allowed to offset. The borders of the market indicate where is possible to purchase CRA: if, for example, it is possible to offset by purchasing land anywhere in the biome, the borders of the market are nationals, that is, extend to the whole Brazil; if, on the other hand, LR debts are required to be offset within the state, CRA can only be purchased from lands of the same biome and same state.

Depending on the borders of the market, the landscape of the Atlantic Forest can look very different: most of the forest could be located in areas where the CRA are cheaper, while the more expensive land is left to agriculture (Bernasconi et al., 2016; de Freitas et al., 2017; Muhar et al., 2018). The cost of the CRA depends on the opportunity cost of the land, that is, the profit that would have been earned if the land would be cultivated (Bernasconi et al., 2016; de Oliveira et al., 2020). The land opportunity cost is determined by the biophysical properties of the landscape: a more fertile land has a higher agricultural productivity leads to higher opportunity costs (Winter & May, 2001).

Another factor that influences the price of the CRA is the ratio between demand and supply of forest credits: the demand results from the legislative requirements and the will to comply with them, while the offer is the land covered in native vegetation available for CRA issuing and, therefore, for

offsetting. If, as it has been proposed by Brazilian istitutions (Brancalion et al., 2016b), already protected areas were made available for CRA issuing, no added reforestation would occur and the price of the credits would drop, making the activity of issuing CRA unattractive (Freitas et al., 2017).
At present, the NVPL imposes a national market with offsetting allowed within the same biome. However, in order to maintain a minimum of native vegetation within the singular states, the regional governments are encouraging land-owners to purchase CRA issued within the same state (Winter & May, 2001). In the case of the states of São Paulo and Minas Gerais, the local institutions are considering shifting this encouragement to actual regulation (Bernasconi et al., 2016; de Oliveira et al., 2020).
Even though it has been theorized in the NVPL, the CRA is at present not operational. This allow researchers to focus on ways to implement the market that can be used to inform policymakers, while decisions have not been finalized yet. A few studies are available on the CRA market and mostly focused on the ways to implement this tool. (Bernasconi et al., 2016) state that a market with restricted borders (i.e. where LR offset is only allowed within the same state) can improve conservation. (Soares-Filho et al., 2016) adopt a more economic perspective, considering demand and supply of land and their results show that the supply of credits exceeds the demand; (de Freitas et al., 2017) compared the outcomes of four possible scenarios, where the offsetting of the LR debt can occur from CRAs issued only from protected vegetation, unprotected one, both or small-scale farmers' land. Their findings suggest that it is possible to ensure maximal forest protection and, at the same time, provide cash flow from large to small land-owners without converting agricultural lands into forest. According to de Freitas et al. (2017), small-scale land-owners could contribute to the CRA market by offering the equivalent of 25 million hectares of native vegetation. However, it is more difficult for a small-scale land-owners to participate in the CRA scheme, compared to a large owner. Firstly, to join the CRA market, it is necessary to officially own the land and be registered in the CAR (Brito, 2017), which are conditions not met by most small-scale land-owners (property smaller than 100 ha) (Coudel et al., 2012). Furthermore, the lack of education, that affects especially small-scale land-owners (Viviana Waichman et al., 2007), hampers law compliance and participation in the CRA market. In Brazil, 23% of the land-owners are considered illiterate (IBGE, 2017). This reduces their opportunities to know law requirements or understand them, which virtually excludes them from programs such as the CRA.

Scope of the study

The above-mentioned studies analyze the CRA market, considering land availability and heterogeneity of land value (Bernasconi et al., 2016; de Freitas et al., 2017; Soares-filho et al., 2014). The literature has not yet explored the role of the land-owners in the CRA market. Land-owners are the targets of the CRA scheme and the actors in the CRA trade as their decisions indirectly determine CRA price by influencing demand and supply.
In Brazil, land-owners are an heterogeneous group regarding factors such as opinion on deforestation, perception of native vegetation (Clewell & Aronson, 2006), access to information (Brannstrom et al., 2012) and economic situation (Brannstrom et al., 2012; Chapman et al., 2020; Clewell & Aronson, 2006; Winter & May, 2001). Among others, these factors influence each land-owner's priorities, drivers and strategies concerning land use, that ultimately determine the willingness to participate (and in what role) in a scheme such as one of the CRA.
CRA supply is the result of the decision of land-owners to preserve native vegetation, just as the demand may be derived from economic reasons. Thus, the role of land-owners in the market is not static, because it shapes the CRA price, and influences, in turn, the strategies of land-owners in the CRA trade. The result is a feedback loop where land-owners affect and are affected by CRA price.
The heterogeneity in the land-owner population concerning compliance strategies as well as their interaction in influencing (and being influenced by) CRA-price are necessary components of the CRA

market. Therefore, this study has the objective to consider, for the first time, the role of the land-owners in the CRA market.
In this study, was developed an Agent-Based Model (ABM). ABMs have been profusely employed in describing the interaction between individuals and natural systems (Grimm et al., 2010; Schouten et al., 2013). For example, Valbuena et al., (2010) developed an ABM to assess how different farmers profiles, farming typologies and decision-making processes determine the shape of the landscape, in a region of the Netherlands.

Why ABM?

An ABM was considered appropriated for this study because, firstly, it allows a physical representation of the territory and, therefore, an explicit depiction of the landscape as agents interact with it and among each other's. Furthermore, ABM facilitates to capture the heterogeneity of the land-owners, both concerning material features, such as the extent of their properties, and immaterial characteristics such as their education, land-use strategies and value attributed to natural vegetation. Thirdly, an ABM allows to observe how the interaction among land-owners influences the market and how land-owners adaptive behavior by changing their strategy in response to the market.
Through carefully designed scenarios, an ABM allows to visualize the implementation of the CRA scheme and highlight potential weak points, issues and implications for conservation and the socio-economical context. Since the CRA scheme is not operational yet, these results can help policy makers in determining the most efficient way to enforce the CRA market.

Hypotheses

As mentioned above, the size of the CRA market has been an issue recurrent in literature (Bernasconi et al., 2016; de Freitas et al., 2017; Soares-Filho et al., 2016; Winter & May, 2001). The first hypothesis concerns the fact that the CRA market is more profitable for credit sellers, the more is restricted (Coudel et al., 2012; May et al., 2015). The CRA price results from the opportunity cost of the land and the ratio between demand and supply. In a national market, the opportunity cost of the land is more varied than within a state (Bernasconi et al., 2016) and, therefore, the price of the CRA is more heterogeneous across the land. If the market is national, CRA purchasers have more options regarding CRA price typologies and presumably prefer the cheapest ones. If land-owners from a land with high opportunity cost want to sell CRA, they would have to compete with the cheapest CRA and would have to reduce the price of their credits. This means that the cost of offsetting is supposedly lower in a national market and that CRA prices are likely to be too low to provide revenues for landowners who decide to issue credits (de Freitas et al., 2017).
On the other hand, in a restricted market, such as one where offsetting is allowed within the state, the CRA prices presumably vary less across the land. This means that there is less availability of cheaper CRA and that the price of offsetting will be similar to the opportunity cost of the land for every state (de Freitas et al., 2017).
A second hypothesis is that success of PES schemes does not solely depend on incentives, but also on degree of participation of land-owners (Brancalion et al., 2014). Indeed, a series of barriers can curb adherence to a PES scheme: lack of a land title, physical isolation, lack of money for the initial investment, social isolation, ignorance about the initiative, little attractiveness for the incentives or distrust towards institutions (Grillos, 2017). These barriers concern mostly small-scale landowners with the result that the participants of PES schemes is often mostly medium and large owners (Coudel et al., 2012; Grieg-Gran et al., 2005; Kollmair, M, 2010). The literature suggests that programs aimed to involve communities and increase participation can increase law compliance and forest restoration (Brannstrom et al., 2012). It is hypothesized that coupling the incentives of the CRA scheme together with active efforts to include land-owners can result in a larger forest cover.

Scenarios and Research Questions

In this study, the CRA market is analyzed by implementing three scenarios through the ABM model:

- Scenario 1 represents a market where the trade is limited to the borders of the state. This means that land-owners can buy CRA only issued from lands within the same state and within the Atlantic Forest biome.

- Scenario 2 depicts a national market, where the trade is allowed across the whole country of Brazil. Land-owners can buy CRA from the whole Atlantic Forest biome.

- Scenario 3: the market is national and, as in scenario 2, the CRA trade is permitted across the whole biome. The third scenario aims to observe a more inclusive CRA market, where the population of agents is enriched by the inclusion of illiterate land-owners.

This work is built on the following research question and sub-questions:

- *Under which implementation scenario concerning the size of the CRA market and farmers inclusion, the interaction among land-owners results in higher forest cover and revenues for credit sellers?*

- *What scenario results in higher area of forest cover?*
- *Which size of the market has more potential to grant higher revenues from the sale of CRA?*
- *What is the contribution of the illiterate land-owners to the area of forest cover?*

Materials & methods

Agent-based modeling

Building Agent-based models (AMB) is a branch of computer programming used to model complex dynamics. The approach of ABM consists in portraying the actors in a system as autonomous agents and by attributing them a certain behavior. The agents' behavior is determined by: an initial configuration, consisting in a series of characteristics that describes an agent and can differentiate it from others; a series of rules that govern the way the agent acts within the environment; how agents interact with each other's in time (Hammond, 2015).

AMBs allow the modelers to study the trajectories of single agents as well as the outcomes emerging from the whole system, that is, resulting from the interaction of the population of agents (Deshmukh, 2019). This family of models essentially allows to observe the unraveling of a world created by the modeler and confirm or deny hypothesis regarding dynamics of a population of agents. The outcomes of the ABM can be compared to statistical data. The added advantage of developing an ABM consists in its flexibility, which allows to overcome a series of issue associated with modeling complexity (Grimm et al., 2010). These issues stem from the difficulty in describing certain features of the individuals in complex systems, namely their heterogeneity, their adaptive behavior and their distribution in the space (Hammond, 2015).

- Heterogeneity among agents is fundamental in real-world phenomena. It can refer to biology, e.g. when individuals belong to different species or different heaths status, or to demography, when agents are different according to e.g. their income or education, and it can refer to behavior, when it concerns e.g. the psychology or moral drivers of individuals (Hammond, 2015). ABMs allow to characterize the agents and observe how heterogeneity plays a role in shaping the outcome of the system.
- Adaptation can be represented as changes in agents' characteristics or behavior in response to others' actions. After interacting with other agents, individuals can change specific features of their profile (e.g. health status, after coming in contact with an agent affected by a contagious disease), or they can adapt their behavior, meaning that they can virtually learn and change their conduct (e.g. xenophobes can move residence if their neighborhood becomes diverse concerning ethnicities).
- ABMs include a spatial area where individuals can perform and with which they can interact. The availability of such feature allows to describe phenomena that are influenced by the spatial distribution of individuals (e.g. pollination) or their physical contact (e.g. the diffusion of a disease) or their interaction with the territory and natural environment (e.g. owners of land of different values) (Hammond, 2015).

Hence, AMBs have been used in many fields, especially to describe systems characterized by heterogeneity of individuals, adaptive behaviors and spatial patterns. In those fields, AMBs are used to: verify hypothesis regarding hidden mechanisms that govern real-world processes; observe the emerging patterns from a population of individuals; inform policy makers and enrich the knowledge that drives their interventions; discover and highlight critical points in a system, for further investigation (Hammond, 2015).

The model & the scenarios

Study Area

The area object of this study is the Atlantic Forest biome that ranges across an area of 1.129.760 km² (FAO, 2012) in Brazil (Fig. 4). The states considered in the model are: Alagoas, Bahia, Espírito Santo, Mato Grosso du Sol, Minas Gerais, Paraíba, Paraná, Pernambuco, Rio de Janeiro, Rio Grande du Norte, Rio Grande du Sol, São Paulo, Santa Catarina and Sergipe. The Atlantic Forest covers either the whole territory of these states or only a portion. The states of Espírito Santo, Rio de Janeiro and Santa Catarina are entirely within the borders of the Atlantic Forest. The other states share their territory with one or two more biomes. In the model, were considered only the municipalities within the Atlantic Forest biome and a list of those municipalities is available in Appendix IV.

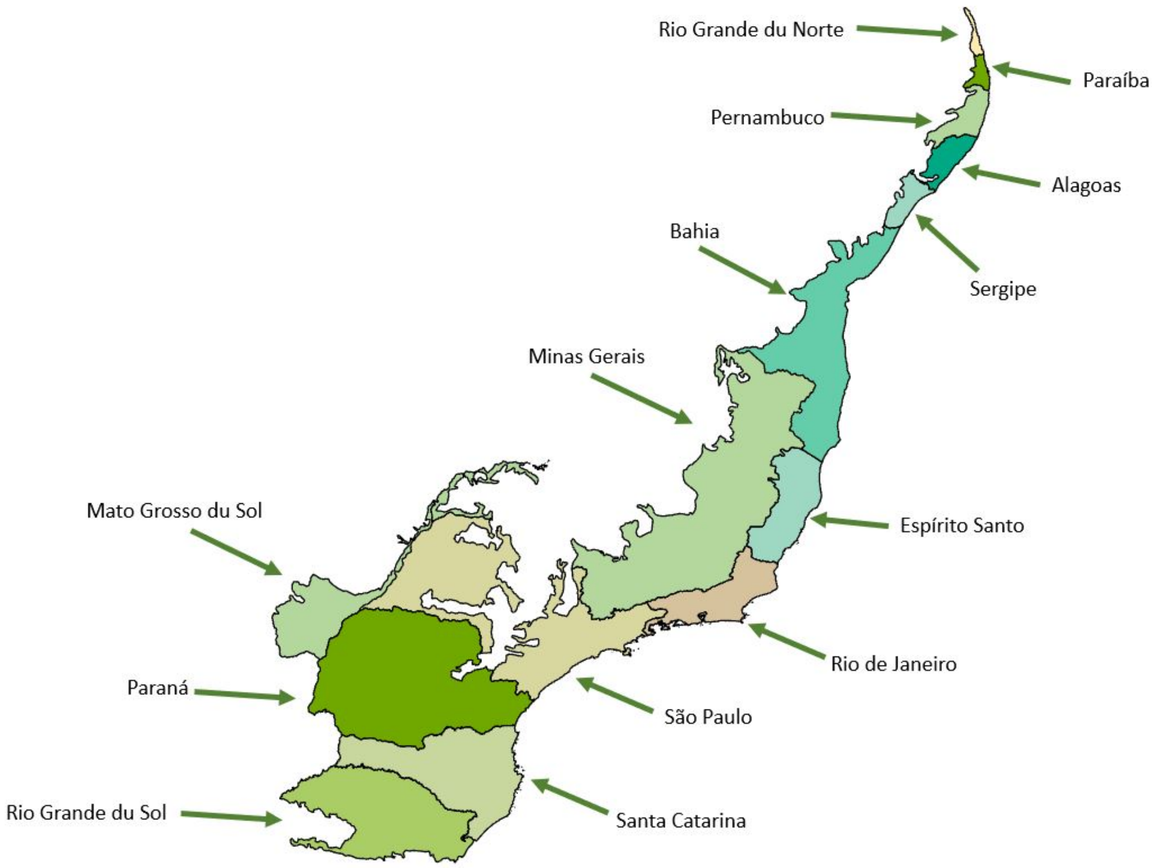

Figure 4: Study area. The Atlantic Forest biome extends across 14 Brazilian states. In the figure, each state has a different color and its name is indicated by the arrows. The maps are retrieved from the IBGE and modified with ArcGIS.

The opportunity cost of the land coincides with the value of agriculture production. Data regarding the agriculture production value per state were obtained from the IBGE, the Brazilian Institute of Geography and Statistics (IBGE, 2018) and are present in Appendix II. The value of agriculture production per hectare per state was calculated by summing the agriculture revenues of temporary and permanent crops and dividing this number for the area cultivated for temporary and permanent crops (eq. 1).

$$Value\ of\ agriculture\ production\ per\ hectare = \frac{(Production\ value\ for\ temporary\ crops + \ Production\ value\ for\ permanent\ crops)}{(Area\ cultivated\ for\ temporary\ crops + acrea\ cultivated\ for\ permanent\ crops)}$$

Eq. 1: Determination of agriculture revenues for each state.

The data are relative to the whole state and, in the model, it was assumed that all the land in a state is characterized by the same one value of agriculture production.

The land-owners

Property size (*Breeds*)

The agents in the model are the owners of agriculture establishments present in the area of the Atlantic Forest biome. Land-owners are a heterogeneous group and their diversity is portrayed in the model by conferring to them different characteristics, such as property size, land opportunity cost, education level and moral values that drive land-use strategies. Data regarding agriculture establishments per state were obtained from the Census of Agriculture (IBGE, 2017), a document devised by the IBGE that reports the nature of agricultural activities concerning factors such as legal status of the land, use of tillage for the soil, use of pesticides, size of the establishments etc. and characteristics of the land-owners, such as age, gender, ethnic group, education level and more.

In the present study, for each municipality in the Atlantic Forest, were obtained data on the number and sizes of agriculture establishments, available in Appendix III. These data were used to divide into categories, called *Breeds,* the properties of land-owners. The properties sizes span from the smallest, that reach 5 ha or lower, to the biggest, that spread for more than 500 ha. In the model, it is not considered type of crop or different agriculture techniques.

In the model, the properties are located in different Brazilian states and the land in each state is assumed to have different opportunity cost. Thus, land-owners can have a more valuable land, if their property is located in an area of higher opportunity cost.

Education level

Land-owners have different education levels, that in the model is translated by the distinction between illiterate and not. In this model, illiterate are considered the land-owners who are not able to write (Aldrich et al., 2006; Richards & VanWey, 2016; Viviana Waichman et al., 2007). The portion of illiterate land-owners were obtained from the Census of Agriculture (IBGE, 2017) and are available in Appendix I. The portion of illiterates is relative to the whole state and, in the model, it is assumed that each municipality per state has the same portion of illiterate land-owners.

Land-use priorities

The land cover in the properties results from the priorities of the land-owners: some exploit their land to obtain the maximum income in the shorter time frame; on the other hands, other land-owners attribute higher value to other elements rather than profit. To the second category belong owners that care to maintain high the quality of the land for future generations, or the ones who believe that preserving biodiversity actually betters the yield of the land, other land-owners attribute a religious significance to native vegetation or use it for recreational purposes (Clewell & Aronson, 2006). The reasons that land-owners have to voluntary designate part of their land to forest cover a large spectrum. In the model, it is assumed that the land-owners who do not seek immediate profit, have a portion of forest on their land that is used for personal LR and an extra area of vegetation, used to issue CRA.

In order to facilitate the reading of this work, the groups of land-owners where assigned names with which they will be addressed:

- The portion of illiterate land-owners forms the group named the *Isolated*.
- The land-owners who seek economic profit are named *Opportunists.*
- The owners who preserve a portion of forest on their lands for reasons different than economics are called *Conservationists*.

The market

Intermediaries

The CRA market is designed to operate through intermediaries, that are public and/or private institutions that handle the transaction of credits (Brito, 2017). In the scenarios, land-owners will not have to find autonomously a credit issuer or purchaser, but they will buy and sell respectively through a third party. In Brazil, there is an organization that operates as intermediary for a voluntary market, the BVRio[1]. BVRio allows land-owners, who wish to gain money from their native vegetation, to make their land available for LR offsetting. Land-owners who prefer offsetting outside of their land, can contact the organization to purchase land available for sale.

In the model, I hypothesize that land-owners can sell credits through the intermediary which has the advantage to connect land-owners of large territories.

CRA contracts

In all scenarios, the purchasing of CRA occurs through the institution of contracts lasting five years (Soares-Filho et al., 2016): signing a contract means that the area of extra forest, from which CRA are issued, is reserved to the buyer for the next five years as LR. The seller, on whose property is the LR, must maintain the reserved hectares as native vegetation. After five years, the contract ends and both sellers and buyers are free to re-evaluate their situation. They can decide to renovate the contract for next five years or one or both of them can change strategy. For example, a land-owner, previously buyer, can decide to offset the LR requirement in their own territory or to start selling credits, even. In that case, they will have to reforest a portion of that land. In this case, after five years the reforested hectares hold native vegetation still in the growing process, however, that can be used to issue CRA and LR offsetting. This assumption was made to limit the economic losses of land-owners who reforest. It is assumed that a contract duration of five years is long enough to allow land-owners to reforest and use that forest for LR, and not too long for the working life of a land-owner.

If a land-owner does not manage to buy CRA due to their limited availability, their LR debt remains. According to the NVPL, after being informed by the authorities about their LR debt, land-owners have twenty years' time to comply with the LR requirement, before incurring in sanctions (Brancalion et al., 2016)

CRA-price

In all scenarios, the price of the CRA was assumed based on the opportunity cost of the land (Brito, 2017; Soares-Filho et al., 2016). In their model, Soares et al. (2016), determined the price of CRA by submitting a questionnaire to land-owners with LR debt or forest surplus in five random municipalities for the Brazilian states of Mato Grosso, Pará, Bahia, Minas Gerais and Paraná (116 land-owners were interviewed in total). They discovered that land-owners attributed different value to CRA depending on the duration of the contracts: for contracts lasting a minimum of 1 and a maximum of 10 years, the CRA price coincided with the production value of land (i.e. the revenues from cultivating the land); on the other hand, for contracts longer than 30 years, land-owners suggested that the CRA price should equal the price at which land is sold. In this study, the initial CRA price is assumed to be one unit lower than the value of agriculture production. The reason behind this choice is that the CRA scheme is assumed to be aimed to increase land-owner compliance by offering an alternative to reforestation. In order for CRA to be attractive for land-owners who prefer to focus on agriculture, the cost of offsetting needs to be cheaper than the value of agriculture. This way, the land-owner profits from cultivating crops on their land and buying CRA somewhere else.

[1] www.BVRio.org

Scenario 1

In this scenario, the CRA market is restricted to the singular states. This means that, in order to offset CRA debt, land-owners must purchase credits issued from the Atlantic Forest biome and the same state where their property is located. In the same state, it is assumed that the differences considering yield and agriculture revenues of the land are negligible and, therefore, it is not considered any heterogeneity in land opportunity cost. Since the price of the CRA is related to land opportunity cost, within the same state the price of the credits is the same. This entails that there is no difference for the land-owners about where they offset in their state. The land opportunity cost (and associated CRA price) is one per each state and is different per different states.

Land-owners can participate in the market or not. The ones who participate can be sellers or buyers of CRA. The agents who do not participate in the market are the illiterate ones, because they are unaware of environmental regulations.

The decision to sell or buy depends on internal factors, such as the drivers of the land-owners, and external, such as the price of the CRA. Some land-owners have a more opportunistic nature (the Opportunists) and chaise economic gain. It is assumed that they change their strategy according to the price of the CRA: if it is lower or equals the agricultural revenues, they continue exploiting their land with agriculture; if CRA price exceeds agricultural production value, they change strategy and start reforest enough land to offset their LR requirement, plus sell CRA. It is assumed that land-owners are not aware of each other's strategies and thus, decide solely based on the relationship between CRA price and agriculture revenues.

Scenario 2

This scenario portrays a market that extents to the whole Atlantic Forest, which means that land-owners are permitted to offset their LR debts within the whole biome, also far away from their properties, e.g. in another state. Indeed, as the opportunity cost of the land varies per each state, so does the CRA price. Thus, in this scenario, a land-owner whose property is in a state with a higher opportunity cost can purchase CRA from a state with lower opportunity cost and, thus, at a lower CRA price. Essentially, this scenario introduces the possibility for land-owners to choose the cheapest land where to offset.

It is assumed that land-owners prefer to spend less and all try to buy the cheapest credits, which, at the beginning, are the ones issued from the least fertile area (lower opportunity cost). However, while the CRA price is based on opportunity cost, it is also influenced by the ratio between demand and supply. I hypothesized that, since all the buying land-owners seek the cheapest CRA, the demand will be higher than the offer and cause an increase of the price of the cheapest CRA. If the price continues to increase, it can exceed the price of the CRA issued from an area of higher opportunity cost. At this point, the opportunity cost of an area is not positively correlated with CRA price in that same area anymore. If this happens, the buying land-owners shift their demand toward the area with the newly cheapest CRA.

With this scenario, I aimed to study how the CRA price variations influence the localization of the forest cover in the Atlantic Forest biome.

The CRA price variation does not only affect the land-owners in terms of where to purchase CRA, but also concerning their land-use strategy: similarly to scenario 1, the Opportunistic land-owners practice agriculture until (and if) the CRA price is lower or equals the value of agriculture production; if the CRA price is higher than agriculture production, the land-owners reforest their lands to establish their LR and to sell credits.

Table 1 summarize the assumptions considered per each scenario.

Table 1: The assumptions that characterize each scenario.

	Scenario 1	Scenario 2	Scenario 3
Market	Within the biome and the singular states	Within the biome	Within the biome
Participants	All land-owners except the illiterates	All land-owners except the illiterates	All land-owners

Scenario 3

Scenario 3 features the same characteristics as scenario 2 per market extension, meaning that it is possible to offset in the whole biome and land-owners have different CRA price options. The trade dynamic is the same as in scenario 2, where the demand is focused on the cheapest CRA and, if it is higher than the offer, causes an increase of the cheapest CRA price. The demand shifts with the change of CRA price: it can stay focused on the land of lowest opportunity cost or shift towards more expensive lands, if their CRA price has become the new lowest.

The difference compared to the previous scenario consists in land-owner participation, as the illiterate portion of agents (the Isolated group) is encouraged to join the CRA market.

This scenario aims to study the contribution of categories excluded from the CRA scheme, such as the illiterates. Hence, it is assumed that is implemented a governmental initiative with the objective to inform illiterate land-owners about native vegetation, environmental regulation, compliance options (i.e. buying CRA) and sources of revenue alternative to agriculture (i.e. selling CRA). This initiative also aims to build a network among illiterate land-owners so they share knowledge and experiences, in order to render their education independent from the initiative, on the long run. Such initiatives, albeit not all governmental, have been enforced in several states and have returned positive outcomes (Clewell & Aronson, 2006; Kingwell et al., 2008; Muhar et al., 2018). For example, according to a study done in Australia, by involving of farmers through institutions of networks and peer groups, they envisioned themselves as stewards of the landscape, gaining a sense of responsibility (Coudel et al., 2012).

In this scenario, the land-owners reached by this program, once informed, can remain reluctant or can decide to join the CRA market: in the first case, the land-owners will simply fulfill their LR requirements by reforesting their land; on the other hand, the newly converted land-owners become CRA sellers, since the aim of the initiative is to foster reforestation. As in scenario 2, the Opportunistic land-owners change land-use strategy according to the relationship between CRA price and agriculture revenues.

Implementation

NetLogo

In this study was used NetLogo, a multi-agent modeling environment, which uses Scala and Java programming languages. NetLogo was conceived by Uri Wilensky and developed at the Northwestern University's Center for Connected Learning and Computer-Based Modeling (CCL).
Every NetLogo file is composed of three parts, accessible through panels: Code, Interface and Information. In the code space, the author writes the script and the interface panel is the world where the model takes form, where the agents and spatial framework are visible. The information panel is essentially a text page that the author can fill to describe how the model works and is not necessary for the model's functioning.
What makes NetLogo apt for developing of AMBs is a feature inherent to every AMB model, the agents. Agents are named *turtles* in NetLogo and they act in the spatial framework that is formed by blocks, named *patches*. The patches are the spatial units that compose the landscape, whereas the turtles are the individuals, the agents taking actions in the space. They both can be asked to perform tasks, however, only the turtles have the ability to move. Both patches and turtles have a series of general attributes (such as position and color) and can be assigned further characteristics, according to the assumptions of each model.
The script is composed of roughly three parts:

- At the beginning of the script are listed the agents (patches and turtles), their general characteristics and possible distinction in groups, called *breeds* in NetLogo.
- The initialization of the model, the starting point of the simulation, where the world to simulate is built. Here, the chosen number of agents are created and assigned attributes.
- The third is the dynamical part, where the agents are given commands and act. At the end of this part, the variables of the models are updated. Variables are elements of the environment or the agents that are affected by the events occurring through the simulation.

The model

Following the structure suggested by Schouten et al. (2013), the model developed in this study was divided in modules: the initialization, the land-owners, the CRA market and the output module (Fig.5). The modules represent sections of the NetLogo script and they happen in sequence during one run of the model (i.e. one time-step). Since they are in a specific order, they are connected, in the sense that one module cannot work without the output from the previous one.
The initialization is the first module and it portrays the beginning of the simulation. It is built to describe the heterogeneity of the agents and the characteristics of the world represented (i.e. about the landscape and the market), with data inserted by the modeler. The second module is the land-owners module, which is meant to represent the behavior of the agents. It is built by modeling the strategies of the land-owners under different contexts (i.e. different CRA prices) and here are stated the rule and constraints to agents' actions. The CRA market module is necessary to update the characteristics of the territory, after the agents have decided how to use their land. Finally, the output module updates the variables of the simulated world (i.e. the CRA price) which will be used in the next time-step, in the initialization.

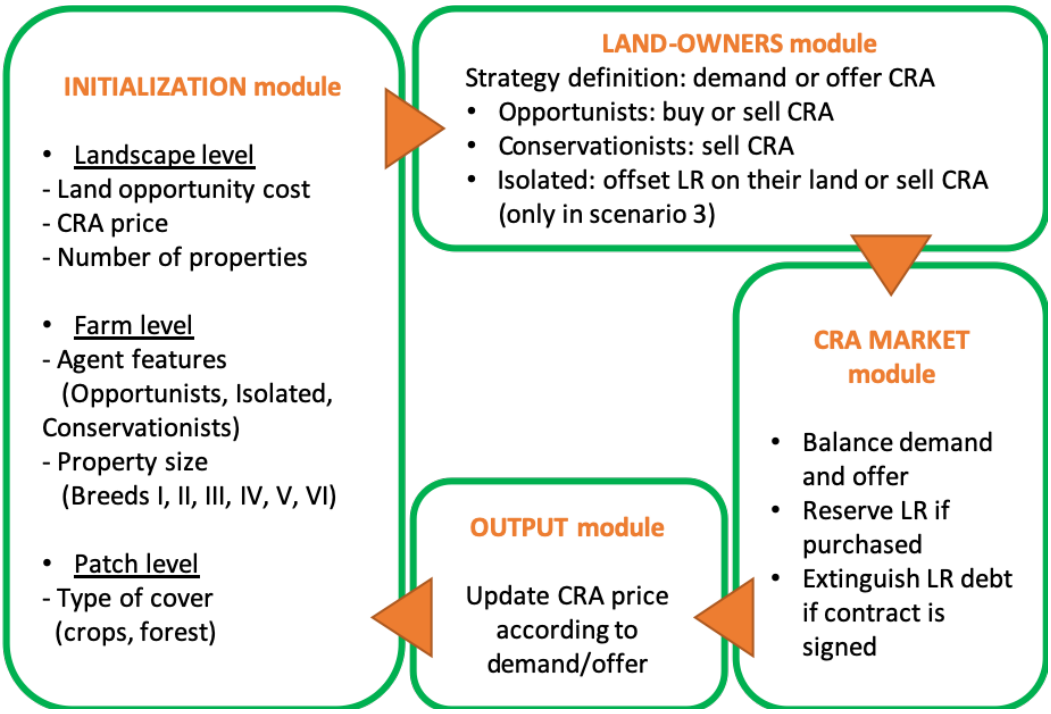

Figure 5: The structure of the model is divided in modules which represent sections of the script. The modules are connected as one cannot work without the output from the previous module.

Initialization module

Landscape level

At landscape level, the model represents the Atlantic Forest biome, divided into 14 states.
NetLogo is provided with a GIS extension which allows the import of maps and visualization in the interface. The visual representation was created with ArcGIS, by intersecting the borders of the Atlantic forest with the state borders, so that only the portion of the state containing the Atlantic Forest could be visualized (Fig.6). The maps of the states and of the Atlantic Forest biome were obtained from the IBGE[2].
In the results, the forest cover is calculated as the portion of forest over the area privately owned. This means that only the hectares in the properties are going to be considered (i.e. inside the circles, in Fig.6), not the unclaimed area (i.e. in Fig. 6, the dark green patches between the properties).
As stated in the *study area* section, each state is characterized by a specific opportunity cost that results from the values of agriculture production.
In scenario 1, each state has its specific opportunity cost.
On the other hand, in scenario 2 and 3, states with similar opportunity costs were grouped into 3 categories (Table 2, Fig.7): OC 1, the area with the cheapest opportunity cost; OC 2, the intermediate; OC 3, the area with the highest opportunity cost.

[2] www.ibge.gov.br

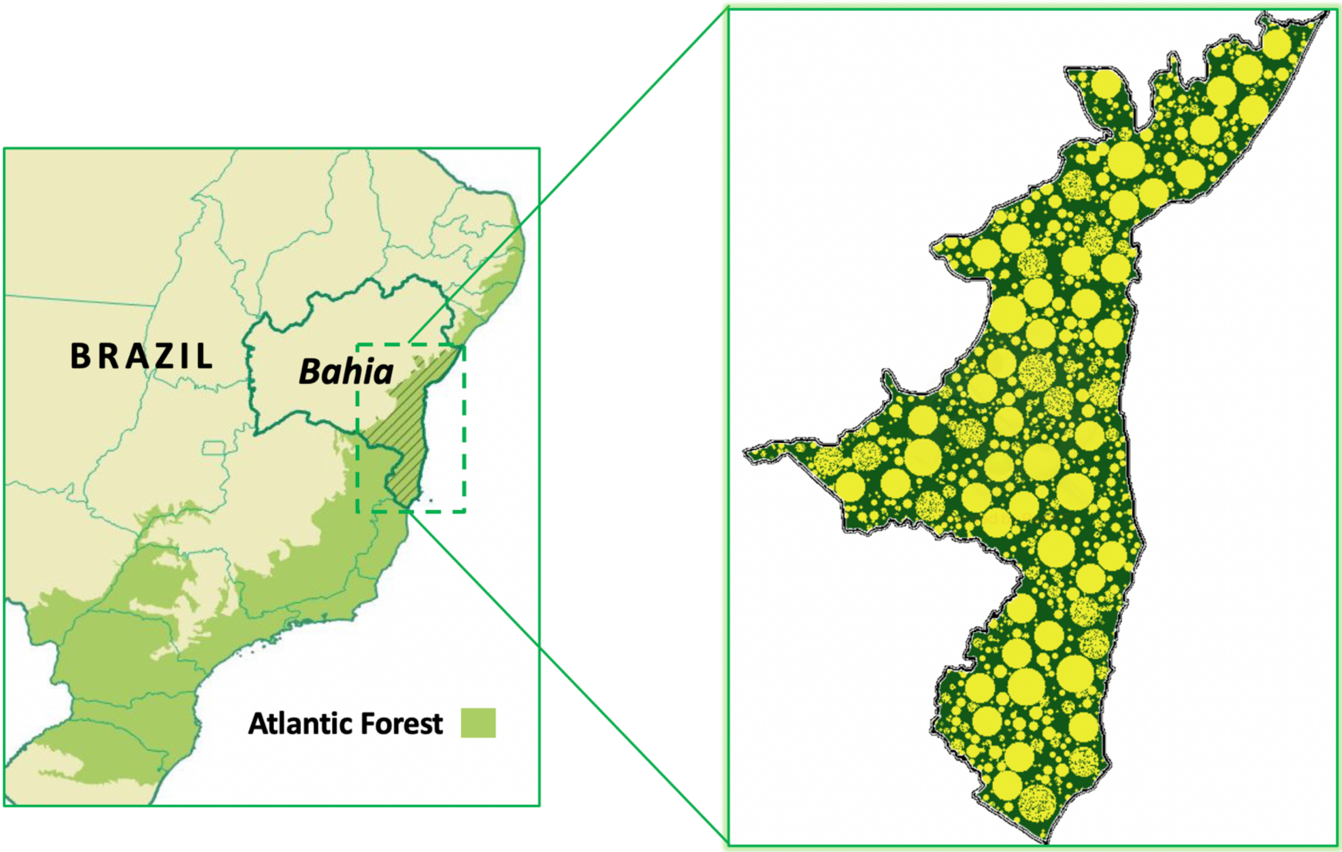

Figure 6: On the left, the state of Bahia, Brazil. The striped area is the portion of Bahia that is within the Atlantic Forest biome. On the right, the outcome of Scenario 1 for the state of Bahia. The circles represent the properties. Inside the properties, the green patches correspond to forest cover, the yellow, the cropland. In the model, only the private area will be considered, i.e. the one inside the circles.

The cost of the CRA at the initialization is one unit smaller than the opportunity cost (Soares-Filho et al., 2016). In scenario 1, there is one CRA price per state. In scenario 2 and 3, the CRA price is different per each OC area, as shown in Table 2.

Table 2: Lists of the states considered in this study and their value of agriculture production. The states were divided into 3 areas (OC 1, OC 2 and OC 3) according to similar value of agriculture production for scenario 2 and 3.

State	Production value per area of cultivated land (M Reais/ha)	Average value of production (M Reais/ha)	Area of opportunity cost in the model
Sergipe	2,9	4	OC 1
Paraiba	3,4		
Mato Grosso do Sul	3,9		
Paranà	3,9		
Alagoas	4,2		
Rio Grande do Sul	4,3		
Bahia	4,8		
Rio Grande do Norte	5,1	6	OC 2
Pernambuco	5,1		
Sao Paulo	6,1		
Santa Catarina	6,4		
Minas Gerais	6,5		

Rio de Janeiro	11,0	11	OC 3
Espirito Santo	11,2		

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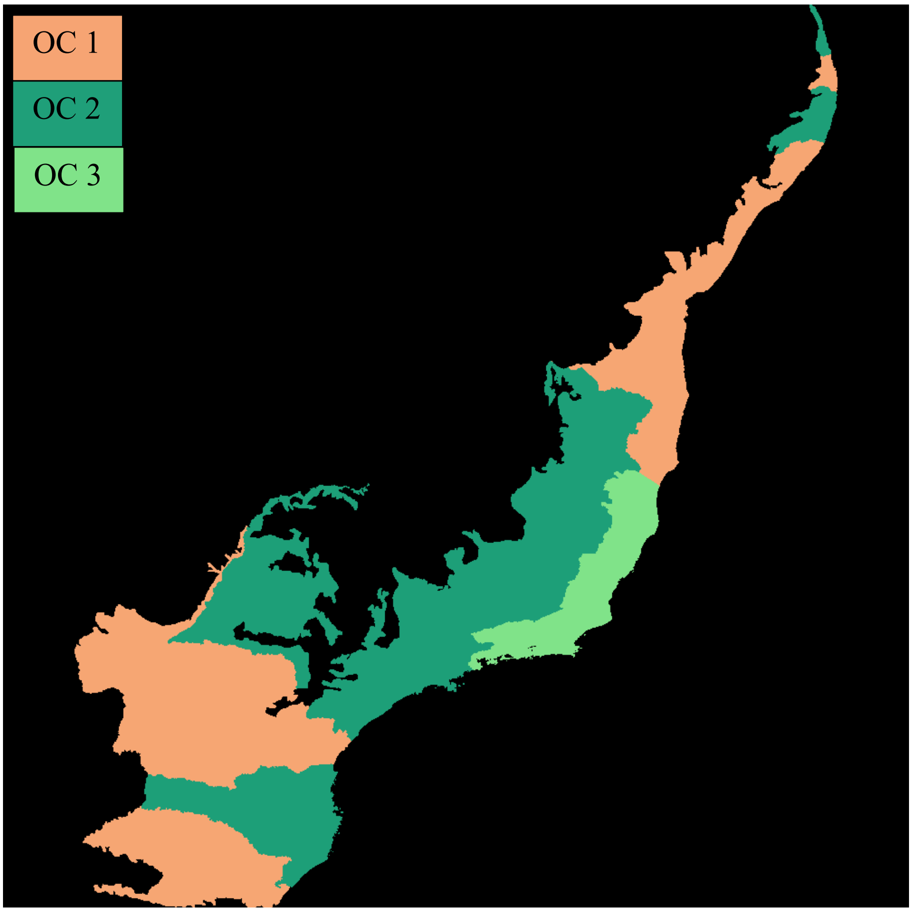

Figure 7: The Atlantic Forest biome. For scenario 2 and 3, the states were grouped into 3 areas: OC 1, with the cheapest opportunity cost (in orange); OC 2, with intermediate opportunity cost (dark green); OC 3, with highest opportunity cost (light green).

Farm level

At farm level, properties were divided into six categories according to their size, showed in Table 3: equal or less then 5 ha; from 5 to and equal 20; between 20 and until or equal to 50; between 50 and until or equal to 100; between 100 and until or equal to 500; larger than 500 ha. The land-owners are divided into groups, called breeds, according to the size category of their property (Table 3).

In the model, all properties in a size category have the same number of ha (Table 3), where every hectare is represented by a patch. The number of patches per property size category, the property size categories and the land-owners associated to these categories are depicted in Table 3.

Table 3: Property size categories (breeds), land-owners division per property size and property extent in the model (ha)

Property size (ha)	Breed	Number of patches per farm
Less than or equal to 5	I	5
Between 5 and until or equal to 20	II	21
Between 20 and until or equal to 50	III	49
Between 50 and until or equal to 100	IV	97
Between 100 and until or equal to 500	V	497
Larger than 500	VI	797

In the NetLogo script, the properties were created around the land-owners, by asking the patches in the circle surrounding the agents to become owned by them and part of their property. The radius of the circle determines the number of patches owned by an agent (Fig. 8).

```
create-IVfarmers 9 [
  set moral-value 0
  set hidden? true
  let potential-farms patches with [all? (patch-set self patches in-radius 5.5) [pcolor =  lime - 3]]
ifelse any? potential-farms [
    move-to one-of potential-farms
    set property (patch-set patch-here patches in-radius 5.5 with [pcolor =  lime - 3])
    ask property [set pcolor yellow
      set cover 1]]
  [print "no space IV"]]
```

Figure 8: In the initialization, creation of farmers belonging to BreedIV. The phrasing "in-radius 5.5" indicates that all the patches in radius 5.5 from the agent become part of their property. In this case, the number of patches is 97.

Land-owners are characterized according to their opinion concerning land use which is described by the phrasing *moral-value* in the script in Fig. 8:

- Opportunists: land-owners that have profit as their only driver. Therefore, their strategy concerning land use will be focused on obtaining the maximum economical revenue.
- Conservationists: agents whose priorities are different than financial gain. Part of their land will always be covered in native vegetation.
- Isolated: a third group of land-owners is composed of the illiterate portion of land-owners. These land-owners do not have the instruments to be aware of the NVPL or to make decisions within the CRA market scheme.

The land-owners were associated to a group in base of their land cover. The data concerning forest cover on individual properties were challenging to analyze. In the CAR (the cadastral registry), data about native vegetation cover and the percentage of APP and LR (if they are present) are available separately, that is, the data are not joined and associated to a property. This makes the task of connecting each property to their respective native vegetation, APP and LR area, time consuming and challenging if not versatile with geospatial analyses tools. Therefore, in this model, were used data obtained from the CAR[3], by performing the upper mentioned task on 36 municipalities in the state of São Paulo [4].

To estimate how many agents to assign to the Conservationists group, was used the portion of properties with extra vegetation on their land per breed. These amounts were used as fixed portions for every state and are showed in Table 5 in the next paragraph. Among properties with extra vegetation were considered:

- properties with native vegetation cover that goes beyond APP area and LR requirements:

$$(\text{Native vegetation} - \text{APP} - \text{LR}) > 0$$

- properties without an officially registered LR but whose native vegetation cover is larger than APP area:

$$(\text{Native vegetation} - \text{APP}) > 0 \quad \text{and LR} = 0$$

[3] https://www.car.gov.br/publico/imoveis/index

[4] Angatuba, Arandu, Barão de Antonina, Bernardino de Campos, Bom Sucesso de Itararé, Buri, Campina do Monte Alegre, Capão Bonito, Cerqueira César, Coronel Macedo, Fartura, Guapiara, Guareì, Ipaussu, Itaì, Itaberà, Itapetininga, Itapeva, Itaporanga, Itararé, Itatinga, Manduri, Nova Campina, Paranapanema, Pilar do Sul, Piraju, Ribeirão Branco, Ribeirão Grande, Riversul, São Miguel Arcanjo, Sarutaià, Taguai, Taquarituba, Taquarivaì, Tejupà, Timburi

The decision to include land-owners without a registered LR are is based on the fact that, even though LR are a legal requirement, landowners have 20 years to comply with the law, after being notified. This could mean that some properties might have extra forest cover not yet legally registered as LR. Concerning the Isolated group, since illiterate land-owners are mostly small owners (Aldrich et al., 2006; Richards & VanWey, 2016; Viviana Waichman et al., 2007), the percentage of illiterates, was divided among the three breeds whose land is less than 50 ha with a proportion of 5:4:1 (eq. 2, Tab. 4).

$$\%\ illiterates\ in\ Breed\ I = \%\ illiterates\ in\ the\ state * 0.5$$
$$\%\ illiterates\ in\ Breed\ II = \%\ illiterates\ in\ the\ state * 0.4$$
$$\%\ illiterates\ in\ Breed\ III = \%\ illiterates\ in\ the\ state * 0.1$$

Eq. 2: Determination of the portion of illiterates per states. The percentage of illiterate land-owners was distributed across the smallest breeds, i.e. property size categories.

Table 4: Per state, percentage of illiterate landowners, defined as incapable to write.. The percentages of illiterates per breed I,II and III were respectively the 50%, 40% and 10% of the portion of illiterates per state.

State	% illiterate land-owners	Breed I (50%)	Breed II (40%)	Breed III (10%)
Espírito Santo	7,0	3,5	2,8	0,7
Rio de Janeiro	9,7	4,8	3,9	1,0
Rio Grande do Norte	39,9	20,0	16,0	4,0
Pernambuco	39,7	19,8	15,9	4,0
Minas Gerais	12,5	6,3	5,0	1,3
São Paulo	3,1	1,5	1,2	0,3
Santa Catarina	3,0	1,5	1,2	0,3
Alagoas	46,2	23,1	18,5	4,6
Sergipe	38,1	19,0	15,2	3,8
Bahia	32,1	16,1	12,8	3,2
Paraná	5,6	2,8	2,2	0,6
Rio Grande do Sul	3,6	1,8	1,4	0,4
Mato Grosso do Sul	7,0	3,5	2,8	0,7
Paraíba	40,5	20,3	16,2	4,1

In the model, land-owners in the Isolated and Conservationists groups are both calculated as a portion of the Opportunists.
The group of the Isolated is given the preference compared to the Conservationists, which means that, if in a state, the totality of the land-owners in a breed are assigned to the Isolated, there won't be any Opportunist or Conservationist agent in that breed.

Patch level

The number of patches (ha) per property is constant throughout the model. What varies are the attributes of the singular patches. Within a property, patches can be LR, extra forest or cultivated field.
In the initialization, different groups have different land covers. Opportunists and Isolated land-owners have their entire property covered in cropland, whereas Conservationists hosts cropland and forest cover. The area of extra forest present in the properties of the Conservationists was calculated on the area of extra vegetation present of the properties in the 36 municipalities analyzed of São Paolo (Tab. 5) and was a fixed portion for every state.

Table 5: Number of land-owners per size category in 36 municipalities of Sao Paulo whose property holds native vegetation (VN). The percentage on number of properties and portion of native vegetation per breed were applied to each state to determine the number of Conservationists per breed and the forest cover on their properties.

Breed	I	II	III	IV	V	VI
agents per breed in the 36 municipalities in São Paolo	2850	6190	4265	2009	2152	488
properties with (VN-APP > 0) and no LR	343	868	727	395	381	51
area VN-APP (no LR) (ha)	0,771	1,75	4,52	9,27	28,77	254,4
properties with VN-APP-LR > 0	26	93	95	78	163	75
VN-APP-LR area (ha)	0,42	2,14	5,1	14	40	252
sum properties	369	961	822	473	544	126
% properties over agents	13	16	19	24	25	26
extra forest (ha)	1,191	3,89	9,62	23,27	68,77	506,4

Land-owners module

In this portion of the model, land-owners choose their strategy according to the price of the CRA and the value of agriculture production on their land. The behavior of each agent is defined by their attributes. Opportunists owners have been programed to cultivate all their land until the CRA price increases over agriculture revenues of their land. If the CRA price exceeds the agriculture value, the Opportunists react by becoming CRA sellers, as shown in Fig 9.

```
to sell

  IF moral-value = 0 [
        ask property [set cover 1
    set pcolor yellow]

        set LR n-of (percentage * count property) property
        ask LR [set pcolor green - 2
    set cover 4]

        set offered-CRA n-of (percentage * count property) property with [cover = 1]
        ask offered-CRA [set cover 2
    set pcolor green]
  ]
```

Figure 9: Portion of the script where land-owners focused on economic gain (Opportunists group) are programmed to sell CRA.

This section of the model corresponds to the end of a CRA contract and the beginning of a new one. The Conservationists are sellers of CRA throughout the whole model, across all scenarios and, once a contract is ended, they reset the ownership of their portion of forest reserved for LR. This way, if the buyer decides to become a seller, their LR do not remain located elsewhere.

The Isolated, inactive in the market in scenario 1 and 2, enters the market only in scenario 3, when a governmental initiative is enforced to inform illiterates about the NVPL and the CRA scheme. At the initialization, two land-owners of the Isolated group are reached by the organization and one is convinced to join the market, one not. Isolated land-owners are assigned an attribute that allows them to be influenced by the beliefs of their neighbors and community: if they are near a land-owner in the Isolated group who has joined the CRA market, they do the same; on the other hand, if the closest Isolated, once informed about the market, is skeptical, they also become skeptical. The Isolated who

are convinced in joining the market, change group and are assigned to the Conservationists, becoming CRA sellers. The agents who prefer to stay out of the market, simply offset their LR requirement, since they have been informed about it.
At the end of this module, there will be patches designed as demanded, and patches designed as offered.

Market module

The output from the previous model has determined demand and offer. Contracts have been signed and now LR needs to be allocated.
This module builds on the last one by balancing demand and offer and, depending on the outcome, LR are assigned. If demand is higher than the offer, all the patches representing extra forest become LR and the extra demanded patches stay demanded. If, on the other hand, the offer is higher than the demand, only the number of demanded hectares become LR, the rest of the forest remains available.

Output module

The balancing of demand and offer that occurred in the previous module is used to update CRA price. If the demand is higher than the offer, the price increases, otherwise it decreases (Fig. 10).
This module contains the update of the variables that will dictate the strategies of the land-owners in the land-owner module, that is, the price of the CRA.

```
ifelse OC1-demand > OC1-offer
  [set OC1CRA-price OC1CRA-price + 1]
  [set OC1CRA-price OC1CRA-price - 1]
]
```

Figure 10: Updating of the variable CRA price as a result of the relationship between demand and offer.

Results

Scenario 1

The state scenario consisted of 14 (sub) models, one per state. Throughout all the models, some similar outcomes could be observed.

As stated in the *Materials & Methods* section, the number of forested hectares was calculated in relation to the total number of private hectares, that is, the total area of agriculture establishments, not the area of the whole state.

The forest cover is the sum of: the patches with LR (offset by the owner of the property or by a buyer from another property), plus the patches of forest offered for offsetting but not purchased. The rest of the patches in the properties of the land-owners were considered cultivated.

For every state, when the CRA price is lower than or equal to the value of agriculture production, the Opportunists prefer to use land to cultivate crops. In order to offset their LR requirement, they aim to buy CRA from other land-owners who have a surplus of forest on their property. The surplus of forest can be used to issue CRA only if it is not registered as APP and if it is not the LR of the owner of the property where is the forest is.

At the initialization (i.e. the beginning of the simulation), the properties of the Opportunists and the Isolated are entirely cropland, there is no forest. On the other hand, the Conservationists have a portion of forest that is enough to comply with their own LR requirements, plus an extra percentage of native vegetation that varies per breed (Table 5).

The initial price of the CRA per hectare is one unit (1 million Brazilian Reais) lower than the value of agriculture production per hectare.

- After the first time-step, corresponding to the end of the first five-year CRA contract, the demand for CRA is higher than the offer for every state: all Opportunists are demanding CRA in order to offset their LR requirement, which amounts to the 20% of their land; the patches offered by the Conservationists are not enough to offset such demand. Thus, all the offered patches are purchased and registered as LR of the purchasers.

  At the end of the first time-step, when demands and offer are balanced, the CRA price is updated. In this case, since there are no more offered patches (they all became LR) the CRA price increases by one unit, that is one million of Brazilian Reais. The CRA-price becomes equal to the value of agriculture production.

  $$\text{DEM} > \text{SUPPL} \rightarrow \text{CRA-PRICE} + 1$$

- In the second time-step, as the CRA price is equal to the value of agriculture production, and the Opportunists try to buy credits again. Indeed, in the model, is assumed that, due to the costs of reforestation, land-owners start selling CRA only when the associated economic revenues are higher than the ones from agriculture, i.e. CRA price higher than the value of agriculture production.

  The amount of offered CRA equals that in the first time-step, since the contracts have ended and the CRA sellers are the Conservationists again. As a result, the number of offset hectares (as LR) and their location is the same, within the properties of Conservationists. Since the demand is still higher than the offer, the CRA price increases again and, this time, overcomes the value of agriculture production.

  $$\text{DEM} > \text{SUPPL} \rightarrow \text{CRA-PRICE} + 1$$

- At the third time-step, the Opportunists, who base their strategy on the past CRA price and agriculture production value, seeing that selling credits bring more revenues than agriculture, decide to invest in them and, for the next contract, instead of offsetting elsewhere, they decide to reforest 40% of their own land, of which 20% is for LR and 20% to sell CRA. This entails that the forest in the properties of the Conservationists that were registered as LR, become available again, since the contract is over and is not renovated. In this run, the offer is higher than the demand and thus, the CRA price lowers, equaling the value of production again.

$$DEM < SUPPL \rightarrow CRA\text{-}PRICE - 1$$

For all the states, the native vegetation cover oscillates between two fixed values, a minimum and a maximum: the minimum corresponds to the time-steps where Opportunists buys credits and Conservationists sells, thus the forest cover consists in the LR in the estates of the Conservationists; the maximum forest cover is observed in the time-steps where the Opportunists offer credits as well as the Conservationists. The results indicate the forest cover is at its maximum when the CRA price is higher than the agriculture value, while it is at its minimum when the CRA price is the same or lower than the value of agriculture production.

In scenario 1, the portion of Isolated land-owners is different for every state. As Isolated are distributed across the three smallest land size categories, the amount of area owned by this group does not correlate linearly with percentage of illiterate across the states (Fig. 11).

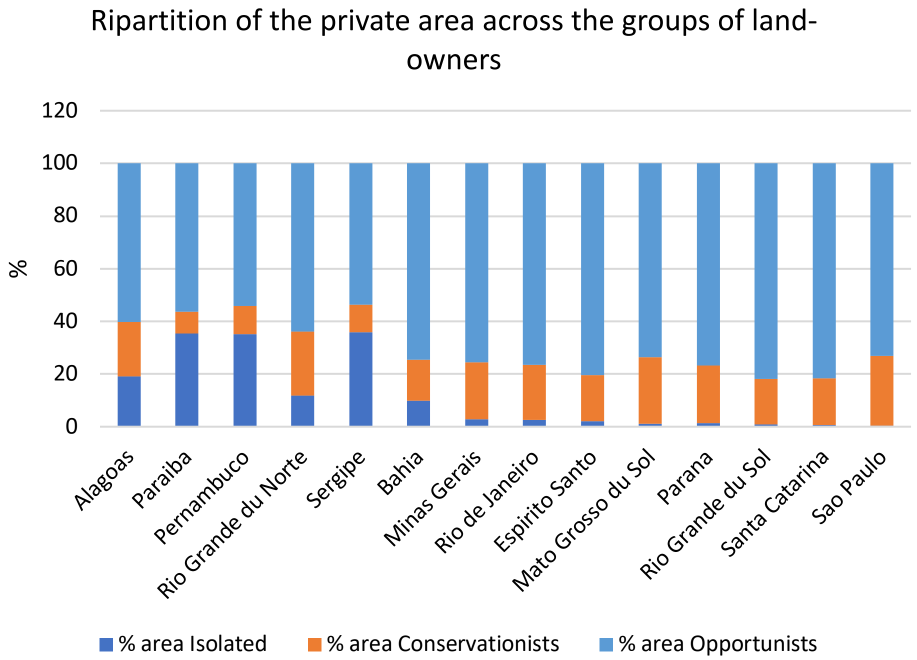

Figure 18:States are ordered from left to right according to the portion of illiterate land-owners. For every state, the blue portion of the column is the percentage of private area owned by the Isolated, the orange portion is the one owned by Conservationists and the light blue, by Opportunists.

In Fig.12, it is indeed possible to notice the correlation between rate of illiteracy and area owned by Isolated land owners. As an example, the state of Alagoas has a portion of 46% of illiterate land-owners, the highest among the states in the Atlantic Forest biome, however the 88% of the land-owners in that state have properties smaller than 20 ha. Thus the area owned by the Isolated group in Alagoas is not the highest, albeit rate of illiteracy is.

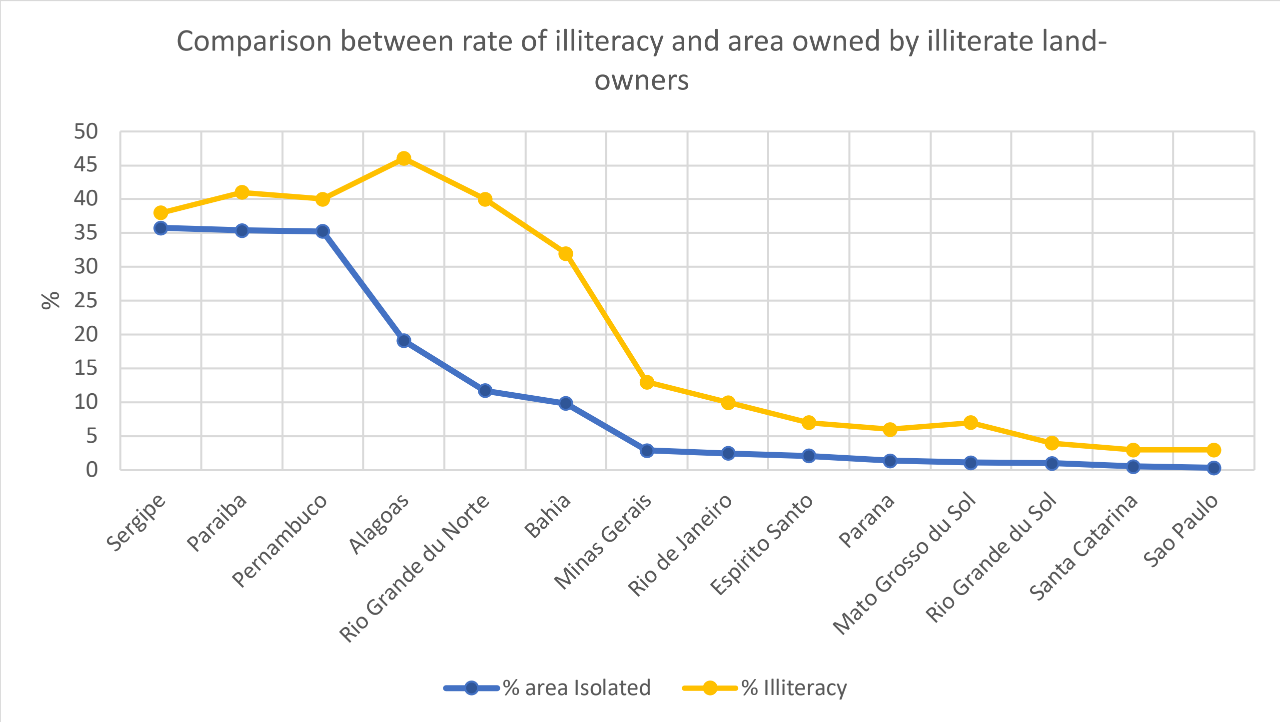

Figure 19: Rate of illiteracy (yellow line) compared to percentage of area owned by illiterate land-owners (blue line), i.e. the Isolated group, across the states of the Atlantic Forest.

In scenario 1, the ratio between the native vegetation maximum and minimum varies among states: it ranges from approximately 4 for Mato Grosso du Sol to 23 for Alagoas. It is noticeable that the higher ratios occur in states where the percentage of land owned by Isolated land-owners is higher (Fig. 13).

Indeed, the land-owners who, during the simulation, hold forest on their land are Conservationists and Opportunists. The Isolated own only croplands throughout scenario 1. As the number of Isolated is calculated as a percentage of Opportunists, as explained in the methods (Table 4, eq. 2), a high amount of land owned by Conservationists and Isolated entails that Opportunists own less area, and, thus, they can reforest a smaller amount of land.

On the other hand, the less area is owned by Conservationists and Isolated, the more is in the properties of Opportunists. The maximum value of forest cover is determined by the forest present in the area of the Opportunists, who reforest when the CRA price exceeds the value of agriculture production. Therefore, in the states where the Isolated own more area, the ratio between maximum forested patches and total private land is lower (Fig. 13).

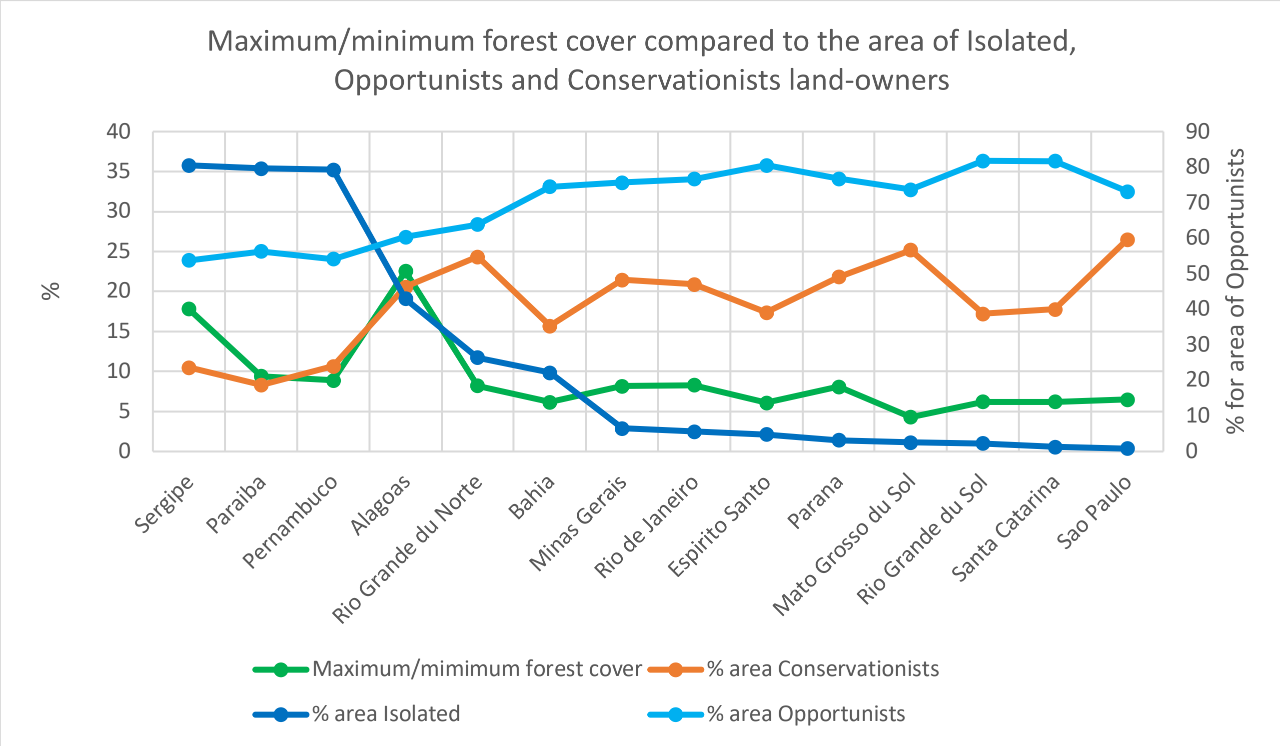

Figure 110: Portion of land owned by Conservationists (orange line), Opportunists (light blue line), Isolated (dark blue line), compared to the ratio between maximum and minimum forest cover, observed for every state in scenario 1. The vertical axe on the right is relative to the area of the Opportunists, while the vertical axe on the left refers to the other lines.

These results show that the amount of forest cover is influenced by the typology of land-owners, among Opportunists, Conservationists and Isolated.

Scenario 2

This scenario is characterized by a national market, that is, a market that entails that land-owners can offset their LR debt anywhere within the Atlantic Forest biome. Compared to scenario 1, where the offset was allowed within the state (and the Atlantic Forest biome), the land is distinguished in three areas according to its opportunity cost and CRA price (Fig. 14). The aim of this scenario is to observe how different CRA prices in different areas influence the strategies of the land-owners and, thus, the location of the forest cover.

1) The first time-step begins with a CRA price in OC 1 (area of lowest opportunity cost) lower than in the other areas and lower than the agricultural value in OC1. In this context, the Opportunists seek to offset their LR debt by purchasing CRA. Since the cheapest credits are issued from OC 1, the Opportunists from OC 1, OC 2 and OC 3 will try to purchase CRA there. The offer consists in the extra forest offered by the Conservationists (Fig. 14, left).
   At this moment, only the CRA in OC 1 are sought and those hectares are less than the demanded ones, thus demand for the CRA in OC 1 is higher than the offer in OC 1.
   Since, according to the law, land-owners have 20 years' time to comply with LR requirements starting from the moment they found uncompliant by authorities, land-owners are not in hurry to offset. Thus, the Opportunists that did not manage to buy the cheapest CRA in this time-step prefer waiting for the next one, rather than purchasing CRA in more expensive areas.
   Therefore, at the end of the transactions for the credits contract, all the offered hectares in OC 1 have been reserved as LR and the excess of demand causes an increase of price for the credits in OC1, that becomes the same than the value of agriculture. In OC 1:

$$\text{DEM} > \text{SUPPL} \rightarrow \text{CRA-PRICE} + 1$$

2) The first contract has ended and, meanwhile, the land-owners have considered their options: five years before, the price of the CRA increased in OC 1, however it did not overcome the production value of agriculture and, since the credit market is still recent, the Opportunists of OC 1 continue to prefer to use their land for agriculture and offset their legal forest obligation elsewhere.
   In the other opportunity cost areas, it is still more profitable to buy credits in OC 1 instead of reforesting, thus the demand focuses again on OC 1.
   At the end of this contract transaction, all the offered forest is reserved as LR in OC 1. The demand is still higher than the offer though, and thus not every land-owner erases their LR debt and the price of the CRA in OC1 increases again, this time exceeding the revenues from agriculture and becoming the same as the value of CRA price OC 2. In OC 1:

   DEM > SUPPL → CRA-PRICE + 1

3) In this time step, seeing the increase of CRA price over agriculture revenues in OC 1, happened at the end of the last time-step, the Opportunists have decided, in the past five years, to convert part of their land to forest (20% for their own LR, 20% to issue CRA) (Fig. 14, right). The beginning of the transaction for CRA contracts sees the Opportunists in OC 1 offering 20 % of their land to issue CRA, together with the Conservationists.
   This time, the offer in OC 1 is enough to offset the LR demand of the Opportunists from OC 2 and OC 3 and, actually there are approximately 30 hectares of extra forest that remain available. For the first time, the offer is higher than the demand in OC 1, so the CRA price for OC 1 decreases, equaling the one of agriculture revenues again. In OC 1:

   DEM < SUPPL → CRA-PRICE - 1

   At the end of this time-step, not all Opportunists in OC 1 managed to sell their CRA and the CRA price lowered. Thus, the Opportunists are foreseeing a risk in the activity of selling CRA and prefer returning to agriculture.

4) When the previous contracts ended, the Opportunists, who were selling CRA, do not renovate them and clear their forest to cultivate crops. In this time-step, the context is the same as the first two time-steps before, when the Opportunists from every area try to buy credits in OC 1. Thus, the demand overcomes the offer once again and the price rises. In OC 1:

   DEM > SUPPL → CRA-PRICE + 1

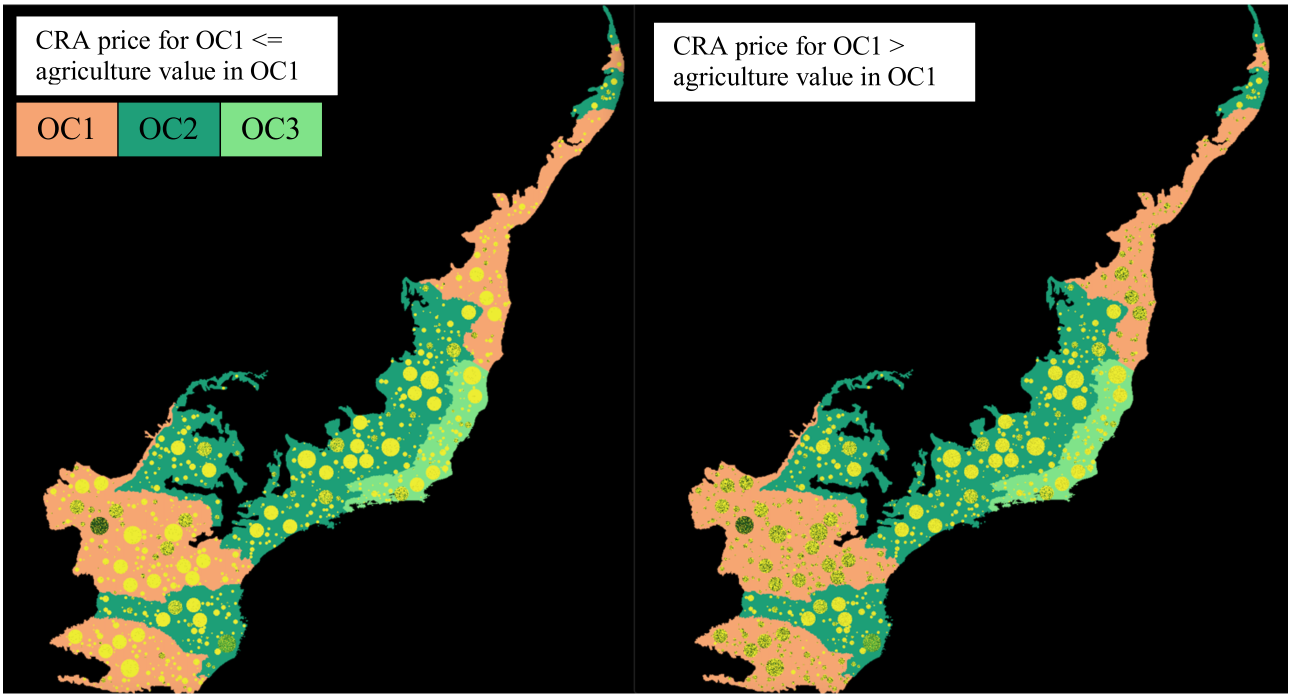

Figure 14: Division of the area of the Atlantic Forest into three areas of different opportunity cost of land: OC1 (orange area) is the area with the cheapest opportunity cost, OC 2 (dark green) is the intermediate and OC 3 (light green) is the area with the most expensive opportunity cost. The circles represent the properties of the land-owners. Inside the circles, the yellow patches are cropland and the green are forest. On the right, Opportunists in OC 1, OC 2 and OC 3 use their land for agriculture and try to buy CRA. On the right, the CRA price in OC 1 equals or is lower than the value of agriculture production in OC 1. On the left, the Opportunists from OC 1 sell CRA. The CRA price in OC 1 is higher than the value of agriculture production in OC 1.

5) The price of the CRA has risen over the agriculture revenues again and the promise of profit has encouraged the Opportunists in OC 1 to reforest again in the past years, so they can sell CRA again. As happened before, the offered hectares are slightly more than the demanded ones, nevertheless the price of the CRA in OC 1 lowers again.

$$\text{DEM} < \text{SUPPL} \rightarrow \text{CRA-PRICE} - 1$$

The results indicate that, once the CRA price has reached the value of agriculture, there is an alternation between two states: one where the demand is higher than supply and one where the supply is higher than the demand. The highest number of forested patches is noticeable in those time-steps where the supply was higher than the demand.

In Fig. 15, is noticeable this alternation of forest cover as a result to the CRA price for OC 1. It is important to mention that in every time-step, the price of the CRA is updated at the end of the simulation, when transactions over the ownerships of the credits are concluded. The land-owners decide their strategy considering the price that CRA reached during the last transaction. Therefore, the strategy of the landowners is not the result of the CRA price of the same time-step, but the time-step before, which is the reason why the curves of CRA price (blue line in Fig. 15) and forest cover (orange line in Fig. 15.) are shifted.

Indeed, the forest cover determines demand and offer, on which the CRA price is updated.

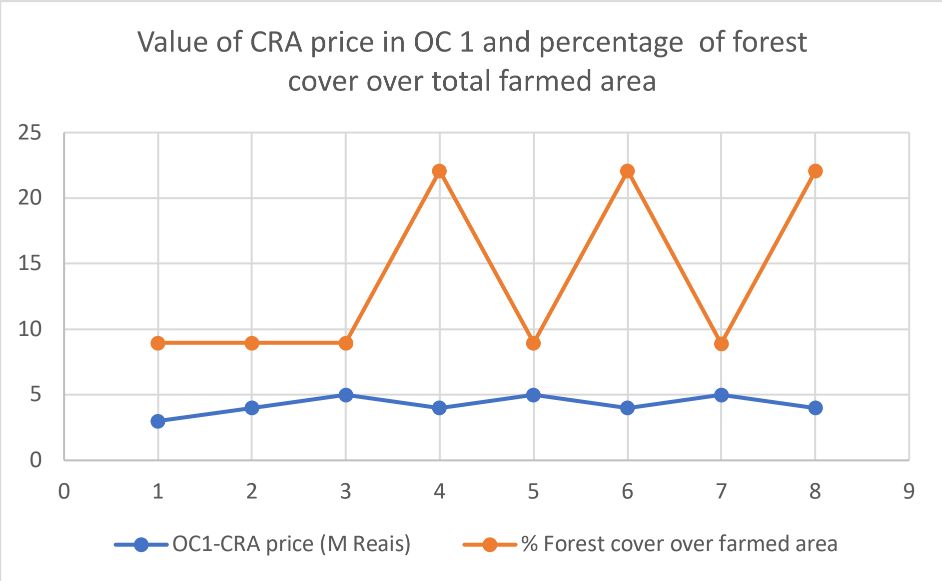

Figure 15: Evolution of the CRA-price over time (blue line); portion of forest cover over total private area (orange line).

If the Opportunists and Conservationists in OC 1 decide to offset their own LR, plus sell a maximum of 20% of their land as forest credits, the LR requirements of all the agents are offset in the area with the cheapest opportunity cost. As shown in Fig. 15, an increase of CRA price of one million Reais, results in an increase of forest cover of 13%.

As can be seen in Fig. 16, after the third time-step, once all agents have offset, most of the forest is localized in OC 1, whereas in OC 2 and OC 3 the forest cover stays constant throughout the simulation.

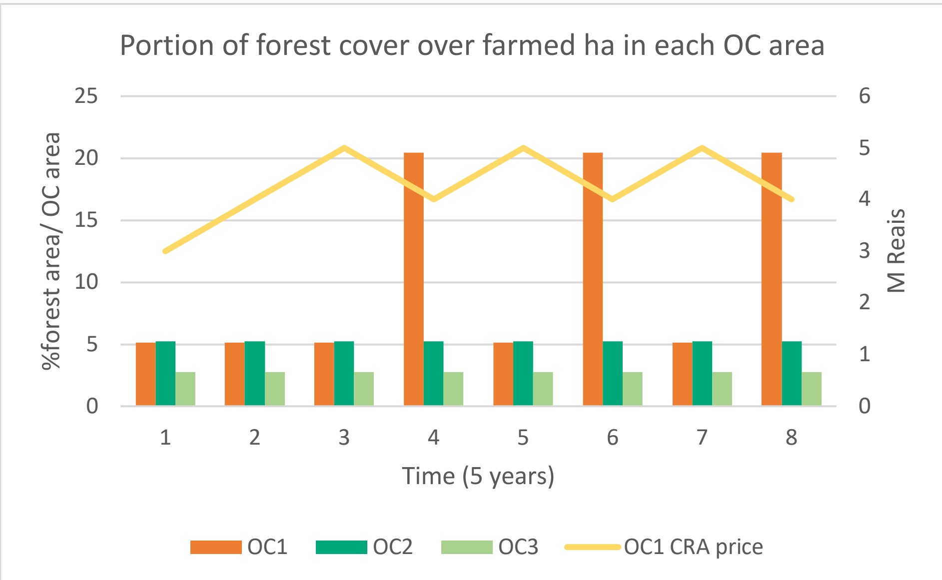

Figure 16: Percentage of forest cover farmed area for every OC area in time, compared to the variation of the CRA price in OC 1 in time.

The amount of forest cover, similarly to scenario 1, fluctuates between 2 values: a minimum, corresponding to a situation where all the Opportunists buy CRA and the cost of the credits is lower than the value of agriculture production everywhere, a maximum, when the Opportunists in OC 1 sell credits, meaning that the CRA price in OC 1 is higher than agriculture production value. The price of the cheapest credit increases of 1 unit at its maximum price compared to the value of agriculture production.

Table 6: Minimum and maximum forest cover calculated as the smallest and largest areas of forest cover, as a percentage of the total private land. The maximum and minimum forest cover values are reported fot Scenario 1 and 2. For Scenario 1, the values are obtained by averaging the results of all the states.

Scenario	1	2
Minimum forest cover (%)	4.7	9
Maximum forest cover (%)	34.7	22

The minimum value of forest cover, representing the vegetation on the properties of the Conservationists is almost double in scenario 1 compared to scenario 2 (Table 6). In scenario 2, the Conservationists is the same portion as in scenario 1, however, in scenario 1, for some states, the number of land-owners in that group was reduced to include the presence of the Isolated group.
The maximum forest cover results from the vegetation owned by the Opportunists, plus the reforested hectares that the Conservationists puts on the market when they join the CRA market. In scenario 2, only the Opportunists that are located in OC 1 experience this change of strategy, because in the other areas, the price of the CRA never exceeds the value of agriculture relative to those lands. On the other hand, in scenario 1 the CRA price is the same within the state and there is no cheaper area where to offset the LR requirement, thus, all the owners in the Opportunists group reforest and the maximum forest cover is higher in scenario 1.

Scenario 3

Scenario 3 includes the participation of the Isolated land-owners. The market is allowed within the whole biome and the Atlantic Forest is divided into OC 1, OC 2, OC 3, as in scenario 2. The results of this scenario show, as for scenario 2, that the area of forest cover fluctuates between two values: a minimum value corresponding to the time-steps when the CRA price for OC 1 equals the agriculture value; a maximum of forested area, when the CRA price for OC 1 exceeds the agriculture revenues.
In this scenario, it is assumed that a governmental initiative starts a campaign to inform illiterate land-owners about the LR requirements and about the CRA scheme. The initiative also aims to connect Isolated land-owners and this connection allows agents to be influenced by the decisions of their neighbors. At the beginning, two Isolated agents are reached by the initiative, one decided to offset their LR debt, the other one became a CRA seller and joined the group of Conservationists.

- As long as the CRA price for OC 1 is lower or equals the agriculture revenues in OC 1, Opportunists buy CRA in every area and the demand for the credits is higher than the offer, which makes the CRA price for OC 1 increase.
  The governmental initiative has started and after the second run, 40% of Isolated became CRA sellers, whereas 44% decided to offset their LR debt. The rest of the isolated still has not been reached by the initiative or neighbors.
- In the third time step, the CRA prices for OC 1 overcame the agriculture value and the Opportunists of OC 1 decided to reforest to offset their own LR and sell credits. At the end of this contract transaction, the offer is higher than the demand, thus the price lowers for the credits in OC 1. At this point, all Isolated have been either converted to selling CRA or offset their LR debt. The newly converted Isolated are 44,2 % and the rest, offset their LR debt.
- In the fourth time-step, the price of the CRA in OC 1 equals the agriculture revenues of the area again and therefore, the land-owners from OC 1 decide to buy CRA.

Compared to scenario 2, the number of patches demanded and offered changes for every run due to the joining of the Isolated land-owners to the market. At the beginning of the simulation, the illiterate portion is 8 % of all the land-owners. After the third time step (i.e. 15 years since the implementation of the CRA scheme), 44,2 % have been converted to land-owners in Group 2, while the rest did not join the market but complied with the environmental law.

Compared to scenario 2, the results from scenario 3 show that the participation of the Isolated group increases the area of forest cover (Fig. 17).

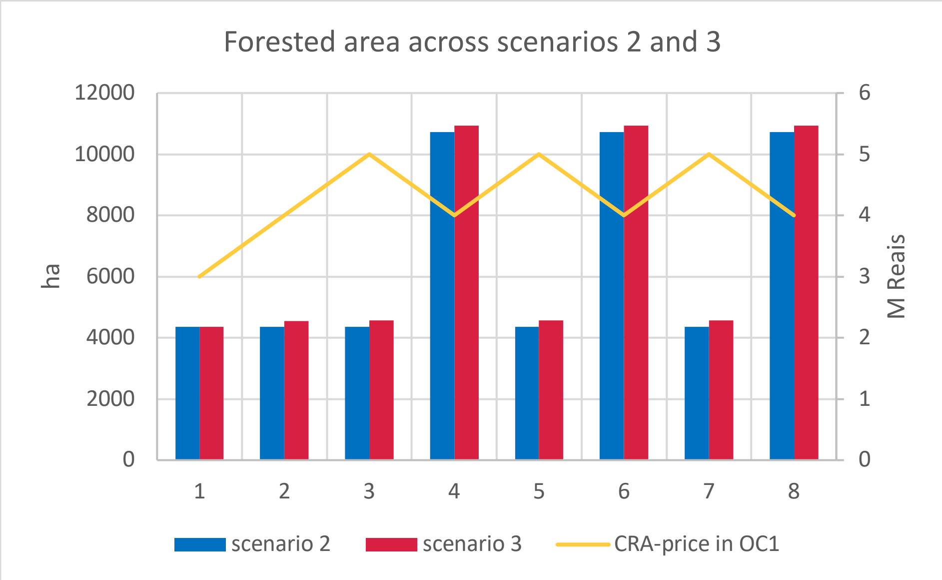

Figure 17: comparison between scenario 2 and 3 concerning the total forest cover per time step.

The portion of illiterates was the same in scenario 2 and 3. In scenario 2, the illiterate land-owners did not participate in the market and neither complied. Essentially, their lack of education prevented them from having knowledge about the regulations. In scenario 3, it is assumed that the Isolated land-owners are made aware of the LR requirements and the CRA scheme. By the third time step of scenario 3, all the illiterate land-owners have changed their strategies. The difference of forest cover between scenario 3 and 2 (Table 7) increases as more illiterate have been reached and informed. At the highest value, the difference between scenario 3 and 2 coincides with 4.92% of the initial forest cover (in scenario 2 and 3).

Table 7: Difference between scenario 2 and 3 concerning forest area over time.

Time-step (5 years)	Scenario 2 Forest area (ha)	Scenario 3 Forest area (ha)	Difference between 3 and 2 (ha)	Difference over initial forest cover (%)
1	4348	4348	0	
2	4348	4552	204	4.69
3	4348	4562	214	4.92
4	10720	10934	214	4.92

The comparison of the results from scenario 2 and 3 showed that the inclusion of the illiterate land-owners, corresponded to and increase of forest by almost 5%. To study these results, the simulation of scenario 3 was repeated increasing the portion of illiterates by 5%. The illiterates were divided among breed I, II and III with the same method described for scenario 3 (eq.2).
The resulting simulation was named scenario 3.1
In scenario 3.1, also at the third time step, 40.3 % of the Isolated group have become credit sellers, while the rest simply reforested 20% of their land to comply with LR requirements.
Compared to scenario 2 (Table 8), the forest cover of scenario 3.1 led to a difference of forest cover amounting to 6.2 % of the forested area at the beginning of the simulation.

Table 8: Comparation of forest cover between scenario 2 and scenario 3.1, modified to include 5 % more illiterate land-owners

Time-step (5 years)	Scenario 2 Forest area (ha)	Scenario 3.1 Forest area (ha)	Difference beteen 3.1 and 2 (ha)	Difference over initial forest cover (%)
1	4348	4348	0	
2	4348	4600	252	5.80
3	4348	4619	271	6.23
4	10720	10991	271	6.23

Compared to scenario 3, an increase by 5% of illiterate agents led to an increase of forest cover of 1.31 %, once all agents in the Isolated group have started comply with the NVPL.
The results of this simulation show that when land-owners are 5% of the population of land-owners, the increase in forest cover is 4,92%, and when they are 10 %, the forest cover increases of 6,23%, Thus, the amount of forest cover does not increase linearly with included illiterates.
This could be explained by the fact that illiterates are a portion on Opportunists in the model. So, the more illiterates there are, the less are the opportunists. When they sell, Opportunists have in their properties a higher area of forest compared to the Isolated: the Opportunists have 40% covered in forest; the Isolated who simply comply, reforest the 20% of their lands, whereas the Isolated who decide to sell CRA, reforest the same portion of land as the Conservationists, that is, 20%, plus a surplus that depends on the size category of the property (Table 5).
Thus, compared to scenario 3, the highest percentage of forest cover over the total farmed patches is only slightly higher in scenario 3.1 (Table 9, last row). However, the difference between the minimum percentage of forest cover between scenario 3.1 and scenario 3 is higher (Table 9, first row). This is due to the fact that, at its minimum value, in scenarios 3 and 3.1, the forest cover is located on the properties of the Conservationists and the Isolated land-owners and therefore, the more are the Isolated, the largest is the forest cover.
Understandably, the correlation between increase of illiteracy and increase of forest cover does not mean that lack of education is beneficial to conservation. The reason behind the increase of vegetation lies in the fact that illiterate landowners have been reached, informed and they started to comply with environmental law.
Scenario 3 does not differ greatly per portion of forest cover over total farmed land compared to scenario 2 (Table 9) and, similarly to scenario 2, it presents a higher forest cover at its minimum value relative to scenario 1 and a lower portion of forest at its maximum, also in relation with scenario 1.

Table 9: comparison bewteen all scenarios for minimum and maximum area of forest

Scenario	1	2	3	3.1
Minimum forest cover (%)	4,7	9	9	9,5
Maximum forest cover (%)	34,7	22	22,5	22,6

Conclusive remarks

In all scenarios, the forest cover fluctuates between two alternate values, which correspond to two values of the cheapest CRA prices: forest cover reaches a minimum value when the CRA price is the same as the agricultural revenues and a maximum when CRA price is one unit higher.
In the model, it is assumed that the main driver of the Opportunists is to increase their profit. It is also assumed that they are not aware of other land-owner’s strategies and they base their decision on the CRA price they had to pay during the last credit contract.

The portion of forest across the scenarios varies depending on these maximum and minimum values: scenario 1 presents a minimum value that is lower compared to the rest of the scenarios, whereas scenario 3.1, due to the highest participation of land-owners, presents the highest value; regarding the maximum values, scenario 1 has the highest forested area, while scenario 2 has the lowest.
The assumption in the model was that in a national market, the opportunity cost of the land varies more compared to a regional market, because the landscape is larger, and opportunity costs may differ more.
In the national market scenario (scenario 2 and 3), the forest cover is all localized in the cheapest opportunity cost land, whereas in the state scenario it is distributed in equal portion in every state because land-owners do not have cheaper alternatives. This entails that the price of the credits in scenario 1 is, on average, higher. In scenarios 2 and 3, in order to offset, the price of the cheapest CRA is one unit higher than the value of production in the land characterized by the lowest agricultural value.
The presence of illiterates affected every scenario: in scenario 1, the amount of area owned by the Isolated group influenced differences in maximum and minimum forest cover among the states; in scenario 3, the gradual participation and/or compliance from the Isolated group resulted in an increase of forest cover of 4.92 % compared to scenario 2. If the initial number of illiterate land-owners is increased by 5%, which means that, at the end of the simulation, 5% more agents comply with LR and/or sell CRA, the forest cover increases by 6.2%, compared to scenario 2 and by 1.3 % compared to scenario 3.

Discussion

Forest Cover Area

The alternation between a maximum forested area and a minimum, visible for every scenario, is the result of the shift in strategy of the Opportunist land-owners. If the CRA price exceeds the agriculture value, the Opportunists face two options for the next contract: investing in a newer enterprise, making a higher profit than before; continuing with the old way (agriculture) and making the same profit as previously. In the model is assumed that land-owners are not aware of each other's strategies and thus, when investing in selling CRA, they do not consider the risks associated with the investment. In finance theory, the tendency to disregard risks when faced with the prospect of a gain is called *Risk Neutrality* (Feder et al., 1985; Kirstein, 2000), however, it is used to describe investors well informed about risks, which land-owners are not. According to risk neutrality theory, the tendency to underestimate risks can derive from biases in gaining and loss: not seeking the higher profit translates to losing it. In this context, continuing with agriculture and not opting for an investment which could return a higher gain, corresponds to loosing that gain difference.

Forest Cover and Illiteracy

An important feature of the model was the portrait of illiterate land-owners, that form the 23% of the Brazilian population (IBGE, 2017). Illiteracy not only curbs the ability of land-owners to be updated on regulations but is also a barrier that can prevent land-owners from joining PES schemes (Brancalion et al., 2014; Grillos, 2017). The literature shows that efforts aiming to raise awareness can increase participation (Chapman et al., 2020; Kingwell et al., 2008). In particular, programs focused on involving communities in the management of their land can create a sense of stewardship of their territory which could bring land-owners not simply to comply, but actively practice in conservation and restoration. According to a study conducted in Brazil, a sense of ownership and stewardship was created by providing technical and legal assistance to land-owners (Brannstrom et al., 2012). A program aimed to develop, in land-owners, appreciation of natural vegetation, could prove to be a longer lasting weapon to aid forest restoration compared to a simple PES scheme, such as the one presented in scenario 2. Indeed, the promise of economic incentives can ensure compliance at first, however, the compliance risks to last only as long as the incentives are administered (Chapman et al., 2020). Scenarios 3 and 3.1 showed that the highest difference in forest cover occurred when the CRA price was equal the value of agriculture, not when it was higher. In the first case, the forest cover was the results of the reforestation efforts of the Conservationists and the compliance of the Isolated. This means that the contribution of Conservationists and Isolated had a relative weight higher than the change in strategy of the Opportunists.

CRA price and Forest Cover

Scenario 2 and 3 showed that all the offset forest is concentrated in the area of lowest opportunity cost, which means that the price paid for every land-owner to have their LR requirement offset is the one of the cheapest CRA. de Freitas et al. (2017) concluded that, since in a national market the CRA supply is expected to exceed the demand, the credit price is presumably lower compared to a federal market, where supply and demand are more balanced. Similarly, according to Soares-Filho et al., (2016) the more physical limitations are applied to CRA market, the higher its economic potential, because a vaster area available for CRA issuing is correlated to higher supply and thus, decrease of CRA price. In this study, the amount of offered area was the same across scenarios. For the national market scenarios, the offered hectares in the cheapest lands were observed to be more than enough to compensate for LRs across the country. Therefore, in this study, the price of the CRA in the national market scenarios is lower compared to a state market not because more land was available, but because sufficient forested area was available at a low price. This is partially concordant with previous studies.

The results of this study show that purchasing CRA does not return the same economic benefits to all Opportunists who manage to sign contracts as buyers. Indeed, in scenario 2 and 3, the CRA price oscillates from a highest value, that equals the value of agriculture production for the area of intermediate opportunity cost (OC 2) and a lowest value, corresponding to the value of agriculture in the lowest opportunity cost area (OC 1). This means that, by buying CRA in OC 1 when the CRA price is lowest, Opportunists from OC 1 spend in CRA the equivalent of what they would have earned by cultivating their land. On the other hand, Opportunists from OC 2 and OC 3, both earn higher agricultural profits than in OC 1 and so, by buying CRA in OC 1 and using their land for agriculture, they pay in CRA less than what they would have lost by reforesting 20% of their land. When the CRA price for OC 1 is equal to the one of OC 2, the Opportunists from OC 2 are paying in CRA the equivalent of the agricultural revenues for the demanded hectares, while the Opportunists in OC 3 are gaining a profit given from the difference between the agricultural revenues in OC 3 and the cheapest CRA price.
This entails that land-owners based in areas with higher agriculture revenue profit more from the CRA market than the land-owners of the cheapest and less fertile lands. Winter & May (2001) state that a national market has the benefit of reducing the compliance costs, however, the results of this study show that that is true only for categories which already obtain the higher revenues from agriculture.
The concentration of forest in cheaper areas means also that more fertile lands are exploited for agriculture and thus leads to land sparing and division. This scenario is not necessarily in line with environmental priorities because areas of high interest for conservation are usually the most fertile for agriculture as well (Muhar et al., 2018). On the other hand, a national market is more likely to ensure vegetation connectivity, whereas, in a state market, forest is more likely to be conserved in patches, with increased border area where forest is exposed and vulnerable to agricultural stress (Coudel et al., 2012).
Before the market became national, the Brazilian norms restricted credit trade within the same watershed; usually areas much smaller that envisaged in the state scenario. Even though this scheme entailed more uniform prices for the credits, it proved to be too narrow, reducing CRA supply to the extent that trading would not be possible (Winter & May, 2001). This leads to the assumption that the optimal extent of a forest credit market is context specific and is affected by ratio between demand and supply, the size of the market, determined by land-owners' individual decisions, and by the heterogeneity of land opportunity cost, which is based on landscape differences (Coudel et al., 2012).
This study shows that in order to increase native vegetation cover, efforts should be directed toward reaching land-owners to inform them about what is required of them by the Native Vegetation Protection Law (NVPL) and how to comply. Measures concerning restricting or enlarging the size of the market, albeit led to forest cover increase, also entailed a compliance only finalized to obtain financial earnings. Indeed, the model showed that once incentives returned lower than agriculture revenues, land-owners cleared their young forests. On the other hand, in scenario 3, once land-owners were acquainted with the law and put in contact with each other, it resulted in constant and long-lasting compliance.
In the real world, the body of issues that curb reforestation efforts in Brazil, seems to go beyond the modalities of implementation of the CRA scheme. Indeed, the Brazilian political class does not seem to regard native vegetation as a priority. Indeed, the election of President Bolsonaro, in 2019, has weakened the efforts to fight deforestation: in 2019, a bill was presented to the Brazilian Senate that proposes the elimination of LR (Metzger et al., 2019); in April 2020, the Minister of the Environment effectively amnestied the deforestation of APPs that occurred before 2008; furthermore, the approval of a measure (technical note 603/2020-MMA) that erases penalties to those who appropriated lands under environmental protection (Associação Nacional dos Servidores de Meio Ambiente, 2020).
Especially in political contexts where environmental conservation and reforestation are feebly imposed from the above, bottom-up initiatives, involvement of communities and adoption of voluntary measures gain relevance.

Limitations of the model

The lack of specific data has forced the creation of assumptions. Firstly, it was hypothesized no heterogeneity of opportunity cost within the same state. This is a rather important assumption because it excludes differences among areas without taking into account factors such as micro-climate, soil quality, water availability, steepness of the land. Concerning the agents, the range of their behaviors was rather flat as it did not consider different willingness to change strategy between buying and selling CRA or a learning ability that would have prevented them from repeating the same strategies every ten years.

The model entails that all agents try to buy and sell at the same time. This entailed that, in one time-step, was expressed the maximum of the demand and, in the next, the maximum of the offer. This caused the fluctuation in the model between maximum and minimum forest cover.

Indeed, especially regarding scenario 1, the maximum forest cover observed seems rather unrealistic. In reality, all opportunistic land-owners would not sell CRA at the same time, creating a large excess of offer and an extinction of the demand. On the other hand, if opportunistic land-owners start selling CRA at different times, some of them could manage to seal contracts to those who are demanding.

Furthermore, it was not considered cost of reforestation nor the time to reforest/ clear.

No time to clear/sell

Conclusions and Recommendations for future work.

The results of this study show that the institution of the CRA market does automatically coincide with forest increase. Reforestation is obtained intermittingly in scenario 1 and 2, when the Opportunists decided to sell CRA. On the other hand, a stable forest cover increase was reached in scenario 3, due to the inclusion of the illiterate land-owners. This is concordant to the second hypothesis. For future research it would be interesting to observe whether how the percentage of included land-owners influences the forest cover.

The first hypothesis stated that a restricted forest credits market correlates to higher forest cover and higher cost of CRA. The results form scenario 1 agree with this statement, however, the largest area of forest cover registered seems to be rather unrealistic. As explained above, the results are due to the assumption, in the model, that all agents join the market (i.e. try to buy and sell) at the same time. It would be interesting to introduce the possibility for land-owners to join the market at different times to assess the resulting forest cover. Indeed, if agents could perform strategies at different times, they would not offer all together and there would not be a fluctuation between minimum and maximum forest cover. Instead, maybe an equilibrium could be reached when opportunistic land-owners sell enough CRA to offset the demand. Similarly, if opportunistic agents had a broader range of characteristics, they would adopt different strategies according to the context. For example, they could be characterized by type of land practices. Indeed, different agricultural techniques entail different relationships with native vegetation, so landowners who practice, for example, agroforestry could continue their practice and sell CRA at the same time. Another factor that could influence the strategy of land-owners are whether they sell their products in a local or an international market. In the second case, the revenues from the agriculture products depend on prices set in other countries, which changes the relationship with CRA price. A more immaterial characteristic of land-owners that would be worth exploring is their willingness to change land-use, in this case, how ready agents are to shift from agriculture to selling CRA. This factor might be correlated to the age of the land-owners, as older generations could maybe be expected to be more conservative and reluctant to change their ways of making incomes (chapman).

Regarding the price of the CRA, this study showed that a national scenario creates a situation where only the land-owners from the cheapest opportunity cost area are willing to reforest and sell CRA. This entails a cash flow from the areas of higher opportunity cost to the lower one, however the revenues from selling CRA are never higher than 1 million Reais more than the value of agriculture production. The scenario where the CRA price is higher is scenario, where all Conservationists can obtain a revenue from selling CRA, not only the ones settled where the CRA price is cheaper. This does not mean that in the national market scenarios, the poorer land-owners receive income from selling CRA, as the opportunity cost of the land is only one of the many factors that affect the income of land-owners. For future research, it would be interesting to explore the role of the income of the land-owners in determining their strategies and analyze how to achieve an increased forest cover coupled with cash flow towards the poorer categories of land-owners.

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APPENDIX I

Among owners of agriculture establishments, portion of illiterates, defined as incapable to write. Retrieved from the Census of Agriculture of the Brazilian Institute of Geography and Statistics (IBGE, 2017).

State	Number of land-owners	Number of illiterates	% illiterates
Espírito Santo	107734	7526	6,98572
Rio de Janeiro	64832	6273	9,67578
Rio Grande do Norte	63222	25256	39,94812
Pernambuco	281386	111607	39,66331
Minas Gerais	605325	75869	12,53360
São Paulo	184798	5690	3,07904
Santa Catarina	181674	5540	3,04942
Alagoas	98362	45416	46,17230
Sergipe	93148	35477	38,08670
Bahia	761921	244642	32,10858
Paraná	303541	16936	5,57948
Rio Grande do Sul	363624	12994	3,57347
Mato Grosso do Sul	70470	4948	7,02143
Paraíba	163083	66120	40,54377

APPENDIX II

Value of agriculture production. Retrieved from of the IBGE (IBGE, 2018)

States	Temporary			Permanent			Total		
	Cultivated area (ha)	Production value (Mil Reais)	value/ ha	Cultivated area (ha)	Production value (Mil Reais)	value/ ha	Cultivated area (ha)	Production value (Mil Reais)	value/ ha
Sergipe	213475	399360	1,87	65801	420653	6,39	279276	820013	2,94
Paraiba	344695	1051864	3,05	32471	238233	7,34	377166	1290097	3,42
Mato Grosso do Sul	5459757	19018718	3,48	161936	2735984	16,90	5621693	21754702	3,87
Paranà	10357553	39092703	3,77	119682	2044791	17,09	10477235	41137494	3,93
Alagoas	403323	1505392	3,73	46380	376400	8,12	449703	1881792	4,18
Rio Grande do Sul	8909135	36449575	4,09	161936	2735984	16,90	9071071	39185559	4,32
Bahia	3199951	14324175	4,48	927933	5336042	5,75	4127884	19660217	4,76
Rio Grande do Norte	226824	1172466	5,17	84206	414532	4,92	311030	1586998	5,10
Pernambuco	695246	1664603	2,39	82976	2325826	28,03	778222	3990429	5,13
Sao Paulo	7856136	39124541	4,98	798485	13921264	17,43	8654621	53045805	6,13
Santa Catarina	1439650	8354971	5,80	77504	1401287	18,08	1517154	9756258	6,43
Minas Gerais	4206628	19507223	4,64	1144958	15526068	13,56	5351586	35033291	6,55
Rio de Janeiro	75912	754705	9,94	33698	456319	13,54	109610	1211024	11,05
Espirito Santo	91259	628457	6,89	476039	5705946	11,99	567298	6334403	11,17

APPENDIX III

Size of agricultural establishments in the Atlantic Forest biome. Retrieved from the Census of Agriculture (IBGE, 2017).

State	**Total**	**<= 5 (ha)**	**> 5 and <= 20 (ha)**	**> 20 and <= 50 (ha)**	**> 50 and <= 100 (ha)**	**> 100 and <= 500 (ha)**	**> 500 (ha)**
Alagoas	23063	12447	7771	1242	603	764	236
Bahia	167053	82196	46623	19174	8390	8581	2089
Espírito Santo	107386	34545	43890	17884	6232	4227	608
Mato Grosso do Sul	11890	1707	5627	2140	623	980	813
Minas Gerais	336643	106525	112986	61507	27912	24481	3232
Paraíba	20958	14951	5089	444	168	228	78
Paraná	300400	88734	113282	54111	19871	20174	4228
Pernambuco	39294	26643	10809	1025	303	365	149
Rio de Janeiro	65091	28269	19212	8670	4035	4290	615
Rio Grande do Norte	1261	706	294	111	51	81	18
Rio Grande do Sul	166784	31017	81002	37621	10146	5957	1041
Santa Catarina	182489	34705	83823	43972	11512	7029	1448
São Paulo	151099	35008	56301	29430	12862	14152	3346
Sergipe	65704	54906	7544	1660	724	751	119

APPENDIX IV

Municipalities that were considered as part of the Atlantic Forest biome. Retrieved from the Census of Agriculture (IBGE, 2017).

Mato Grosso do Sul	Paraíba	Pernambuco	Rio Grande do Norte	Sergipe
Angélica (MS)	Alhandra (PB)	Abreu e Lima (PE)	Arês (RN)	Amparo de São Francisco (SE)
Coronel Sapucaia (MS)	Baía da Traição (PB)	Água Preta (PE)	Baía Formosa (RN)	Aracaju (SE)
Deodápolis (MS)	Bayeux (PB)	Aliança (PE)	Canguaretama (RN)	Arauá (SE)
Eldorado (MS)	Caaporã (PB)	Amaraji (PE)	Espírito Santo (RN)	Barra dos Coqueiros (SE)
Glória de Dourados (MS)	Cabedelo (PB)	Barreiros (PE)	Goianinha (RN)	Boquim (SE)
Iguatemi (MS)	Capim (PB)	Belém de Maria (PE)	Montanhas (RN)	Brejo Grande (SE)
Itaquiraí (MS)	Conde (PB)	Buenos Aires (PE)	Pedro Velho (RN)	Canhoba (SE)
Ivinhema (MS)	Cruz do Espírito Santo (PB)	Cabo de Santo Agostinho (PE)	Senador Georgino Avelino (RN)	Capela (SE)
Japorã (MS)	Cuité de Mamanguape (PB)	Camaragibe (PE)	Tibau do Sul (RN)	Carmópolis (SE)
Jateí (MS)	Curral de Cima (PB)	Camutanga (PE)	Vila Flor (RN)	Cedro de São João (SE)
Mundo Novo (MS)	Itapororoca (PB)	Carpina (PE)		Cristinápolis (SE)
Naviraí (MS)	Jacaraú (PB)	Catende (PE)		Divina Pastora (SE)
Novo Horizonte do Sul (MS)	João Pessoa (PB)	Chã de Alegria (PE)		Estância (SE)
Paranhos (MS)	Juripiranga (PB)	Chã Grande (PE)		General Maynard (SE)
Sete Quedas (MS)	Lucena (PB)	Condado (PE)		Ilha das Flores (SE)
Tacuru (MS)	Mamanguape (PB)	Cortês (PE)		Indiaroba (SE)
	Marcação (PB)	Escada (PE)		Itabaiana (SE)
	Mari (PB)	Fernando de Noronha (PE)		Itaporanga d'Ajuda (SE)
	Mataraca (PB)	Ferreiros (PE)		Japaratuba (SE)
	Pedras de Fogo (PB)	Gameleira (PE)		Japoatã (SE)
	Pilar (PB)	Glória do Goitá (PE)		Laranjeiras (SE)
	Pitimbu (PB)	Goiana (PE)		Maruim (SE)
	Pedro Régis (PB)	Igarassu (PE)		Neópolis (SE)
	Riachão do Poço (PB)	Ipojuca (PE)		Nossa Senhora de Lourdes (SE)
	Rio Tinto (PB)	Ilha de Itamaracá (PE)		Nossa Senhora do Socorro (SE)
	Santa Rita (PB)	Itambé (PE)		Pacatuba (SE)
	São José dos Ramos (PB)	Itapissuma (PE)		Pedrinhas (SE)
	São Miguel de Taipu (PB)	Itaquitinga (PE)		Pirambu (SE)
	Sapé (PB)	Jaboatão dos Guararapes (PE)		Propriá (SE)
	Sobrado (PB)	Jaqueira (PE)		Riachuelo (SE)
		Joaquim Nabuco (PE)		Rosário do Catete (SE)
		Lagoa de Itaenga (PE)		Salgado (SE)

		Macaparana (PE)		Santa Luzia do Itanhy (SE)
		Maraial (PE)		Santana do São Francisco (SE)
		Moreno (PE)		Santa Rosa de Lima (SE)
		Nazaré da Mata (PE)		Santo Amaro das Brotas (SE)
		Olinda (PE)		São Cristóvão (SE)
		Palmares (PE)		São Francisco (SE)
		Paudalho (PE)		Siriri (SE)
		Paulista (PE)		Telha (SE)
		Pombos (PE)		Tomar do Geru (SE)
		Primavera (PE)		Umbaúba (SE)
		Quipapá (PE)		
		Recife (PE)		
		Ribeirão (PE)		
		Rio Formoso (PE)		
		São Benedito do Sul (PE)		
		São José da Coroa Grande (PE)		
		São Lourenço da Mata (PE)		
		Sirinhaém (PE)		
		Tamandaré (PE)		
		Timbaúba (PE)		
		Tracunhaém (PE)		
		Vicência (PE)		
		Vitória de Santo Antão (PE)		
		Xexéu (PE)		

Alagoas	**Bahia**	**Espírito Santo**	**Rio de Janeiro**	**Rio Grande do Sul**
Anadia (AL)	Alcobaça (BA)	Afonso Cláudio (ES)	Angra dos Reis (RJ)	Água Santa (RS)
Atalaia (AL)	Almadina (BA)	Águia Branca (ES)	Aperibé (RJ)	Alecrim (RS)
Barra de Santo Antônio (AL)	Anagé (BA)	Água Doce do Norte (ES)	Araruama (RJ)	Alpestre (RS)
Barra de São Miguel (AL)	Arataca (BA)	Alegre (ES)	Areal (RJ)	Ametista do Sul (RS)
Boca da Mata (AL)	Aratuípe (BA)	Alfredo Chaves (ES)	Armação dos Búzios (RJ)	André da Rocha (RS)
Branquinha (AL)	Aurelino Leal (BA)	Alto Rio Novo (ES)	Arraial do Cabo (RJ)	Anta Gorda (RS)
Cajueiro (AL)	Barra do Choça (BA)	Anchieta (ES)	Barra do Piraí (RJ)	Antônio Prado (RS)
Campestre (AL)	Barra do Rocha (BA)	Apiacá (ES)	Barra Mansa (RJ)	Aratiba (RS)
Campo Alegre (AL)	Barro Preto (BA)	Aracruz (ES)	Belford Roxo (RJ)	Arroio do Meio (RS)
Capela (AL)	Belmonte (BA)	Atílio Vivacqua (ES)	Bom Jardim (RJ)	Arroio do Tigre (RS)
Chã Preta (AL)	Belo Campo (BA)	Baixo Guandu (ES)	Bom Jesus do Itabapoana (RJ)	Arvorezinha (RS)
Colônia Leopoldina (AL)	Boa Nova (BA)	Barra de São Francisco (ES)	Cabo Frio (RJ)	Áurea (RS)

Coqueiro Seco (AL)	Bom Jesus da Serra (BA)	Boa Esperança (ES)	Cachoeiras de Macacu (RJ)	Barão de Cotegipe (RS)
Coruripe (AL)	Buerarema (BA)	Bom Jesus do Norte (ES)	Cambuci (RJ)	Barra do Guarita (RS)
Feliz Deserto (AL)	Caatiba (BA)	Brejetuba (ES)	Carapebus (RJ)	Barra do Rio Azul (RS)
Flexeiras (AL)	Cabaceiras do Paraguaçu (BA)	Cachoeiro de Itapemirim (ES)	Comendador Levy Gasparian (RJ)	Barros Cassal (RS)
Ibateguara (AL)	Cachoeira (BA)	Cariacica (ES)	Campos dos Goytacazes (RJ)	Benjamin Constant do Sul (RS)
Igreja Nova (AL)	Caetanos (BA)	Castelo (ES)	Cantagalo (RJ)	Bento Gonçalves (RS)
Jacuípe (AL)	Cairu (BA)	Colatina (ES)	Cardoso Moreira (RJ)	Boa Vista do Buricá (RS)
Japaratinga (AL)	Camacan (BA)	Conceição da Barra (ES)	Carmo (RJ)	Boa Vista do Sul (RS)
Jequiá da Praia (AL)	Camamu (BA)	Conceição do Castelo (ES)	Casimiro de Abreu (RJ)	Bom Jesus (RS)
Joaquim Gomes (AL)	Canavieiras (BA)	Divino de São Lourenço (ES)	Conceição de Macabu (RJ)	Bom Progresso (RS)
Jundiá (AL)	Candeias (BA)	Domingos Martins (ES)	Cordeiro (RJ)	Bom Retiro do Sul (RS)
Junqueiro (AL)	Cardeal da Silva (BA)	Dores do Rio Preto (ES)	Duas Barras (RJ)	Boqueirão do Leão (RS)
Maceió (AL)	Castro Alves (BA)	Ecoporanga (ES)	Duque de Caxias (RJ)	Braga (RS)
Maragogi (AL)	Catu (BA)	Fundão (ES)	Engenheiro Paulo de Frontin (RJ)	Cacique Doble (RS)
Marechal Deodoro (AL)	Coaraci (BA)	Governador Lindenberg (ES)	Guapimirim (RJ)	Caiçara (RS)
Matriz de Camaragibe (AL)	Conceição do Almeida (BA)	Guaçuí (ES)	Iguaba Grande (RJ)	Camargo (RS)
Messias (AL)	Conceição do Jacuípe (BA)	Guarapari (ES)	Itaboraí (RJ)	Cambará do Sul (RS)
Murici (AL)	Conde (BA)	Ibatiba (ES)	Itaguaí (RJ)	Campestre da Serra (RS)
Novo Lino (AL)	Cruz das Almas (BA)	Ibiraçu (ES)	Italva (RJ)	Campinas do Sul (RS)
Paripueira (AL)	Dário Meira (BA)	Ibitirama (ES)	Itaocara (RJ)	Campo Novo (RS)
Passo de Camaragibe (AL)	Dias d'Ávila (BA)	Iconha (ES)	Itaperuna (RJ)	Candelária (RS)
Penedo (AL)	Dom Macedo Costa (BA)	Irupi (ES)	Itatiaia (RJ)	Cândido Godói (RS)
Piaçabuçu (AL)	Encruzilhada (BA)	Itaguaçu (ES)	Japeri (RJ)	Canudos do Vale (RS)
Pilar (AL)	Entre Rios (BA)	Itapemirim (ES)	Laje do Muriaé (RJ)	Capão Bonito do Sul (RS)
Pindoba (AL)	Esplanada (BA)	Itarana (ES)	Macaé (RJ)	Capitão (RS)
Porto Calvo (AL)	Eunápolis (BA)	Iúna (ES)	Macuco (RJ)	Carlos Barbosa (RS)
Porto de Pedras (AL)	Firmino Alves (BA)	Jaguaré (ES)	Magé (RJ)	Carlos Gomes (RS)
Porto Real do Colégio (AL)	Floresta Azul (BA)	Jerônimo Monteiro (ES)	Mangaratiba (RJ)	Casca (RS)
Rio Largo (AL)	Gandu (BA)	João Neiva (ES)	Maricá (RJ)	Caseiros (RS)
Roteiro (AL)	Gongogi (BA)	Laranja da Terra (ES)	Mendes (RJ)	Caxias do Sul (RS)
Santa Luzia do Norte (AL)	Governador Mangabeira (BA)	Linhares (ES)	Mesquita (RJ)	Centenário (RS)
Santana do Mundaú (AL)	Guaratinga (BA)	Mantenópolis (ES)	Miguel Pereira (RJ)	Charrua (RS)
São José da Laje (AL)	Ibicaraí (BA)	Marataízes (ES)	Miracema (RJ)	Ciríaco (RS)
São Luís do Quitunde (AL)	Ibicuí (BA)	Marechal Floriano (ES)	Natividade (RJ)	Colinas (RS)
São Miguel dos Campos (AL)	Ibipitanga (BA)	Marilândia (ES)	Niterói (RJ)	Constantina (RS)
São Miguel dos Milagres (AL)	Ibirapuã (BA)	Mimoso do Sul (ES)	Nova Friburgo (RJ)	Coqueiro Baixo (RS)

Satuba (AL)	Ibirataia (BA)	Montanha (ES)	Nova Iguaçu (RJ)	Coronel Pilar (RS)
Teotônio Vilela (AL)	Igrapiúna (BA)	Mucurici (ES)	Paracambi (RJ)	Cotiporã (RS)
União dos Palmares (AL)	Iguaí (BA)	Muniz Freire (ES)	Paraíba do Sul (RJ)	Coxilha (RS)
Viçosa (AL)	Ilhéus (BA)	Muqui (ES)	Paraty (RJ)	Crissiumal (RS)
	Ipiaú (BA)	Nova Venécia (ES)	Paty do Alferes (RJ)	Cristal do Sul (RS)
	Itabela (BA)	Pancas (ES)	Petrópolis (RJ)	Cruzaltense (RS)
	Itabuna (BA)	Pedro Canário (ES)	Pinheiral (RJ)	Cruzeiro do Sul (RS)
	Itacaré (BA)	Pinheiros (ES)	Piraí (RJ)	David Canabarro (RS)
	Itagibá (BA)	Piúma (ES)	Porciúncula (RJ)	Derrubadas (RS)
	Itagimirim (BA)	Ponto Belo (ES)	Porto Real (RJ)	Dois Irmãos das Missões (RS)
	Itaju do Colônia (BA)	Presidente Kennedy (ES)	Quatis (RJ)	Dois Lajeados (RS)
	Itajuípe (BA)	Rio Bananal (ES)	Queimados (RJ)	Doutor Maurício Cardoso (RS)
	Itamaraju (BA)	Rio Novo do Sul (ES)	Quissamã (RJ)	Doutor Ricardo (RS)
	Itamari (BA)	Santa Leopoldina (ES)	Resende (RJ)	Encantado (RS)
	Itambé (BA)	Santa Maria de Jetibá (ES)	Rio Bonito (RJ)	Engenho Velho (RS)
	Itanagra (BA)	Santa Teresa (ES)	Rio Claro (RJ)	Entre Rios do Sul (RS)
	Itanhém (BA)	São Domingos do Norte (ES)	Rio das Flores (RJ)	Erebango (RS)
	Itaparica (BA)	São Gabriel da Palha (ES)	Rio das Ostras (RJ)	Erechim (RS)
	Itapé (BA)	São José do Calçado (ES)	Rio de Janeiro (RJ)	Ernestina (RS)
	Itapebi (BA)	São Mateus (ES)	Santa Maria Madalena (RJ)	Erval Grande (RS)
	Itapetinga (BA)	São Roque do Canaã (ES)	Santo Antônio de Pádua (RJ)	Erval Seco (RS)
	Itapitanga (BA)	Serra (ES)	São Francisco de Itabapoana (RJ)	Esmeralda (RS)
	Itarantim (BA)	Sooretama (ES)	São Fidélis (RJ)	Esperança do Sul (RS)
	Itororó (BA)	Vargem Alta (ES)	São Gonçalo (RJ)	Estação (RS)
	Ituberá (BA)	Venda Nova do Imigrante (ES)	São João da Barra (RJ)	Estrela (RS)
	Jaguaripe (BA)	Viana (ES)	São João de Meriti (RJ)	Estrela Velha (RS)
	Jandaíra (BA)	Vila Pavão (ES)	São José de Ubá (RJ)	Fagundes Varela (RS)
	Jucuruçu (BA)	Vila Valério (ES)	São José do Vale do Rio Preto (RJ)	Farroupilha (RS)
	Jussari (BA)	Vila Velha (ES)	São Pedro da Aldeia (RJ)	Faxinalzinho (RS)
	Lajedão (BA)	Vitória (ES)	São Sebastião do Alto (RJ)	Fazenda Vilanova (RS)
	Lauro de Freitas (BA)		Sapucaia (RJ)	Flores da Cunha (RS)
	Macarani (BA)		Saquarema (RJ)	Floriano Peixoto (RS)
	Maiquinique (BA)		Seropédica (RJ)	Fontoura Xavier (RS)
	Manoel Vitorino (BA)		Silva Jardim (RJ)	Forquetinha (RS)
	Maragogipe (BA)		Sumidouro (RJ)	Frederico Westphalen (RS)
	Maraú (BA)		Tanguá (RJ)	Garibaldi (RS)
	Mascote (BA)		Teresópolis (RJ)	Gaurama (RS)
	Mata de São João (BA)		Trajano de Moraes (RJ)	Gentil (RS)

	Medeiros Neto (BA)		Três Rios (RJ)	Getúlio Vargas (RS)
	Mirante (BA)		Valença (RJ)	Gramado dos Loureiros (RS)
	Mucuri (BA)		Varre-Sai (RJ)	Gramado Xavier (RS)
	Muniz Ferreira (BA)		Vassouras (RJ)	Guabiju (RS)
	Muritiba (BA)		Volta Redonda (RJ)	Guaporé (RS)
	Nazaré (BA)			Herveiras (RS)
	Nilo Peçanha (BA)			Horizontina (RS)
	Nova Canaã (BA)			Humaitá (RS)
	Nova Ibiá (BA)			Ibarama (RS)
	Nova Viçosa (BA)			Ibiaçá (RS)
	Pau Brasil (BA)			Ibiraiaras (RS)
	Piraí do Norte (BA)			Ibirapuitã (RS)
	Planalto (BA)			Ilópolis (RS)
	Poções (BA)			Imigrante (RS)
	Pojuca (BA)			Independência (RS)
	Porto Seguro (BA)			Ipê (RS)
	Potiraguá (BA)			Ipiranga do Sul (RS)
	Prado (BA)			Iraí (RS)
	Presidente Tancredo Neves (BA)			Itapuca (RS)
	Ribeirão do Largo (BA)			Itatiba do Sul (RS)
	Salinas da Margarida (BA)			Jacutinga (RS)
	Salvador (BA)			Jaquirana (RS)
	Santa Cruz Cabrália (BA)			Lagoa Bonita do Sul (RS)
	Santa Cruz da Vitória (BA)			Lagoão (RS)
	Santa Luzia (BA)			Lagoa Vermelha (RS)
	Santo Amaro (BA)			Lajeado (RS)
	Santo Antônio de Jesus (BA)			Liberato Salzano (RS)
	São Félix (BA)			Machadinho (RS)
	São Felipe (BA)			Marau (RS)
	São Francisco do Conde (BA)			Marcelino Ramos (RS)
	São José da Vitória (BA)			Mariano Moro (RS)
	São Sebastião do Passé (BA)			Marques de Souza (RS)
	Sapeaçu (BA)			Mato Castelhano (RS)
	Saubara (BA)			Mato Leitão (RS)
	Simões Filho (BA)			Maximiliano de Almeida (RS)
	Taperoá (BA)			Miraguaí (RS)
	Teixeira de Freitas (BA)			Montauri (RS)
	Teolândia (BA)			Monte Alegre dos Campos (RS)
	Terra Nova (BA)			Monte Belo do Sul (RS)

	Ubaitaba (BA)			Mormaço (RS)
	Ubatã (BA)			Muçum (RS)
	Una (BA)			Muitos Capões (RS)
	Uruçuca (BA)			Muliterno (RS)
	Valença (BA)			Nicolau Vergueiro (RS)
	Varzedo (BA)			Nonoai (RS)
	Vera Cruz (BA)			Nova Alvorada (RS)
	Vereda (BA)			Nova Araçá (RS)
	Vitória da Conquista (BA)			Nova Bassano (RS)
	Wenceslau Guimarães (BA)			Nova Bréscia (RS)
				Nova Candelária (RS)
				Nova Pádua (RS)
				Nova Prata (RS)
				Nova Roma do Sul (RS)
				Novo Machado (RS)
				Novo Tiradentes (RS)
				Novo Xingu (RS)
				Paim Filho (RS)
				Palmitinho (RS)
				Paraí (RS)
				Passa Sete (RS)
				Passo Fundo (RS)
				Paulo Bento (RS)
				Paverama (RS)
				Pinhal da Serra (RS)
				Pinheirinho do Vale (RS)
				Pinto Bandeira (RS)
				Planalto (RS)
				Pontão (RS)
				Ponte Preta (RS)
				Porto Lucena (RS)
				Porto Mauá (RS)
				Porto Vera Cruz (RS)
				Pouso Novo (RS)
				Progresso (RS)
				Protásio Alves (RS)
				Putinga (RS)
				Quatro Irmãos (RS)
				Redentora (RS)
				Relvado (RS)
				Rio dos Índios (RS)

				Roca Sales (RS)
				Rodeio Bonito (RS)
				Ronda Alta (RS)
				Rondinha (RS)
				Sananduva (RS)
				Santa Cecília do Sul (RS)
				Santa Clara do Sul (RS)
				Santa Cruz do Sul (RS)
				Santa Rosa (RS)
				Santa Tereza (RS)
				Santo Antônio do Palma (RS)
				Santo Cristo (RS)
				Santo Expedito do Sul (RS)
				São Domingos do Sul (RS)
				São Francisco de Paula (RS)
				São João da Urtiga (RS)
				São Jorge (RS)
				São José do Herval (RS)
				São José do Inhacorá (RS)
				São José do Ouro (RS)
				São José dos Ausentes (RS)
				São Marcos (RS)
				São Martinho (RS)
				São Valentim (RS)
				São Valentim do Sul (RS)
				Seberi (RS)
				Sede Nova (RS)
				Segredo (RS)
				Serafina Corrêa (RS)
				Sério (RS)
				Sertão (RS)
				Severiano de Almeida (RS)
				Sinimbu (RS)
				Sobradinho (RS)
				Soledade (RS)
				Tabaí (RS)
				Tapejara (RS)
				Taquari (RS)
				Taquaruçu do Sul (RS)

				Tenente Portela (RS)
				Teutônia (RS)
				Tiradentes do Sul (RS)
				Travesseiro (RS)
				Três Arroios (RS)
				Três de Maio (RS)
				Três Palmeiras (RS)
				Três Passos (RS)
				Trindade do Sul (RS)
				Tucunduva (RS)
				Tunas (RS)
				Tupanci do Sul (RS)
				Tuparendi (RS)
				União da Serra (RS)
				Vacaria (RS)
				Vale do Sol (RS)
				Vanini (RS)
				Venâncio Aires (RS)
				Vera Cruz (RS)
				Veranópolis (RS)
				Vespasiano Corrêa (RS)
				Viadutos (RS)
				Vicente Dutra (RS)
				Vila Flores (RS)
				Vila Lângaro (RS)
				Vila Maria (RS)
				Vista Alegre (RS)
				Vista Alegre do Prata (RS)
				Vista Gaúcha (RS)
				Westfália (RS)

Minas Gerais	**Paraná**	**Santa Catarina**	**São Paulo**
Abre Campo (MG)	Abatiá (PR)	Abdon Batista (SC)	Adamantina (SP)
Acaiaca (MG)	Adrianópolis (PR)	Abelardo Luz (SC)	Adolfo (SP)
Açucena (MG)	Agudos do Sul (PR)	Agrolândia (SC)	Águas da Prata (SP)
Aguanil (MG)	Almirante Tamandaré (PR)	Agronômica (SC)	Águas de Lindóia (SP)
Águas Formosas (MG)	Altamira do Paraná (PR)	Água Doce (SC)	Alfredo Marcondes (SP)
Aimorés (MG)	Altônia (PR)	Águas de Chapecó (SC)	Altair (SP)
Aiuruoca (MG)	Alto Paraná (PR)	Águas Frias (SC)	Alto Alegre (SP)
Alagoa (MG)	Alto Piquiri (PR)	Águas Mornas (SC)	Alumínio (SP)
Albertina (MG)	Alvorada do Sul (PR)	Alfredo Wagner (SC)	Álvares Florence (SP)
Além Paraíba (MG)	Amaporã (PR)	Alto Bela Vista (SC)	Álvares Machado (SP)

Alfredo Vasconcelos (MG)	Ampére (PR)	Anchieta (SC)	Álvaro de Carvalho (SP)
Almenara (MG)	Anahy (PR)	Angelina (SC)	Alvinlândia (SP)
Alpercata (MG)	Andirá (PR)	Anita Garibaldi (SC)	Americana (SP)
Alto Caparaó (MG)	Ângulo (PR)	Anitápolis (SC)	Américo Brasiliense (SP)
Alto Rio Doce (MG)	Antonina (PR)	Antônio Carlos (SC)	Américo de Campos (SP)
Alvarenga (MG)	Antônio Olinto (PR)	Apiúna (SC)	Amparo (SP)
Alvinópolis (MG)	Apucarana (PR)	Arabutã (SC)	Andradina (SP)
Alvorada de Minas (MG)	Arapongas (PR)	Araquari (SC)	Anhumas (SP)
Amparo do Serra (MG)	Arapuã (PR)	Araranguá (SC)	Aparecida (SP)
Andradas (MG)	Araruna (PR)	Armazém (SC)	Aparecida d'Oeste (SP)
Andrelândia (MG)	Araucária (PR)	Arroio Trinta (SC)	Apiaí (SP)
Antônio Carlos (MG)	Ariranha do Ivaí (PR)	Arvoredo (SC)	Araçariguama (SP)
Antônio Dias (MG)	Assaí (PR)	Ascurra (SC)	Araçatuba (SP)
Antônio Prado de Minas (MG)	Assis Chateaubriand (PR)	Atalanta (SC)	Araçoiaba da Serra (SP)
Aracitaba (MG)	Astorga (PR)	Aurora (SC)	Arapeí (SP)
Araçuaí (MG)	Atalaia (PR)	Balneário Arroio do Silva (SC)	Araraquara (SP)
Arantina (MG)	Balsa Nova (PR)	Balneário Camboriú (SC)	Araras (SP)
Araponga (MG)	Bandeirantes (PR)	Balneário Barra do Sul (SC)	Arco0Íris (SP)
Arceburgo (MG)	Barbosa Ferraz (PR)	Balneário Gaivota (SC)	Areias (SP)
Argirita (MG)	Barracão (PR)	Bandeirante (SC)	Ariranha (SP)
Astolfo Dutra (MG)	Barra do Jacaré (PR)	Barra Bonita (SC)	Artur Nogueira (SP)
Ataléia (MG)	Bela Vista da Caroba (PR)	Barra Velha (SC)	Arujá (SP)
Baependi (MG)	Bela Vista do Paraíso (PR)	Bela Vista do Toldo (SC)	Aspásia (SP)
Bandeira (MG)	Bituruna (PR)	Belmonte (SC)	Assis (SP)
Bandeira do Sul (MG)	Boa Esperança (PR)	Benedito Novo (SC)	Atibaia (SP)
Barão de Cocais (MG)	Boa Esperança do Iguaçu (PR)	Biguaçu (SC)	Auriflama (SP)
Barão de Monte Alto (MG)	Boa Ventura de São Roque (PR)	Blumenau (SC)	Avanhandava (SP)
Barbacena (MG)	Boa Vista da Aparecida (PR)	Bocaina do Sul (SC)	Bady Bassitt (SP)
Barra Longa (MG)	Bocaiúva do Sul (PR)	Bombinhas (SC)	Bálsamo (SP)
Barroso (MG)	Bom Jesus do Sul (PR)	Bom Jardim da Serra (SC)	Bananal (SP)
Bela Vista de Minas (MG)	Bom Sucesso (PR)	Bom Jesus (SC)	Barbosa (SP)
Belmiro Braga (MG)	Bom Sucesso do Sul (PR)	Bom Jesus do Oeste (SC)	Bariri (SP)
Belo Horizonte (MG)	Borrazópolis (PR)	Bom Retiro (SC)	Barra Bonita (SP)
Belo Oriente (MG)	Braganey (PR)	Botuverá (SC)	Barra do Chapéu (SP)
Belo Vale (MG)	Brasilândia do Sul (PR)	Braço do Norte (SC)	Barra do Turvo (SP)
Bertópolis (MG)	Cafeara (PR)	Braço do Trombudo (SC)	Bastos (SP)
Betim (MG)	Cafelândia (PR)	Brunópolis (SC)	Bauru (SP)
Bias Fortes (MG)	Cafezal do Sul (PR)	Brusque (SC)	Bebedouro (SP)
Bicas (MG)	Califórnia (PR)	Caçador (SC)	Bento de Abreu (SP)
Boa Esperança (MG)	Cambará (PR)	Caibi (SC)	Bernardino de Campos (SP)
Bocaina de Minas (MG)	Cambé (PR)	Calmon (SC)	Bertioga (SP)
Bom Jardim de Minas (MG)	Cambira (PR)	Camboriú (SC)	Bilac (SP)

Bom Jesus da Penha (MG)	Campina da Lagoa (PR)	Capão Alto (SC)	Birigui (SP)
Bom Jesus do Galho (MG)	Campina do Simão (PR)	Campo Alegre (SC)	Biritiba Mirim (SP)
Bom Repouso (MG)	Campina Grande do Sul (PR)	Campo Belo do Sul (SC)	Boa Esperança do Sul (SP)
Bonfim (MG)	Campo Bonito (PR)	Campo Erê (SC)	Bocaina (SP)
Borda da Mata (MG)	Campo do Tenente (PR)	Campos Novos (SC)	Boituva (SP)
Botelhos (MG)	Campo Largo (PR)	Canelinha (SC)	Bom Jesus dos Perdões (SP)
Brás Pires (MG)	Campo Magro (PR)	Canoinhas (SC)	Borá (SP)
Braúnas (MG)	Campo Mourão (PR)	Capinzal (SC)	Boracéia (SP)
Brazópolis (MG)	Cândido de Abreu (PR)	Capivari de Baixo (SC)	Borborema (SP)
Brumadinho (MG)	Candói (PR)	Catanduvas (SC)	Bragança Paulista (SP)
Bueno Brandão (MG)	Cantagalo (PR)	Caxambu do Sul (SC)	Braúna (SP)
Bugre (MG)	Capanema (PR)	Celso Ramos (SC)	Brejo Alegre (SP)
Cabo Verde (MG)	Capitão Leônidas Marques (PR)	Cerro Negro (SC)	Buritama (SP)
Cachoeira de Minas (MG)	Carambeí (PR)	Chapadão do Lageado (SC)	Caçapava (SP)
Caeté (MG)	Carlópolis (PR)	Chapecó (SC)	Cachoeira Paulista (SP)
Caiana (MG)	Cascavel (PR)	Cocal do Sul (SC)	Caconde (SP)
Cajuri (MG)	Castro (PR)	Concórdia (SC)	Cafelândia (SP)
Caldas (MG)	Catanduvas (PR)	Cordilheira Alta (SC)	Caiabu (SP)
Camanducaia (MG)	Centenário do Sul (PR)	Coronel Freitas (SC)	Caieiras (SP)
Cambuí (MG)	Cerro Azul (PR)	Coronel Martins (SC)	Caiuá (SP)
Cambuquira (MG)	Céu Azul (PR)	Corupá (SC)	Cajamar (SP)
Campanário (MG)	Chopinzinho (PR)	Correia Pinto (SC)	Cajati (SP)
Campanha (MG)	Cianorte (PR)	Criciúma (SC)	Cajobi (SP)
Campestre (MG)	Cidade Gaúcha (PR)	Cunha Porã (SC)	Campinas (SP)
Campo Belo (MG)	Clevelândia (PR)	Cunhataí (SC)	Campo Limpo Paulista (SP)
Campo do Meio (MG)	Colombo (PR)	Curitibanos (SC)	Campos do Jordão (SP)
Campos Gerais (MG)	Colorado (PR)	Descanso (SC)	Campos Novos Paulista (SP)
Canaã (MG)	Congonhinhas (PR)	Dionísio Cerqueira (SC)	Cananéia (SP)
Cana Verde (MG)	Conselheiro Mairinck (PR)	Dona Emma (SC)	Canas (SP)
Candeias (MG)	Contenda (PR)	Doutor Pedrinho (SC)	Cândido Mota (SP)
Cantagalo (MG)	Corbélia (PR)	Entre Rios (SC)	Cândido Rodrigues (SP)
Caparaó (MG)	Cornélio Procópio (PR)	Ermo (SC)	Canitar (SP)
Capela Nova (MG)	Coronel Domingos Soares (PR)	Erval Velho (SC)	Capão Bonito (SP)
Capitão Andrade (MG)	Coronel Vivida (PR)	Faxinal dos Guedes (SC)	Capela do Alto (SP)
Caputira (MG)	Corumbataí do Sul (PR)	Flor do Sertão (SC)	Capivari (SP)
Caraí (MG)	Cruzeiro do Iguaçu (PR)	Florianópolis (SC)	Caraguatatuba (SP)
Caranaíba (MG)	Cruzeiro do Oeste (PR)	Formosa do Sul (SC)	Cardoso (SP)
Carandaí (MG)	Cruzeiro do Sul (PR)	Forquilhinha (SC)	Casa Branca (SP)
Carangola (MG)	Cruz Machado (PR)	Fraiburgo (SC)	Castilho (SP)
Caratinga (MG)	Cruzmaltina (PR)	Frei Rogério (SC)	Catanduva (SP)
Careaçu (MG)	Curitiba (PR)	Galvão (SC)	Catiguá (SP)
Carlos Chagas (MG)	Curiúva (PR)	Garopaba (SC)	Cedral (SP)

Carmésia (MG)	Diamante do Norte (PR)	Garuva (SC)	Cerquilho (SP)
Carmo da Cachoeira (MG)	Diamante do Sul (PR)	Gaspar (SC)	Cesário Lange (SP)
Carmo da Mata (MG)	Diamante D'Oeste (PR)	Governador Celso Ramos (SC)	Charqueada (SP)
Carmo de Minas (MG)	Dois Vizinhos (PR)	Grão Pará (SC)	Clementina (SP)
Carmópolis de Minas (MG)	Douradina (PR)	Gravatal (SC)	Conchal (SP)
Carrancas (MG)	Doutor Camargo (PR)	Guabiruba (SC)	Cordeirópolis (SP)
Carvalhos (MG)	Enéas Marques (PR)	Guaraciaba (SC)	Coroados (SP)
Casa Grande (MG)	Engenheiro Beltrão (PR)	Guaramirim (SC)	Cosmópolis (SP)
Cataguases (MG)	Esperança Nova (PR)	Guarujá do Sul (SC)	Cosmorama (SP)
Catas Altas (MG)	Entre Rios do Oeste (PR)	Guatambú (SC)	Cotia (SP)
Catas Altas da Noruega (MG)	Espigão Alto do Iguaçu (PR)	Herval d'Oeste (SC)	Cruzália (SP)
Catuji (MG)	Farol (PR)	Ibiam (SC)	Cruzeiro (SP)
Caxambu (MG)	Faxinal (PR)	Ibicaré (SC)	Cubatão (SP)
Central de Minas (MG)	Fazenda Rio Grande (PR)	Ibirama (SC)	Cunha (SP)
Chácara (MG)	Fênix (PR)	Içara (SC)	Diadema (SP)
Chalé (MG)	Fernandes Pinheiro (PR)	Ilhota (SC)	Dirce Reis (SP)
Chiador (MG)	Figueira (PR)	Imaruí (SC)	Divinolândia (SP)
Cipotânea (MG)	Floraí (PR)	Imbituba (SC)	Dobrada (SP)
Coimbra (MG)	Flor da Serra do Sul (PR)	Imbuia (SC)	Dois Córregos (SP)
Comercinho (MG)	Floresta (PR)	Indaial (SC)	Dolcinópolis (SP)
Conceição das Pedras (MG)	Florestópolis (PR)	Iomerê (SC)	Dracena (SP)
Conceição de Ipanema (MG)	Flórida (PR)	Ipira (SC)	Echaporã (SP)
Conceição do Mato Dentro (MG)	Formosa do Oeste (PR)	Iporã do Oeste (SC)	Eldorado (SP)
Conceição do Rio Verde (MG)	Foz do Iguaçu (PR)	Ipuaçu (SC)	Elias Fausto (SP)
Conceição dos Ouros (MG)	Francisco Alves (PR)	Ipumirim (SC)	Elisiário (SP)
Confins (MG)	Francisco Beltrão (PR)	Iraceminha (SC)	Embaúba (SP)
Congonhal (MG)	Foz do Jordão (PR)	Irani (SC)	Embu das Artes (SP)
Congonhas (MG)	General Carneiro (PR)	Irati (SC)	Embu0Guaçu (SP)
Congonhas do Norte (MG)	Godoy Moreira (PR)	Irineópolis (SC)	Emilianópolis (SP)
Conselheiro Lafaiete (MG)	Goioerê (PR)	Itá (SC)	Engenheiro Coelho (SP)
Consolação (MG)	Goioxim (PR)	Itaiópolis (SC)	Espírito Santo do Pinhal (SP)
Contagem (MG)	Grandes Rios (PR)	Itajaí (SC)	Espírito Santo do Turvo (SP)
Coqueiral (MG)	Guaíra (PR)	Itapema (SC)	Estrela d'Oeste (SP)
Cordislândia (MG)	Guairaçá (PR)	Itapiranga (SC)	Estrela do Norte (SP)
Coroaci (MG)	Guamiranga (PR)	Itapoá (SC)	Euclides da Cunha Paulista (SP)
Coronel Fabriciano (MG)	Guapirama (PR)	Ituporanga (SC)	Fartura (SP)
Coronel Murta (MG)	Guaporema (PR)	Jaborá (SC)	Fernandópolis (SP)
Coronel Pacheco (MG)	Guaraci (PR)	Jacinto Machado (SC)	Fernando Prestes (SP)
Coronel Xavier Chaves (MG)	Guaraniaçu (PR)	Jaguaruna (SC)	Fernão (SP)
Córrego do Bom Jesus (MG)	Guarapuava (PR)	Jaraguá do Sul (SC)	Ferraz de Vasconcelos (SP)
Córrego Novo (MG)	Guaraqueçaba (PR)	Jardinópolis (SC)	Flora Rica (SP)

Crisólita (MG)	Guaratuba (PR)	Joaçaba (SC)	Floreal (SP)
Cristais (MG)	Honório Serpa (PR)	Joinville (SC)	Flórida Paulista (SP)
Cristiano Otoni (MG)	Ibaiti (PR)	José Boiteux (SC)	Florínea (SP)
Cristina (MG)	Ibema (PR)	Jupiá (SC)	Francisco Morato (SP)
Crucilândia (MG)	Ibiporã (PR)	Lacerdópolis (SC)	Franco da Rocha (SP)
Cruzília (MG)	Icaraíma (PR)	Lages (SC)	Gabriel Monteiro (SP)
Cuparaque (MG)	Iguaraçu (PR)	Laguna (SC)	Gália (SP)
Delfim Moreira (MG)	Iguatu (PR)	Lajeado Grande (SC)	Garça (SP)
Descoberto (MG)	Imbaú (PR)	Laurentino (SC)	Gastão Vidigal (SP)
Desterro de Entre Rios (MG)	Imbituva (PR)	Lauro Müller (SC)	Gavião Peixoto (SP)
Desterro do Melo (MG)	Inácio Martins (PR)	Lebon Régis (SC)	General Salgado (SP)
Diogo de Vasconcelos (MG)	Inajá (PR)	Leoberto Leal (SC)	Getulina (SP)
Dionísio (MG)	Indianópolis (PR)	Lindóia do Sul (SC)	Glicério (SP)
Divinésia (MG)	Ipiranga (PR)	Lontras (SC)	Guaiçara (SP)
Divino (MG)	Iporã (PR)	Luiz Alves (SC)	Guaimbê (SP)
Divino das Laranjeiras (MG)	Iracema do Oeste (PR)	Luzerna (SC)	Guapiaçu (SP)
Divinolândia de Minas (MG)	Irati (PR)	Macieira (SC)	Guapiara (SP)
Divinópolis (MG)	Iretama (PR)	Mafra (SC)	Guaraçaí (SP)
Dom Cavati (MG)	Itaguajé (PR)	Major Gercino (SC)	Guaraci (SP)
Dom Joaquim (MG)	Itaipulândia (PR)	Major Vieira (SC)	Guarani d'Oeste (SP)
Dom Silvério (MG)	Itambaracá (PR)	Maracajá (SC)	Guararapes (SP)
Dom Viçoso (MG)	Itambé (PR)	Maravilha (SC)	Guararema (SP)
Dona Eusébia (MG)	Itapejara d'Oeste (PR)	Marema (SC)	Guaratinguetá (SP)
Dores de Campos (MG)	Itaperuçu (PR)	Massaranduba (SC)	Guariba (SP)
Dores de Guanhães (MG)	Itaúna do Sul (PR)	Matos Costa (SC)	Guarujá (SP)
Dores do Turvo (MG)	Ivaí (PR)	Meleiro (SC)	Guarulhos (SP)
Durandé (MG)	Ivaiporã (PR)	Mirim Doce (SC)	Guzolândia (SP)
Elói Mendes (MG)	Ivaté (PR)	Modelo (SC)	Herculândia (SP)
Engenheiro Caldas (MG)	Ivatuba (PR)	Mondaí (SC)	Holambra (SP)
Entre Folhas (MG)	Jaboti (PR)	Monte Carlo (SC)	Hortolândia (SP)
Entre Rios de Minas (MG)	Jacarezinho (PR)	Monte Castelo (SC)	Iacri (SP)
Ervália (MG)	Jaguapitã (PR)	Morro da Fumaça (SC)	Ibirá (SP)
Esmeraldas (MG)	Jandaia do Sul (PR)	Morro Grande (SC)	Ibirarema (SP)
Espera Feliz (MG)	Janiópolis (PR)	Navegantes (SC)	Ibitinga (SP)
Espírito Santo do Dourado (MG)	Japira (PR)	Nova Erechim (SC)	Ibiúna (SP)
Estiva (MG)	Japurá (PR)	Nova Itaberaba (SC)	Icém (SP)
Estrela Dalva (MG)	Jardim Alegre (PR)	Nova Trento (SC)	Iepê (SP)
Eugenópolis (MG)	Jardim Olinda (PR)	Nova Veneza (SC)	Igaraçu do Tietê (SP)
Ewbank da Câmara (MG)	Jataizinho (PR)	Novo Horizonte (SC)	Igaratá (SP)
Extrema (MG)	Jesuítas (PR)	Orleans (SC)	Iguape (SP)
Faria Lemos (MG)	Joaquim Távora (PR)	Otacílio Costa (SC)	Ilhabela (SP)
Felisburgo (MG)	Jundiaí do Sul (PR)	Ouro (SC)	Ilha Comprida (SP)
Fernandes Tourinho (MG)	Juranda (PR)	Ouro Verde (SC)	Ilha Solteira (SP)

Ferros (MG)	Jussara (PR)	Paial (SC)	Indaiatuba (SP)
Fervedouro (MG)	Kaloré (PR)	Painel (SC)	Indiana (SP)
Florestal (MG)	Lapa (PR)	Palhoça (SC)	Indiaporã (SP)
Franciscópolis (MG)	Laranjal (PR)	Palma Sola (SC)	Inúbia Paulista (SP)
Frei Gaspar (MG)	Laranjeiras do Sul (PR)	Palmeira (SC)	Ipaussu (SP)
Frei Inocêncio (MG)	Leópolis (PR)	Palmitos (SC)	Iperó (SP)
Frei Lagonegro (MG)	Lidianópolis (PR)	Papanduva (SC)	Ipiguá (SP)
Fronteira dos Vales (MG)	Lindoeste (PR)	Paraíso (SC)	Iporanga (SP)
Galiléia (MG)	Loanda (PR)	Passo de Torres (SC)	Iracemápolis (SP)
Goiabeira (MG)	Lobato (PR)	Passos Maia (SC)	Irapuã (SP)
Goianá (MG)	Londrina (PR)	Paulo Lopes (SC)	Irapuru (SP)
Gonçalves (MG)	Luiziana (PR)	Pedras Grandes (SC)	Itajobi (SP)
Gonzaga (MG)	Lunardelli (PR)	Penha (SC)	Itaju (SP)
Governador Valadares (MG)	Lupionópolis (PR)	Peritiba (SC)	Itanhaém (SP)
Guanhães (MG)	Mallet (PR)	Pescaria Brava (SC)	Itaoca (SP)
Guapé (MG)	Mamborê (PR)	Petrolândia (SC)	Itapecerica da Serra (SP)
Guaraciaba (MG)	Mandaguaçu (PR)	Balneário Piçarras (SC)	Itapevi (SP)
Guaranésia (MG)	Mandaguari (PR)	Pinhalzinho (SC)	Itapira (SP)
Guarani (MG)	Mandirituba (PR)	Pinheiro Preto (SC)	Itapirapuã Paulista (SP)
Guarará (MG)	Manfrinópolis (PR)	Piratuba (SC)	Itápolis (SP)
Guaxupé (MG)	Mangueirinha (PR)	Planalto Alegre (SC)	Itapuí (SP)
Guidoval (MG)	Manoel Ribas (PR)	Pomerode (SC)	Itapura (SP)
Guiricema (MG)	Marechal Cândido Rondon (PR)	Ponte Alta (SC)	Itaquaquecetuba (SP)
Heliodora (MG)	Maria Helena (PR)	Ponte Alta do Norte (SC)	Itariri (SP)
Iapu (MG)	Marialva (PR)	Ponte Serrada (SC)	Itatiba (SP)
Ibertioga (MG)	Marilândia do Sul (PR)	Porto Belo (SC)	Itobi (SP)
Ibirité (MG)	Marilena (PR)	Porto União (SC)	Itu (SP)
Ibitiúra de Minas (MG)	Mariluz (PR)	Pouso Redondo (SC)	Itupeva (SP)
Ibituruna (MG)	Maringá (PR)	Praia Grande (SC)	Jaboticabal (SP)
Igarapé (MG)	Mariópolis (PR)	Presidente Castello Branco (SC)	Jacareí (SP)
Ijaci (MG)	Maripá (PR)	Presidente Getúlio (SC)	Jaci (SP)
Ilicínea (MG)	Marmeleiro (PR)	Presidente Nereu (SC)	Jacupiranga (SP)
Imbé de Minas (MG)	Marquinho (PR)	Princesa (SC)	Jaguariúna (SP)
Inconfidentes (MG)	Marumbi (PR)	Quilombo (SC)	Jales (SP)
Ingaí (MG)	Matelândia (PR)	Rancho Queimado (SC)	Jambeiro (SP)
Inhapim (MG)	Matinhos (PR)	Rio das Antas (SC)	Jarinu (SP)
Ipaba (MG)	Mato Rico (PR)	Rio do Campo (SC)	Jaú (SP)
Ipanema (MG)	Mauá da Serra (PR)	Rio do Oeste (SC)	Joanópolis (SP)
Ipatinga (MG)	Medianeira (PR)	Rio dos Cedros (SC)	João Ramalho (SP)
Ipuiúna (MG)	Mercedes (PR)	Rio do Sul (SC)	José Bonifácio (SP)
Itabira (MG)	Mirador (PR)	Rio Fortuna (SC)	Júlio Mesquita (SP)
Itabirinha (MG)	Miraselva (PR)	Rio Negrinho (SC)	Jumirim (SP)

Itabirito (MG)	Missal (PR)	Rio Rufino (SC)	Jundiaí (SP)
Itaguara (MG)	Moreira Sales (PR)	Riqueza (SC)	Junqueirópolis (SP)
Itaipé (MG)	Morretes (PR)	Rodeio (SC)	Juquiá (SP)
Itajubá (MG)	Munhoz de Melo (PR)	Romelândia (SC)	Juquitiba (SP)
Itamarati de Minas (MG)	Nossa Senhora das Graças (PR)	Salete (SC)	Lagoinha (SP)
Itambacuri (MG)	Nova Aliança do Ivaí (PR)	Saltinho (SC)	Laranjal Paulista (SP)
Itambé do Mato Dentro (MG)	Nova América da Colina (PR)	Salto Veloso (SC)	Lavínia (SP)
Itamogi (MG)	Nova Aurora (PR)	Sangão (SC)	Lavrinhas (SP)
Itamonte (MG)	Nova Cantu (PR)	Santa Cecília (SC)	Leme (SP)
Itanhandu (MG)	Nova Esperança (PR)	Santa Helena (SC)	Limeira (SP)
Itanhomi (MG)	Nova Esperança do Sudoeste (PR)	Santa Rosa de Lima (SC)	Lindóia (SP)
Itaobim (MG)	Nova Fátima (PR)	Santa Rosa do Sul (SC)	Lins (SP)
Itapeva (MG)	Nova Laranjeiras (PR)	Santa Terezinha (SC)	Lorena (SP)
Itatiaiuçu (MG)	Nova Londrina (PR)	Santa Terezinha do Progresso (SC)	Lourdes (SP)
Itaverava (MG)	Nova Olímpia (PR)	Santiago do Sul (SC)	Louveira (SP)
Itinga (MG)	Nova Santa Bárbara (PR)	Santo Amaro da Imperatriz (SC)	Lucélia (SP)
Itueta (MG)	Nova Santa Rosa (PR)	São Bernardino (SC)	Luiziânia (SP)
Itumirim (MG)	Nova Prata do Iguaçu (PR)	São Bento do Sul (SC)	Lupércio (SP)
Itutinga (MG)	Nova Tebas (PR)	São Bonifácio (SC)	Lutécia (SP)
Jacinto (MG)	Novo Itacolomi (PR)	São Carlos (SC)	Macatuba (SP)
Jacuí (MG)	Ortigueira (PR)	São Cristóvão do Sul (SC)	Macaubal (SP)
Jacutinga (MG)	Ourizona (PR)	São Domingos (SC)	Macedônia (SP)
Jaguaraçu (MG)	Ouro Verde do Oeste (PR)	São Francisco do Sul (SC)	Magda (SP)
Jampruca (MG)	Paiçandu (PR)	São João do Oeste (SC)	Mairinque (SP)
Jeceaba (MG)	Palmas (PR)	São João Batista (SC)	Mairiporã (SP)
Jequeri (MG)	Palmeira (PR)	São João do Itaperiú (SC)	Manduri (SP)
Jequitinhonha (MG)	Palmital (PR)	São João do Sul (SC)	Marabá Paulista (SP)
Jesuânia (MG)	Palotina (PR)	São Joaquim (SC)	Maracaí (SP)
Joaíma (MG)	Paraíso do Norte (PR)	São José (SC)	Marapoama (SP)
Joanésia (MG)	Paranacity (PR)	São José do Cedro (SC)	Mariápolis (SP)
João Monlevade (MG)	Paranaguá (PR)	São José do Cerrito (SC)	Marília (SP)
Jordânia (MG)	Paranapoema (PR)	São Lourenço do Oeste (SC)	Marinópolis (SP)
José Raydan (MG)	Paranavaí (PR)	São Ludgero (SC)	Martinópolis (SP)
Juatuba (MG)	Pato Bragado (PR)	São Martinho (SC)	Matão (SP)
Juiz de Fora (MG)	Pato Branco (PR)	São Miguel da Boa Vista (SC)	Mauá (SP)
Juruaia (MG)	Paula Freitas (PR)	São Miguel do Oeste (SC)	Mendonça (SP)
Ladainha (MG)	Paulo Frontin (PR)	São Pedro de Alcântara (SC)	Meridiano (SP)
Lagoa Dourada (MG)	Peabiru (PR)	Saudades (SC)	Mesópolis (SP)
Lagoa Santa (MG)	Perobal (PR)	Schroeder (SC)	Miguelópolis (SP)
Lajinha (MG)	Pérola (PR)	Seara (SC)	Mineiros do Tietê (SP)
Lambari (MG)	Pérola d'Oeste (PR)	Serra Alta (SC)	Miracatu (SP)

Lamim (MG)	Piên (PR)	Siderópolis (SC)	Mira Estrela (SP)
Laranjal (MG)	Pinhais (PR)	Sombrio (SC)	Mirandópolis (SP)
Lavras (MG)	Pinhalão (PR)	Sul Brasil (SC)	Mirante do Paranapanema (SP)
Leopoldina (MG)	Pinhal de São Bento (PR)	Taió (SC)	Mirassol (SP)
Liberdade (MG)	Pinhão (PR)	Tangará (SC)	Mirassolândia (SP)
Lima Duarte (MG)	Piraquara (PR)	Tigrinhos (SC)	Mococa (SP)
Luisburgo (MG)	Pitanga (PR)	Tijucas (SC)	Mogi das Cruzes (SP)
Luminárias (MG)	Pitangueiras (PR)	Timbé do Sul (SC)	Mogi Guaçu (SP)
Machacalis (MG)	Planaltina do Paraná (PR)	Timbó (SC)	Mogi Mirim (SP)
Madre de Deus de Minas (MG)	Planalto (PR)	Timbó Grande (SC)	Mombuca (SP)
Malacacheta (MG)	Ponta Grossa (PR)	Três Barras (SC)	Monções (SP)
Manhuaçu (MG)	Pontal do Paraná (PR)	Treviso (SC)	Mongaguá (SP)
Manhumirim (MG)	Porecatu (PR)	Treze de Maio (SC)	Monte Alegre do Sul (SP)
Mantena (MG)	Porto Amazonas (PR)	Treze Tílias (SC)	Monte Alto (SP)
Mar de Espanha (MG)	Porto Barreiro (PR)	Trombudo Central (SC)	Monte Aprazível (SP)
Maria da Fé (MG)	Porto Rico (PR)	Tubarão (SC)	Monte Azul Paulista (SP)
Mariana (MG)	Porto Vitória (PR)	Tunápolis (SC)	Monte Castelo (SP)
Marilac (MG)	Prado Ferreira (PR)	Turvo (SC)	Monteiro Lobato (SP)
Mário Campos (MG)	Pranchita (PR)	União do Oeste (SC)	Monte Mor (SP)
Maripá de Minas (MG)	Presidente Castelo Branco (PR)	Urubici (SC)	Morungaba (SP)
Marliéria (MG)	Primeiro de Maio (PR)	Urupema (SC)	Motuca (SP)
Marmelópolis (MG)	Prudentópolis (PR)	Urussanga (SC)	Murutinga do Sul (SP)
Martins Soares (MG)	Quarto Centenário (PR)	Vargeão (SC)	Nantes (SP)
Mata Verde (MG)	Quatiguá (PR)	Vargem (SC)	Narandiba (SP)
Materlândia (MG)	Quatro Barras (PR)	Vargem Bonita (SC)	Natividade da Serra (SP)
Mateus Leme (MG)	Quatro Pontes (PR)	Vidal Ramos (SC)	Nazaré Paulista (SP)
Matias Barbosa (MG)	Quedas do Iguaçu (PR)	Videira (SC)	Neves Paulista (SP)
Matipó (MG)	Querência do Norte (PR)	Vitor Meireles (SC)	Nhandeara (SP)
Medina (MG)	Quinta do Sol (PR)	Witmarsum (SC)	Nipoã (SP)
Mendes Pimentel (MG)	Quitandinha (PR)	Xanxerê (SC)	Nova Aliança (SP)
Mercês (MG)	Ramilândia (PR)	Xavantina (SC)	Nova Canaã Paulista (SP)
Mesquita (MG)	Rancho Alegre (PR)	Xaxim (SC)	Nova Castilho (SP)
Minduri (MG)	Rancho Alegre D'Oeste (PR)	Zortéa (SC)	Nova Europa (SP)
Miradouro (MG)	Realeza (PR)	Balneário Rincão (SC)	Nova Granada (SP)
Miraí (MG)	Rebouças (PR)		Nova Guataporanga (SP)
Moeda (MG)	Renascença (PR)		Nova Independência (SP)
Monsenhor Paulo (MG)	Reserva (PR)		Novais (SP)
Monte Belo (MG)	Reserva do Iguaçu (PR)		Nova Luzitânia (SP)
Monte Formoso (MG)	Ribeirão Claro (PR)		Nova Odessa (SP)
Monte Santo de Minas (MG)	Ribeirão do Pinhal (PR)		Novo Horizonte (SP)
Monte Sião (MG)	Rio Azul (PR)		Ocauçu (SP)
Morro do Pilar (MG)	Rio Bom (PR)		Óleo (SP)

Munhoz (MG)	Rio Bonito do Iguaçu (PR)		Olímpia (SP)
Muriaé (MG)	Rio Branco do Ivaí (PR)		Onda Verde (SP)
Mutum (MG)	Rio Branco do Sul (PR)		Oriente (SP)
Muzambinho (MG)	Rio Negro (PR)		Orindiúva (SP)
Nacip Raydan (MG)	Rolândia (PR)		Osasco (SP)
Nanuque (MG)	Roncador (PR)		Oscar Bressane (SP)
Naque (MG)	Rondon (PR)		Osvaldo Cruz (SP)
Natércia (MG)	Rosário do Ivaí (PR)		Ourinhos (SP)
Nazareno (MG)	Sabáudia (PR)		Ouroeste (SP)
Nepomuceno (MG)	Salgado Filho (PR)		Ouro Verde (SP)
Nova Belém (MG)	Salto do Itararé (PR)		Pacaembu (SP)
Nova Era (MG)	Salto do Lontra (PR)		Palestina (SP)
Nova Lima (MG)	Santa Amélia (PR)		Palmares Paulista (SP)
Nova Módica (MG)	Santa Cecília do Pavão (PR)		Palmeira d'Oeste (SP)
Nova Resende (MG)	Santa Cruz de Monte Castelo (PR)		Palmital (SP)
Novo Cruzeiro (MG)	Santa Fé (PR)		Panorama (SP)
Novo Oriente de Minas (MG)	Santa Helena (PR)		Paraguaçu Paulista (SP)
Olaria (MG)	Santa Inês (PR)		Paraibuna (SP)
Olímpio Noronha (MG)	Santa Isabel do Ivaí (PR)		Paraíso (SP)
Oliveira (MG)	Santa Izabel do Oeste (PR)		Paranapuã (SP)
Oliveira Fortes (MG)	Santa Lúcia (PR)		Parapuã (SP)
Onça de Pitangui (MG)	Santa Maria do Oeste (PR)		Pariquera0Açu (SP)
Oratórios (MG)	Santa Mariana (PR)		Parisi (SP)
Orizânia (MG)	Santa Mônica (PR)		Paulicéia (SP)
Ouro Branco (MG)	Santana do Itararé (PR)		Paulínia (SP)
Ouro Fino (MG)	Santa Tereza do Oeste (PR)		Paulo de Faria (SP)
Ouro Preto (MG)	Santa Terezinha de Itaipu (PR)		Pederneiras (SP)
Ouro Verde de Minas (MG)	Santo Antônio da Platina (PR)		Pedra Bela (SP)
Padre Paraíso (MG)	Santo Antônio do Caiuá (PR)		Pedrinhas Paulista (SP)
Paiva (MG)	Santo Antônio do Paraíso (PR)		Pedro de Toledo (SP)
Palma (MG)	Santo Antônio do Sudoeste (PR)		Penápolis (SP)
Palmópolis (MG)	Santo Inácio (PR)		Pereira Barreto (SP)
Pará de Minas (MG)	São Carlos do Ivaí (PR)		Pereiras (SP)
Paraguaçu (MG)	São Jerônimo da Serra (PR)		Peruíbe (SP)
Passabém (MG)	São João (PR)		Piacatu (SP)
Passa Quatro (MG)	São João do Caiuá (PR)		Piedade (SP)
Passa Tempo (MG)	São João do Ivaí (PR)		Pilar do Sul (SP)
Passa Vinte (MG)	São João do Triunfo (PR)		Pindamonhangaba (SP)
Patrocínio do Muriaé (MG)	São Jorge d'Oeste (PR)		Pindorama (SP)
Paula Cândido (MG)	São Jorge do Ivaí (PR)		Pinhalzinho (SP)
Paulistas (MG)	São Jorge do Patrocínio (PR)		Piquerobi (SP)

Pavão (MG)	São José da Boa Vista (PR)		Piquete (SP)
Peçanha (MG)	São José das Palmeiras (PR)		Piracaia (SP)
Pedra Azul (MG)	São José dos Pinhais (PR)		Piracicaba (SP)
Pedra Bonita (MG)	São Manoel do Paraná (PR)		Piraju (SP)
Pedra do Anta (MG)	São Mateus do Sul (PR)		Pirangi (SP)
Pedra Dourada (MG)	São Miguel do Iguaçu (PR)		Pirapora do Bom Jesus (SP)
Pedralva (MG)	São Pedro do Iguaçu (PR)		Pirapozinho (SP)
Pedro Leopoldo (MG)	São Pedro do Ivaí (PR)		Pitangueiras (SP)
Pequeri (MG)	São Pedro do Paraná (PR)		Planalto (SP)
Perdões (MG)	São Sebastião da Amoreira (PR)		Platina (SP)
Periquito (MG)	São Tomé (PR)		Poá (SP)
Pescador (MG)	Sapopema (PR)		Poloni (SP)
Piau (MG)	Sarandi (PR)		Pompéia (SP)
Piedade de Caratinga (MG)	Saudade do Iguaçu (PR)		Pontalinda (SP)
Piedade de Ponte Nova (MG)	Serranópolis do Iguaçu (PR)		Pontes Gestal (SP)
Piedade do Rio Grande (MG)	Sertaneja (PR)		Populina (SP)
Piedade dos Gerais (MG)	Sertanópolis (PR)		Porangaba (SP)
Pingo d'Água (MG)	Siqueira Campos (PR)		Porto Feliz (SP)
Piracema (MG)	Sulina (PR)		Potim (SP)
Piranga (MG)	Tamarana (PR)		Potirendaba (SP)
Piranguçu (MG)	Tamboara (PR)		Pracinha (SP)
Piranguinho (MG)	Tapejara (PR)		Presidente Bernardes (SP)
Pirapetinga (MG)	Tapira (PR)		Presidente Epitácio (SP)
Piraúba (MG)	Teixeira Soares (PR)		Presidente Prudente (SP)
Pitangui (MG)	Telêmaco Borba (PR)		Presidente Venceslau (SP)
Poços de Caldas (MG)	Terra Boa (PR)		Promissão (SP)
Pocrane (MG)	Terra Rica (PR)		Quadra (SP)
Ponte Nova (MG)	Terra Roxa (PR)		Quatá (SP)
Ponto dos Volantes (MG)	Tibagi (PR)		Queiroz (SP)
Porto Firme (MG)	Tijucas do Sul (PR)		Queluz (SP)
Poté (MG)	Toledo (PR)		Quintana (SP)
Pouso Alegre (MG)	Tomazina (PR)		Rafard (SP)
Pouso Alto (MG)	Três Barras do Paraná (PR)		Rancharia (SP)
Prados (MG)	Tunas do Paraná (PR)		Redenção da Serra (SP)
Presidente Bernardes (MG)	Tuneiras do Oeste (PR)		Regente Feijó (SP)
Queluzito (MG)	Tupãssi (PR)		Registro (SP)
Raposos (MG)	Turvo (PR)		Ribeira (SP)
Raul Soares (MG)	Ubiratã (PR)		Ribeirão Branco (SP)
Recreio (MG)	Umuarama (PR)		Ribeirão do Sul (SP)
Reduto (MG)	União da Vitória (PR)		Ribeirão dos Índios (SP)
Resende Costa (MG)	Uniflor (PR)		Ribeirão Grande (SP)
Resplendor (MG)	Uraí (PR)		Ribeirão Pires (SP)

Ressaquinha (MG)	Wenceslau Braz (PR)		Rincão (SP)
Ribeirão das Neves (MG)	Ventania (PR)		Rinópolis (SP)
Ribeirão Vermelho (MG)	Vera Cruz do Oeste (PR)		Rio das Pedras (SP)
Rio Acima (MG)	Verê (PR)		Rio Grande da Serra (SP)
Rio Casca (MG)	Alto Paraíso (PR)		Riolândia (SP)
Rio Doce (MG)	Doutor Ulysses (PR)		Rosana (SP)
Rio do Prado (MG)	Virmond (PR)		Roseira (SP)
Rio Espera (MG)	Vitorino (PR)		Rubiácea (SP)
Rio Manso (MG)	Xambrê (PR)		Rubinéia (SP)
Rio Novo (MG)			Sabino (SP)
Rio Piracicaba (MG)			Sagres (SP)
Rio Pomba (MG)			Sales (SP)
Rio Preto (MG)			Salmourão (SP)
Rio Vermelho (MG)			Saltinho (SP)
Ritápolis (MG)			Salto (SP)
Rochedo de Minas (MG)			Salto de Pirapora (SP)
Rodeiro (MG)			Salto Grande (SP)
Rosário da Limeira (MG)			Sandovalina (SP)
Rubim (MG)			Santa Adélia (SP)
Sabará (MG)			Santa Albertina (SP)
Sabinópolis (MG)			Santa Bárbara d'Oeste (SP)
Salto da Divisa (MG)			Santa Branca (SP)
Santa Bárbara (MG)			Santa Clara d'Oeste (SP)
Santa Bárbara do Leste (MG)			Santa Cruz da Conceição (SP)
Santa Bárbara do Monte Verde (MG)			Santa Cruz do Rio Pardo (SP)
Santa Bárbara do Tugúrio (MG)			Santa Ernestina (SP)
Santa Cruz de Minas (MG)			Santa Fé do Sul (SP)
Santa Cruz do Escalvado (MG)			Santa Gertrudes (SP)
Santa Efigênia de Minas (MG)			Santa Isabel (SP)
Santa Helena de Minas (MG)			Santa Lúcia (SP)
Santa Luzia (MG)			Santa Maria da Serra (SP)
Santa Margarida (MG)			Santa Mercedes (SP)
Santa Maria de Itabira (MG)			Santana da Ponte Pensa (SP)
Santa Maria do Salto (MG)			Santana de Parnaíba (SP)
Santa Maria do Suaçuí (MG)			Santa Rita d'Oeste (SP)
Santana da Vargem (MG)			Santa Salete (SP)
Santana de Cataguases (MG)			Santo Anastácio (SP)
Santana do Deserto (MG)			Santo André (SP)
Santana do Garambéu (MG)			Santo Antônio de Posse (SP)
Santana do Jacaré (MG)			Santo Antônio do Aracanguá (SP)
Santana do Manhuaçu (MG)			Santo Antônio do Jardim (SP)

Santana do Paraíso (MG)			Santo Antônio do Pinhal (SP)
Santana dos Montes (MG)			Santo Expedito (SP)
Santa Rita de Caldas (MG)			Santópolis do Aguapeí (SP)
Santa Rita de Jacutinga (MG)			Santos (SP)
Santa Rita de Minas (MG)			São Bento do Sapucaí (SP)
Santa Rita de Ibitipoca (MG)			São Bernardo do Campo (SP)
Santa Rita do Itueto (MG)			São Caetano do Sul (SP)
Santa Rita do Sapucaí (MG)			São Francisco (SP)
Santo Antônio do Amparo (MG)			São João da Boa Vista (SP)
Santo Antônio do Aventureiro (MG)			São João das Duas Pontes (SP)
Santo Antônio do Grama (MG)			São João de Iracema (SP)
Santo Antônio do Itambé (MG)			São João do Pau d'Alho (SP)
Santo Antônio do Jacinto (MG)			São José do Barreiro (SP)
Santo Antônio do Rio Abaixo (MG)			São José do Rio Pardo (SP)
Santos Dumont (MG)			São José do Rio Preto (SP)
São Bento Abade (MG)			São José dos Campos (SP)
São Brás do Suaçuí (MG)			São Lourenço da Serra (SP)
São Domingos das Dores (MG)			São Luiz do Paraitinga (SP)
São Domingos do Prata (MG)			São Miguel Arcanjo (SP)
São Félix de Minas (MG)			São Paulo (SP)
São Francisco de Paula (MG)			São Pedro (SP)
São Francisco do Glória (MG)			São Pedro do Turvo (SP)
São Geraldo (MG)			São Roque (SP)
São Geraldo da Piedade (MG)			São Sebastião (SP)
São Geraldo do Baixio (MG)			São Sebastião da Grama (SP)
São Gonçalo do Rio Abaixo (MG)			São Vicente (SP)
São Gonçalo do Sapucaí (MG)			Sarapuí (SP)
São João da Mata (MG)			Sarutaiá (SP)
São João del Rei (MG)			Sebastianópolis do Sul (SP)
São João do Manhuaçu (MG)			Serra Negra (SP)
São João do Manteninha (MG)			Sete Barras (SP)
São João do Oriente (MG)			Severínia (SP)
São João Evangelista (MG)			Silveiras (SP)
São João Nepomuceno (MG)			Socorro (SP)
São Joaquim de Bicas (MG)			Sud Mennucci (SP)
São José da Lapa (MG)			Sumaré (SP)
São José da Safira (MG)			Suzano (SP)
São José da Varginha (MG)			Tabapuã (SP)
São José do Alegre (MG)			Tabatinga (SP)
São José do Divino (MG)			Taboão da Serra (SP)
São José do Goiabal (MG)			Taciba (SP)

São José do Jacuri (MG)			Taguaí (SP)
São José do Mantimento (MG)			Taiaçu (SP)
São Lourenço (MG)			Taiúva (SP)
São Miguel do Anta (MG)			Tambaú (SP)
São Pedro da União (MG)			Tanabi (SP)
São Pedro dos Ferros (MG)			Tapiraí (SP)
São Pedro do Suaçuí (MG)			Tapiratiba (SP)
São Sebastião da Bela Vista (MG)			Taquaral (SP)
São Sebastião da Vargem Alegre (MG)			Taquaritinga (SP)
São Sebastião do Anta (MG)			Tarabai (SP)
São Sebastião do Maranhão (MG)			Tarumã (SP)
São Sebastião do Paraíso (MG)			Tatuí (SP)
São Sebastião do Rio Preto (MG)			Taubaté (SP)
São Sebastião do Rio Verde (MG)			Tejupá (SP)
São Tiago (MG)			Teodoro Sampaio (SP)
São Tomás de Aquino (MG)			Terra Roxa (SP)
São Thomé das Letras (MG)			Tietê (SP)
Sapucaí0Mirim (MG)			Timburi (SP)
Sardoá (MG)			Torre de Pedra (SP)
Sarzedo (MG)			Trabiju (SP)
Sem0Peixe (MG)			Tremembé (SP)
Senador Amaral (MG)			Três Fronteiras (SP)
Senador Cortes (MG)			Tuiuti (SP)
Senador Firmino (MG)			Tupã (SP)
Senador José Bento (MG)			Tupi Paulista (SP)
Senhora de Oliveira (MG)			Turiúba (SP)
Senhora do Porto (MG)			Turmalina (SP)
Senhora dos Remédios (MG)			Ubarana (SP)
Sericita (MG)			Ubatuba (SP)
Seritinga (MG)			Uchoa (SP)
Serra Azul de Minas (MG)			União Paulista (SP)
Serra dos Aimorés (MG)			Urânia (SP)
Serranos (MG)			Urupês (SP)
Serro (MG)			Valentim Gentil (SP)
Silveirânia (MG)			Valinhos (SP)
Simão Pereira (MG)			Valparaíso (SP)
Simonésia (MG)			Vargem (SP)
Sobrália (MG)			Vargem Grande do Sul (SP)
Soledade de Minas (MG)			Vargem Grande Paulista (SP)
Tabuleiro (MG)			Várzea Paulista (SP)
Taparuba (MG)			Vera Cruz (SP)

Taquaraçu de Minas (MG)			Vinhedo (SP)
Tarumirim (MG)			Viradouro (SP)
Teixeiras (MG)			Vista Alegre do Alto (SP)
Teófilo Otoni (MG)			Vitória Brasil (SP)
Timóteo (MG)			Votorantim (SP)
Tiradentes (MG)			Votuporanga (SP)
Tocantins (MG)			Zacarias (SP)
Tocos do Moji (MG)			Chavantes (SP)
Toledo (MG)			Estiva Gerbi (SP)
Tombos (MG)			
Três Corações (MG)			
Três Pontas (MG)			
Tumiritinga (MG)			
Turvolândia (MG)			
Ubá (MG)			
Ubaporanga (MG)			
Umburatiba (MG)			
Urucânia (MG)			
Vargem Alegre (MG)			
Varginha (MG)			
Vermelho Novo (MG)			
Vespasiano (MG)			
Viçosa (MG)			
Vieiras (MG)			
Virgem da Lapa (MG)			
Virgínia (MG)			
Virginópolis (MG)			
Virgolândia (MG)			
Visconde do Rio Branco (MG)			
Volta Grande (MG)			
Wenceslau Braz (MG)			