Food production in the Atlantic Forest

Challenges for sustainable, healthy and carbon neutral farming practices in Brazil's top food producing biome

Luis Fernando Guedes Pinto, Jean Paul Metzger and Gerd Sparovek

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01 Summary

The Atlantic Forest biome (present in 15% of Brazil's terrestrial area) hosts 27% of the country's agricultural lands, where 40% of the country's rural establishments are located. It is responsible for approximately half of the national agricultural production, but with the emission of only 26% of the total greenhouse gases (GHGs) of this sector. The Atlantic Forest has a large participation in the production of commodities for export and accounts for most of the agricultural production of direct consumption of the Brazilian population. It is also a region with high consumption of pesticides. The combination of the end of deforestation with forest restoration and low-carbon agricultural production systems allow the Atlantic Forest to become neutral and be negative of GHG emissions in the land use sector. This opportunity, combined with ending dependence on pesticides, can support a new paradigm for healthy and sustainable food systems for Brazil and the world.

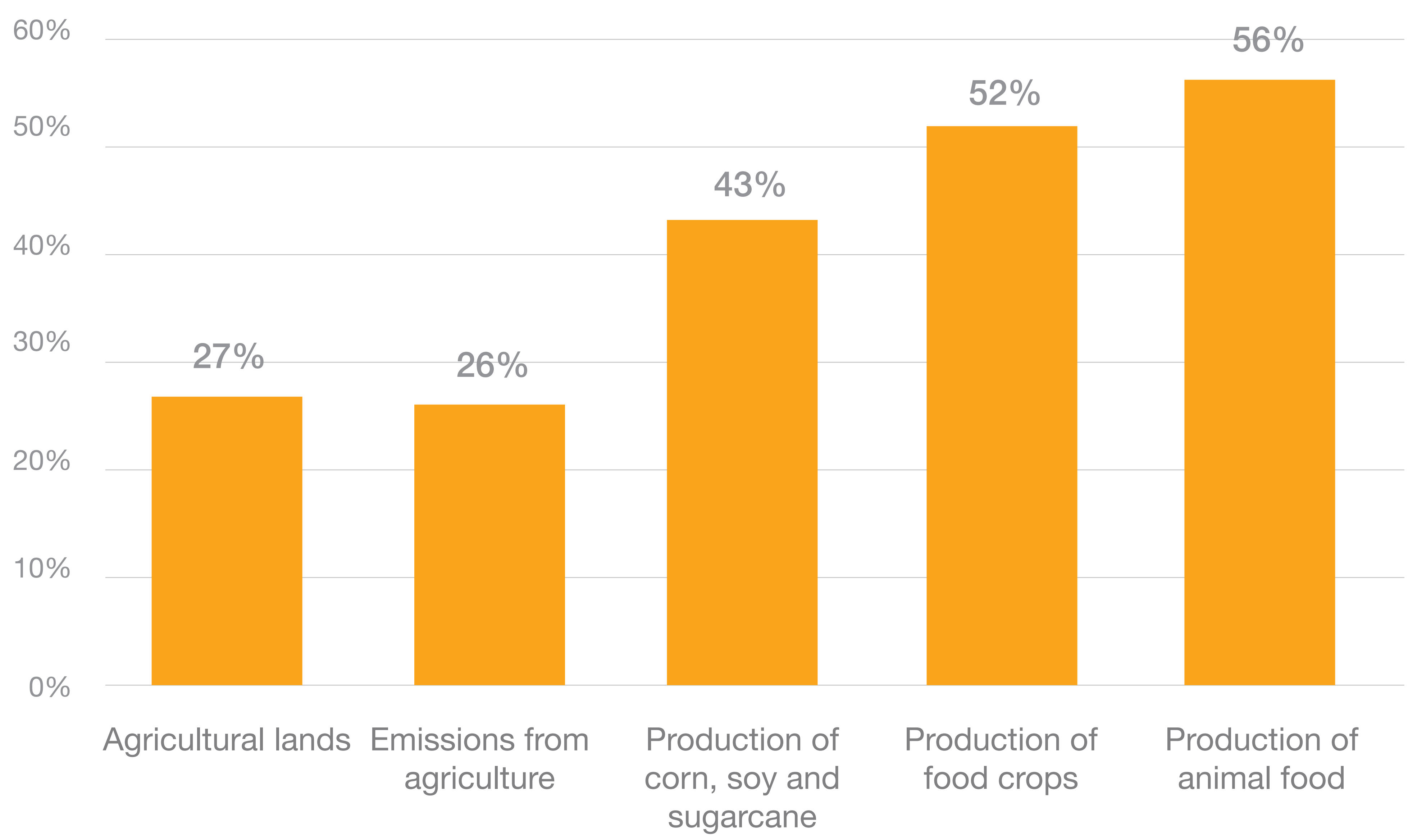


Image summary – Data from the Atlantic Forest biome: share in agricultural lands, greenhouse gas emissions from agriculture and from plant and animal production in Brazil.

02 Introduction

The Atlantic Forest biome encompasses 3,429 municipalities and is shared by 17 states in Brazil, spreading over 15% of the Brazilian territory. With a wide variety of ecosystems and vegetation physiognomies, forests predominate within this megadiverse biome (Figure 1), considered one of the planet's top hotspots for biodiversity. The Atlantic Forest also supplies essential ecosystem services to 70% of the population in Brazil, as well as to most of the country's large cities and important urban centers. It is also home to traditional populations and indigenous groups.

The biome was deemed a National Heritage Site by the Brazilian Federal Constitution and is protected by specific law: the Atlantic Forest Law, published in 2006. The Atlantic Forest is Brazil's most devastated biome and its remnants are distributed unequally throughout the country. Intrinsically linked with the history of Brazil, the biome's destruction reflects several economic cycles that beset the country since Portugal's occupation in 1500. Since Brazil was first colonized, its population has been fed by the agricultural production of the Atlantic Forest, which also produced a surplus for exportation.

For much of history, Brazil's agrifood system has relied on the Atlantic Forest. The country has been undergoing a centuries-long pattern of clearing forests, depleting its production capacity and opening new farming areas; this in addition to traditional production systems, which are based on alternating restoration and cultivation (slash and burn agriculture) for long periods of time.

Over the last decades, especially since the 1970s, Brazilian agriculture—aided by the technologies that came from the Green Revolution—underwent a deep transformation and expanded to other regions in the country. As a result, there were great increases in production and productivity, and the country went from being a food importer to becoming a food exporter. However, this process was marked by profoundly contrasting realities: on the one hand, there was growth in production and wealth; on the other, destruction of biodiversity, soil, water and human contamination by chemicals, substantial emission of greenhouse gases, multiplication of infectious and non-infectious diseases and large social inequalities. During this same period, the country enjoyed a larger supply of food at lower prices. Hunger was reduced—despite the worrisome reversal of this achievement in the last few years—less malnutrition-related health problems were reported, such as obesity and other diseases associated with poor diets and sedentary lifestyles (diabetes, cardiovascular disease and others).

On a planetary scale, agrifood systems play a key role in the conservation of natural resources and to ensure the well-being and health of populations, in rural and urban contexts. Decisions about the future of agrifood systems shape our ability to secure ecosystem services, fight climate change, and ensure health and food security for the entire world.

The Atlantic Forest has historical importance for Brazil's agricultural sector and food supply, but we currently lack information on its present importance. This study seeks to fill this knowledge gap and to identify, on a preliminary basis, which aspects of the biome's agricultural production should become the objects of in-depth analysis.

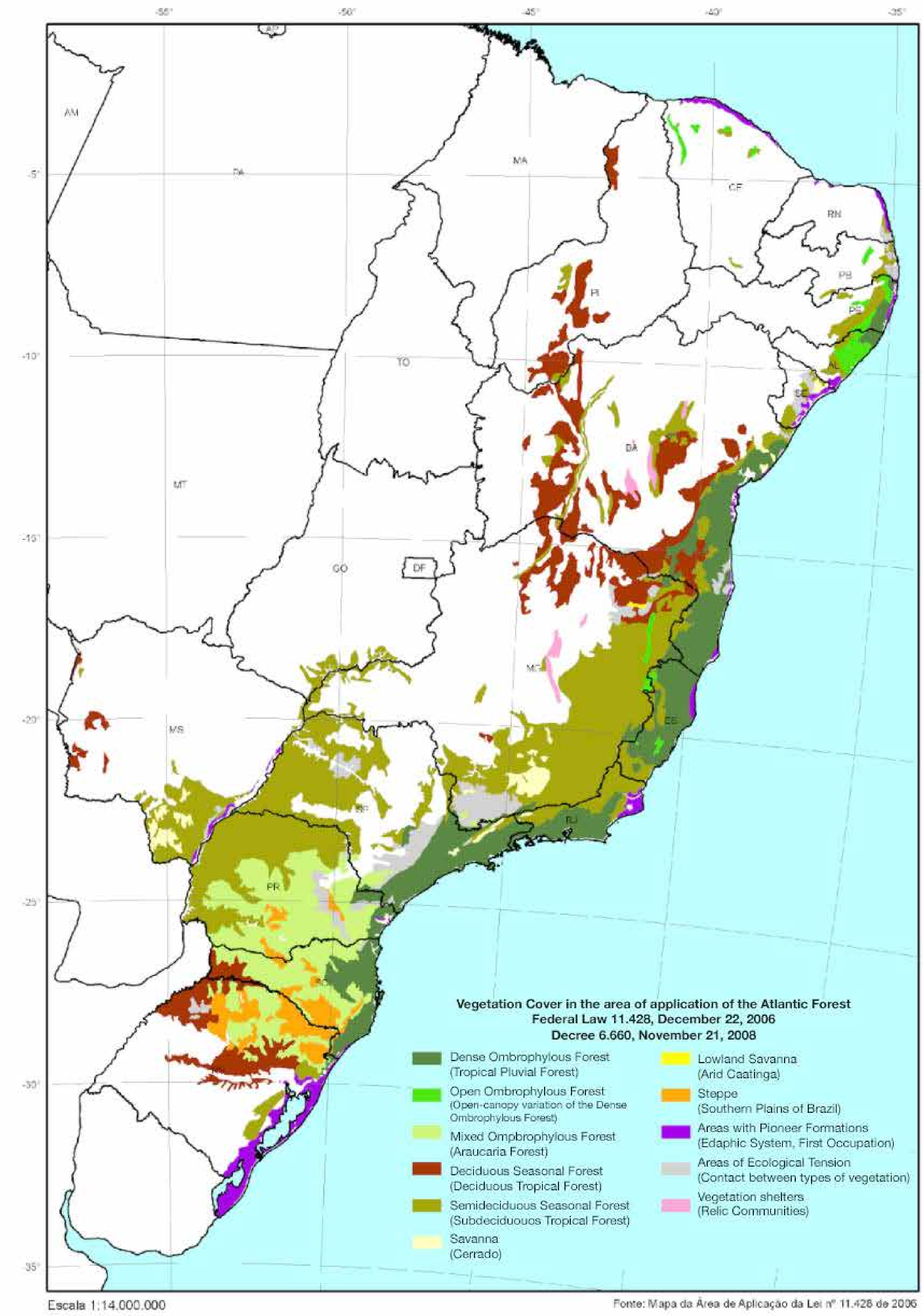
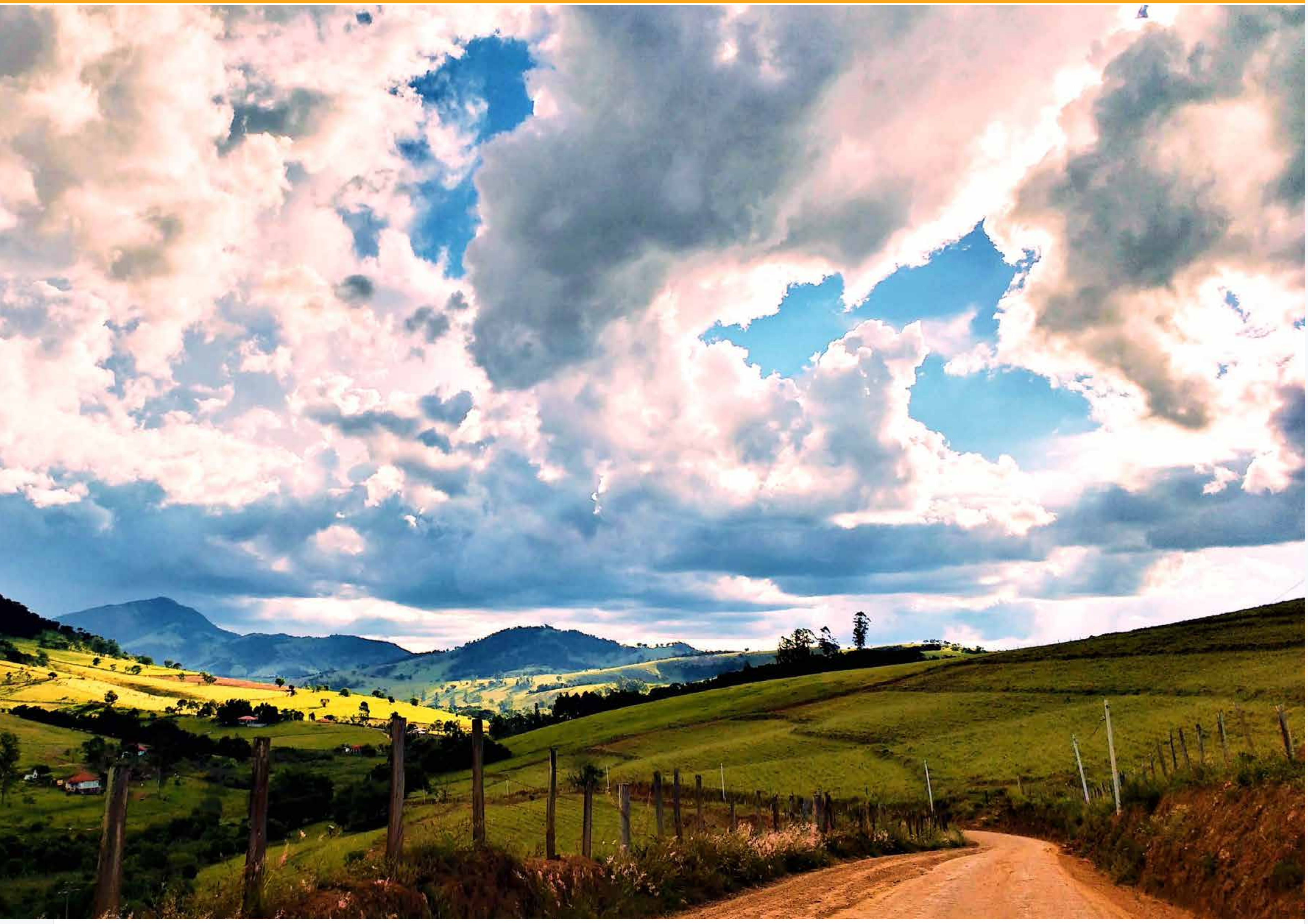


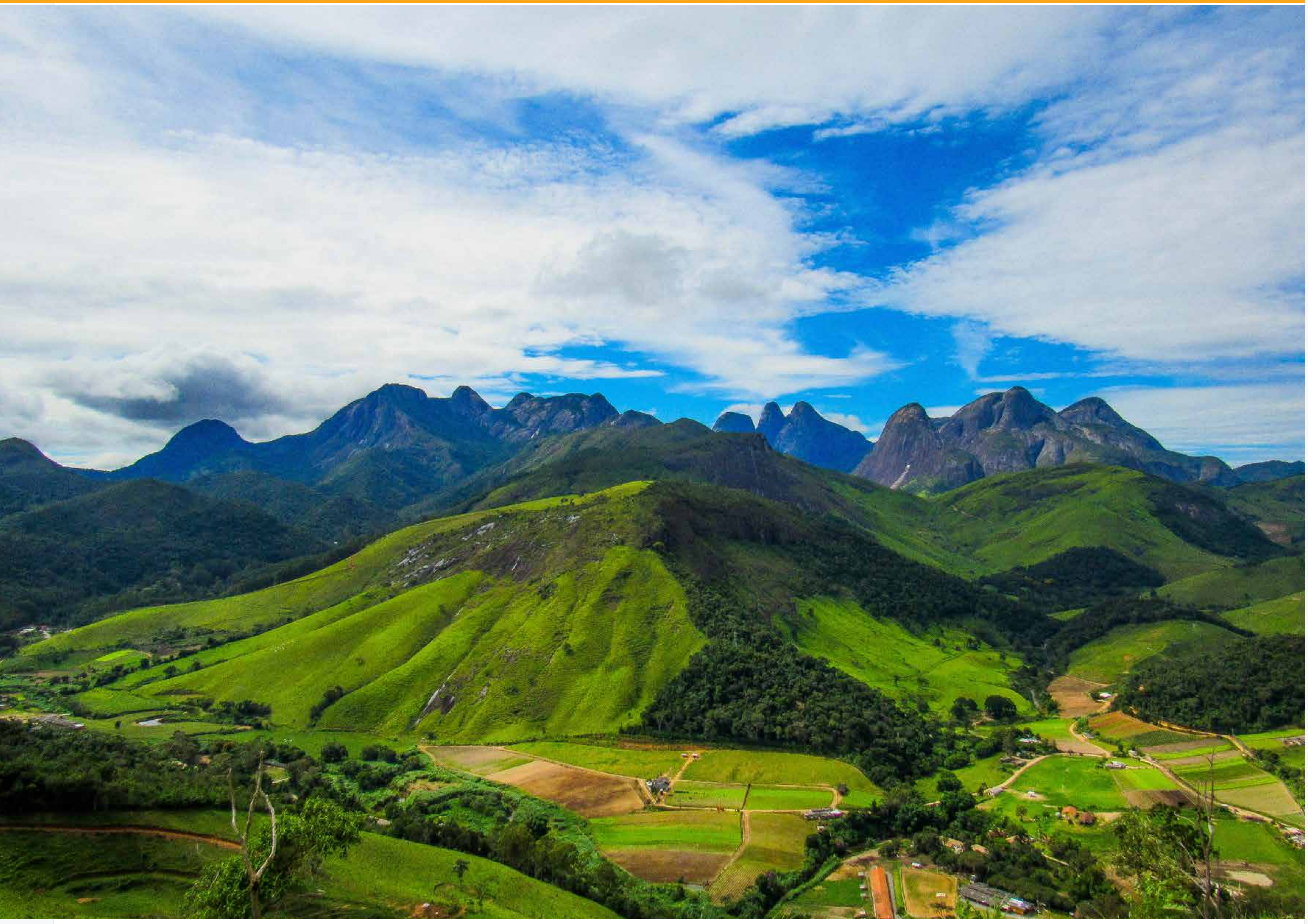
Figure 1. Region of occurrence for the different vegetation physiognomies of the Atlantic Forest, according to Federal Law 11.428/2006 and Decree 6.660/2008.

03 Objectives



This study aims to present an integrated assessment of the following situations in the Atlantic Forest: land tenure, land use, agricultural and food production. It also seeks to identify trends and opportunities for the biome to contribute to healthy and sustainable agrifood systems, establishing guidelines that will make agriculture and food production compatible with climate neutrality in the biome's land-use sector by 2042.

04 Methods



To performed our analysis, we gathered several studies and secondary data sources about the Atlantic Forest's land tenure, land-use and agricultural production situations, as well as references about the sustainable agriculture initiatives developed in the biome.

Our main sources included IBGE's Census of Agriculture, from 2006 to 2017; and the land-use database from MapBiomas and the Atlas of Brazilian Agriculture. Another key reference was the study conducted by SOS Mata Atlântica, SEEG and Imaflora, which pointed the necessary conditions to achieve greenhouse gas neutrality in the biome's land-use sector by 2042—the Atlantic Forest NDCs.

05 Results

1. Land distribution across different land tenure categories

Land distribution in the Atlantic Forest has a very distinguishing feature: private lands (78%) outnumber public lands (6.3%) by a large margin. This sets the biome apart from others in Brazil, especially the Amazon, where there is a greater predominance of public lands, although they are unallocated. In terms of lands that aren't registered in any official database with georeferenced information, we can affirm that they occur less in the Atlantic Forest than in the rest of the country, but the number is still significant, approximately 10% of the biome's territory falls in this category (Figure 2).

Private lands reflect the predominant land tenure situation in the Atlantic Forest, which means that 80% of the biome's native vegetation remnants are in this category, albeit very fragmented and in small patches of less than 50ha (Ribeiro *et al.*, 2009). This highlights the potential of Private Natural Heritage Reserves (RPPNs) to complement the public lands designated for conservation purposes (a very small proportion of less than 3%, not considering Environmental Protection Areas [APAs, "Áreas de Proteção Ambiental"]) (Table 1); about 1% if we consider public lands with full protection – (Ribeiro *et al.*, 2009).

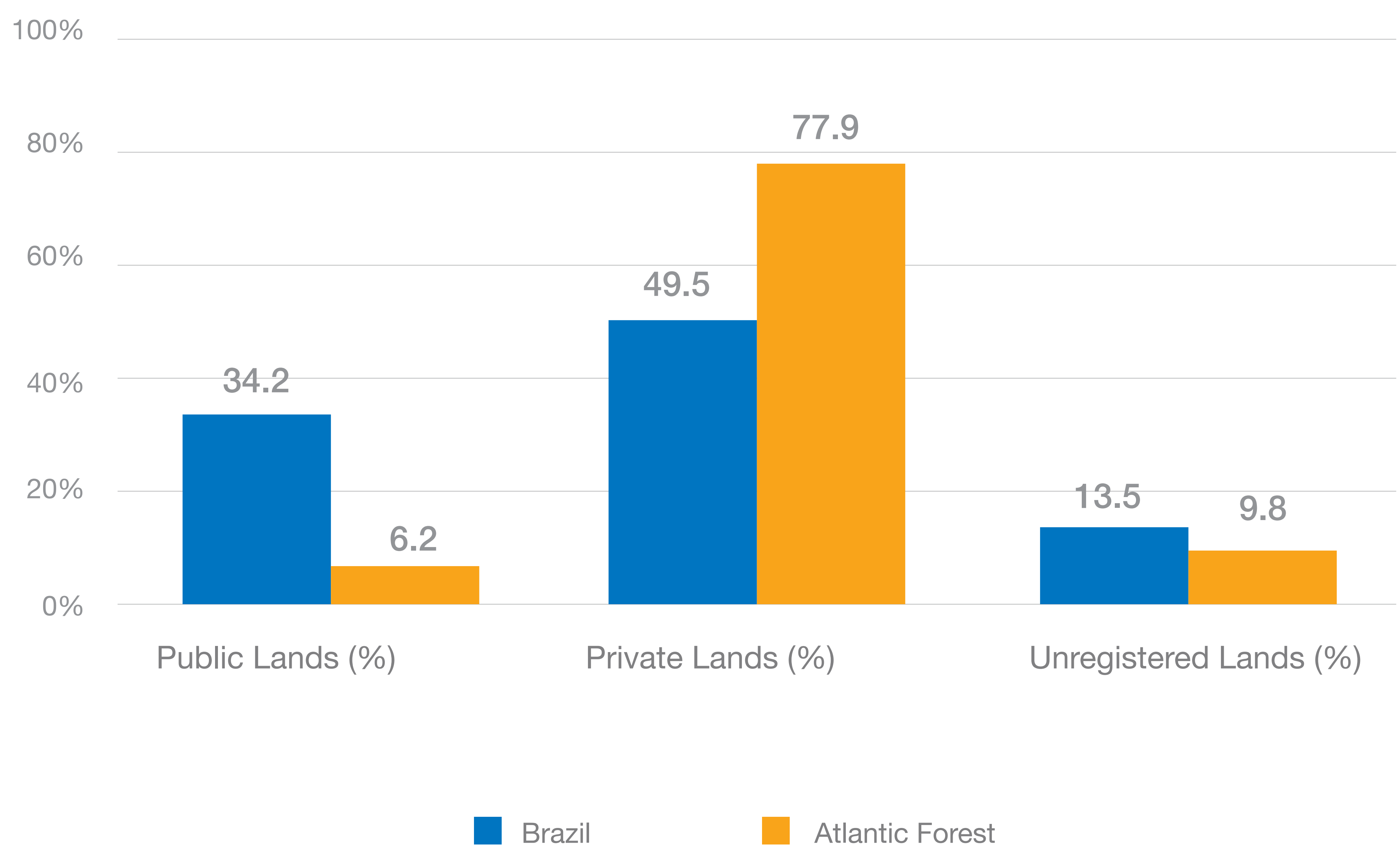


Figure 2. Proportion of public, private and unregistered lands in in the Atlantic Forest found in public databases with georeferenced information. Source: Atlas of Brazilian Agriculture.

Another distinguishing mark of land distribution in the Atlantic Forest is that small properties (less than four standard modules for tax purposes) are the norm (when adding the CAR and SIGEF records) (Table 1). These lands occupy 32% of the biome. If we add lands occupied by rural settlement, this number increases to 35%. The second most relevant land tenure situation in the biome is that of large private properties (more than 15 standard modules for tax purposes), which take up 26% of the biome's total area.

There are no studies to date on the land concentration situation of each biome in Brazil, but Pinto et. al (2021) identified that the states located within the Atlantic Forest (Espírito Santo, Santa Catarina and Rio de Janeiro), or that fall mostly within the biome (Paraná), had the lowest levels of unequal land distribution, falling below Brazil's average (Gini Index). The states where the Cerrado and Amazon biomes predominate had the highest levels of unequal distribution.

Another distinguishing feature of the Atlantic Forest is the low proportion of unallocated government land, which today is the cause of social conflicts and conflicts over land. Deforestation has been expanding the most in the unallocated lands of the Amazon (Azevedo-Ramos et al., 2020). In the Atlantic Forest, unallocated lands make up less than 0,5% of the public lands present in the biome, in comparison with 5% in Brazil and a high proportion in the Amazon.

Despite the low number of unallocated lands in the Atlantic Forest, we found that 5.7 million hectares of unallocated lands had overlapping land titles, which means they are declared as both private and public. This was found mainly in the CAR records for indigenous lands and conservation units (Faria *et al.*, 2021), and indicates that the biome's land tenure situation is not fully resolved and not all land conflicts have been overcome. However, land safety in the biome seems to be better than in most other regions of Brazil, comparatively speaking.

Table 1. Brazil and the Atlantic Forest: land distribution in different land tenure categories. Source: (Faria *et al.*, 2021).

Land tenure category	BRAZIL				ATLANTIC FOREST			
	Area (ha)	%	Number	%	Area (ha)	%	Number	%
Indigenous lands	114.081.833	13,4%	1.273	0,0%	1.310.123	1,0%	370	0,0%
Conservation Unit	89.514.533	10,5%	2.758	0,0%	3.747.753	2,9%	1.552	0,1%
Community territory	2.470.144	0,3%	793	0,0%	1.474	0,0%	35	0,0%
Military field	2.900.239	0,3%	149	0,0%	36.953	0,0%	27	0,0%
Rural settlement	40.183.813	4,7%	11.297	0,2%	3.047.486	2,3%	2.811	0,1%
Unallocated land	41.664.844	4,9%	68.227	1,0%	83.289	0,1%	3.850	0,1%
Total public land	**290.815.405**	**34,2%**	**84.497**	**1,3%**	**8.227.077**	**6,3%**	**8.645**	**0,3%**
Private property through CAR								
Small	94.298.039	11,1%	5.254.107	78,4%	36.916.965	28,2%	2.469.191	83,5%
Mid-sized	39.029.771	4,6%	158.025	2,4%	12.672.801	9,7%	82.001	2,8%
Large	43.306.059	5,1%	30.307	0,5%	9.476.974	7,2%	13.414	0,5%
Private property through SIGEF								
Small	24.611.957	2,9%	501.341	7,5%	5.588.235	4,3%	205.891	7,0%
Mid-sized	58.177.155	6,8%	166.830	2,5%	12.029.872	9,2%	57.442	1,9%
Large	144.143.751	17,0%	72.334	1,1%	25.070.335	19,1%	23.218	0,8%
Private property through the Terra Legal program	14.407.771	1,7%	150.323	2,2%	2.982	0,0%	127	0,0%
Quilombola territory (former slaves)	2.550.770	0,3%	672	0,0%	335.734	0,3%	261	0,0%
Total private land	420.525.272	49,5%	6.333.939	94,5%	102.093.898	77,9%	2.851.545	96,4%
Unregistered land (vacant)	114.499.415	13,5%			12.884.118	9,8%		
Road network, urbanization or water bodies	24.438.126	2,9%	286.024	4,3%	7.793.532	5,9%	98.075	3,3%
Total	850.278.218	100,0%	6.704.460	100,0%	130.998.625	100,0%	2.958.265	100,0%

2. Land-use change and greenhouse gas emissions

The Atlantic Forest is Brazil's most anthropized biome. Centuries of predatory economic cycles characterized by alternating periods of economic growth and decline, or collapse, have profoundly transformed its landscape. These cycles contributed very little to the development of the country over the centuries (Dean, 1996) and a similar process happened in the Amazon regions (Rodrigues *et al.*, 2009).

As a result of this, 64% of the biome's territory was anthropized to make way for the country's main metropolises, cities, urban areas, road and energy infrastructures. Most of the anthropized areas, however, are pasturelands, which cover 25% of the biome's territory. Another 17% is occupied by agriculture, 14% by an agriculture and pastureland mosaic, and 3.5% by forestry. In other words, farming takes up 60% of the biome's territory, spanning 78 million hectares. The anthropized region of the Cerrado biome, by contrast, is 15% larger and agriculture alone takes up 86 million hectares in the Cerrado biome (MapBiomas 2022) (Figure 3).

Sixteen million hectares of pasturelands showed some level of degradation in 2020, and 4 million hectares—the same size as the state of Rio de Janeiro—were considered severely degraded (MapBiomas, 2022).

The remaining 31% of the territory has a native vegetation cover. Forests cover 24% of the entire biome, but we also find other vegetation types and natural ecosystems, such as savannas, mangroves and restingas in coastal areas, and grasslands in high-altitude areas.

The forest cover, however, is not sufficient in size to ensure biodiversity conservation because it does not attain the critical threshold of 30% (Banks-Leite *et al.*, 2014). Moreover, forest remnants are unequally distributed and some landscapes have a native vegetation cover of less than 5%. Recent studies reveal there are regions where the forest cover is decreasing and losing both biomass and biodiversity (Rosa *et al.*, 2021; Lima et al., 2020).

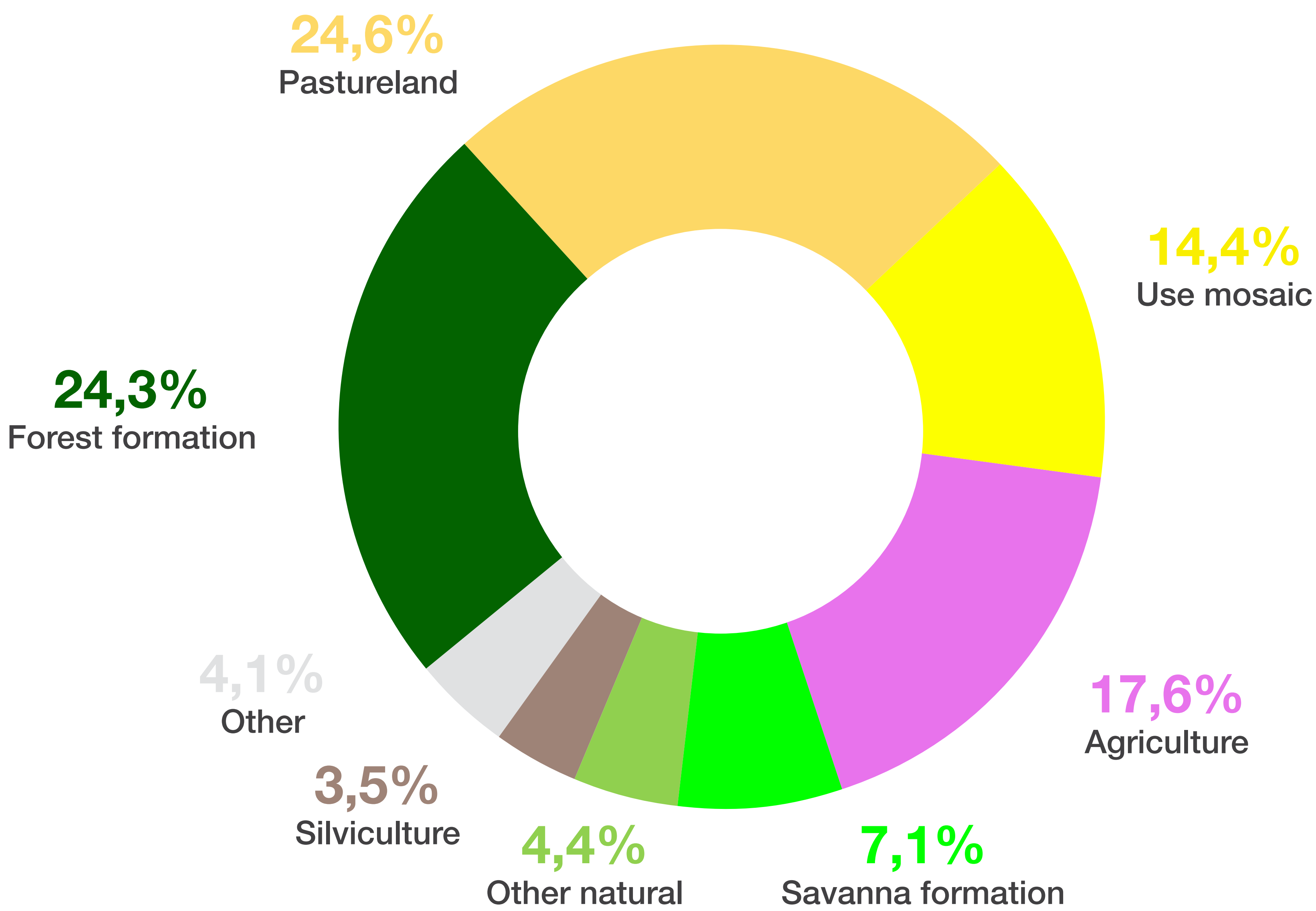


Figure 3. Land-use in the Atlantic Forest in 2021. Source: MapBiomas - Coleção 7.0 (2022).

In the last 35 years (since 1985), some important quantitative transformations have taken place in the landscape, such as a reduction in pasturelands, more area dedicated to agriculture and planted forests, and a stable natural vegetation cover (Figure 4). The aggregate data reveals the forest cover is relatively stable, however, this might downplay specific situations that are cause for concern. Aggregate stability takes into account the losses (deforestation) and gains (regeneration), and the Atlantic Forest had a net loss of 1 million hectares over a period of 35 years. This number is too high for a threatened biome with low forest cover. In the first half of 2022 alone, a deforestation detection system called SAD Atlantic Forest mapped 21,302 suppressed hectares, from 3,358 valid notifications.

The net balance also conceals an increasing loss of mature forests, which is being compensated by the regeneration of very young forests with lower biomass and biodiversity (Rosa *et al.*, 2021). While there has been vigorous regeneration of young forests, these forests are also being lost in a very short time frame: at least 1/3 are lost within four to eight years, before reaching higher levels of ecological maturity (Piffer et al., 2022).

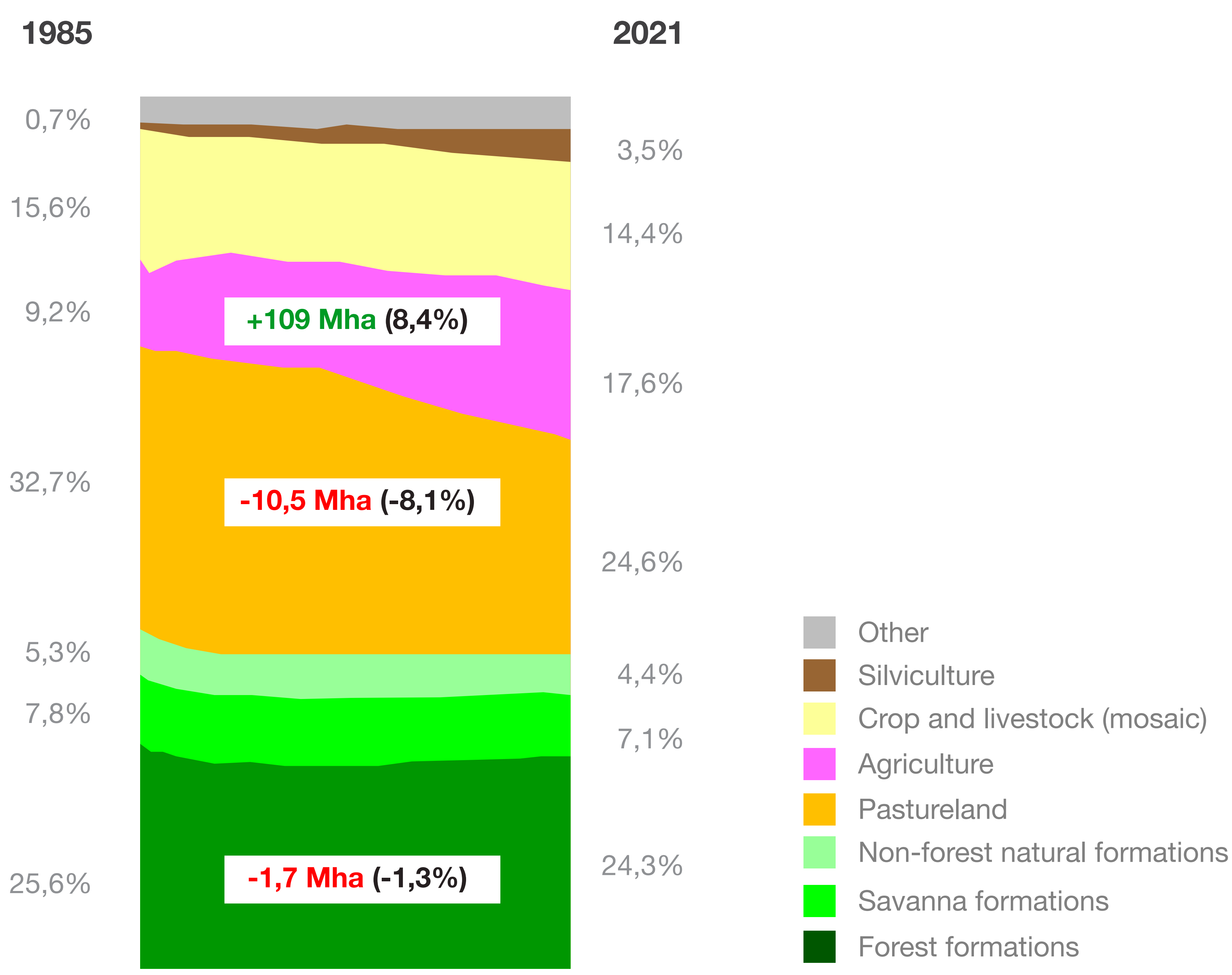


Figure 4. Land-use changes in the Atlantic Forest between 1985 and 2021. Source: MapBiomas - Coleção 7.0 (2022).

With intense land-use changes, strong agriculture and high energy consumption, the Atlantic Forest ranks second in the emission of greenhouse gases in Brazil, when we consider all the involved sectors (Figure 5). Although the biome's emission profile is different from the rest of the country and the Amazon, mainly due to the energy sector, its land-use sector is responsible for 50% of its emissions and appears as the most relevant in this aspect when we add deforestation (17%) and agriculture (32%) (Figure 6) (Pinto *et al.*, 2021). When we analyze the emissions from the agricultural sector alone, the Atlantic Forest ranks second in the country, with 26% of Brazil's total emissions for this sector, while the Cerrado ranks first, with 32% of total emissions (Figure 7).

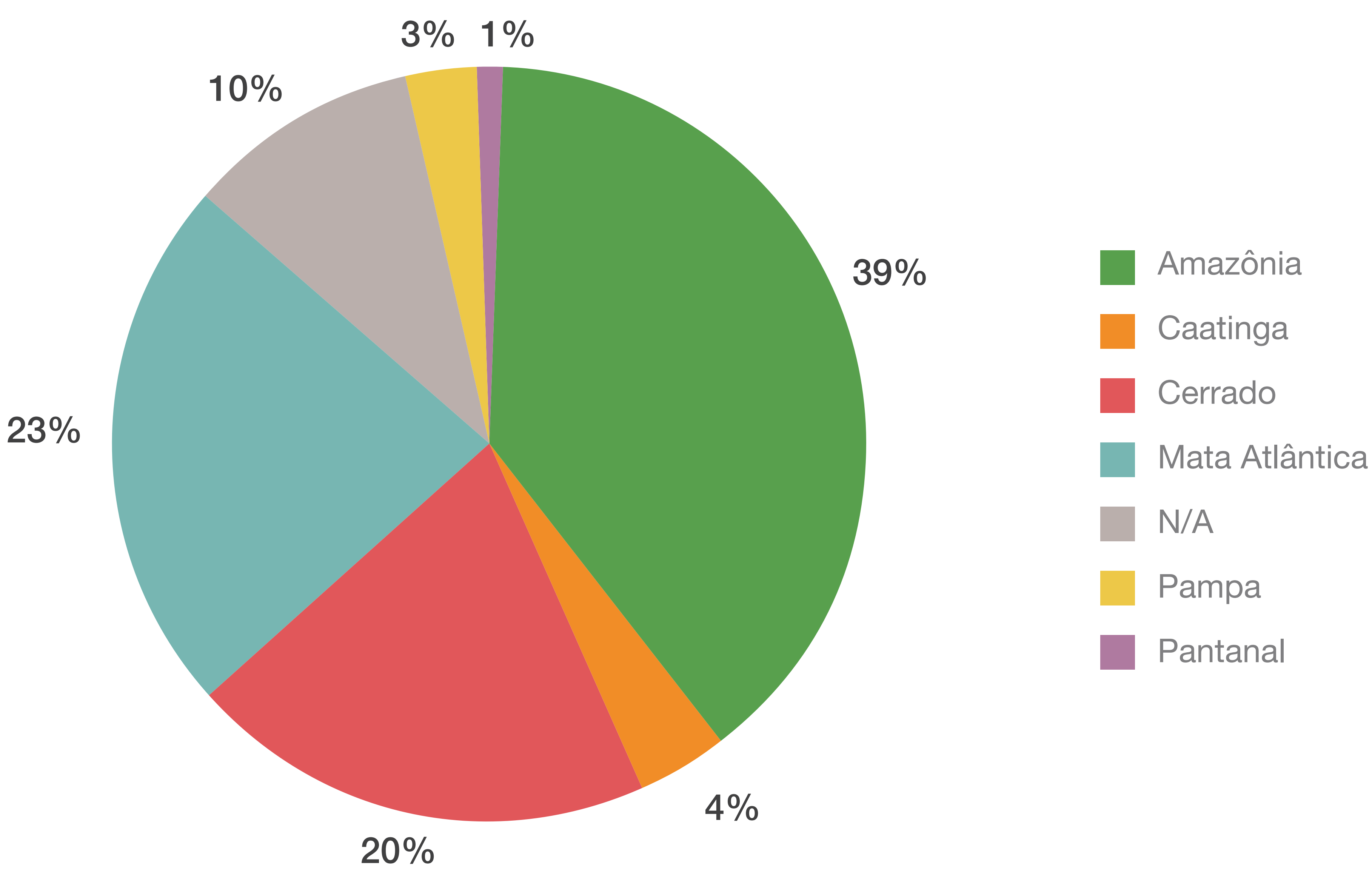


Figure 5. Greenhouse gas emissions in Brazil, in 2018, organized by biome. Source: Pinto *et al.*, (2021).

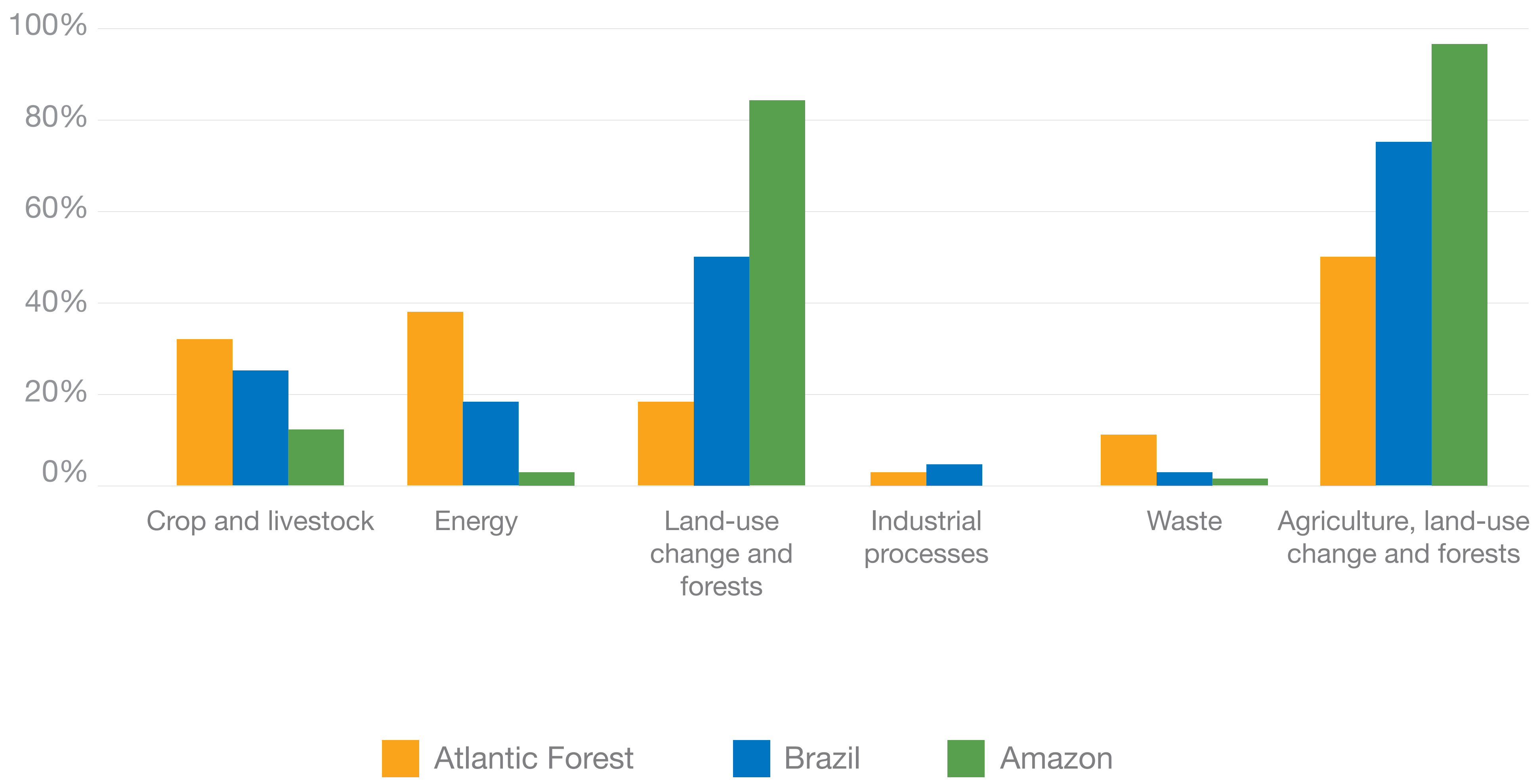


Figure 6. Profile of the greenhouse gas emissions in the Atlantic Forest, Brazil and the Amazon in 2018. Source: Pinto *et al.*, (2021); nomenclature established by SEEG for the emission sectors.

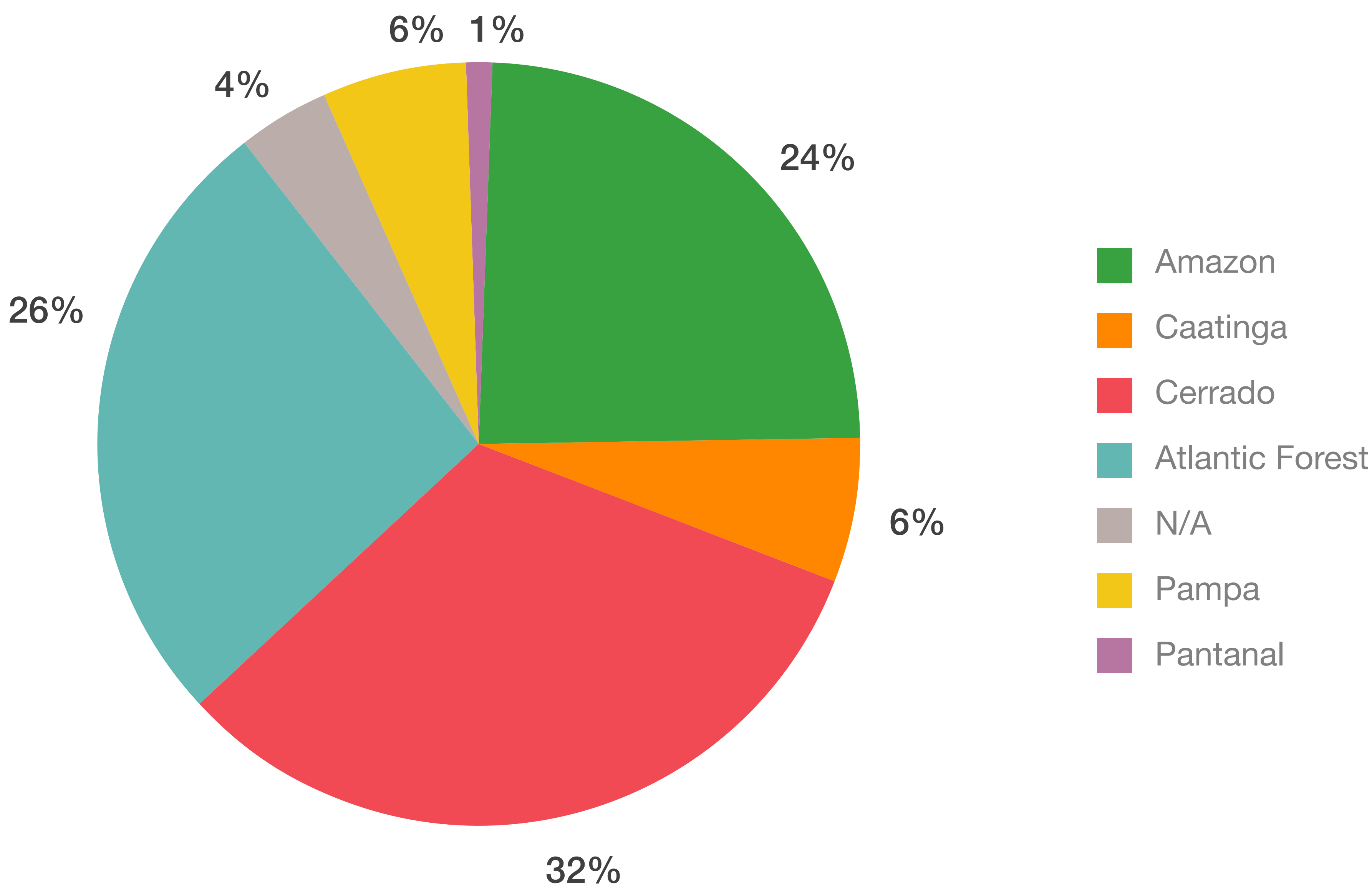


Figure 7. Proportion of total emissions from the agricultural sector for each biome, in 2017. Source: SEEG.

Although the land-use sector has greatly increased the country's total emissions, Pinto *et al.* (2021) revealed that the sector can achieve carbon neutrality by 2042, and become negative from that point on (Figure 8) if the following conditions are met: zero deforestation by 2030; 15 million hectares restored between 2005 and 2050; large-scale adoption of low-carbon agricultural practices. The study concluded that neutrality can be achieved despite the current land situation (without native vegetation) and without curtailing current production targets for crops and livestock.

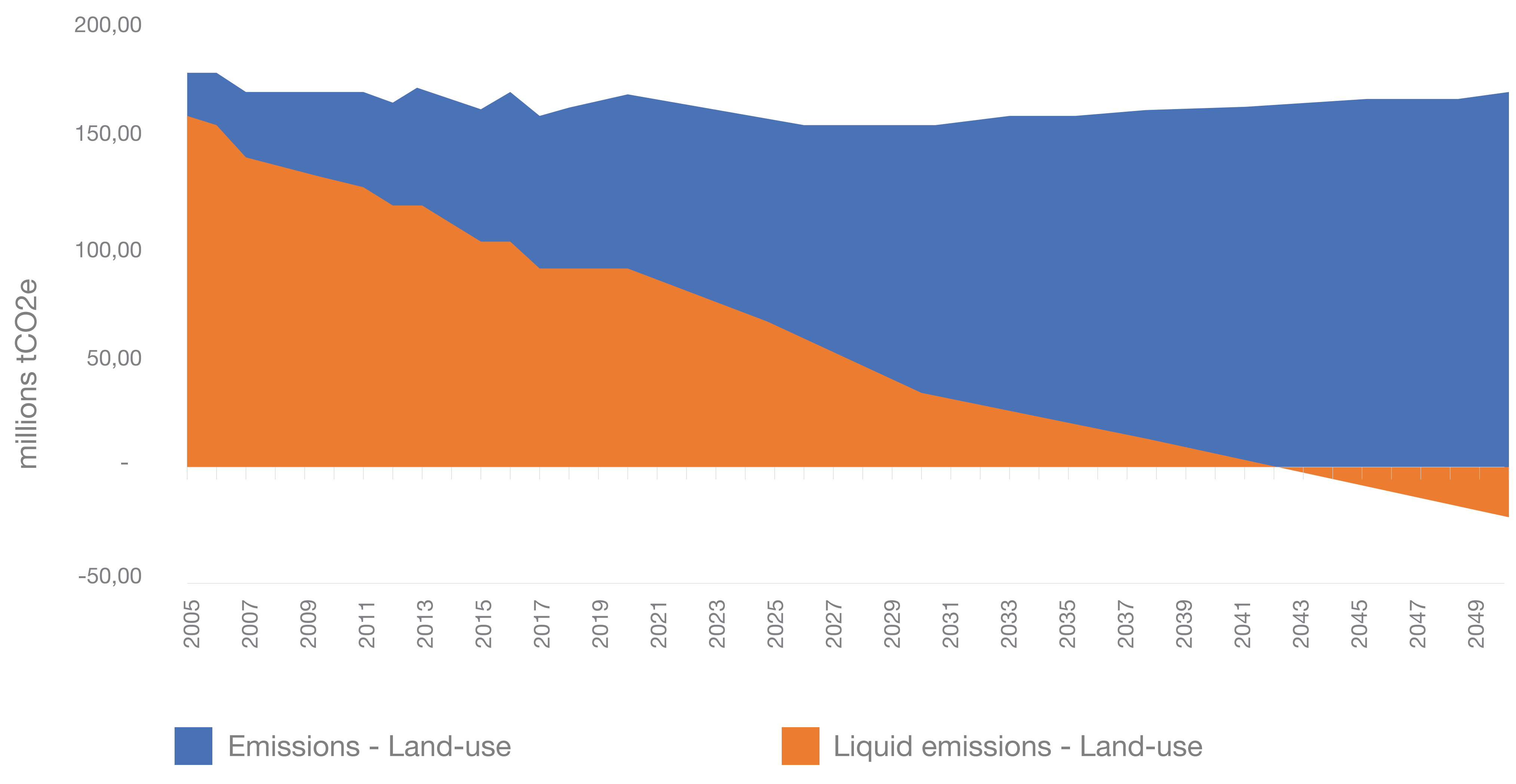


Figure 8. Balance of greenhouse gas emissions and removals from land-use activities (farming + land-use change) in the Atlantic Forest until 2050. Source: Pinto et al., (2021).

3. Agricultural and Food Production

Agriculture in Brazil started in the Atlantic Forest. Brazil started as a colony and became an empire over the course of many centuries, and for all this time it has produced export commodities, such as sugar and coffee, in the biome, which was also responsible for ensuring Brazil's domestic food supply (Dean, 1996).

The same happened for most of the 20th century. However, the technologies disseminated by the Green Revolution in Brazil helped expand agriculture to other biomes, especially the Cerrado, starting in the 1970s. Since then, Brazil's agriculture has undergone a period of profound changes and continued expansion of cultivated areas. It has also enjoyed great leaps in productivity, especially in crop production (Sparovek et al., 2018). This led to a drop in prices for staple foods and food exports. Brazil went from being a food importer to becoming one of the world's top agriculture and livestock producers and exporters. Large public investments were made to support the sector and fund credit lines, research and extension, but the process also led to profoundly negative outcomes, such as environmental impacts, inequality and violence (Pinto *et al.*, 2016).

The land distribution pattern of the Atlantic Forest, as identified in our land tenure analysis, was confirmed by an evaluation of the data set forth in IBGE's Census of Agriculture. The biome's total area and number of rural establishments remained stable between 2006 and 2017; it contained 40% of Brazil's total number of rural establishments and 25% of its total area (Table 2).

We also confirmed a predominance of small establishments, both in total number (93% in 2017) and total area (39% in 2017), although an unequal distribution became quite evident: 1% of large properties occupied 29% of the total area (Figures 9 and 10). Large properties are found mostly in the regions of Mato Grosso do Sul, Minas Gerais, Bahia, Paraná and Santa Catarina (Figure 11); some of them also have the greatest deforestation rates of the biome (SOS Mata Atlântica Foundation and INPE, 2022).

Table 2. Number and area of agricultural establishments in the Atlantic Forest and Brazil, in 2006 and 2017. Source: 2006 and 2017 Census of Agriculture compiled by GeoLab - Esalq/USP.

	Atlantic Forest	AF Representation (%)	Brazil
Number of agricultural establishments			
2006	2.115.819	40,9%	5.175.636
2017	2.009.252	39,6%	5.073.324
Variação	-5,3%	-	-2,0%
Area of rural establishments (ha)			
2006	83.954.991	25,1%	333.680.037
2017	85.117.709	24,2%	351.289.816
Variação	1,4%	-	5%

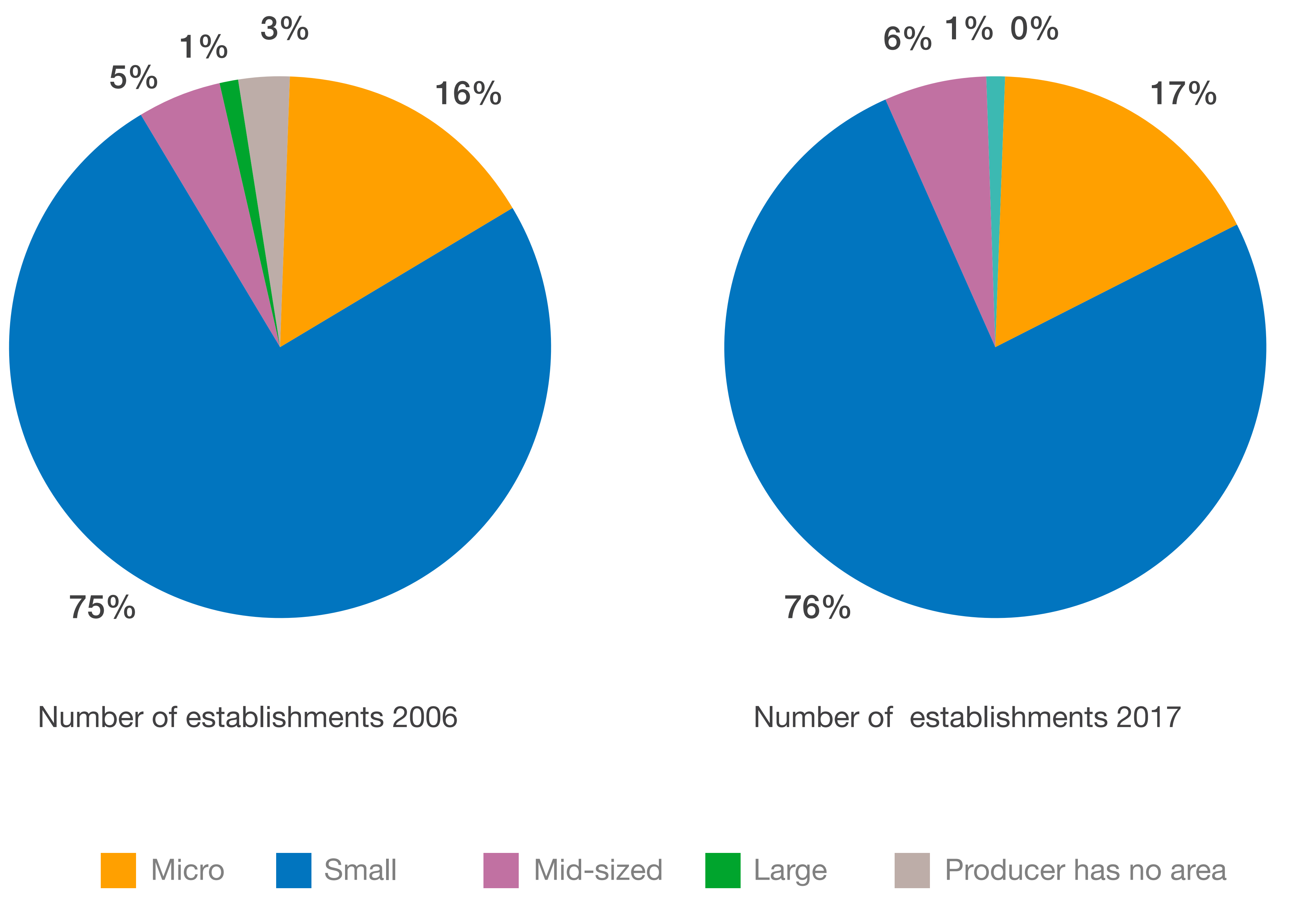


Figure 9. Number of rural establishments in the Atlantic Forest, in 2006 and 2017, according to different size categories. Source: 2006 and 2017 Census of Agriculture compiled by GeoLab - Esalq/USP.

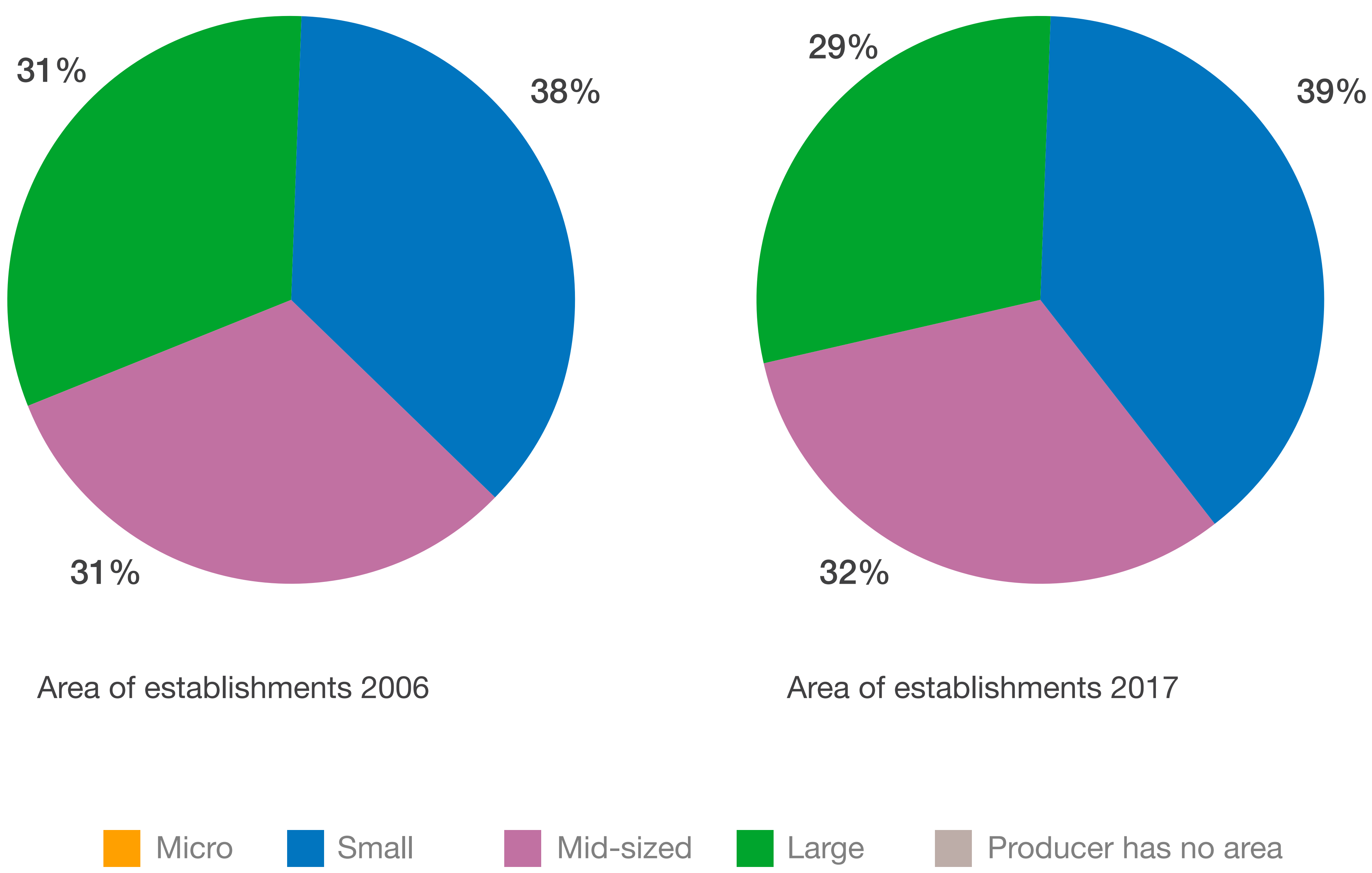


Figure 10. Area occupied by rural establishment in the Atlantic Forest, in 2006 and 2017, according to different size categories. Source: 2006 and 2017 Census of Agriculture compiled by GeoLab - Esalq/USP.

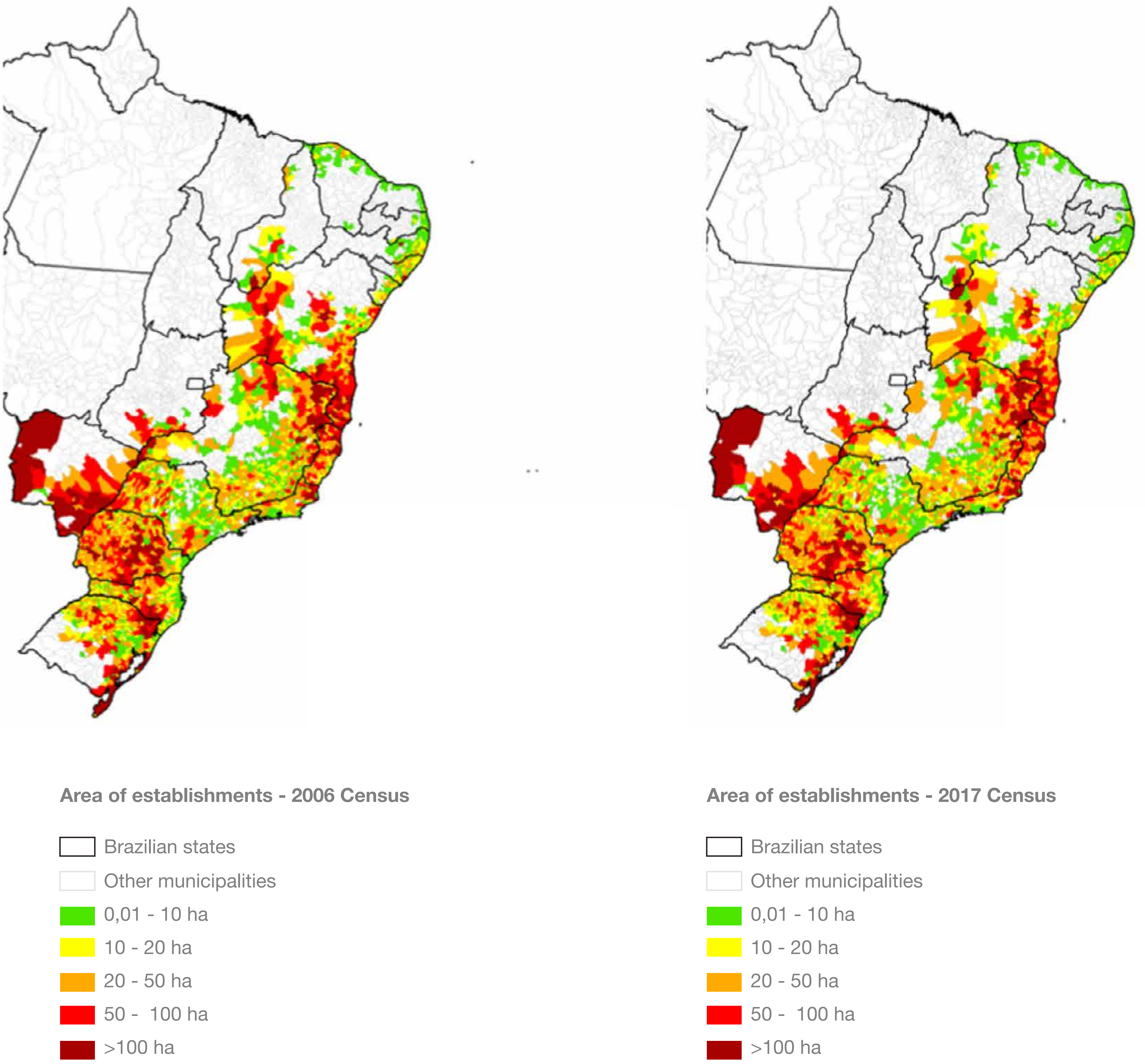


Figure 11. Geographic distribution of rural establishments in the Atlantic Forest according to different land size categories, in 2006 and 2017. Source: 2006 and 2017 Census of Agriculture compiled by GeoLab - Esalq/USP.

With an agricultural area that spans almost 70 million hectares, or 27% of Brazil's total agricultural area (263 million hectares), the Atlantic Forest ranks second in agricultural land area and the *Cerrado* ranks first, with 87 million hectares of land dedicated to crop and livestock farming. In 2017, the Atlantic Forest was responsible for most of the country's agricultural output and a wide variety of crops (Table 3):

- 52% of the plant food production for direct human consumption (except corn, soy and sugarcane);
- 30% of non-food crops (fiber, latex and cotton);
- 43% of the soy, corn and sugar cane output; food crops for direct and indirect consumption (animal feed) and energy;
- 56% of animal source foods;
- 62% of the country's livestock animals (cattle, sheep, poultry, swine).

From 2006 to 2017, Brazil's output of plant foods increased from 48% to 52%, while the opposite happened for corn, soy and sugarcane, which dropped from 50% to 43%, and non-food crops, which went from 38% to 30%. Livestock production increased from 53% to 56%, while the number of livestock animals decreased from 64% to 62%.

With lower relative participation in the domestic production figures, corn, soy and sugarcane increased 42% (from 249 million to 356 million), while other plant crops grew 46% (from 41 to 60 million tons) between 2006 and 2017. In 2017, corn, soy and sugarcane production had volumes that were six times greater than those of other similar plant crops. Livestock production increased 60% (from 12.4 to 19.4 million tons), while the number of livestock animals increased only 13% during the same period (Table 3).

Table 3. Total and aggregate relative crop and livestock production (tons) figures for the Atlantic Forest, in 2006 and 2017. Source: IBGE-SIDRA, 2021. 2006 and 2017 Census of Agriculture compiled by GeoLab - Esalq/USP. In press.

Class	Products	2006			2017		
		Brazil	Atlantic Forest (AF)	MA / BR	Brazil	Atlantic Forest	MA / BR
Crop production	Food crops (Tons)[1]	85.957.,574	41.028.777	48%	114.381.251	60.008.091	52%
	Nonfood crops (Tons)[2]	14.361.750	5.462.244	38%	16.161.710	4.856.852	30%
	Sugarcane, soy and corn (Tons)	495.090.022	249.150.325	50%	829.945.752	356.482.407	43%
Livestock production	Animal source foods[3] (Tons)	23.289.420	12.441.581	53%	34.617.088	19.499.147	56%
	Livestock numbers[4] (Unit)	1.409.561.852	897.175.177	64%	1.637.259.507	1.017.983.802	62%

1 except sugarcane, soy and corn

2 ffiber, latex, cotton (except timber and seedlings)

3 milk, cheese, eggs, beef, pork and poultry

4 cattle, buffalo, poultry, swine, equine, goats, sheep, mules

According to another aggregate scale and IBGE's classification system, in 2017 the biome was responsible for 39% of the country's cereal production, 56% milk and milk products, 80% herbs, roots and condiments, and 44% fruit.

According to non-aggregated data, in 2017 the biome had great livestock production and a wide variety of food crops for direct consumption, as well as a significant participation in the domestic output figures (Table 4).

Table 4. Atlantic Forest's participation in food crops and livestock production in 2017. Source: IBGE-SIDRA, 2021. 2017 Census of Agriculture compiled by GeoLab - Esalq/USP. In press.

Crops	Production in the Atlantic Forest (%)
Yerba mate	97
Apple	97
Black beans	90
Conilon coffee	90
Broccoli	88
Choko	86
Mushroom	84
Wheat grain	80
Oats	76
Beet	70
Poultry	68
Eggplant	68
Tomato	68
Arabica coffee	65
Swine	64
Eggs	63
Banana	63
Onion	61
Cocoa	56
Potato	54
Cassava	51
Sugarcane	46
Rice	38
All beans	34
Soybeans	32
Beef cattle	27

06 Aspects of the Atlantic Forest for the future of agrifood systems

In keeping with its historical trend, the Atlantic Forest remains a key region for agriculture and livestock farming in contemporary Brazil. The biome achieved outstanding production results in several different commodities for domestic consumption and for exportation. It also produces most of the agriculture crops and animal products that feed the Brazilian population. It has achieved these results with a smaller agricultural area and lower levels of greenhouse gas emissions, when compared to the *Cerrado*, which has become the paradigm for successful agriculture in the last decades because of its large-scale monoculture farming in large properties. Our results show that the differences, specificities and learning points about agriculture and food production in the Atlantic Forest and the Cerrado need to be further investigated, both in their historical and current context.

The biome's agricultural activities include a wide variety of crops, with a predominance of small rural properties and less inequality in land distribution than in other Brazilian regions, although inequality remains high.

The biome underwent profound changes in its land-use sector in the last decades, when pasturelands became agricultural land through an ongoing deforestation process that affected primary and secondary forests, although this was concealed by the regeneration of young forests. Forest losses have led to increased levels of greenhouse gas emissions and environmental losses in biodiversity and ecosystem services.

Despite this unfortunate situation, the Atlantic Forest's agrifood sector can make great strides in the fight against climate change. Carbon neutrality can be achieved with sustainable production practices and healthy foods, through the implementation of the following changes:

a. Ending deforestation;

b. Increasing regeneration and ensuring the long-term permanence of naturally regenerated forests;

c. Conducting forest regeneration in areas with low potential for natural regeneration;

d. Broadening the use of low-carbon systems for agricultural production.

There are specific structural conditions that may bolster these changes, such as:

a. Most Brazilians live in urban areas within the Atlantic Forest region (70% of the population), which means there is increasing demand for ecosystem services, especially those associated with the blue agenda;

b. The Atlantic Forest concentrates 80% of the country's GDP, which improves its access to financing for restoration purposes and creates a market for restoration products;

c. The technologies and services used for ecologically restoring the most important vegetation physiognomies of the Atlantic Forest are very advanced;

d. The top consumer centers for agricultural and food products are large urban centers in the Atlantic Forest.

A commitment to end deforestation by 2030 was made by the Brazilian government in 2021, during the COP 26 meeting in Glasgow. State governments in the Atlantic Forest, such as São Paulo, Minas Gerais and Espírito Santo, adhered to the Race to Zero project, which is also committed to ending deforestation. Throughout its history, the Atlantic Forest has enjoyed periods of controlled or decreased deforestation, such as the sharp drop in deforestation that occurred in the beginning of the 2000s and again in early 2010 (Figure 12) (SOS Mata Atlântica Foundation and INPE, 2022). Between 2004 and 2013, we also learned important lessons about controlling deforestation in the Amazon (Ferreira *et al.*, 2014).

Controlling deforestation and ensuring the long-term permanence of regenerating forests depends on the rigorous application of the Atlantic Forest Law, published in 2006. The Prosecution Office also plays a central role in this through their Standing Atlantic Forest Operation, which strengthens the inspection routines performed by environmental agencies. Inspections are now supported by a new Deforestation Alert System (SAD Atlantic Forest), developed by SOS Mata Atlântica and MapBiomas.

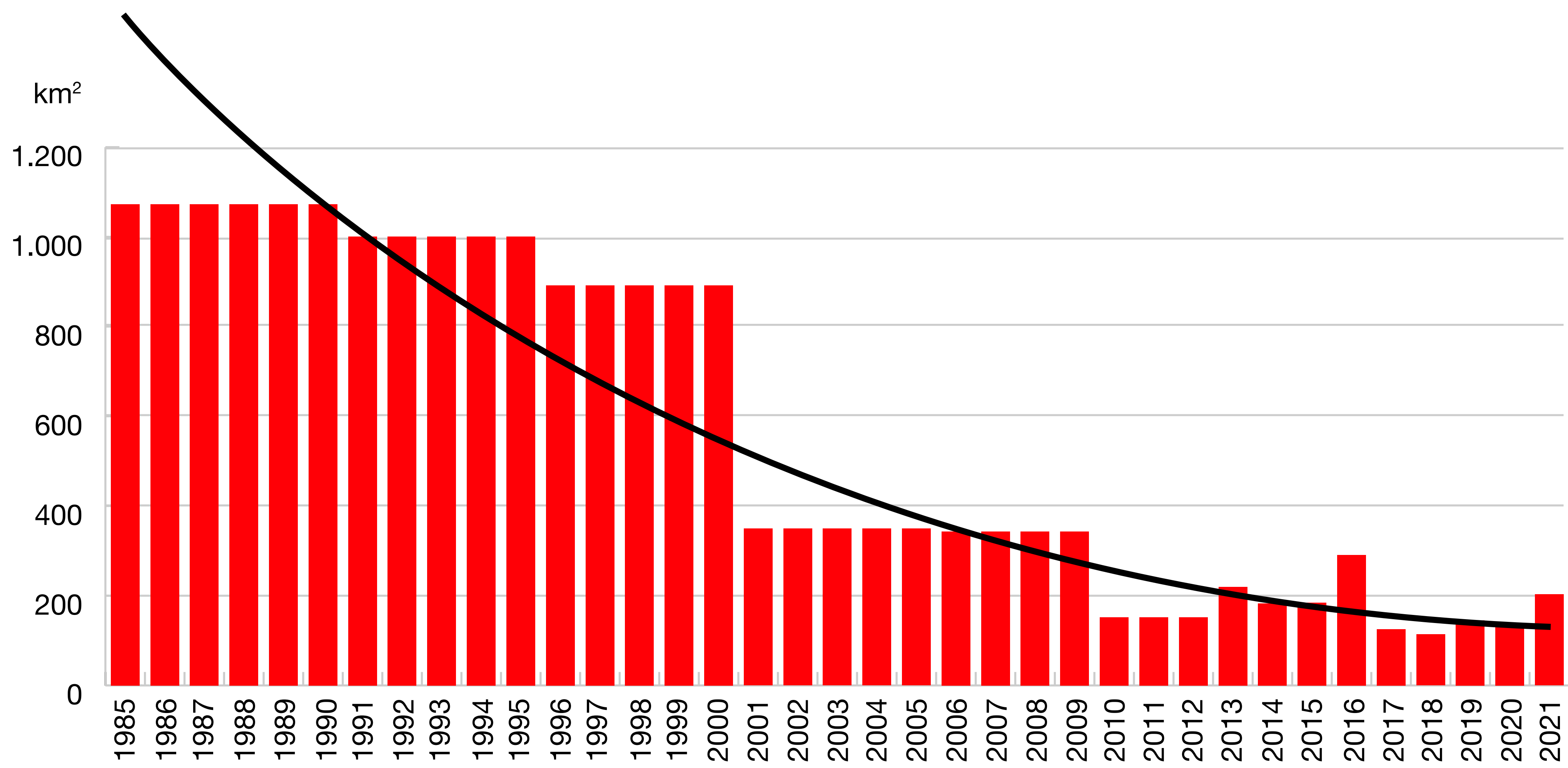


Figure 12. Progression of deforestation in the Atlantic Forest between 1985 and 2021. Source: SOS Mata Atlântica and INPE, 2022.

Active forest restoration will follow the implementation of the Forest Code and the large-scale implantation of silviculture with native species and agroforestry systems for the production of food and other diverse products. Faria et al. (2021) estimated the current deficit of native vegetation in Areas of Permanent Protection (APP) at 2.7 million hectares. This needs to be restored to ensure the biome is in compliance with the Forest Code. In addition to highly detailed and reliable data, the Atlantic Forest also relies on collective intelligence, technology and the Atlantic Forest Restoration Pact to achieve its ambitious restoration goals (Crouzeilles *et al*., 2019).

Studies on the productive, operational and economic performance of small and large-scale projects in the biome, across different socioeconomic realities, support agroforestry and silviculture systems. They also point to the feasibility and competitiveness of these alternatives, even for traditional commodities (Batista, 2021; Soares, 2021; Agroicone, n.d.; Agroicone, 2021; Escolhas, 2022).

In the Atlantic Forest, a set of successful agroecological and organic production experiences (Agroecologia, 2011) has been systematized and several articles have been published about it in Revista Agriculturas (organized by ASPTA) and in agroecology networks. Many of these experiences have been replicated in agrarian reform projects through agroforestry and other production systems, combining biodiversity conservation with production and inclusion (Painter *et al.*, 2020; Shennan-Farpón et al., 2022; Chazdon, 2020; Rodrigues et al., 2007; Leite *et al*., 2014).

Many have also been associated with so-called short systems for fresh and healthy food projects, with a shorter distance between producers and consumers. Many important experiences in food production are also taking place in the peri-urban and urban areas of the biome's largest cities (Instituto Escolhas, 2020; Ligue os Pontos, 2018), and they have recently been identified as solutions to food insecurity and as a way to offer healthy produce, helping to mitigate and adapt cities to deal with climate changes (Macdonald e Chellew, 2022).

Despite the positive examples, agriculture in the biome has its share of unpleasant side effects. Some states within the biome—such as Paraná, Santa Catarina, Rio Grande do Sul, São Paulo and Espírito Santo—have a high number of rural establishments that use pesticides. Moreover, Paraná, São Paulo and Santa Catarina rank the highest in human intoxication by pesticide (Bombardi, 2017).

So it remains to be seen whether this top food producing region, with the greatest crop diversity, will overcome its pesticide dependence. Can the Atlantic Forest come under a new, full-scale and hegemonic agroecological and healthy paradigm to replace current Green Revolution technologies?

For this, we already have vast experience and a set of guiding policies, such as: Atlantic Forest Law (11.428/2006); Forest Code (12.651/2012); Climate Change Adaptation and Mitigation Sector Plan for the Consolidation of a Low Carbon Economy in Agriculture (ABC Plan); National Plan for Native Vegetation Recovery (PLANAVEG); National Program to Strengthen Family Farming (PRONAF); Food Acquisition Program (PAA); National Policy for Agroecology and Organic Production (PNAPO); National Policy for Food and Nutrition (PNAN); National School Feeding Program (PNAE) and RenovaBio. We need to resume, strengthen and truly implement some of these policies, but it is also essential that we integrate our perspectives and coordinate our efforts to achieve a sustainable and healthy agrifood system.

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MASTHEAD

Food Production in the Atlantic Forest
Challenges for sustainable, healthy and carbon neutral farming practices in Brazil's top food producing biome

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