National Accounts
number 73

Environmental-Economic Accounts
1

Ecosystem Accounts

Land Use in the Brazilian Biomes

2000 - 2018

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Instituto Brasileiro de Geografia e Estatística

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Summary

Conventions

-	Numerical data equal to zero not resulting from rounding;
..	No numerical data is applicable;
...	Numerical data is not available;
x	Numerical data omitted to avoid individualization of information;
0; 0,0; 0,00	Numerical data equal to zero resulting from rounding of an originally positive numerical data; and
-0; -0,0; -0,00	Numerical data equal to zero resulting from rounding of an originally negative numerical data.

Presentation

With the launch of this publication, the Brazilian Institute of Geography and Statistics (IBGE) introduces a new line of products for mapping and analysis of Brazilian ecosystems in several environmental perspectives, presenting a territorial reflection on the environment that is essential to understanding the use and destination of the stock of natural resources, as well as the resulting environmental services.

This study is based on the methodological framework of the *System of Environmental-Economic Accounting 2012: Central Framework* (UNITED NATIONS, 2014a), known as SEEA Central Framework, and more specifically, the *System of Environmental-Economic Accounting 2012: Experimental Ecosystem Accounting Manual*, known as SEEA-EEA (UNITED NATIONS, 2014b), which propose an integrated evaluation of environmental information and its relation with the economy, allowing a combined analysis in a single framework.

By presenting the Brazilian territorial dynamic from the initial and final stocks, in physical terms, of natural resources, according to the different land uses mapped in a temporal period of 18 years in the six Brazilian biomes - Amazônia, Mata Atlântica, Cerrado, Caatinga, Pampa and Pantanal - this publication proposes a reflection on the changes experienced by each environmental unit during a given accounting period.

This land use dynamic directly impacts carbon stocks (CO^2) in the vegetation and soil biomass, resulting in climate change, soil degradation processes, loss of vegetational varieties and even posing risks to biodiversity. Therefore, this study also intends to present an essential knowledge base for the development, implementation, and monitoring of public policies intended to ensure the efficient use of natural capital and propose actions for the prevention and recovery of terrestrial ecosystems.

With this publication, IBGE restates its commitment to depicting the information required to learn about Brazil's true reality, from the presentation and analysis of information on the environment, which is relevant to the promotion and regulation of the sustainable use of its natural capital.

Claudio Stenner
Director of Geosciences

Introduction

Natural capital accounting uses an accounting framework to systematically assess the stocks and flows of natural resources and assets, as well as account for the ecosystem assets and services they provide. Through this accounting structure, it is possible to measure and compare, over time, the contribution of natural resources and ecosystems to social and economic aspects of a given territory. Accounts provide dynamic and standardized statistics for the decision-making and planning process, as pointed out in the European Union report (NATURAL..., 2019).

For this purpose, the *Sistema de Contas Econômicas Ambientais* - SCEA was developed, methodologically based on the *System of Environmental-Economic Accounting 2012: Experimental Ecosystem Accounting*, SEEA-EEA (UNITED NATIONS, 2014b), to address environmental information and its relation to the economy in an integrated manner under a single structure. The SCEA is based on internationally accepted accounting concepts and tables for the production of comparable indicators around the world. Through a robust methodology, classifications and rules are described for evaluating the changes in the stocks and flows of environmental assets (UNITED NATIONS, 2016).

In general terms, the Environmental-Economic Accounts – EEA (*Contas Econômicas Ambientais* – CEA) are structured sets of information integrating environmental data and economic statistics, and specifically for the accounting component of ecosystems, the methodology provides its development under a spatially explicit approach. Therefore, the Environmental-Economic Accounts are built in Geographic Information Systems - GIS, where several layers of information can be integrated, thus allowing analyses in several environmental profiles, such as biomes or hydrographic basins.

Data production for environmental-economic accounting is coherently aligned with an institution such as IBGE, which includes a staff of skilled specialists who work in the understanding of the Environmental-Economic Accounts, both in physical and monetary terms. Therefore, the line of products related to these Accounts is not only appropriate to the institutional mission of IBGE, but it provides an integrating perspective for the entity's research, while also certifying its operation in the sense of systematizing the production of its technical information.

In order to reflect upon the importance of the methodological perspective of Ecosystem Accounting, it is important to emphasize that, according to the System of National Accounts (SNA), not all environmental resources are considered as economic assets; only those that are owned and provide economic benefits are recorded in the national balance sheet (UNITED NATIONS *et al.*, 2009). Thus, part of the benefits generated by nature, which are called ecosystem services, are not captured by the SNA since they do not constitute an economic production process. This is the case, for instance, in climate regulation provided by forest areas.

Therefore, the term ecosystem services[1] is used to encompass all flows through which human beings can benefit from nature, such as provisioning, extraction of materials from the ecosystems, regulating – fundamental elements to their maintenance –, and cultural benefits related to well-being. This scope is present in the methodology proposed in the *System of Environmental-Economic Accounting 2012: Experimental Ecosystem Accounting*, SEEA-EEA (UNITED NATIONS, 2014b), a satellite system of the System of National Accounts.

Ecosystem accounting is a coherent and integrated approach for measuring ecosystem assets and identifying their service flows for economic and other human activities (UNITED NATIONS, 2015). This accounting complements the accounting of environmental assets, as described in the SEEA Central Framework (*System of Environmental-Economic Accounting 2012: Central Framework* - UNITED NATIONS, 2014a), where the environmental assets are accounted for as individual resources, such as water and wood, for instance. In addition, in a complementary approach, the SEEA-EEA manual incorporates regulating and cultural aspects, while the SEEA Central Framework includes non-renewable resources, such as petrol and gas.

This discussion becomes very relevant when one evaluates that the calculation of the Gross Domestic Product (GDP) for the countries is currently sustained by the SNA, and that there are several goods and services provided by the ecosystem assets that are not computed therein. The natural capital present in the national territories is not part of this accounting structure since it is outside the scope of the SNA; therefore, its expansion would broaden the production, consumption, and income measures, as well as the actual value associated with the assets and the appropriate measurement of their depletion.

The incorporation of ecosystems in standardized accounting structures may help integrate nature into the decision-making process, thus promoting more efficient and sustainable choices in terms of resources. Through the measurement of natural capital

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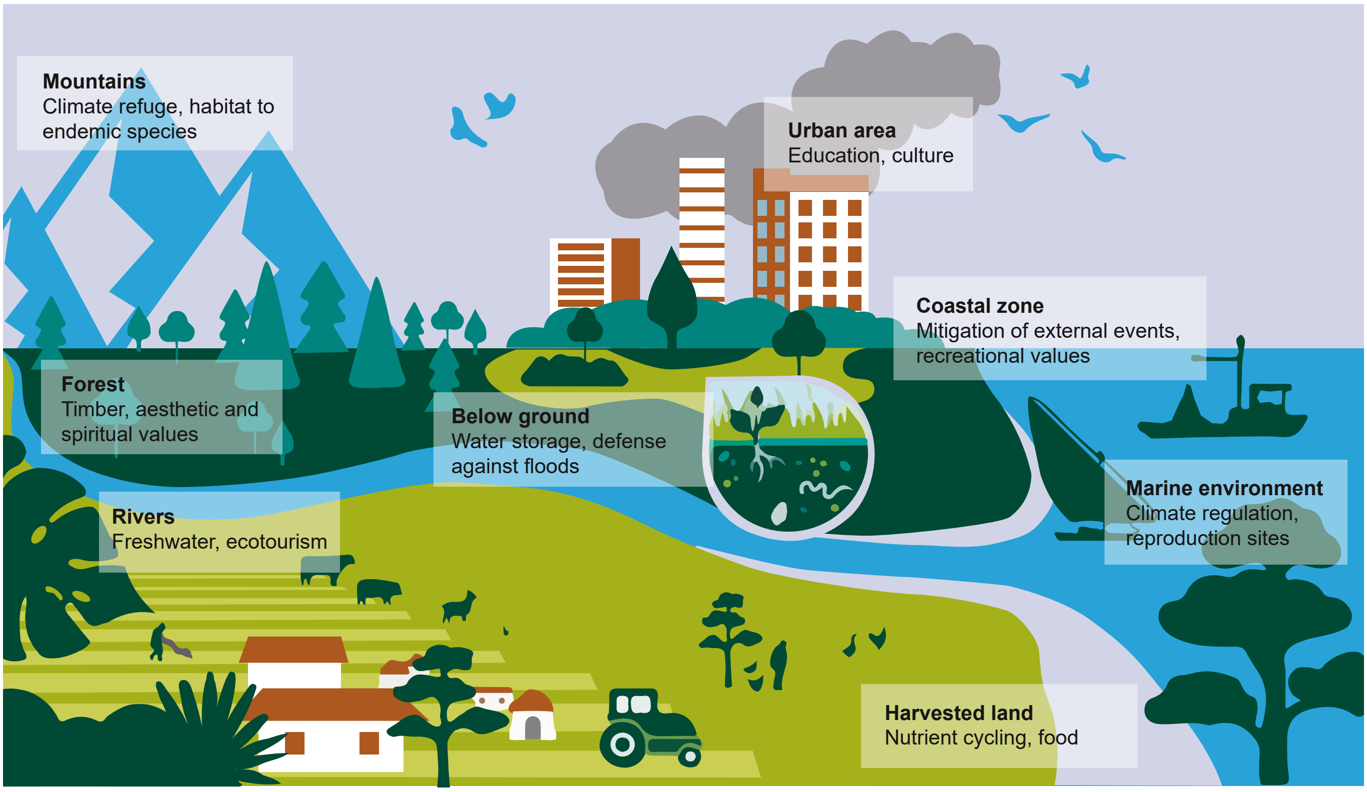
[1] For the IBGE publication series within the framework of the SEEA-EEA manual (*System of Environmental-Economic Accounting 2012: Experimental Ecosystem Accounting Manual* – UNITED NATIONS, 2014), the expression "*ecossistemas*" was adopted as a Portuguese translation of "ecosystem", which is commonly referred to in Brazilian literature as "*ecossistêmicos*". Although they have the same essence, this highlight is given due to the services provided by ecosystems for human benefits, according to the concept consolidated internationally by the Millennium Ecosystem Assessment - MEA initiative. Such an assessment is largely responsible for the insertion of this approach in the political agendas of nations and the basis of studies that measure, assess and value the various aspects related to society's dependence on the ecological processes of nature (ODUM; ODUM, 2000; COSTANZA *et al.*, 2017).

stocks and conditions on a variety of scales and the integration of the use value or of non-use of the ecosystem services in the accounting systems, it is possible to develop indicators that provide relevant information related to the environment, together with the GDP, as noted in the report from the European Union (NATURAL..., 2019).

The Ecosystem Accounts can be developed in physical or monetary terms, thus intending to explain, including from a spatial perspective, the broad range of services provided by the ecosystems and demonstrate, in monetary terms, the benefits of investing in nature and in the sustainable management of resources.They also allow the development of macro-indicators for evaluating the economic importance and value of the ecosystems, through a comprehensive view of the stocks of their assets and the flows of their services.

As previously stated, the ecosystem services offer a range of benefits: the provisioning services include the supply of food and production of timber, for instance; the regulating services include the filtering of air and water, pollination, climate regulation, and protection against natural disasters such as floods, for instance; and the cultural services include recreation and leisure, education, aesthetic and spiritual benefits, among other aspects (Figure 1). Most ecosystem services are decreasing, including those that regulate and maintain our life support systems, and many of these services and the ecosystems providing them are not replaceable (DASGUPSTA, 2020).

Figure 1 - Diversity of ecosystem services



Source: DASGUPTA, P. *The Dasgupta review:* independent review on the economics of biodiversity: interim report. London: HMTreasury, 2020. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/882222/The_Economics_of_Biodiversity_The_Dasgupta_Review_Interim_Report.pdf. Accessed: August 2020. Adapted.

The depletion and degradation of these reserves can irreversibly reduce the availability of their benefits for future generations, and many ecosystems can become so degraded that future generations may not be able to profit from them, as pointed out in the European Union report (NATURAL..., 2019). Due to the importance, or value, of nature and the vast number of services it offers, there is a growing political demand to find ways of clarifying the cycle established between the natural resources and their benefits in a clear and systematic manner, so that they can be added to the set of decisions that affect the well-being today, as well as our common future.

In order to monitor this matter, Ecosystem Accounting proposes the description of the environment in terms of sets of ecosystem assets, in a statistically consistent unit, for the gathering of geospatial information on ecosystems. Therefore, the biophysical and economic data related to the extent and the condition of the ecosystems are systematically integrated so that they can be aggregated and disaggregated on the necessary scale, including at a national level, in order to complement the economic performance figures (NATURAL..., 2019).

The *Technical recommendations in support of the system of environmental-economic accounting 2012: experimental ecosystem accounting* (UNITED NATIONS, 2019b) manual presents the approach on which this publication is based. In addition, it also monitors the process of formal review of the SEEA-EEA manual, scheduled to be completed in 2021, which establishes the first international statistical standard for ecosystem accounting. With all this, in order to evaluate the natural extent of the Brazilian ecosystems, the spatial profile of the terrestrial biomes was adopted, which were evaluated regarding their original remaining cover today, as well as the several conversions in land use that take place in each of them.

Thus, the purpose of the Extent Accounts is to present the variation of the different ecosystem types in a given geographical area, as well as its change during a given accounting period. Therefore, this publication presents the first issue of the Ecosystem Accounts in Brazil through the analysis of the extent of the natural ecosystem areas in the National Territory, as well as an approximation of their state of preservation from the changes in their extent from 2000 to 2018. In order to do so, it adopted the official environmental profile compatible with the ecological concept addressed in the spatial units provided in the Experimental Ecosystem Accounting methodology (UNITED NATIONS, 2014b): the Brazilian terrestrial biomes defined in the IBGE methodological report (BIOMAS...,2019).

Therefore, this publication portrays the spatial arrangement of the natural and anthropized areas in the National Territory, using the spatial unit of analysis of the biome and the information from the Monitoring of Land Cover and Land Use in Brazil, developed by IBGE (MONITORAMENTO..., 2020). This accomplishment also provides an understanding of the main use conversions in the Brazilian ecosystems from 2000 to 2018, according to the Monitoring's historical series, and shows the environmental territorial dynamic of the Country over the past two decades. In addition, an analysis of the intensity of the most recent changes in land cover and land use verified in the Brazilian geographic space between two reference years was developed - in this evaluation, the years 2016 and 2018 - to show the areas in the Country where the main and current conversion processes took place.

This study is inserted in the context of the Natural Capital Accounting and Valuation of Ecosystem Services - NCAVES project launched in 2017 by the United Nations Statistics Division (UNSD) and by the United Nations Environment Programme (UNEP) with funding from the European Union[2]. NCAVES has the objective of supporting the review of the SEEA-EEA manual, encouraging the development of environmental accounting and ecosystems in five countries, including Brazil, through support and training of the national institutions.

[2] The content of the Ecosystem Accounts does not necessarily reflect the opinions of the European Union.

Technical notes

Domestic and foreign policy developments

The General Assembly of the United Nations proclaimed the UN Decade of Ecosystem Restoration 2021-2030 through Resolution 73/284, dated 03/01/2019, emphasizing the importance of the regeneration of the environment for the provision of ecosystem services, such as the provision of water and those services arising from biodiversity, such as pollination (NATURAL..., 2019). Its implementation is led by international agencies such as the United Nations Environment Programme (UNEP) and the Food and Agriculture Organization of the United Nations (FAO), which estimate that the restoration of 350 million hectares of degraded land may generate USD 9 trillion in services (UNITED NATIONS, 2019).

The proclamation of the Decade is a global appeal in a world where several terrestrial, aquatic, and marine landscapes have a high potential for restoration of their ecological functionalities, and gathers political support and scientific research from initiatives and organizations scattered throughout the world, through the Convention on Biological Diversity (*Convenção sobre Diversidade Biológica* - CBD)[3]. The environmental degradation with accelerated processes of soil erosion, for example, may lead to the depletion of the resource and a consequent decline in productivity; in this scenario, the degradation of land would encourage the abandoning of areas and the pressure on new farming frontiers.

3 The Convention on Biological Diversity - CBD is a treaty by the United Nations, and one of the most important international tools related to the environment. It was established in the United Nations Conference on Environment and Development, which was known as ECO-92, held in Rio de Janeiro in June 1992, and ratified through Decree No. 2519, dated 03/16/1998, and it currently the main global forum for matters related to biodiversity.

Therefore, this current articulation is a significant contribution to the scope of the Sustainable Development Goals - SDGs, with emphasis on food safety, water and biodiversity preservation, through articulated actions to recover the capacity of the ecosystems in meeting human needs. In this sense, there is a perspective of reinforcing the global/regional commitments in actions targeted not only in the prevention or reversion of ecosystem degradation, but also in the improvement and application of ecological restoration in decision-making processes (UNITED NATIONS, 2020).

The UN Decade of Ecosystem Restoration 2021-2030 also provides support to the Bonn Challenge [4], the largest initiative in restoration of forest landscapes in the world, which fosters the implementation of public policies for the industry with the objective of restoring 50 million hectares by 2020 and 350 million hectares by 2030, throughout the world (BRAZIL, 2018d). In 2016, Brazil announced its commitment to contributing with 12 million hectares of forest areas by 2030, an action that is being implemented through the National Policy on the Recovery of Native Vegetation (Política Nacional de Recuperação da Vegetação Nativa – Proveg), instituted by Decree No. 8972, dated 01/23/2017 (BRAZIL, 2017a).

Proveg's main instrument is the National Plan for the Recovery of Native Vegetation (Plano Nacional de Recuperação da Vegetação Nativa – Planaveg), which was broadly disseminated during the 23rd session of the Conference of the Parties to the UN Framework Convention on Climate Change[5], known as COP23, after its official publication in Brazil (BRAZIL, 2017c). Planaveg was coordinated by the Ministry of the Environment and has the objective of expanding and strengthening the public policies, financial incentives, and good farming practices for the recovery, mainly in Permanent Preservation Areas (APP) and Legal Reservation Areas (RL), but also in low-productivity degraded areas (BRAZIL, 2017b).

In this context, another important point to mention is the implementation of Enredd+, known as the National Strategy for Redd+[6], created with the purpose of formalizing the Brazilian effort in the sense of prevention and control of deforestation, as well as fostering the sustainable management of forests (BRAZIL, 2016a). It is an instrument to integrate several public policies related to the protection of native vegetation and biodiversity, and to foster a low carbon (CO^2) forest economy.

The potential for mitigation of emissions through the increase of forest carbon stock in Brazil, assuming the deforestation and forest degradation are partially offset by removing CO^2 depends essentially on the current standard of change in land use. According to data from the National Inventory of Greenhouse Gases, disclosed in 2020 by the Ministry of Science, Technology, Innovations and Communications[7], this is the main source of emissions in Brazil. Therefore, national mitigation actions are

[4] Bonn's Challenge was launched in 2011 by the German Government and the International Union for Conservation of Nature (IUCN) and subsequently endorsed and extended by the New York Declaration on Forests, formulated in the United Nations Climate Summit, held in New York in 2014. Subjacent to Bonn's Challenge there is the approach for the restoration of forest landscape, which focuses on ecological integrity while improving human well-being through multifunctional landscapes. For further information on the topic, please visit: https://www.bonnchallenge.org/.

[5] The 23rd United Nations Climate Change Conference 2017, known as COP23, was held in Bonn, in 2017.

[6] REDD+ is an economic instrument developed within the scope of the United Nations Framework Convention on Climate Change (UNFCCC) to provide financial and technological incentives to developing countries for increasing the forest coverage (BRAZIL, 2014c). The adoption of Warshah Framework for REDD+ in 2013 made Brazil eligible to receive payment for the results of the reduction in greenhouse gas emissions in the forest sector, particularly from the Green Climate Fund (GCF) through the Amazon Fund (BRAZIL, 2016b).

[7] The Ministry was recreated on June 12, 2020, and currently includes the Sciences, Technology, and Innovation secretariats.

essential (BRAZIL, 2020). According to this inventory, Brazil decreased its net emission rates from 1990 to 2015. However, in 2016, it presented a 27.1% increase, mainly due to increased deforestation in the Amazônia Biome.

The Brazilian territory has a wide variety of landscapes, expressed in the biome profile, which reflects the carbon from vegetation biomass and soil. In an analysis of the Inventory historical series, the Amazônia and Cerrado biomes present the greatest contributions in relation to the emissions. Despite the decrease expressly observed from 2004 to 2015, these figures currently present a fluctuation on a yearly basis. Regarding REDD+ actions, Brazil has the commitment of accomplishing, in 2020, a reduction of 80% in the deforestation rate in the Amazônia Biome in relation to the average from 1996 to 2005, and of 40% in the Cerrado Biome, in relation to the average from 1999 to 2008; for the other biomes, it seeks to stabilize the emissions at the 2005 levels (BRAZIL, 2018a).

Another strategic action is Brazil's sovereign commitment towards the protection of native vegetation for the well-being of current and future generations, reiterated in Law No. 12651, dated 05/25/2012, referred to as the Forestry Code (Código Florestal). This law establishes the areas that must be preserved and which are authorized to receive the different types of rural production, upon restrictions on land use in areas of native vegetation in the interior of private properties: Permanent Preservation Areas (Áreas de Preservação Permanente - APP) and Legal Reserve Areas (Reserva Legal - RL), as defined by law, must be preserved by the owners of rural properties (BRAZIL, 2012).

It is also important to highlight another important instrument of the environmental public policy in Brazil, Decree No. 5092, dated 05/21/2004, which establishes rules for the identification of Priority Areas for Preservation, Sustainable Use and Sharing of the Benefits of Biodiversity, within the scope of the duties of the Ministry of Environment, focusing on the planning and implementation of measures aimed at the recovery and sustainable use of ecosystems for decision making. Its rules for identification include the terrestrial biomes and the coastal-marine system (BRAZIL, 2004).

These areas are considered for the purposes of instituting conservation units within the scope of the National System of Nature Preservation Units (Sistema Nacional de Unidades de Conservação da Natureza – SNUC), for the recovery of degraded areas, survey of endangered species and also for sharing benefits derived from access to genetic resources and associated traditional knowledge. The instrument includes the identification and measures to be locally implemented, providing geospatial information on the action priorities in each area, according to Conabio Deliberation No. 40, dated 02/07/2006 (COMISSÃO NACIONAL DE BIODIVERSIDADE, 2006).

The identification process of the areas considered a priority is periodically updated, by biome, based on the methodology for the Systematic Conservation Planning (*Planejamento Sistemático da Conservação* - PSC), by Margules & Pressey (2000), and is compliant with the CBD. That Convention, as stated, was ratified by Brazil through Decree No. 2519, dated 03/16/1998 (BRAZIL, 1998), is still in force and works as a legal and political framework for several other thematic programs and transversal initiatives, such as the United Nations' Ncaves project.

The Strategic Plan for Biodiversity 2011-2020, resulting from the 10th Conference of the Parties to the UN Framework Convention on Biological Diversity[8], features an important milestone, with the establishment of the 20 Aichi Biodiversity Targets[9], and whose implementation proposal also includes an interface with the 2030 Agenda and the SDGs. The member states of the CBD were invited to define their own targets, considering their priorities and capacities, and Brazil established them in Conabio Resolution No. 06, dated 09/03/2013 (COMISSÃO NACIONAL DE BIODIVERSIDADE, 2013), with the purpose of reducing pressures and losses on species and ecosystems, as well as human well-being.

The 2020 Global Environmental Agenda presents an important transition year, which marks the consolidation of the Ecosystem Environmental-Economic Accounting, including the way they meet the growing political demands of the post-2020 CBD framework, also including a renewed discussion on the Aichi Biodiversity Targets. It will discuss strategies for the long-term development of the integration of biological diversity, and efforts gathered through the United Nations Statistical Commission (UNSC) for the global recognition of the UN Decade of Ecosystem Restoration 2021-2030 (UNITED NATIONS, 2020).

This entire reflection on the international perspective, and especially on the key national actions and priorities, is essential for the establishment of the Ecosystem Accounts in Brazil. The choice of the spatial units, the attributes to be evaluated, and the indicators proposed for evaluating the health of the ecosystems, are essential for the applicability of the public policies. Therefore, it is important to clarify that this publication presents the first issue of the Ecosystem Extent Accounts of Brazil, from the existing data relevant for environmental analysis and planning, and that the methodology of the SEEA-EEA manual is flexible for adopting other geographic profiles or scales, and even other topics, according to the availability of information and the Country's priority agenda.

Experimental Ecosystem Accounts: the methodology of SEEA-EEA manual

The concept of natural capital is not new, and represents the natural base the economy depends on - both from the input side (natural resources) and the product side (goods), also considering the impacts and changes caused on its stock, resulting from the use and disposal of waste (wastewater, pollutants, among others) by the economic agents. Therefore, natural capital includes the resources found in nature, such as minerals, petrol, the stocks of fish and of wood in the forests, water, farm land, etc., but also includes the ecosystem service that are produced by ecosystems and are invisible for most people, such as the purification of air and water, protection against flooding and/or erosion, sequestration and storage of carbon, habitat provided to the species, among others.

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[8] The Tenth Meeting of the Conference of the Parties to the Convention on Biological Diversity, known as COP10, was held in Nagoya in 2010.

[9] The Aichi Biodiversity Targets are propositions established within the Strategic Plan for Biodiversity. Gathered under five strategic objectives, the 20 Aichi Biodiversity Targets are related to the preservation of biodiversity and constitute the base for the current planning related to the implementation of the Convention on Biological Diversity - CBD. For further information on the topic, please visit: https://www.cbd.int/sp/targets/. Also visit: https://www.mma.gov.br/images/arquivo/80049/Conabio/Documentos/Resolucao_06_03set2013.pdf.

A major step towards natural capital accounting was taken with the adoption of the System of Environmental Economic Accounting (SEEA) Central Framework by the United Nations Statistical Commission (UNSC) in 2012 This system provides an internationally agreed method, compatible with the System of National Accounts (SNA) currently in force, to account for renewable and non-renewable natural resources, such as minerals, timber, water, among others, in a physical manner. Since most of these resources are tradeable in instituted markets, their pricing was included based on well-known methodologies in the environmental economy. After its adoption, the countries represented in the UNSC pointed to the importance of also accounting for ecosystems and the services they provide to economic activities and human needs. Such accounting is a way to evaluate the environment from the spatial delimitation of the ecosystems, considered geographically limited natural assets, and the evaluation of the flows of ecologic functions they provide, commonly known as ecosystem services, for human life, including economic activities.

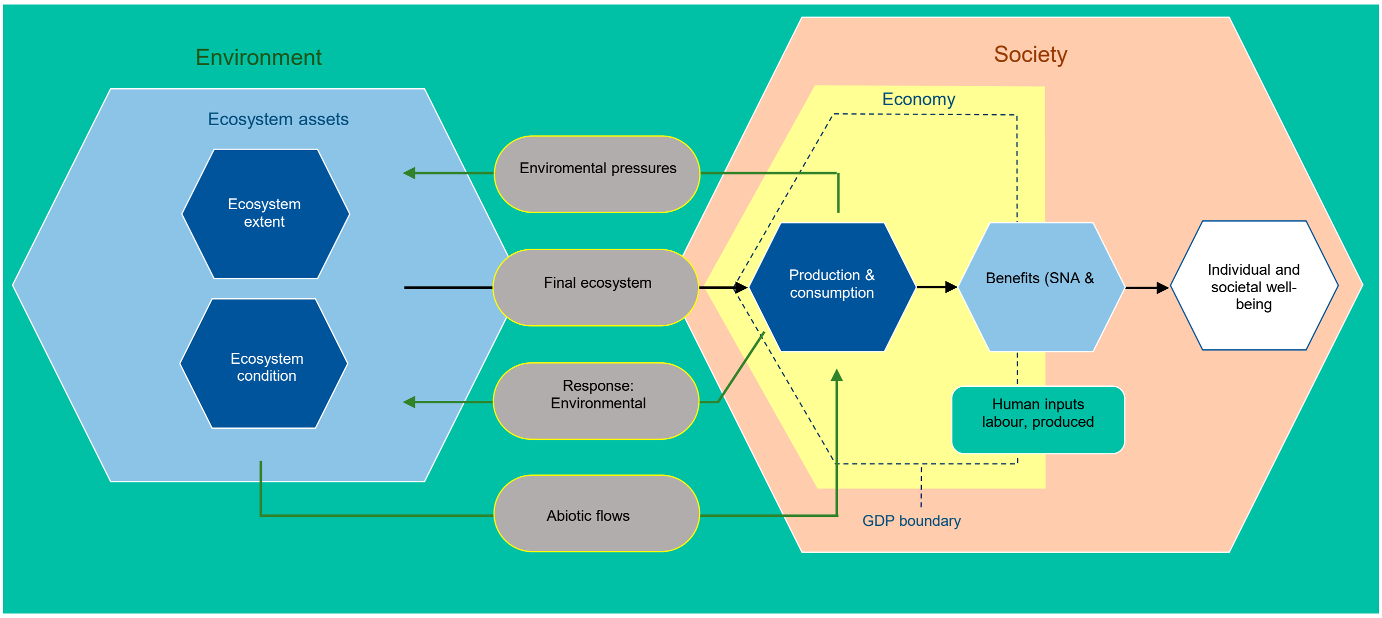
The first step to consider such natural assets and ecologic services or functions provided to human activities within environmental economic accounting is to define their spatial and functional dimensions, the latter based on the measurement and evaluation of their service flows. The measurement and evaluation of these two components – spatial and functional – and the identification of the inter-relation of these components with human activities, particularly with the economy, allows the ecosystems to be integrated into an accounting structure that has the statistical standard already implemented in the SNA in force as a starting point.

However, most of the services originating from ecosystems, known as ecosystem services, are neither measured nor traded in markets. Therefore, their insertion in the SNA requires research and international debate among experts regarding the methodology to be used in each case, due to the complexity and diversity of ecosystems in the world. Thus, this new methodology is in the experimental phase, being tested in several countries, with countries piloting different accounts and services depending on their own priorities and circumstances. The framework is recognized as SEEA-EEA (System of Environmental-Economic Accounting - Experimental Ecosystem Accounting).

The great benefit of performing such accounting is to demonstrate, in a clear manner, the inter-relation between the economy and the environment, treating both of them as the integrated system they actually are, where the decisions of economic agents are reflected on the environment and vice versa, in an unmistakable manner. The use of an accounting framework allows the identified ecosystems and the evaluated service flows to be viewed both in relation to each other and also in relation to a series of other environmental, economic, and social information.

Ecosystem accounting thus treats these natural areas as physical assets (stocks), and the range of ecosystem services (flows) they provide as an integral part of the natural processes in their spatial area. These steps are identified in the Ecosystem Environmental-Economic Accounts as Extent Accounts (spatial dimension) and Condition Accounts (functional dimension) (Figure 2). The availability of continuous data in temporal series on the extent and condition of the ecosystems that sustain the economy is of great worth to guide the planning and implementation of public policies.

Figure 2 - General Structure of Ecosystem Accounting



Source: UNITED NATIONS. Statistics Division. *Technical recommendations in support of the system of environmental-economic accounting 2012*: experimental ecosystem accounting. New York, 2019c. p. 20. (Studies in methods. Series M, n. 97). Available at: https://seea.un.org/sites/seea.un.org/files/documents/EEA/seriesm_97e.pdf. Accessed: August 2020. Adapted.

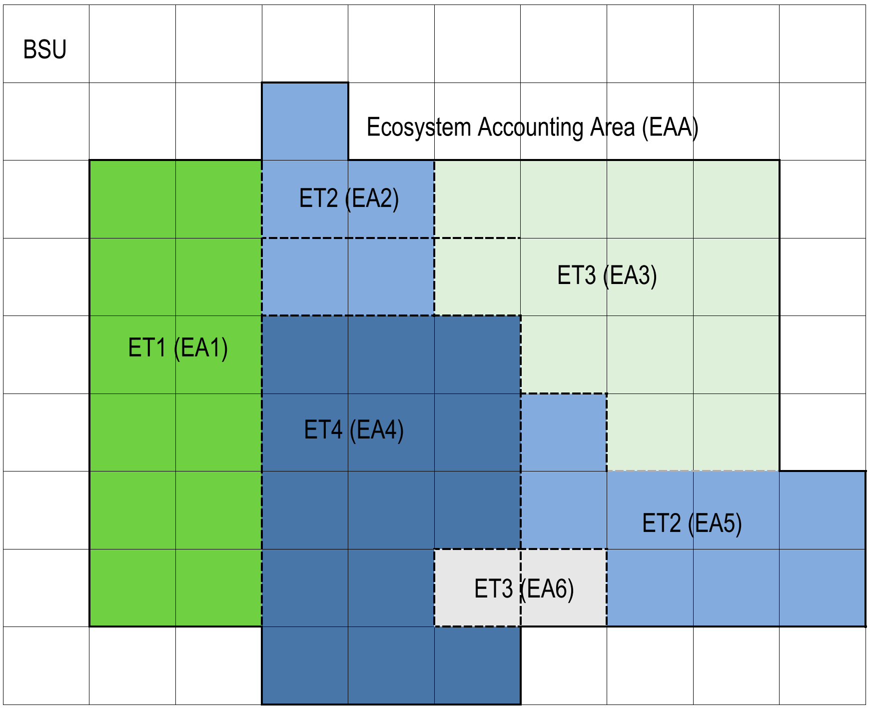
Extent Accounts

The first step in defining the Ecosystem Accounts is to provide a spatial delimitation of the threshold of the area to be accounted for, the Ecosystem Accounting Area - EAA (*Área de Contabilidade do Ecossistema* - ACE). This area can encompass the total size of a country,but can also be a geopolitical or administrative delimitation (regions or states) or environmental profiles (hydrographic basins or Preservation Units, for instance), according to their specific purposes, considering the scale of the analysis, the data available, and the national public policies.

After the choice of the Ecosystem Accounting Area, an information organization stage is required to establish which Ecosystem Types - ET (Tipos de Ecossistemas - TE) will be addressed, which will provide the basis for the subsequent measurement of the condition of the ecosystem and its services. In other words, within the accounting area considered, there may be several ecosystem types that need to be spatially identified so that the changes or conversions in their natural extents can be identified, differentiating them according to their inclusion in the marine, terrestrial and aquatic environments.

Finally, for accounting purposes, it is necessary to delimitate the Ecosystem Assets - EA (Ativos do Ecossistema - AE), considered as statistical units of reference for the ecosystem accounting, which is based on the mapping of mutually exclusive thresholds. Thus, the Extent Accounts record the changes in composition within an Ecosystem Accounting Area with information on the different types of Ecosystem Assets, usually grouped to show a summary for the different Ecosystem Types analyzed (Figure 3).

Figure 3 - Relationship between the spatial areas in ecosystem accounting



Source: UNITED NATIONS. Statistics Division. *SEEA experimental ecosystem accounting*: technical recommendations: consultation draft. New York, 2015. Prepared under the auspices of the United Nations, United Nations Environment Programme - UNEP, Convention on Biological Diversity - CBD and the Norwegian Ministry of Foreign Affairs. Available at: https://unstats.un.org/unsd/envaccounting/ceea/meetings/eleventh_meeting/BK-11-3b-2.pdf. Accessed: August 2020. Adapted.

Although the total ecosystem accounting area remains stable, the determination of the assets and types of ecosystems will undergo changes over time due to natural changes and land use. Thus, the Extent Accounts provide a common base to guide the discussions on the drivers of change in the ecosystems and their causal relations. The spatial information captured in an Extent Account provides the basis for understanding where the different ecosystem types are located in a given ecosystem accounting area, and how they are changing over time (for instance, in terms of fragmentation of the landscape or changes compared to a historical baseline). In other words, the Extent Accounts provide a subjacent infrastructure for measuring the condition of the ecosystem and for modeling many of its services, turning it into a base for the implementation of deforestation indicators, conversion to cropland, desertification, fragmentation, among other change processes that are dynamic, complex, and often non-linear in the ecosystems, such as the case of biodiversity. Therefore, the Extent Accounts also assist in measuring diversity in the ecosystems, in deriving indicators and in identifying change processes in biodiversity.

The Extent Accounts are structured as accounting entries that include opening and closing spatial extents in the different ecosystem types, additions and reductions in stock, and re-evaluations, usually on a yearly basis. Such information is important, even if it is not possible to account for all the different types of additions and reductions, since they identify the general trends of the ecosystem types. Whenever possible, it is recommended to distinguish the additions and reductions in the stock into natural or managed, emphasizing that the natural expansions or reductions could have been indirectly caused by humans, such as desertification resulting from deforestation, or the loss of coral reefs due to climate change.

Re-evaluations can result in either additions or reductions, and are caused by the updating of information on the area of the different ecosystem types. The changes in the ecosystem types are referred to as ecosystem conversion, and are of particular interest to understanding the trends in the conditions of the ecosystems, biodiversity, and ecosystem service flows. The identification of these conversions depends on the clear determination of when the record of the opening extent took place, length of the accounting period, and the identification of the differences between the ecosystem types. The compilation of a matrix related to the change of ecosystem types aids this visualization, and the dates for the opening and closing extents can be recent or historical.

Condition Accounts

The value of Ecosystem Assets depends on their biophysical existence, and, therefore, cannot be inserted in the establishment of flows of benefit or property rights, as required for the SNA economic assets. However, for the integration of the ecosystem data in the SNA, economic and institutional property of such assets must be established, and their benefits must be discerned.

Over time, the condition of each Ecosystem Asset undergoes changes, as previously mentioned in the Extent Account topic, whether due to natural processes or human action. Thus, the Condition Accounts are structured to record the condition of the ecosystem at pre-established time intervals in a qualitative and quantitative manner, and the changes in condition that occurred. This record of changes in condition is one of the essential objectives of ecosystem accounting.

The condition of an ecosystem is its quality, measured in terms of its biotic and abiotic characteristics. The quality is measured in terms of its structure, composition, and functions, and these concepts allow the measurement of its integrity and its capacity to provide ecosystem services. Then, the Condition Accounts offer information on the characteristics and the quality of the Ecosystem Assets and their change processes in given periods of time.

The Condition Accounts must supplement the existing environmental monitoring systems and programs in the country and add to them, integrating the ecologic data in order to ease its use by several sectors. By providing comprehensive and comparable measurements between different ecosystem conditions, these Accounts are of pivotal importance in supporting several public policies on preservation and sustainable management, frequently focused on the protection, maintenance, and restoration of the ecosystem conditions.

Database and methods for extent of ecosystems in Brazil

The spatial profile of the biomes as an analysis unit

The *Map of biomes and coastal-marine system in Brazil: compatible with a 1:250 000 scale*, developed by IBGE (MAPA..., 2019), is a document containing a physical-biotic representation of the country. It was based on the *Map of Brazilian biomes: first approach*, also by IBGE (MAPA…, 2004), and its key contribution resides in the sustainable management of natural resources. The biome has always been associated to the concept of preservation, and its visualization has been sought by the aggregation of ecosystems by proximity and regionalization. At IBGE, its representation follows very specific criteria, starting from the definition of biome:

> set of life (vegetable and animal) constituted by the grouping of types of contiguous vegetation, identifiable in regional scale, with similar geoclimatic conditions and shared history of changes, resulting in a particular biological diversity (MAPA..., 2004).

The *Map of biomes and coastal-marine system in Brazil: compatible with the 1:250 000 scale* is, therefore, guided by the *Map of vegetation in Brazil: 1:250 000 scale* (IBGE, 2018), criterion duly justified since this mapping corresponds to the land cover resulting from the interaction of the environmental components (rocks, landform, soil, and climate). The Map of Biomes was developed in stages, and the following considerations are relevant: each biome includes large continuous areas, observing their mapping conditions; the vegetation disjunctions are incorporated to the dominant biome; and the areas of vegetational contact are attached to one of the neighboring biomes, using the dominant vegetation typology in each of them as criterion.

In the areas of natural vegetation (not anthropized), it was rather elementary to perform this grouping. However, in the anthropized areas in the territory, two main issues were presented: one, simpler, when the past vegetation was not in contact; and the other, more complex, where these contacts were further investigated, using the mapping of the other natural resources (IBGE, 2018), in addition to literature reviews. In case of doubt in the attribution of those areas, they were further investigated in field work.

The grouping of forest areas generated two large continuous areas:

- In the Northern Region, covered mainly by Dense, Open, Seasonal Evergreen Ombrophilous Forests, originated the Amazônia Biome; and
- Along the coast, the forests established by humidity conditions, Dense and Open Ombrophilous Forests, continued by Semi-deciduous and Deciduous Seasonal Forests, entering the continent and the south of the Country, and the Mixed Ombrophilous Forest, also referred to as Araucária Forest, define the Mata Atlântica Biome.

The grouping of savannah, shrubland and grassland physiognomies presented three different areas:

- In the central region of the country, the Cerrado Biome, with predominance of Savannah;

- In the Brazilian Northeast, the Caatinga Biome was formed by the predominance of the steppe-like savannah; and
- In the south of the Country, the Pampa Biome was predominantly delimited by Steppe, both with natural and anthropized physiognomies.

In the southeastern part of the Cerrado Biome, the Pantanal, an exception biome, was delimitated by its particular hydrologic system, where the physical environment - mainly landform and soil - grants specific characteristics, with periods of flooding, but with vegetation typologies similar to its surroundings. The continuity criterion led the biomes to present types of vegetation[10] internally other than those that were characteristic or dominant, since areas indicating a given biome, when occurring inside another one, are incorporated to the biome in which they are inserted.

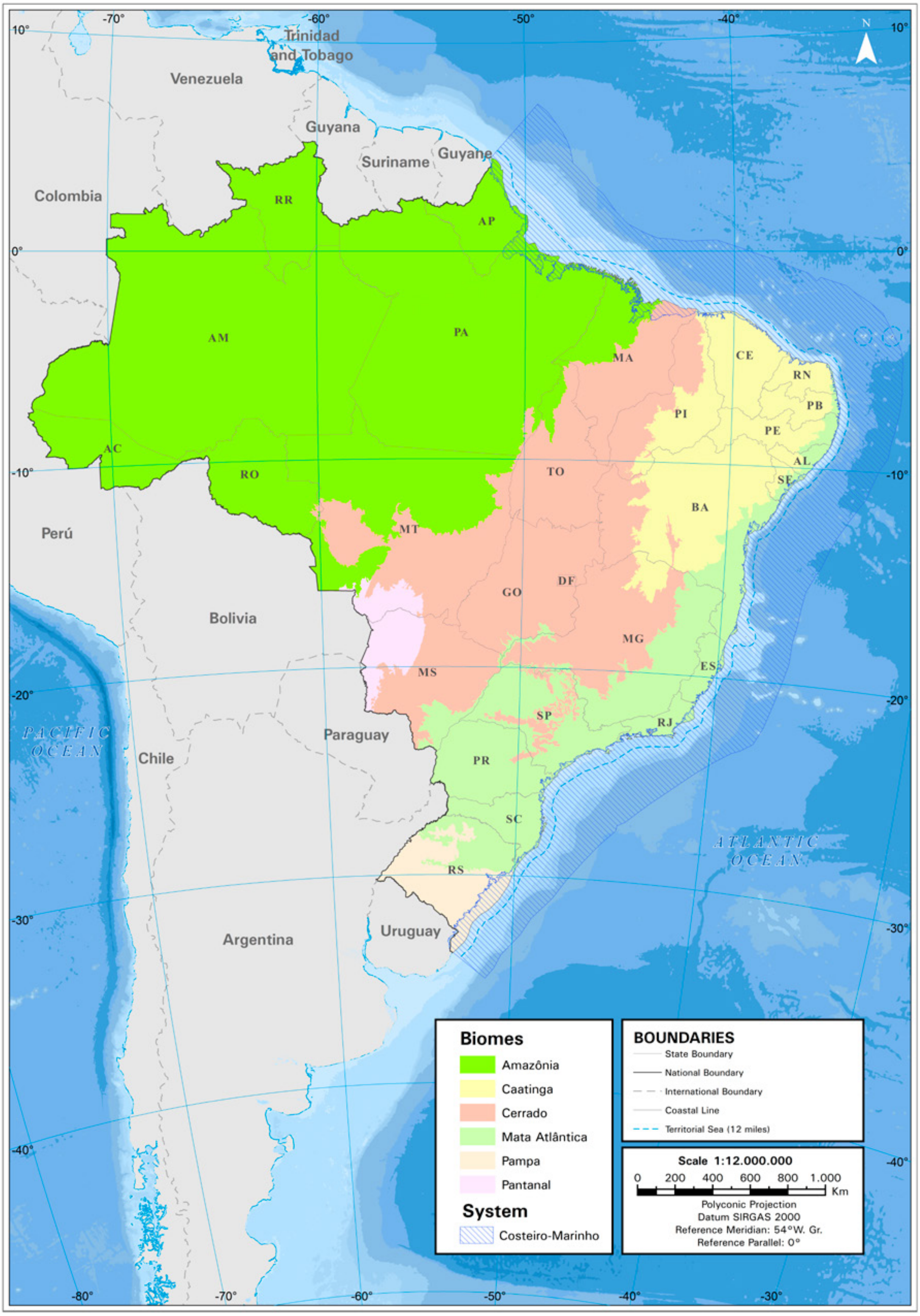
In summary, these six groups of vegetation types with similar physiognomy generated, in general lines, the Brazilian biomes (Map 1), which received denominations linked to the Brazilian phytogeography, but considering the most current and popular terms, namely: Amazônia (Amazon), Mata Atlântica (Atlantic Forest), Caatinga, Cerrado, Pantanal and Pampa. The Coastal-Marine System was established due to the fragility of the coastal environments, its particular dynamic, and its enormous influence on the associated biodiversity, also strongly affected by anthropogenic activities.

The Coastal-Marine System was then delimited in its continental portion, from the areas with marine and river influences of the mapping of natural resources (IBGE, 2018), based on the weighted analysis of the Vegetation, Geology, and Geomorphology topics, supported by the mapping of the soils. The maritime portion, in turn, was delimited based on the large marine ecosystems (LARGE..., 2017) of the U.S. Geological Survey (USGS), since, in the absence of more relevant studies, these sections consider the form and depth of the ocean floor; oceanographic parameters, such as temperature, salinity, presence of ocean currents, etc.; the amount of carbon produced per unit of water; and the movement of carbon from the base to the top of the food chain (SHERMAN, 1991).

Due to the entire peculiarity of this System, and according to the methodological recommendations of the Ecosystem Accounts, this profile – or marine environment, as it is referred in the Global Ecosystem Typology from the International Union for Conservation of Nature (IUCN), proposed in the SEEA-EEA manual – must be treated in a different manner; and therefore, in this publication, only the terrestrial biomes were considered for analysis purposes. The detailing of the development of each of the limits of the Map of Biomes can be found in IBGE methodological report (BIOMAS..., 2019) and the spatial representation of the brief descriptions presented herein can be viewed in Map 1.

[10] The formation of Campinarana, since it is a type of oligotrophic vegetation, mainly connected to characteristic soils and with predominant occurrence in the context of the Amazônia Biome, was not individualized as a biome.

Map 1 - Biomes and Coastal-Marine System in Brazil.



Source: MAPA de biomas e sistema costeiro-marinho do Brasil. Rio de Janeiro: IBGE, 2019. 1 map. Scale 1:250 000. Polyconic projection. Available at: https://www.ibge.gov.br/geociencias/informacoes-ambientais/estudos-ambientais/15842-biomas.html?edicao=25799&t=acesso-ao-produto. Accessed: August 2019. Adapted.

Monitoring of land cover and land use

One of the ways of representing and analyzing the occupation process of the territory is to spatialize and account for, in a systematic and periodic manner, the changes occurred in the land cover and land use. This represents an important instrument to support and provide guidance to the planning actions, as well as supporting other studies, such as the evaluation of environmental impacts, territorial ordination, environmental accounts, evaluation of ecosystem services, emission estimation and removal of greenhouse gases, and production of indicators related to the SDGs.

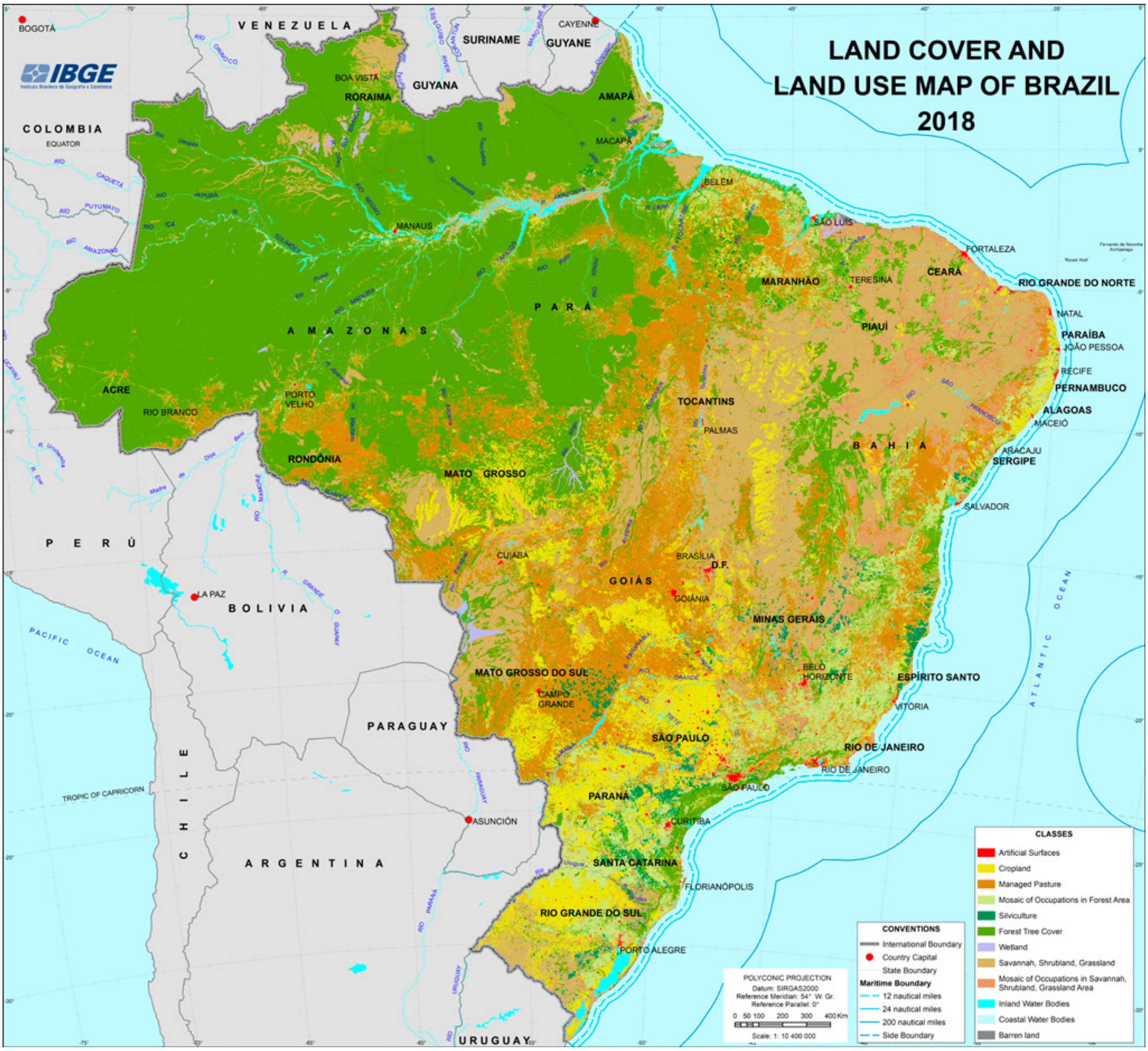
The data regarding land cover and land use in this study originate from the information disclosed by the Monitoring of Land Cover and Land Use in Brazil (*Monitoramento da Cobertura e Uso da Terra do Brasil*), developed by IBGE, for the historical series of 2000 to 2018, with the last report (MONITORAMENTO..., 2020) providing details on its production. Monitoring data covering the period from 2000 to 2018 has been officially published by IBGE since 2015[11].

In a summarized manner, the Monitoring follows these steps: first, OLI/Landsat-8 orbital images available for recovering of the National Territory are acquired and processed; then, each grid cell is associated to one of the pre-defined land cover and land use categories , from the interpretation of images with the aid of complementary inputs, such as the Continuous Cartographic Base (*Base Cartográfica Contínua*) in the 1:250 000 scale, BC250 (BASE..., 2017), and the Map of Vegetation from IBGE (IBGE, 2018).

Currently, in the mapping work, the following land cover and land use categories are used: artificial surfaces (1), cropland (2), managed pasture (3), mosaic of occupations in forest area (4), silviculture (5), forest tree cover (6), wetland (9), savannah, shrubland, grassland (10), mosaic of occupations in savannah, shrubland, and grassland area (11), inland water bodies (12), coastal water bodies (13), and barren land (14). In Map 2, the last product published on the topic is shown for illustration purposes.

[11] For further information on the topic, please visit the Interactive Geographic Platform at: https://www.ibge.gov.br/apps/monitoramento_cobertura_uso_terra/v1/.

Map 2 - Land Cover and Land Use Map Of Brazil



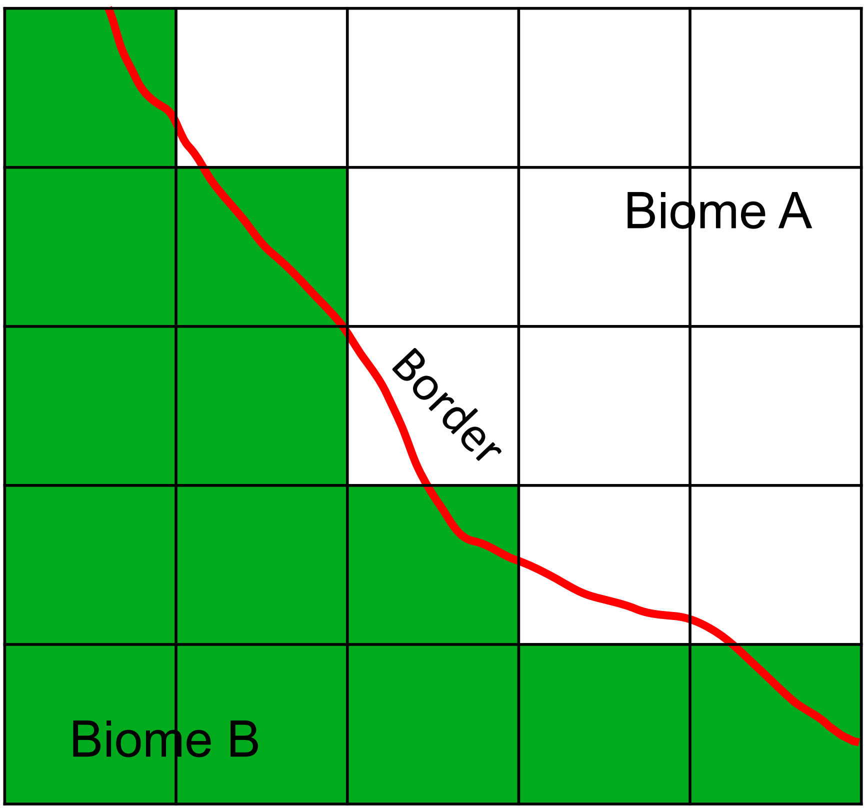
Source: MONITORAMENTO da cobertura e uso da terra. Downloads. Rio de Janeiro: IBGE, 2020. Available at: https://www.ibge.gov.br/geociencias/cartas-e-mapas/informacoes-ambientais/15831-cobertura-e-uso-da-terra-do-brasil.html?=&t=downloads. Accessed: August 2020.

Integration of data in the statistical grid

The availability of data in a statistical grid allows, from a basic spatial unit, not only the integration and the comparison between different types of geoscientific and statistical data, but also the historical monitoring of the spatialization of economic activities and the impact on the natural resources in the Country. In this way, IBGE systematized the Brazilian territory, kilometer by kilometer, for every portion (1 km²) having an address in the regular grid cell (GRADE..., 2016), where it is possible to operationalize several spatial attributes, thus easing the inter-thematic analyses and the full monitoring of the temporal data series.

For the territorial profile of land cover and land use by biome, it was necessary to perform some methodological procedures, in order to incorporate the Brazilian terrestrial biome polygons in the scale of 1:250 000 (IBGE, 2019b) in the statistical grid with 1-km² cells, upon union of polygons. Thus, with the biome united to the grid, it was necessary to have a method for defining the limit, since the biome polygons were not compatible with the grid because one cell could not be divided and should belong to only one biome. Therefore, with the purpose of not significantly changing the area and maintaining the format of biomes in 1-km² cells, the limiting criteria already employed in the Federation Units in the disclosure of the Monitoring was used (MONITORAMENTO..., 2020). That criterion consists in the inclusion of all internal cells of the biome, and also those that, when touching the boundaries, had over 50% of its area inserted in the corresponding biome. In that way, each cell would be assigned to a single biome, as shown in Figure 4.

Figure 4 - Procedure to incorporate the Brazilian biome polygons in the statistical grid



Source: IBGE, Diretoria de Geociências, Coordenação de Recursos Naturais e Estudos Ambientais.

After the incorporation of each biome to the grid, information on land cover and land use was added (MONITORAMENTO..., 2020) through a unique identifier present in each cell. Finally, with each cell containing information on the biome and on land cover and land use, statistics were generated for the biomes for the analyzed years (2000, 2010, 2012, 2014, 2016, 2018), according to the statistical series available from the Monitoring of Land Cover and Land Use in Brazil.

The Change Intensity Indicator

The Change Intensity Indicator (*Indicador de Intensidade de Mudança* - IIM) was proposed by IBGE (AVALIAÇÃO..., 2019) as parameter for evaluating the dynamic of changes in land cover and land use in Brazil. This evaluation mainly focuses on the transformations of the territory in terms of land use and changes in natural land cover. From this analysis, it is possible to point out areas where the changes in land use were more prominent, and that, in many cases, deserve special attention in the territory planning actions and in the management of the National Environmental Policy, established in Law No. 6938, dated 08/31/1981.

It was also verified that this parameter may be an important input for studies on environmental accounting, since it indicates areas where the ecosystem assets were more or less modified. That being said, the following section in this publication presents a preliminary analysis, developed in a punctual manner, for an accounting period selected from the Accounts, the most current one, with the purpose of pondering a new improvement for its application in a more comprehensive way, in the evaluation of the extent and condition of the Brazilian ecosystems.

The IIM was defined from the types of changes incurred among 12 land cover and land use categories considered in the Monitoring performed by IBGE every two years (MONITORAMENTO..., 2020). A numerical coefficient was attributed to each type of change, with a total of 144 possibilities, that is, a value that establishes the degree or intensity of transformation of the land cover or land use that took place during the period. For this analysis within the scope of Ecosystem Accounts, the environmental profile of the terrestrial biomes was taken into consideration as a reference base and spatial evaluation.

Therefore, the first step for calculating the IIM was the identification of the cells that, in the referred Monitoring, presented differences in the land cover and land use categories between the two reference years - in the current evaluation, 2016 and 2018. The differences found were then considered as types of change in the land cover and land use; and, with the identified cells, the possible types of change were organized in a classified matrix, which is an analysis model where, for every type of change, an intensity value ranging from 1 to 3 was assigned.

This scale of values was adopted by IBGE (AVALIAÇÃO..., 2019) in an analogy to the one proposed by Crepani *et al.* (2001), which was developed from the principles of Tricart's Ecodynamics (1977) and its classification in stable-*intergrade*-unstable for landscape analysis. Thus, similarly, the attribution of categories (1, 2, 3) to the types of changes found in the Monitoring aimed at correcting extreme and intermediary conditions. This type of scale has been used in the conversion of categorical data, such as the thematic mapping units, into numerical data in studies that integrate ecological-economic zoning.

Therefore, the scale from 1 to 3 was designed considering a balance between two conditions in different extremities in the land cover and land use categories. In this way, a numerical interval was formed that encompasses two extremities (1 and 3) and one transition (2): natural areas lie at one of the extremities and anthropized areas at the other.

When analyzing the types of changes that occurred throughout the two years of reference, it must be pointed out that the most prominent, or intense, are those whose changes between the initial and final categories of coverage and use shifted from the extremity of natural coverage areas to the extremity of anthropized coverage. The less intense changes, in turn, are those that take place among the natural areas themselves, considering the mapping scale in the Monitoring.There are also the types of change with intermediary intensities, considered more or less intense, according to the participation of one of those extremities in the final land cover and land use category. However, it is important to clarify that these values were used in the sense of establishing a scale of differences, observed between the categories in the initial (2016) and final year (2018). For such purpose, a set of changes ranging in 0.5 intervals was established, with definition criteria summarized as follows:

- A value of 1.0 points to changes in natural areas within themselves. For instance: a category of natural vegetation, forest or savannah, shrubland and grassland that becomes barren land (dunes) or that is transformed into a wetland;
- The value of 1.5 is assigned whenever the change, from any of the categories of anthropogenic use, results in natural areas (forest,savannah, shrubland and grassland vegetation, wetland, or barren land);
- If the change, either from use or natural coverage category, results in a mosaic of occupations in forest or savannah, shrubland and grassland areas, a value of 2 is assigned;
- A value of 2.5 is assigned to changes verified between one and other categories of anthropogenic use (silviculture, cropland, managed pasture, or artificial surfaces); and
- If the initial category is of natural coverage (forest, savannah, shrubland and grassland vegetation, wetland , or barren land), and the final category is one of the other categories of anthropogenic use (silviculture, cropland , managed pasture, or artificial surfaces), a value of 3 is assigned.

Therefore, the full scale of IIM includes the following values: 1.0; 1.5; 2.0; 2.5 and 3.0 – the value 1 corresponds to the changes with lower intensity, and the value of 3 to those with a greater intensity, that is, the ones that are more prominent or intense, as observed in the studied period (Table 1). It is important to emphasize that water bodies were not taken into consideration for this analysis, since the publication is focused exclusively on describing terrestrial environments. As a result of this procedure, it is observed that for every 1-km^2 cell, an intensity value per type of change in the land cover and land use is obtained.

Table 1 - Characterization of the Change Intensity Indicator - IIM, by changes in categories of land cover and land use in Brazil

From \ To	Forest Tree Cover	Savannah, Shrubland, Grassland	Wetland	Barren Land	Mosaic in Forest Area	Mosaic in Savannah, Shrubland, Grassland Area	Silviculture	Cropland	Managed Pasture	Artificial Surfaces
Forest Tree Cover		1	1	1	2	2	3	3	3	3
Savannah, Shrubland, Grassland	1		1	1	2	2	3	3	3	3
Wetland	1	1		1	2	2	3	3	3	3
Barren Land	1	1	1		2	2	3	3	3	3
Mosaic in Forest Area	1,5	1,5	1,5	1,5		2	2,5	2,5	2,5	2,5
Mosaic in Savannah, Shrubland, Grassland Area	1,5	1,5	1,5	1,5	2		2,5	2,5	2,5	2,5
Silviculture	1,5	1,5	1,5	1,5	2	2		2,5	2,5	2,5
Cropland	1,5	1,5	1,5	1,5	2	2	2,5		2,5	2,5
Managed Pasture	1,5	1,5	1,5	1,5	2	2	2,5	2,5		2,5
Artificial Surfaces	1,5	1,5	1,5	1,5	2	2	2,5	2,5	2,5	

Source: AVALIAÇÃO da dinâmica das mudanças de cobertura e uso da terra no Brasil 2014-2016. Rio de Janeiro: IBGE, 2019. (Textos para discussão. Diretoria de Geociências, n. 4). Available at: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101691. Accessed: August 2020. Adapted.

According to IBGE (AVALIAÇÃO..., 2019), these type of evaluations aim at highlighting, through a numerical indicator, the areas where more or less significant transformations take place (or not) in land cover and land use in Brazil between the two reference years or accounting period. It is important to emphasize that the category approach was implemented seeking an expression in numbers for the future composition of an index, to be calculated with other relevant indicators, to measure the conditions of the ecosystems. And finally, it is worth mentioning that this evaluation has no preservationist connotation.

Analysis of results

The results presented herein are based on an international methodology that is currently undergoing review[12] and relies on the collaboration of several statistical and geographical institutions and experts in the world for its consolidation, and that is why it is still treated as experimental. IBGE actively participates in this process – through tests applied to countries and participation in international discussion forums –, which is divided into thematic groups. It can be said that, for the Extent Accounts, there are minor appointments for methodological changes. With that, the results presented herein, using environmental databases already consolidated for the country, are not considered experimental, but a portrait of the environmental territorial dynamic in Brazil.

In order to evaluate the ecosystem extents in the National Territory proposed herein, two analyses are presented: one, more synthetic, on the spatialization and statistics from natural and anthropized areas; and the other, more specific, which presents the main conversions of land use categories for each biome and where the main drivers of change in the Brazilian territorial dynamic are interpreted for the analyzed period, from 2000 to 2018[13]. It is important to clarify that, for the purposes of spatial representation, the authors opted for presenting

[12] The process of formal review of the Ecosystem Accounts methodological manual is performed by the United Nations Statistics Division (UNSD), and all stages and technical documentation can be found at: https://seea.un.org/content/seea-experimental-ecosystem-accounting-revision.

[13] Regarding the data from the Monitoring of Land Use and Land Cover in Brazil, performed by IBGE, the values presented herein may present slight differences from those obtained in the Environmental Information Database - BDiA , also from IBGE, available at: https://bdiaweb.ibge.gov.br/. This is due to the grid used in that portal being adjusted to the South American Integrated Map and not including the maritime section of 12 miles and continental waters, especially in Lagoa dos Patos and Lagoa Mirim, which are not linked to any city.

the maps in this publication only for 2018, the most current snapshot; however, the mapping for the other years is available for consultation in the Environmental Information Database (*Banco de Dados de Informações Ambientais* - BDiA) (IBGE, [2018]).

Also regarding the most current period, after the presentation of the corresponding synthetic and specific analysis, the application of the Change Intensity Indicator - IIM is demonstrated for the types of changes detected between the two reference years studied, 2016 and 2018, in Brazil. This examination has a spatial perspective in cells, associated with IBGE's Statistical Grid, considered as a unit of operational analysis, or basic spatial unit, as described in the *Technical recommendations in support of the system of environmental-economic accounting 2012 - experimental ecosystem accounting* manual (UNITED NATIONS, 2019). Therefore, this analysis presents a portrait of the most current changes mapped under a unified methodology for the National Territory.

The extent of natural and anthropized areas in Brazil

Map 3 shows a synthetic approach of the ecosystem extents based on the mapping of natural areas – whether forest or non-forest –, in Brazil: the forests were identified from the category of forest tree cover; and the non-forest areas from the aggregation of the savannah, grassland and shrubland , wetlands and barren land categories, according to data from the Monitoring of Land Cover and Land Use in Brazil, developed by IBGE (MONITORAMENTO..., 2020). This differentiation between vegetation structure is valuable, in a territory as diverse as Brazil, for the Ecosystem Accounts due to the different ecological functions those environments have and, consequently, the services and benefits they can provide. The wetlands and barren lands were grouped with the savannah, grassland and shrubland formations, despite their diversity of environments, since its differentiation was considered to be more relevant in contrast with more elevated vegetation strata.

Therefore, for the anthropized areas, the land use categories in IBGE Monitoring that were considered are: artificial surfaces, cropland, silviculture, managed pasture, and mosaics of occupations in forest and savannah, shrubland and grassland areas, the latter, for presenting a significant percentage of anthropic interference. Within this scope, it is emphasized that only the terrestrial natural areas were analyzed, since the appreciation of the aquatic environment does not integrate the proposed analysis, since the mapping methodology of the Monitoring adopts the water mass polygons from the official cartographic base according to the updates in the Continuous Cartographic Base in the 1:250 000 scale, (Base Cartográfica Contínua na escala 1:250 000 – BC250), from IBGE (BASE..., 2017).

An analysis of the map first shows a clear concentration of continuous natural forest tree cover areas currently in the Amazônia Biome. That area has a predominance of the Dense and Open Ombrophilous Forest in the Country, with estimated original coverage of 72.6% of the total area of the biome, according to data from BDiA (IBGE, [2018]). Secondly, it is also important to note that in the Mata Atlântica - a biome which has 76.5% of estimated original forest coverage - these same two phyto-ecological regions added by Mixed Ombrophilous, Semi-deciduous Seasonal, and Deciduous Forests present very little vegetation remnants, with high fragmentation, currently concentrated in very small regions along the coast. And in third place, it is important to observe the forest tree cover areas currently in the southwestern area of the Caatinga

Biome, which hold Semi-deciduous and Deciduous Seasonal Forests, corresponding to 10.6% of its estimated original area, mainly in the region of *Depressões Sertanejas*. And finally, in the remaining biomes, the natural potential forest coverage is less than 10%.

Map 3 - Spatialization of natural areas of the Brazilian ecosystems

Source: IBGE, Diretoria de Geociências, Coordenação de Recursos Naturais e Estudos Ambientais.

Note: Developed from the Ecosystem Extent Accounts and Monitoring of Land Use and Land Cover in Brazil.

In relation to savannah, shrubland and grassland areas, the Cerrado Biome, with 65.4% estimated original coverage of Savannahs, according to data from BDiA (IBGE, [2018]), is prominent for its higher level of anthropization, especially in the southern area of that phyto-ecological region. The Pantanal Biome, on the other hand, which had originally 70.8% of its territory covered by Savannahs and Steppe-like Savannahs, it is currently the most preserved biome, with little anthropogenic interference in its eastern border. With the predominance of this same phyto-ecology, 65.0% potential, the Caatinga Biome currently holds the highest degree of anthropogenic interference in its Eastern sector. The Pampa Biome, with the characteristic preponderance of Steppe and Steppe-like Savannah (65.3% potential) presents a pattern of strong human occupation in the uplands.

From a statistical analysis in an accounting structure (Table 2), it can be observed that, among the additions and reductions in the extent of natural areas, all of the Brazilian terrestrial biomes had a negative balance in the period from 2000 to 2018. Therefore, this accounts for a loss of these coverages in several areas throughout the country, with a total reduction of approximately 500,000 km^2 of natural ecosystems. When analyzing the historical time series, however, it can be noted that despite the overall negative balance, the rate of the reduction of natural areas has been decreasing over the years. A warning must be made in relation to the net change, those representing a reduction in natural areas do not match the increase in anthropized areas, since on many occasions there are conversions to and from water bodies — or aquatic environments that, it is worth reiterating, are not being evaluated in this publication.

The greatest absolute reductions in natural areas were concentrated in the Amazônia and Cerrado Biomes, respectively to 269,801 km^2 and 152,706 km^2. The greatest percentage loss took place in the Pampa Biome, where 16.8% of its natural area as of 2000 was converted into anthropogenic uses, considering the terrestrial environment under study, as well as the highest rate of movement in natural areas of the analyzed biomes (17.5%), which includes both additions and reductions. On the other hand, the Pantanal was the biome with the smallest decreases in natural areas, both in absolute (2,109 km^2) and in relative terms (1.6%), showing a lower dynamic of conversions of land use in that region of the country.

Following this trend, the Amazônia and Cerrado Biomes also showed the highest percentages (118.6% and 44.3%, respectively) regarding the total changes in anthropized areas in relation to their extent in 2000. On the other hand, the biomes with the smallest relative movements in the analyzed period, thus evidencing the smallest transformations in the Brazilian space, and therefore, being the most stable throughout the period from 2000 to 2018, were Pantanal, with only 5.8% in its analyzed area, and Mata Atlântica and Caatinga, with 13.6% and 12.2%, respectively, of movement in natural and anthropized areas; these same regions were also the ones recording the smallest relative net change values.

It is interesting to note that, during the historical series, the Mata Atlântica and Caatinga Biomes were the ones that recorded the greatest decreases in the conversion of natural areas, from 8,793 km^2 in the initial period (2000-2010) to 577 km^2 in the present period (2016-2018) for Mata Atlântica, and from 17,165 km^2 to 1,604 km^2, in the case of Caatinga, in the corresponding periods. However, when looking at the relative amount of original vegetation within those biomes, the situation is very different: while Mata Atlântica , with the longest and most intense historical occupation territory in Brazil, presents the lowest value, with only 16.6% of natural areas today, Caatinga ranks as the third most preserved biome in the country, with only 36.2% of its territory currently under anthropogenic influence.

Table 2 - Ecosystem Extent Accounts in the Brazilian Biomes - 2000/2018

Variables	Total		Biome			
			Amazônia		Cerrado	
	Natural areas	Anthropized areas	Natural areas	Anthropized areas	Natural areas	Anthropized areas
			2000			
Opening extent (km²)	**5,877,298**	**2,510,306**	**3,684,512**	**450,865**	**1,185,192**	**790,693**
Additions	2,955	460,530	1,282	248,427	509	135,983
Reductions	326,066	137,419	193,539	56,170	96,274	40,218
			2010			
Extent (km²)	5,554,187	2,833,417	3,492,255	643,122	1,089,427	886,458
Additions	1,509	107,787	385	39,064	284	37,357
Reductions	69,316	39,980	27,376	12,073	23,068	14,573
			2012			
Extent (km²)	5,486,380	2,901,224	3,465,264	670,113	1,066,643	909,242
Additions	3,592	93,615	2,043	39,654	320	35,913
Reductions	49,030	48,177	21,123	20,574	18,392	17,841
			2014			
Extent (km²)	5,440,942	2,946,662	3,446,184	689,193	1,048,571	927,314
Additions	2,118	60,715	644	36,413	314	16,599
Reductions	36,435	26,398	23,541	13,516	8,417	8,496
			2016			
Extent (km²)	5,406,625	2,980,979	3,423,287	712,090	1,040,468	935,417
Additions	12,894	74,296	8,185	38,566	2,706	25,583
Reductions	32,098	55,245	16,761	30,057	10,688	17,671
			2018			
Closing extent (km²)	**5,387,421**	**3,000,030**	**3,414,711**	**720,599**	**1,032,486**	**943,329**
Net change						
Absolute (km²)	(-) 489,877	489,724	(-) 269,801	269,734	(-) 152,706	152,636
Percentage (%)	(-) 8.34	19.51	(-) 7.32	59.83	(-) 12.88	19.30
Movement						
Absolute (km²)	536,013	1,104,162	294,879	534,514	160,972	350,234
Percentage (%)	9.12	43.99	8.00	118.55	13.58	44.29

Variables	Biome							
	Mata Atlântica		Caatinga		Pantanal		Pampa	
	Natural areas	Anthropized areas	Natural areas	Anthropized areas	Natural areas	Anthropized areas	Natural areas	Anthropized areas
				2000				
Opening extent (km²)	**195,614**	**896,686**	**581,581**	**274,213**	**134,205**	**15,358**	**96,194**	**82,491**
Additions	257	43,490	519	21,477	378	1,707	10	9,446
Reductions	8,793	34,954	17,165	4,831	1,649	436	8,646	810
				2010				
Extent (km²)	187,078	905,222	564,935	290,859	132,934	16,629	87,558	91,127
Additions	248	13,515	293	15,285	290	134	9	2,432
Reductions	3,083	10,680	13,375	2,203	189	235	2,225	216
				2012				
Extent (km²)	184,243	908,057	551,853	303,941	133,035	16,528	85,342	93,343
Additions	44	7,362	1,000	6,895	101	243	84	3,548
Reductions	735	6,671	5,327	2,568	216	128	3,237	395
				2014				
Extent (km²)	183,552	908,748	547,526	308,268	132,920	16,643	82,189	96,496
Additions	213	4,428	648	2,264	278	74	21	937
Reductions	1,509	3,132	1,801	1,111	326	26	841	117
				2016				
Extent (km²)	182,256	910,044	546,373	309,421	132,872	16,691	81,369	97,316
Additions	102	4,513	1,545	2,376	123	1,026	233	2,232
Reductions	577	4,039	1,604	2,328	899	254	1,569	896
				2018				
Closing extent (km²)	**181,781**	**910,518**	**546,314**	**309,469**	**132,096**	**17,463**	**80,033**	**98,652**
Net change								
Absolute (km²)	(-) 13,833	13,832	(-) 35,267	35,256	(-) 2,109	2,105	(-) 16,161	16,161
Percentage (%)	(-) 7.07	1.54	(-) 6.06	12.86	(-) 1.57	13.71	(-) 16.80	19.59
Movement								
Absolute (km²)	15,561	132,784	43,277	61,338	4,449	4,263	16,875	21,029
Percentage (%)	7.95	14.81	7.44	22.37	3.32	27.76	17.54	25.49

Source: IBGE, Diretoria de Geociências, Coordenação de Recursos Naturais e Estudos Ambientais.
Note: Developed from the Ecosystem Extension Accounts and Monitoring of Coverage and Use of Land in Brazil.

In the environmental preservation chart, it is important to observe the Pantanal Biome, with approximately 90% of natural areas of its ecosystems, and the lowest relative loss of that coverage among all biomes along the historical series, with a movement of approximately 3%. It is important to emphasize that this biome has the smallest territorial extent in the country, and a particular dynamic due to its physiographic characteristics and responses to the hydrologic cycle in the region, which may render it more sensitive to changes. However, the most prominent scenario, with absolute and relative figures above the national average, belongs to the Amazônia Biome, regarding the processes of anthropization in the period from 2000 to 2018, followed by the Cerrado Biome, which has similar total figures.

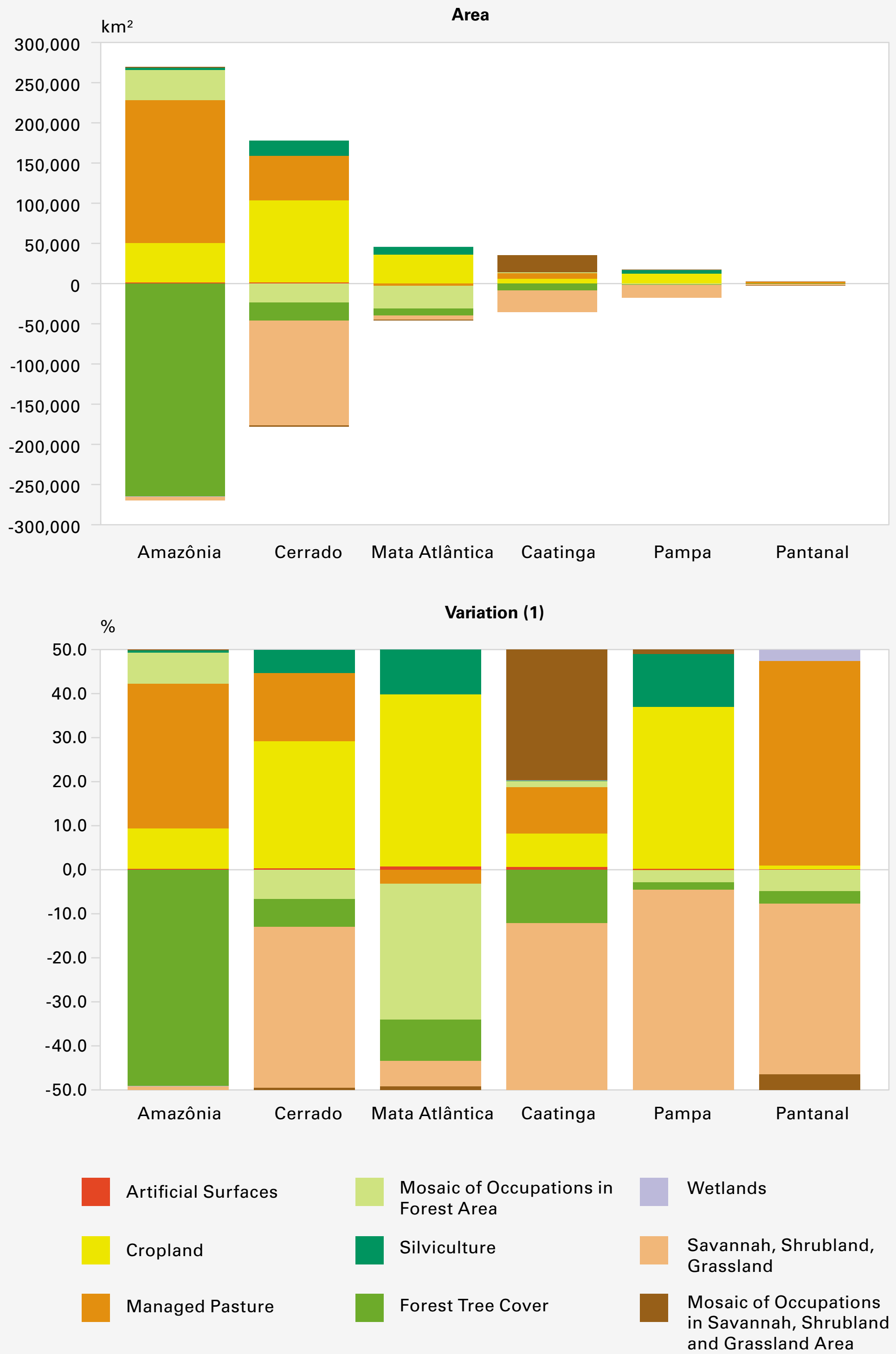
In order to specifically understand which land cover and land use represented such changes, Chart 1 shows IBGE's Monitoring categories representing the previously described processes in each biome. It can be noticed that, in relative terms, the main changes in natural areas in the Brazilian ecosystems took place in the Amazônia and Caatinga Biomes, as shown by the loss of forest tree cover and of savannah, shrubland and grassland vegetation. However, as the Caatinga spatial expression is almost five-fold smaller than the Amazônia, the greatest losses in absolute figures for the corresponding categories were actually identified in the Amazônia and Cerrado Biomes.

The Caatinga Biome is also highlighted for having presented, in the analyzed period, the hegemonic inner conversion among the categories of anthropic uses, whether they are restricted, as managed pasture and croplands, or broad, such as mosaics of occupations in forest and savannah, shrubland and grassland areas, while in the Cerrado and Amazônia Biomes, there is a predominance of a more intense process of anthropization, pictured by the greater gain, both in absolute and relative terms, of cropland and managed pasture. In relative terms, however, the main increase in the Pantanal Biome is of managed pasture in the period from 2000 to 2018. In addition, there is the increase in the category of wetland in that region of the country, especially due to its greater concentration in a large flood plain, in which the dynamic of the waters dominates the structural processes of the landscape.

The case of the Mata Atlântica is also worth mentioning, being the only Brazilian terrestrial biome with a predominant loss of areas with broad anthropogenic uses in the studied period - the mosaics of occupations in forest areas. With a significant spatial expression in the Country, this biome experienced gains in categories with greater levels of anthropization, where several crops are developed. Accompanying this trend, the Cerrado Biome also experienced, with a lower intensity in relative and absolute terms, the loss of areas in such mosaics and the increase of farming and silviculture areas.

On the other hand, the Caatinga biome presented the highest absolute and relative increases of mosaics of occupation in savannah, shrubland and grassland areas, according to the regional phyto-ecological region, which shows the concentration of diversified anthropogenic uses in this part of the Brazilian region, in small rural areas, according to its traditional use. Regarding the increase of forest mosaics, it is important to emphasize its predominance in portions of the fragmented Amazonian landscape, since in this region, the increase of that type of land use has been observed in absolute and relative terms, since it constitutes its complex environmental territorial dynamic.

Chart 1 - Dynamic of net variation of land cover and land use in the Brazilian biomes, in absolute and relative terms - 2000/2018



Source: IBGE, Diretoria de Geociências, Monitoramento da Cobertura e Uso da Terra do Brasil.
(1) Percentage in relation to absolute area of change in each biome.

Both in the Mata Atlântica Biome and in the Caatinga Biome, there was evidence, in minimum absolute terms, of the relative increase in the artificial surfaces category, which represents the urban expansion of the country. The Mata Atlântica includes the oldest and most consolidated areas in the country due to its occupation history, and such data is evidence of a process of expansion of such regions. In the Caatinga, in turn, the urbanization grew in medium-sized cities and in the peri-metropolitan outskirts (REGIÕES..., 2008), easily identified in the mapping that is the base of this analysis, with scale associated to the 1-km^2 grid. In the perspective of a quantitative approach on those changes, the following topic presents the details of the conversions of use observed in the biomes.

Transformations in land use, by biome

For a more detailed analysis of the interior of each biome, the main conversions of land use categories are presented below, originated from IBGE historical Monitoring series, where the main drivers of change in the Brazilian environmental territorial dynamic can be interpreted from 2000 to 2018 (MONITORAMENTO..., 2020). For this publication, the authors opted to emphasize the data in graphics for each biome; however, the physical accounting tables by land use category can be found in the attachments, at the end of the publication, for each accounting period analyzed, and their corresponding change matrixes are available on the IBGE website.

Regarding the charts presented in this section, it is important to note that they were built from the main conversions of land cover and land use categories observed in the biomes, that is, those with greater dynamics in the analyzed period. Therefore, they represent the predominant processes acting in each Brazilian region, while also easing the reading and understanding of the data, by directly and explicitly illustrating them in the factions of internal and external circles representative of changes that took place at its origin and destination. Thus, it is important to state that the size of the fractions corresponding to the categories in each circle constitute a relative perspective of the preponderant changes in each biome.

In addition, although the focus of this publication is the accounting, in physical terms, of the ecosystem extents, it also correlates some economic data, with evidence to the potentiality of this integration under the perspective of Environmental Economic Accounting through a unified framework. However, it is important to emphasize that this is a demonstration of the possibility of crossing physical data and those resulting from social-economic research relevant to the environmental sector, thus indicating other possibilities of deployment of Ecosystem Accounts in Brazil. For instance, it can be observed that one of the challenges will be the integration of physiographic data with other data generated in political-administrative units; and therefore, during the analyses presented herein, it can be noted that the comparative profiles are not always an absolute match.

Amazônia Biome

The Amazon Rainforest is considered the largest extension of Tropical Rainforest in the world, according to the *Global forest atlas* (2014). It is also the largest hydrographic region of the planet, covering approximately 6 million square kilometers, with 1,100 tributaries. Its main river, the Amazonas, cuts through the entire region to its mouth in the Atlantic Ocean, launching approximately 175 million liters of water per second; therefore, it is considered the largest biome in Brazil, comprising approximately ⅓ of all tropical wood in South America and the world, according to data from the Ministry of the Environment (BRAZIL, [2020a]).

The occupation pattern for that territory was established from governmental occupation projects for the Amazônia in the 1970s, part of the National Integration Program (Programa de Integração Nacional- PIN), which started with the policies of construction of large road works by the federal government in the region, followed by settlement projects. This pattern followed the logic of building country roads near the roads, or rivers, and was propelled by timber extraction and mining, with punctual deforestation. Subsequently, there was the implementation of land projects, eased by tax benefits, which fostered not only large agricultural enterprises, but also the building of new roads that propelled the expansion of pastures, usually managed by wildfires, as reported in the *Ecologic-economic macrozoning of the Legal* Amazônia (*Macrozoneamento ecológico-econômico da Amazônia Legal - MacroZEE*) (BRAZIL, [2010a]).

The Macro ZEE of Amazônia Legal also addresses the lack of financial resources for immigrating farmers, as well as the depletion and abandonment of pastures, that are in fallow without immediate use, favoring the regeneration of secondary vegetation, which leads to new processes of expansion and deforestation in adjacent areas through new migratory processes of the small rural producers. In parallel, where there is greater potential for mechanization and treatment of soil, such as in the uplands and chapadas, as well as better infrastructure (paved roads, urbanization, among other elements), economic agents with greater resources invest in the replacement of pastures by farming areas, mainly for planting grass and cereals, with emphasis on single crops, such as soybean.

Amazônia was the biome with the greatest number of percentage changes in land use observed between 2000 and 2018, with emphasis on the reduction of its forest tree cover, which, in the last year considered, represented 75.7% of its total area. In that period, the forest tree cover was reduced with 265,113 km^2 (Attachment 1), a figure that represents the greatest reduction of natural cover among the Brazilian biomes in the analyzed period. In total, 50.2% of all changes observed in the Amazônia Biome resulted from the conversion of other land use categories into managed pasture, and 31.0% is related to conversions of forest tree cover to a mosaic of occupations in forest area.

The forest tree cover category was mainly replaced by managed pasture areas (Photo 1), which shifted from 248,794 km^2 in 2000, to 426,424 km^2 of the biome in 2018, and the mosaic of occupations in forest area (Photo 2) showing a fragmentation of the landscape in the region. The Amazon Rainforest provides important ecosystem services which are essential, both at a local (extraction products, fire wood, etc.), regional (maintenance of climate and quality of water, for instance) and global levels (carbon sequestration, regulation of hydrological cycles, among other aspects). The maintenance of its huge biodiversity contains an enormous potential for both agronomic and medicinal research.

Photo 1 - Managed pasture in Amazonian landscape in Pará

Photo: Bruno Almeida da Silva, 2018.

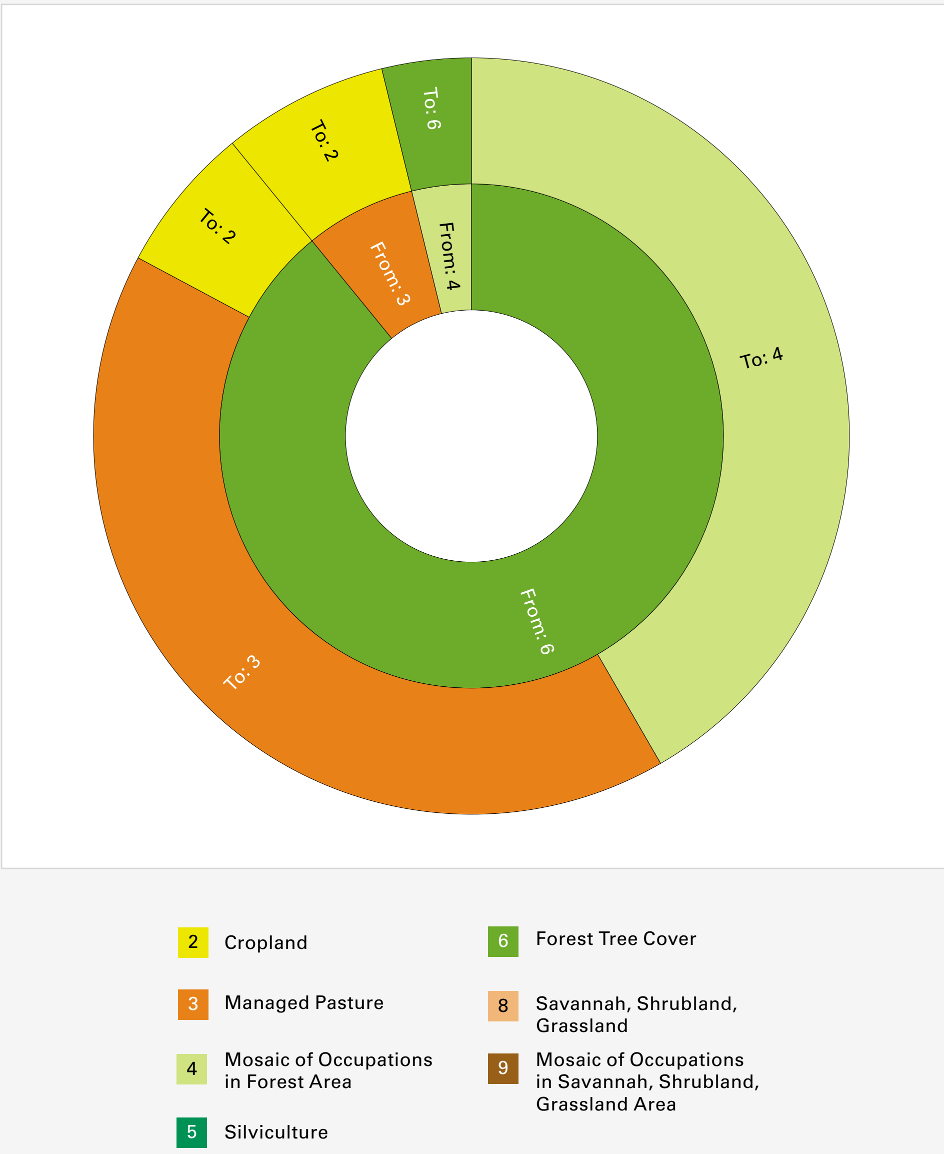
Photo 2 - Forest mosaic in Amazônia, a small plantation in an area under deforestation process (Rondônia)

Photo: Fernando Peres Dias, 2018.

Therefore, the Amazônia Biome presented, during that period, an increase of 71.4% in the managed pasture area, and of 288.6% in the cropland area, the latter mainly between 2012 and 2014. In particular, after 2012, approximately 43% of the new cropland areas resulted from the conversion of managed pasture areas. Therefore, it is important to observe the gradual increase of croplands in the region, which remained steady over the years, growing from an area of 17,073 km^2 in 2000 to 66,350 km^2 in 2018 (Attachment 1). Therefore, this biome is responsible for 74.0% and 23.9% of the growth, respectively, of the total changes in managed pasture and cropland categories in Brazil between 2000 and 2018.

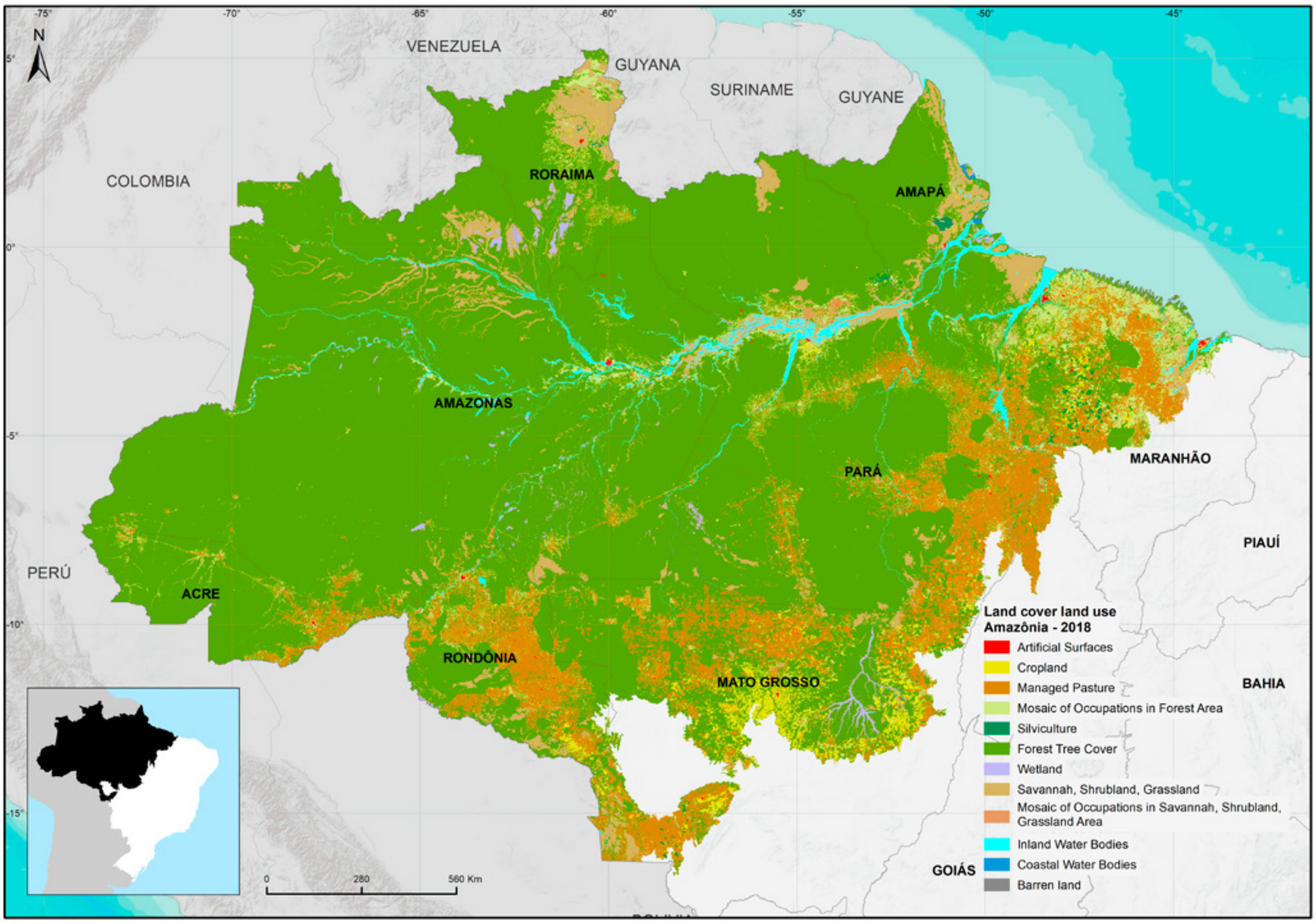
With all that, the Amazônia Biome dynamic observed in the analyzed period (Chart 2) is marked by the transitions between forest vegetation, mosaic of occupations in forest areas, and managed pastures, which often overlap, but following the general growth trend of the pasture and mosaic of occupations in forest area categories, and a decrease in the forest tree cover category. These changes indicate the pattern of use of what is referred to as the “consolidated settlement arc”, initially observed on the borders of the Amazônia Biome, in areas of contact with the Cerrado Biome, and now presenting a considerable interiorization (Map 4), by following the construction of roads, river banks and adjacencies of infrastructure works.

Chart 2 - Conversions of land cover and land use in the Amazônia Biome - 2000/2018



Source: IBGE, Diretoria de Geociências, Monitoramento da Cobertura e Uso da Terra do Brasil.
Note: The inner circle is related to 2000, while the outer is related to 2018.

Map 4 - Land Cover and Land Use in the Amazon Biome - 2018



Source: MONITORAMENTO da cobertura e uso da terra do Brasil 2016-2018. Rio de Janeiro: IBGE, 2020. Available at: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101703. Accessed: August 2020.

This dynamic is considered relevant, since despite the natural abundance and cultural wealth of the Amazônia Biome, which hosts great inventories of timber, fish, ore, among other resources, it is also home to the largest traditional populations in Brazil (NEUGARTEN *et al.*, 2015). In addition, the balance of the local ecosystems, which are sustained through complex flows of matter and energy in the soil-vegetation-atmosphere system, where the organic matter itself provides life, is highly sensitive to external disturbances (WILSON, 1988). Those damages, as those resulting from the processes of conversion of forest tree cover which start with a low-impact activity – the selective extraction of timber, for instance, which fragments the forest and makes it more susceptible to fires, especially during the dry season, eventually giving way to the farming occupation – were pointed out by researchers from the National Institute for Space Research (*Instituto Nacional de Pesquisas Espaciais* - INPE) (PINHEIRO *et al.*, 2016).

The natural wealth of the Amazon rainforest poses a drastic contrast to the low social-economic indexes in the region, with low demographic intensity and growing urbanization (BECKER; GALVÃO, 2010) This is demonstrated by the results from the percentage participation of the Great Regions in the components of the Gross Domestic Product - GDP from an income point of view, where the Northern Region comes in last among all components, according to data from the Regional Accounts System (*Sistema de Contas Regionais* - SCR) from IBGE (SISTEMA..., 2019). It can be concluded that the use of forest resources can be strategic for some locations in the region. Currently, in the exploitation of Amazonian natural resources relevant to the local/regional economy, it is important to mention two cities located in the state of Pará, leaders in the value of the national extractive production, according to data from the survey on Production of Plant Extraction and Silviculture (*Produção da Extração Vegetal e da Silvicultura* - PEVS) 2018, from IBGE: Limoeiro do Ajuru, leading exporter of açaí, and Portel, leading exporter of logs (PRODUÇÂO..., 2018).

According to the SCR, the state of Pará is also remarkable regarding the extraction and palletization of iron ore for the steel industry, which benefitted from a price increase of 12.3% (in Brazilian reais) between 2016 and 2017, associated to a production increase according to the SCR (SISTEMA..., 2019), after the Mining Complex S11D began operations in Serra dos Carajás, inaugurated by Vale at the end of 2016 (VALE, 2018). Therefore, the economic performance of the state of Pará in 2017 was linked to capital-intensive activities, with the aforementioned extraction of iron ore and the generation of hydroelectric power from the increase in the number of turbines in operation at the Belo Monte Hydroelectric Power Plant. Between 2016 and 2017 in the Brazilian economy, the farming sector grew 14.2% in GDP volume. In the Northern Region, the growth of that sector was negative, both in the state of Acre, where the share in terms of volume variation for the gross added value from the farming activity was -10.5%, and in the state of Amazonas, which recorded -3.0%, according to the SCR (SISTEMA..., 2019).

On the other hand, the states of Pará and Rondônia presented significant positive variations (7.4% and 19.6%, respectively), mostly due to cattle and dairy production, respectively. Those states are also prominent in industrial production due to the plant and mineral extraction activities in Pará (4.4%) and the production of electricity in the Hydroelectric Plants of Santo Antônio and Jirau in Rondônia (8.1%). Differing from that scenario, the state of Mato Grosso, inserted in the Amazônia Biome and located in the Midwestern Region, recorded a volume variation in the gross added value for the farming activity of 45.2% according to the SCR (SISTEMA..., 2019). Therefore, the farming activity in the Amazônia Biome, despite occupying a considerable extent of land in absolute terms, and expanding, is not expressive in the value of the national production, nor in employment or income, indicating extensive production in cattle raising and low-productivity farming.

Cerrado Biome

The Cerrado is the second largest biome in Brazil, second only to the Amazônia, and occupies an area of approximately 200 million hectares, or about 24% of the National Territory, according to IBGE (BIOMAS..., 2019). This territorial space encloses the sources for the major hydrographic basins in South America: the headwaters of the Amazon Basin and of the hydrographic regions of Tocantins-Araguaia, São Francisco, and Paraná-Prata, which play a pivotal role in the distribution of water resources in the country, according to data on water availability and water demands (AGÊNCIA NACIONAL DE ÁGUAS, 2005). Considered to be one of the global hotspots of biodiversity by Conservation International - CI, the Cerrado Biome is known as the wealthiest savannah in the world, hosting a wide variety of habitats and refuges of endemic species, according to data from the Ministry of the Environment (BRASIL, [2020b]), and thus providing essential ecosystem services.

Despite the international recognition of its biological relevance, the Cerrado Biome has only 8.21% of its territory legally protected by Conservation Units, and from that total, 2.85% constituted Full Protection Units, and 5.36% Sustainable Use Conservation Units, including Private Natural Heritage Reserves (0.07%), according to data from Instituto Chico Mendes de Conservação da Biodiversidade - ICMBio. This biome is the second in Brazil in terms of the number of changes resulting from the advance of anthropogenic uses, constituting the expansion front of the farming frontier in the country, especially for the purpose of producing grains and meat for export, whose volume totaled approximately USD 17 billion in 2018, considering the states of Goiás, Mato Grosso, Mato Grosso do Sul and Minas Gerais (BRASIL, [2018b]).

Therefore, the most prominent characteristic of the land use transformations in the Cerrado Biome is the continuous and accelerated expansion of agriculture. Its presence increased in area by 102,603 km^2 between 2000 and 2018 (Attachment 2). It is important to note that the savannah, shrubland and grassland and forest tree cover areas also showed progressive reductions, becoming replaced by managed pasture and croplands (Photo 3). Pasture is the second largest land use category in this biome (Photo 4), and its relevance is due to the historical occupation characteristics, with cattle farming being a traditional and significant activity in the economic formation of the regions that constitute this biome.

However, it is interesting to note that there has been a stagnation of growth in the pasture areas since 2010, and a decrease in their areas between 2016 and 2018 in the Cerrado Biome (Attachment 2), reflecting an important change having taken place in the period – managed pasture areas became cropland areas. This increase in the productive area is reflected in the GDP of the Midwestern Region, where most of the biome is located, which presented percentage variation in volume of 3.9% in 2017, the highest in Brazil according to the SCR (SISTEMA..., 2019). By observing this trend, it is possible to state that, as the pasture gives way to croplands, they replace natural areas in other locations, especially by advancing over areas bordering the Amazônia Biome.

Photo 3 - Traditional planting of soybean in the Brazilian Planalto Central (Goiás)

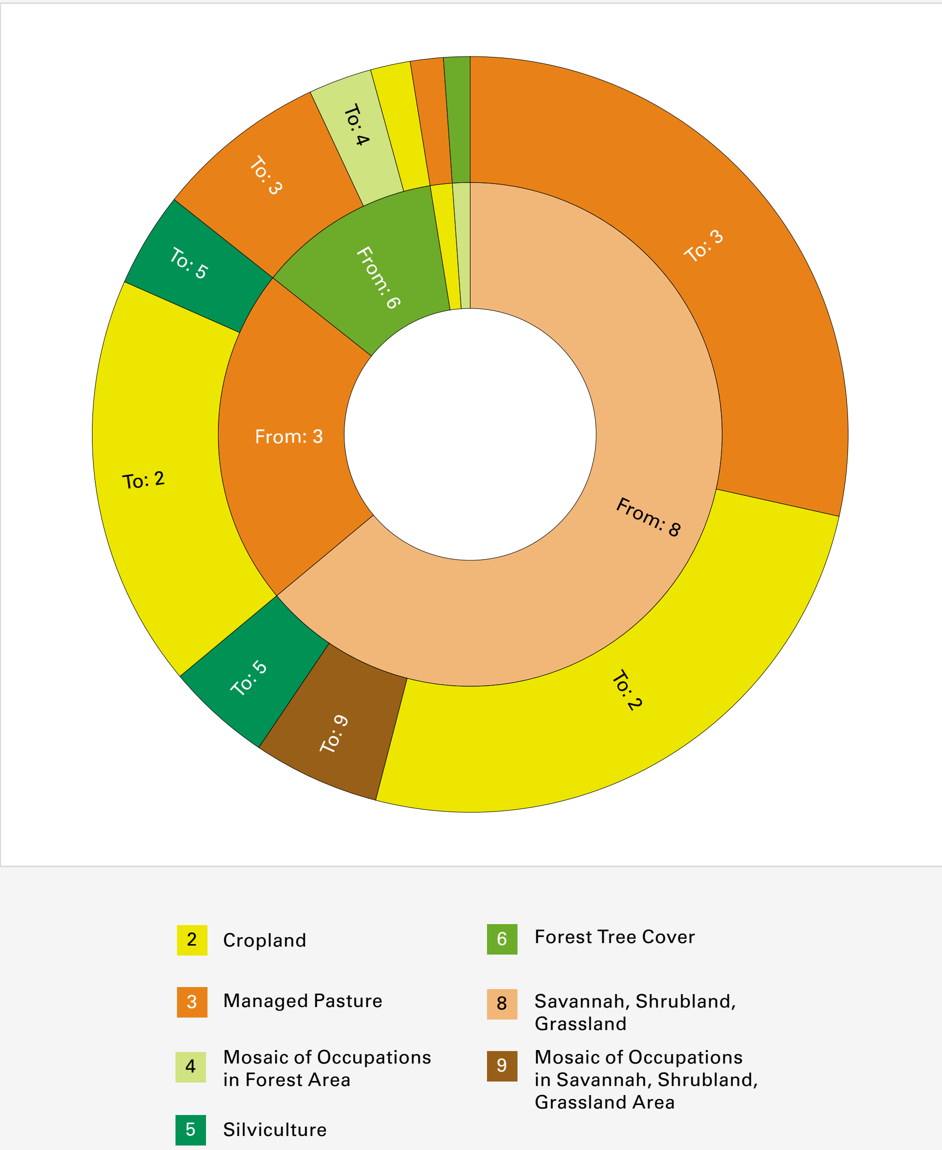
Photo: Antônio Jose Marcelino de Paula, 2017.

Photo 4 - Managed pasture in Mato Grosso; in the background, *chapadas* with remaining natural vegetation

Photo: Fernando Peres Dias, 2015.

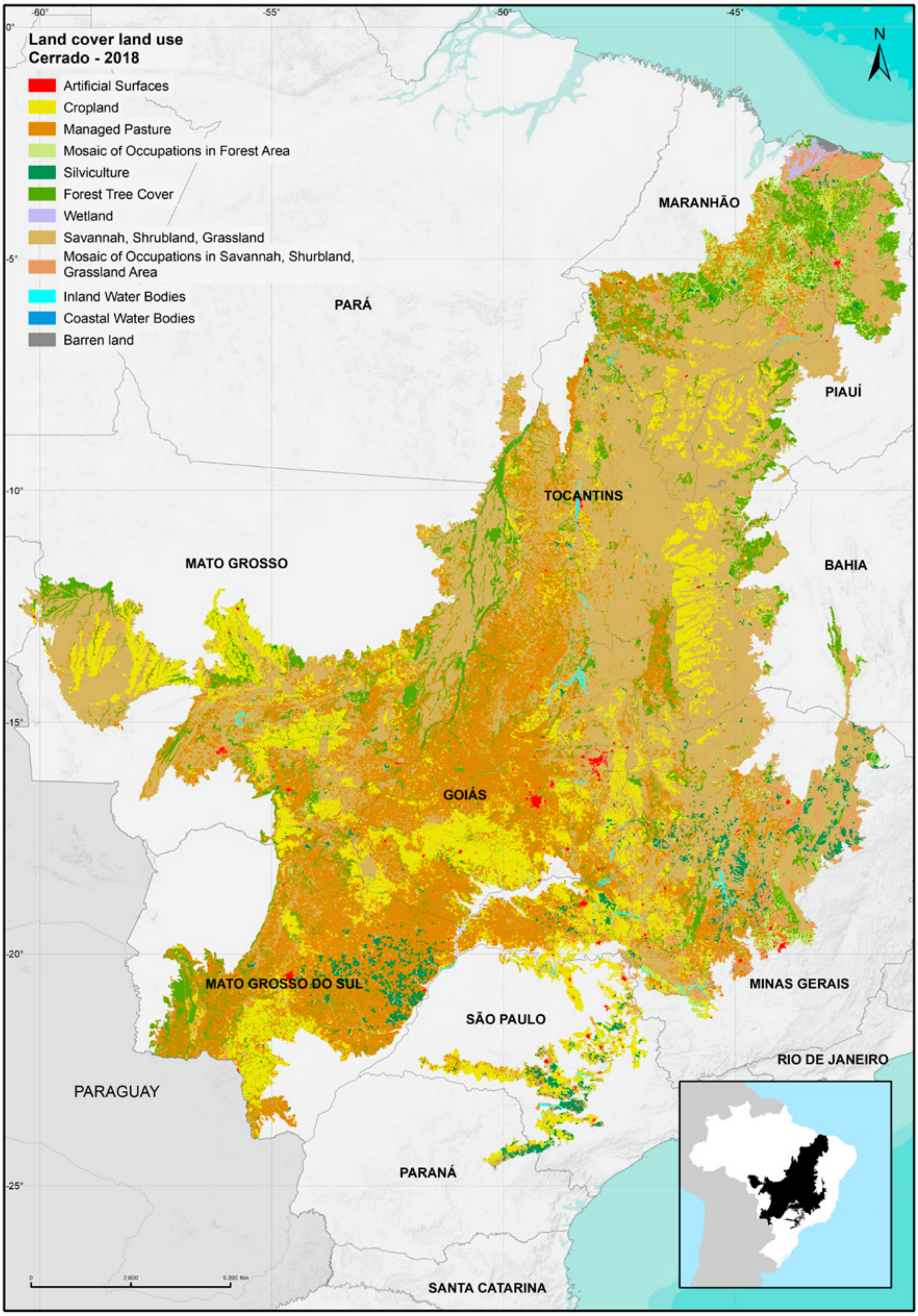
The expansion of agriculture (Chart 3) is related to agribusiness and investments in agricultural commodities, with two large concentrations in the Cerrado Biome. One is in the Center-Southern region – including the states of Paraná, São Paulo, Minas Gerais, Goiás, and Mato Grosso do Sul (Map 5) –, and has a dynamic of replacing strict anthropogenic uses, usually managed pastures, home to single-crop areas. The dynamic of this region is influenced by the high investment capacity of the stakeholders involved, according to the Agricultural Census 2017 performed by IBGE (CENSO..., [2020]), as well as the farming aptitude of the soil, especially in the chapadas and uplands sustained by basaltic spills, according to data from BDiA (IBGE,[2018]), where the soil is potentially favorable to several uses, including through agricultural technologies.

Chart 3 - Conversions of land cover and land use in the Cerrado Biome - 2000/2018



Source: IBGE, Diretoria de Geociências, Monitoramento da Cobertura e Uso da Terra do Brasil.
Note: The inner circle is related to 2000, while the outer is related to 2018.

Map 5 - Land Cover and Land Use in the Cerrado Biome - 2018



Source: MONITORAMENTO da cobertura e uso da terra do Brasil 2016-2018. Rio de Janeiro: IBGE, 2020. Available at: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101703. Accessed: August 2020.

The other remarkable area of farming expansion is situated in the region known as Matopiba[14] - a regional investment project initially developed within the scope of the Brazilian Agriculture Research Company - Embrapa, coined in 2015 to be used in discussions related to the economic and political planning of the region. The term consists in the joining of the acronyms for the states that constitute it (Maranhão, Tocantins, Piauí and Bahia), which have been experiencing progressive occupation of their upland and chapada areas by soybean, cotton and other single grain and cereal crops, according to data from the Agricultural Census 2017 (CENSO..., [2020]), which represents a continuous expansion of the pattern from South to North in the Brazilian agriculture, over time.

The expansion of silviculture, in turn, is notably associated, in terms of production value, to the activities in the paper and pulp industry, which presented growth in the mentioned period, according to data from PEVS (PRODUÇÃO..., 2018), followed by the traditional use for fire wood and charcoal production. The growth recorded in the production of the latter was a dominant factor for the increase in the value of silviculture production, since with the improvement in the performance of the steel industry in 2018, according to the SCR (SISTEMA..., 2019), which is the industry with the highest consumption of charcoal as energy source, there was a significant increase in its demand, which was reflected as an increase of the average price in the market, and in consequent incentive to the producer, resulting in an increase of 18.9% in the annual production.

Therefore, in 2018, 44.6% of the cropland areas and 42.7% of the silviculture areas in Brazil were located in the Cerrado Biome, mainly due to the conversion of managed pasture into those use categories, from 2012. These areas grew in this biome in the period from 2000 to 2018 a total of 52.9% for the cropland areas and 104.3% for the silviculture areas. Thus, it is also important to note that in the Cerrado Biome, silviculture is a relevant category, with an increase of 18,748 km^2 in its area between 2000 and 2018 (Attachment 2), mainly recorded in the states of Minas Gerais, Mato Grosso do Sul, and Maranhão, including over natural areas of savannah, shrubland and grassland .

The performance in volume of the national GDP from 2002 to 2017 presented average growth of 2.4% per year, mostly due to the farming activity, according to the SCR (SISTEMA..., 2019). This occurred mainly due to agriculture in the Cerrado Biome (in the state of Mato Grosso, and in the expansion to the Matopiba region, adding part of the state of Piauí, west Bahia and south Maranhão), due to the development of the soybean, maize and cotton crops for export. Foreign trade data shows an increase of approximately 24-fold in volume between 2000 and 2018, derived from products of vegetable origin, in the states of Maranhão, Tocantins, Piauí and Bahia (BRAZIL, [2018c]).

Mata Atlântica Biome

Diverse and widely disclosed data regarding this biome conclude that it is one of the most biodiverse and also one of the most threatened biomes on the planet. That is why it is the only one protected by specific environmental legislation in the country, namely Law No. 11428, dated 12/22/2006 (BRASIL, 2006), and is also the focus of socio-environmental responsibility programs from the Ministry of Environment and Ministry of Science, Technology and Communication, such as the Biodiversity and Climate Changes in the Atlantic Forest Program (Projeto Biodiversidade e Mudanças Climáticas na Mata Atlântica), or Atlantic Forest Project (Projeto Mata Atlântica), and the Recovery

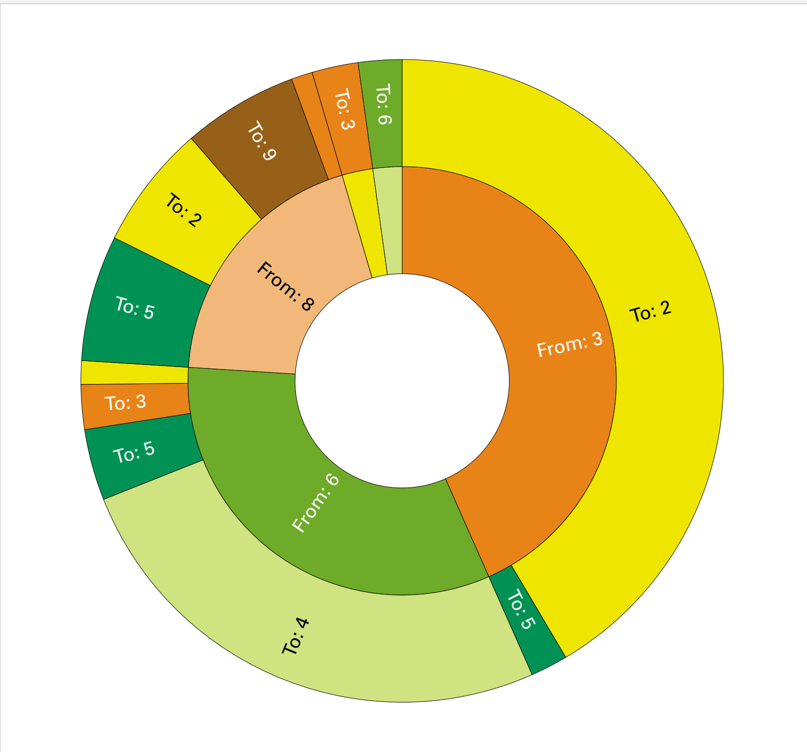
[14] Legally justified region, with public policies aimed at the sustainable economic development based on the agriculture and farming activities, according to provisions in Decree No. 8447, dated 05/06/2015 (BRAZIL, 2015).

and Protection of Services of Climate and Biodiversity Project in the Southeastern Corridor, also known as Conexão Mata Atlântica. Monitoring research in this biome, such as that performed by the Satellite Deforestation Monitoring Project in the Brazilian Biomes (*Projeto de Monitoramento do Desmatamento nos Biomas Brasileiros Por Satélite* - PMDBBS) point to the reduced percentage of its original coverage.

Furthermore, studies developed by Brazilian researchers, such as from INPE, point out that 32% to 40% of these remnants are formed by secondary forest, in small fragments of less than 100 hectares (RIBEIRO *et al.*, 2009). As such, the Mata Atlântica Biome currently represents the bulk of environmental initiatives in the country (BRAZIL, 2010b), not only addressing the importance of the ecosystem services the forest provides, but also encouraging rural properties towards preservation via awareness of environmental legislation, especially those related to Legal Reserves and Permanent Protection Areas. These initiatives also include the Municipal Plans for Preservation and Recovery of the Mata Atlântica, which demonstrate the application of land use models that consider the productive process and the preservation of the ecosystems.

In this sense, Mata Atlântica is the only Brazilian terrestrial biome whose predominant land cover and land use category is not of natural coverage. Forest tree cover, whose physiognomies were originally predominant in its ecosystems, currently represent only 12.6% of its territory, representing 13.3% in 2000 (Attachment 3). In relative terms, the natural areas were only slightly affected in the study period, but they continue to be reduced. Nevertheless, it is important to state that in the Mata Atlântica Biome, a small part of the forest tree cover originating from the mosaics can be observed, which can be interpreted as a process of regeneration from areas with diversified uses, and a reduction of managed pasture (Chart 4) from 2012.

Chart 4 - Conversions of land cover and land use in the Mata Atlântica Biome - 2000/2018



2 Cropland
3 Managed Pasture
4 Mosaic of Occupations in Forest Area
5 Silviculture
6 Forest Tree Cover
8 Savannah, Shrubland, Grassland
9 Mosaic of Occupations in Savannah, Shrubland, Grassland Area

Source: IBGE, Diretoria de Geociências, Monitoramento da Cobertura e Uso da Terra do Brasil.

Note: The inner circle is related to 2000, while the outer is related to 2018.

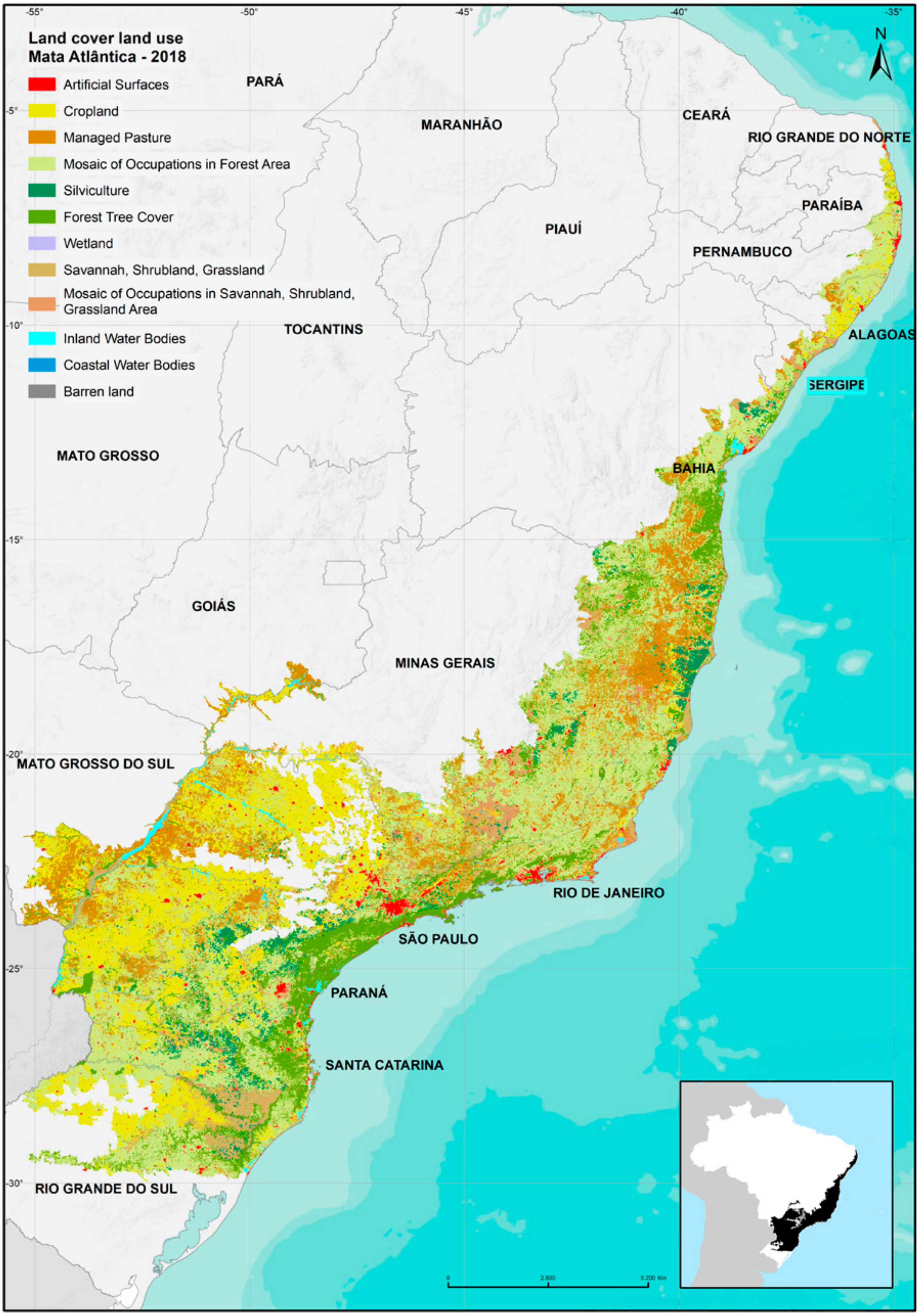
The highlights in the conversions of categories in this biome are the cropland and silviculture areas, which represented 32.9% and 42.7%, respectively, of the areas in the region in 2018, with the latter presenting the largest growth, at 33.9%, followed by the cropland area at 19.6%. An outright expansion of the cropland areas can be observed (Photo 5), mostly advancing over previous pasture areas. Accompanying the dynamic of the Cerrado Biome in the Center-Southern region of the country, the cropland areas are mainly located in the Western São Paulo, Triângulo Mineiro, Mato Grosso do Sul, and Northern Paraná regions (Map 6), where the characteristics of fertile soil and flat landscapes, according to data from BDiA (IBGE, [2018]), favor the implementation of several agricultural crops. This region, commonly known as Center-South, leads the production of important Brazilian agricultural products such as coffee, sugarcane, oranges, and others, according to the Agricultural Census 2017 (CENSO..., [2020]).

The expansion of silviculture is also relevant in this biome, frequently associated with other uses (Photo 6), growing from an area of 27,418 km² in 2000 to 36,703 km² in 2018 (Attachment 3), concentrated in the states of Santa Catarina, Paraná, and Espírito Santo – areas whose farming is mainly associated with the production of paper and pulp industries, according to data from PEVS (PRODUÇÃO..., 2018). Also according to this research, the areas with eucalyptus plantations corresponded to 76.2% of the forests planted for commercial purposes in the country, with 42.3% of them concentrated in the Southeastern Region and production focusing on the international paper and pulp market, according to the SCR (SISTEMA, 2019).

Photo 5 - Croplands in mosaic of complex landscape characteristic of the Mata Atlântica

Photo: Sirlene Thon Rocha, 2017.

Map 6 - Land Cover and Land Use in the Mata Atlântica Biome - 2018



Source: MONITORAMENTO da cobertura e uso da terra do Brasil 2016-2018. Rio de Janeiro: IBGE, 2020. Available at: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101703. Accessed: August 2020.

Photo 6 - Silviculture included in several farming plantations in forest mosaic areas in Espírito Santo

Photo: Fernando Peres Dias, 2017.

Furthermore, the Mata Atlântica Biome covers the most industrialized and productive areas in the country, considering that the states of Rio de Janeiro and São Paulo alone generated 42.4% of the Brazilian GDP in 2017, according to the SCR (SISTEMA..., 2019). This biome includes the largest metropolitan cities in Brazil, providing essential ecosystem services to them, at a local (food, wood, etc.), regional (erosion control, protection against natural disasters, for example), and global level (carbon sequestration, maintenance of biodiversity, among others). In global terms, it is important to emphasize the concentration of endangered species (BRAZIL, 2014a, 2014b) which survive in a landscape characterized by mosaics with forest fragments, crops and abandoned pasture.

The Mata Atlântica is the biome with the greatest demographic density in the country, housing 49.3% of the urban areas in the National Territory in 2018. These characteristics are mainly due to its history of occupation and urbanization, from coastal areas inland, in the Brazilian territorial formation, as pointed out by a study from Figueiredo (2016) published by IBGE. Traditionally, it is the biome that has undergone the most change in the country; therefore, it can be noted that the category of artificial surfaces, even if relatively stable, is much more present when compared to the same category in other biomes, occupying a total area of 18,887 km² in 2018 (Attachment 3).

Caatinga Biome

The Caatinga Biome is a predominantly steppe formation and unique in Brazil, according to IBGE (BIOMAS..., 2019), hosting many endemic species (BRAZIL, 2011); it is characteristic of the semi-arid region in the Northeast and occupies an area of approximately 11% of the National Territory, according to data from BDiA (IBGE, [2018]). The Brazilian semi-arid region is classified as an area susceptible to desertification, according to the criteria in the United Nations Convention to Combat Desertification (UNCCD), especially since it is frequently affected by droughts, which makes it sensitive from a social-environmental point of view, and therefore, there are programs specifically destined to it, with focus on the institution of the Superintendence of the Development of Northeast (Superintendência do Desenvolvimento do Nordeste - Sudene) through Complementary Law No. 125, dated 01/03/2007 (BRAZIL, 2007).

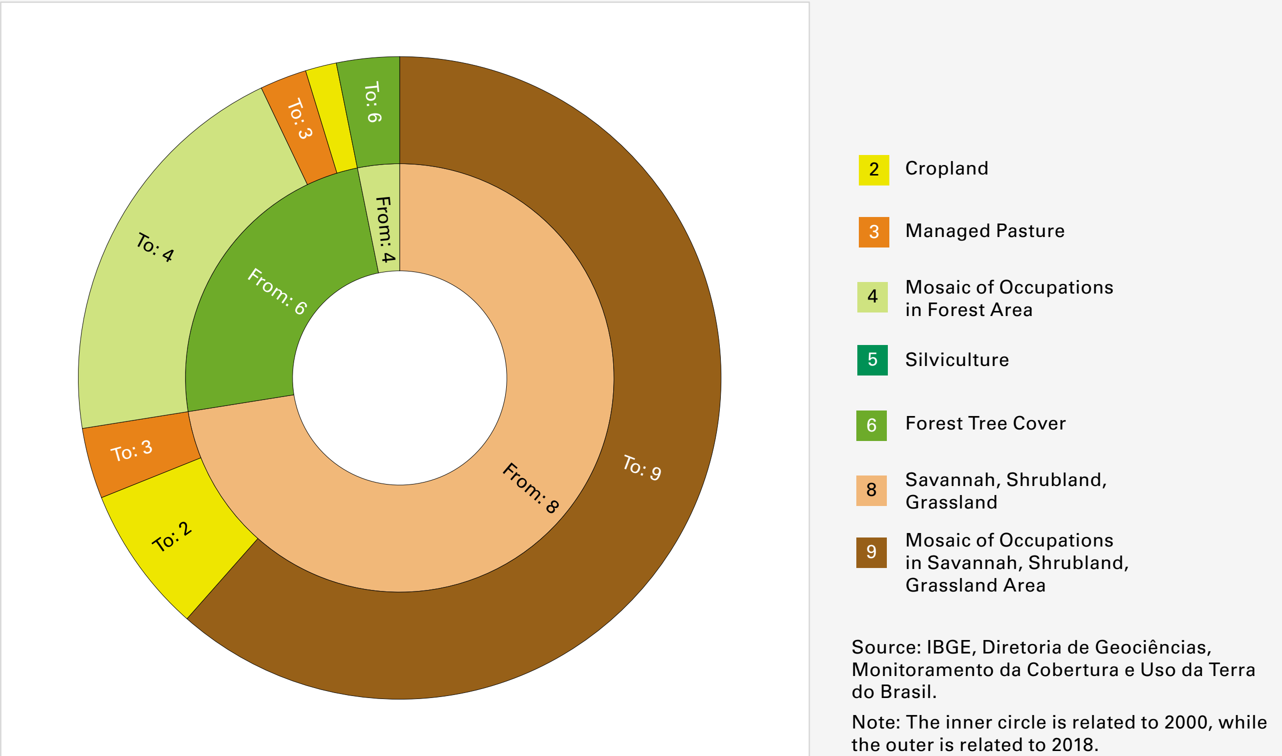
In the Caatinga Biome, in 2018, there was a predominance of the savannah, shrubland and grassland category in 46.8% of its territory, followed by mosaic of occupations in savannah, shrubland and grassland areas (17.4%) and forest tree cover (16.4%) categories, with only 5.6% of strictly anthropogenic uses under the form of managed pasture . However, the biome presents a continuous decrease in its natural cover (Photo 7), both in savannah, shrubland and grassland areas and in forest tree cover areas: the former, between 2000 and 2018, had its area reduced by 26,768 km², while the later recorded a reduction of 8,560 km² (Attachment 4).

Photo 7 - Area of natural savannah, shrubland and grassland vegetation in Bahia

Photo: Ana Clara Alencar Lambert, 2019.

The reduction observed in the natural areas accompanies the growth in the mosaic of occupations, cropland, and managed pasture areas (Chart 5), a process most prominently registered between 2000 and 2014, with a slower growth in the remaining period. In the total period analyzed, that is, from 2000 to 2018, 47.3% of the changes in land use and land cover that occurred in the Caatinga Biome were related to the conversion of savannah, shrubland and grassland vegetation into mosaic of occupations in savannah, shrubland and grassland areas. Also during that period, 48.7% of new cropland areas in the biome originated from the conversion of savannah, shrubland and grassland vegetation, and only 2.5% from managed pasture. Although representing only 1.5% of the area of the biome, the cropland area category presented a noteworthy increase, growing from an area of 7,213 km² in 2000 to 12,621 km² in 2018, corresponding to a 74.9% increase.

Chart 5 - Conversions of land cover and land use in the Caatinga Biome - 2000/2018



Source: IBGE, Diretoria de Geociências, Monitoramento da Cobertura e Uso da Terra do Brasil.

Note: The inner circle is related to 2000, while the outer is related to 2018.

Regarding the total growth of the managed pasture and cropland areas in Brazil between 2000 and 2018, only 3.1% and 2.6%, respectively, took place in the Caatinga Biome, which is mostly located in the Northeastern Region, with nine states representing only 14.5% of the national GDP, according to the SCR (SISTEMA..., 2019). In terms of *per capita* GDP, in 2017, Piauí was the second smallest state in Brazil, followed by Paraíba, Alagoas, Ceará, Acre, Bahia, Sergipe, and Rio Grande do Norte, all in the Northeastern Region, except for Acre. In 2017, some states in the Northeastern Region presented a positive development in GDP volume, which increased the percentage of the region to 1.6% when compared to the previous year, mostly due to the services sector.

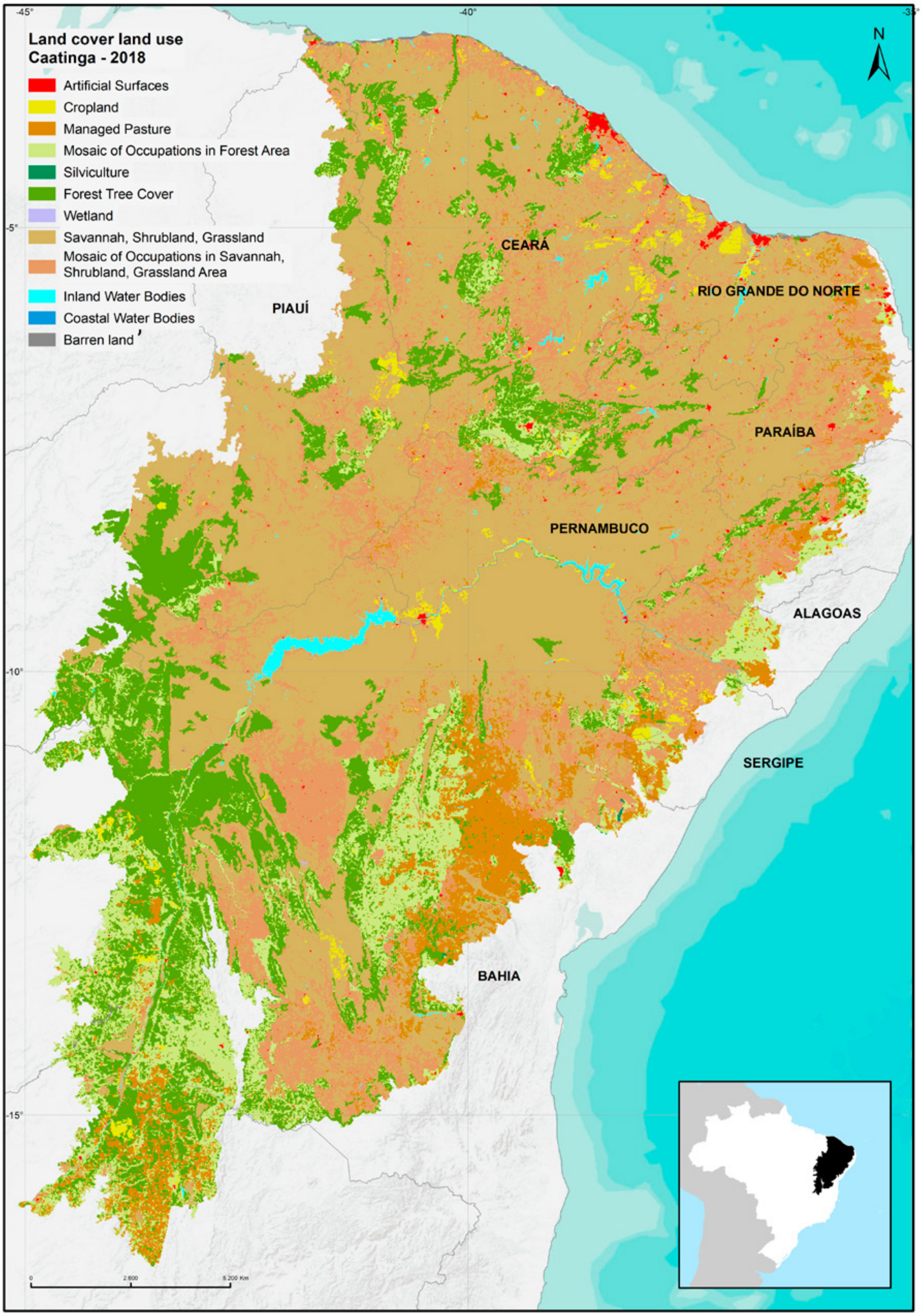
The forest and savannah, shrubland and grassland mosaic categories are strongly present in the region. This is due to the occupation form of the territory, represented by a high number of small rural properties, as shown in the Agricultural Census 2017 (CENSO..., [2020]), characterized by subsistence harvesting or diversified crops, or even small pasture lands (Photo 8). Another type of use that may have contributed to this occupation pattern are the agro-forestry systems, one among the several adaptation strategies used by farmers to the edaphic and climatological conditions in the Semi-arid region, corresponding to approximately 20% of the area of the enterprises in the region (CENSO..., [2020]). It is important to note that, given the spatial scale of analysis of the data, these uses with a small spatial expression are identified as mosaics in the mapping of IBGE's Monitoring, and even small population centers can be associated with those categories.

Photo 8 - Cattle among the savannah, shrubland and grassland vegetation in the sertanejo (backcountry) landscape.

Photo: Adriana de Azevedo Santino, 2017

In this way, the Caatinga Biome has been deforested, mainly in recent years, due to the consumption of native logs for domestic and industrial purposes, according to the Ministry of the Environment (ATLAS..., 2007), pasture, and conversion into small farming areas. That is, the changes in land cover have mainly been caused by the search for essential human needs (wood for energy purposes, extensive pasture for subsistence farming, for instance), reason for which the mosaics of occupation remain. It is important to emphasize that there are a few exceptions, where artificial irrigation allowed the harvesting of fruit for export in the Semi-arid region, as pointed out in a study from Embrapa (CORREIA; ARAÚJO; CAVALCANTI, 2001), and also in the São Francisco River Basin (Map 7).

Map 7 - Land Cover and Land Use in the Caatinga Biome - 2018



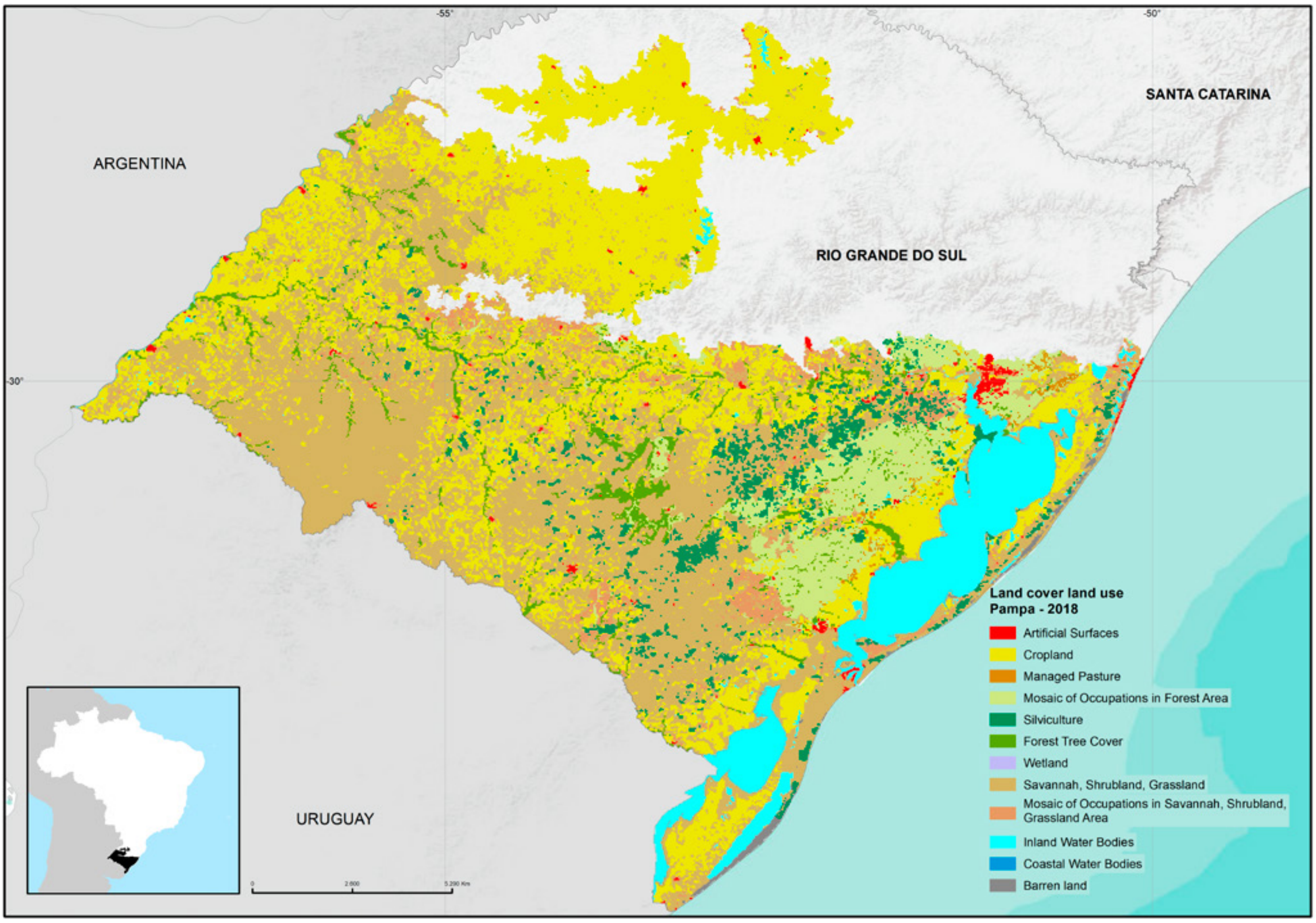
Source: MONITORAMENTO da cobertura e uso da terra do Brasil 2016-2018. Rio de Janeiro: IBGE, 2020. Available at: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101703. Accessed: August 2020.

Pampa Biome

The Pampa Biome is restricted to the state of Rio Grande do Sul and occupies 68.8% of the state territory and 2.1% of the Brazilian territory. It is characterized by the predominance of native grasslands, according to data from BDiA (IBGE, [2018]), which constitute a much less exuberant vegetation structure when compared to the Brazilian forests and savannahs, but not less relevant from the point of view of the services the ecosystems provide. The potential for sustainable development of the region is intimately linked to the flora species in the rural area with foraging, feed, ornamental and medicinal value, as pointed out by the Instituto Brasileiro do Meio Ambiente e Recursos Naturais Renováveis - Ibama (PAMPA..., [2015]), but which are also responsible for other environmental regulating services, such as the control of soil erosion and carbon sequestration, for example.

In 2018, the Pampa Biome was predominantly savannah, shrubland and grassland (37.4%), followed by the cropland category (36.3%), as well as 19.3% of the natural barren land areas in Brazil, which includes dunes and sandy areas. However, its territory underwent intense changes in the past decades, registering a reduction of 15,607 km^2 in its natural savannah, shrubland and grassland vegetation from 2000 to 2018 (Attachment 5). During this period, the largest areas converted into other land uses were: 58.0% of savannah, shrubland and grassland into cropland; and 18.8% into silviculture area. Also worth noting is the fact that this expansion takes place over sedimentary basins, an important area of reloading of the Guarani aquifer, one of the largest and most important underground water bodies in the country (Map 8).

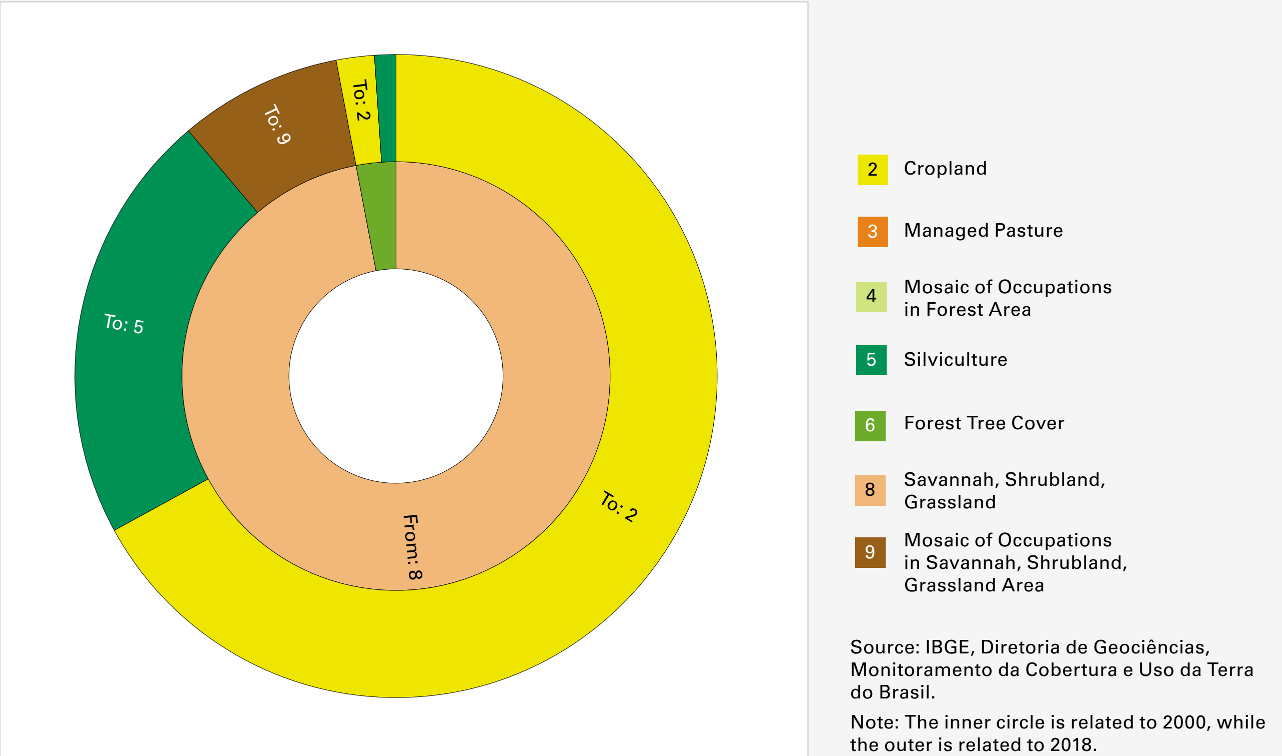
Map 8 - Land Cover and Land Use in the Pampa Biome - 2018



Source: MONITORAMENTO da cobertura e uso da terra do Brasil 2016-2018. Rio de Janeiro: IBGE, 2020. Available at: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101703. Accessed: August 2020.

Such replacement (Chart 6) was directly responsible for the expansion of croplands, following the national trend of investment in commodities, especially soybean and other grains, but also with emphasis on the farming of food items, such as rice (Photo 9) and wheat, according to the Agricultural Census 2017 (CENSO..., [2020]). The progressive introduction and expansion of single crops in the region has led to a disfigurement of southern natural landscapes in Brazil, as well as the traditional figure of the *gaúcho* – a national ecological and cultural heritage (PAMPA..., [2015]). However, the state of Rio Grande do Sul experienced a loss of GDP mainly due to the farming sector, due to the reduction in price of its main products in 2016 and 2017, according to the SCR (SISTEMA..., 2019).

Chart 6 - Conversions of land cover and land use in the Pampa Biome - 2000/2018



Source: IBGE, Diretoria de Geociências, Monitoramento da Cobertura e Uso da Terra do Brasil.

Note: The inner circle is related to 2000, while the outer is related to 2018.

The remarkable expansion of silviculture, growing from an area of 2,700 km² to 6,838 km², was in part caused by a large increase between 2000 and 2010. After 2010, silviculture continues expanding at a slower, but constant rate. This land use in the region is associated to the paper and pulp industry: the Southern Region, where the state of Rio Grande do Sul is located, had in 2018 the largest share in the value of national production from silviculture (32.5%). It is important to mention that the state contains the predominant areas covered by pine forests in the country, corresponding to half of that observed in the total of the Great Region, according to PEVS (PRODUÇÃO..., 2018).

Since the Iberic colonization, extensive cattle raising on native fields (Photo 10) has been the main economic activity in the region (PAMPA..., [2015]). It can be noted that the managed pasture category is not representative in the Pampa Biome, even if the region is relevant in the production of cattle, horses, and other herds, according to data from the Municipal Farming Survey (*Pesquisa da Pecuária Municipal* - PPM) developed by IBGE (PESQUISA..., [2020]). This is because the pasture land use category occurs in the rural areas with natural coverage in the pampas, where the cattle farmers in the region have the tradition of using it for extensive breeding of cattle.

Photo 9 - Rice plantation in the southern grasslands

Photo: Elisete Fatima Pilz Paules, 2017.

Photo 10 - Grassland areas with pasture in the fields of Rio Grande do Sul

Photo: Ana Clara Alencar Lambert, 2019.

Pantanal Biome

The flood plain of the Pantanal Biome (Photo 11), where the Pantanal Mato-Grossense National Park is located, is internationally protected under the Convention on Wetlands of International Importance, also known as the Ramsar Convention[15], signed in 1971 in Ramsar, Iran, and promulgated in Brazil through Decree No. 1905, dated 05/16/1996 (BRAZIL, 1996). This treaty establishes landmarks for national actions and for cooperation between countries for the purpose of promoting the preservation and rational use of wetlands in the world, and was added to the country's legal framework. These actions are based on the recognition, by the signatory countries to the Convention, of the ecological importance and the social, economic, cultural, scientific, and recreational value of such areas.

Photo 11 - Flood plain in the Pantanal Biome

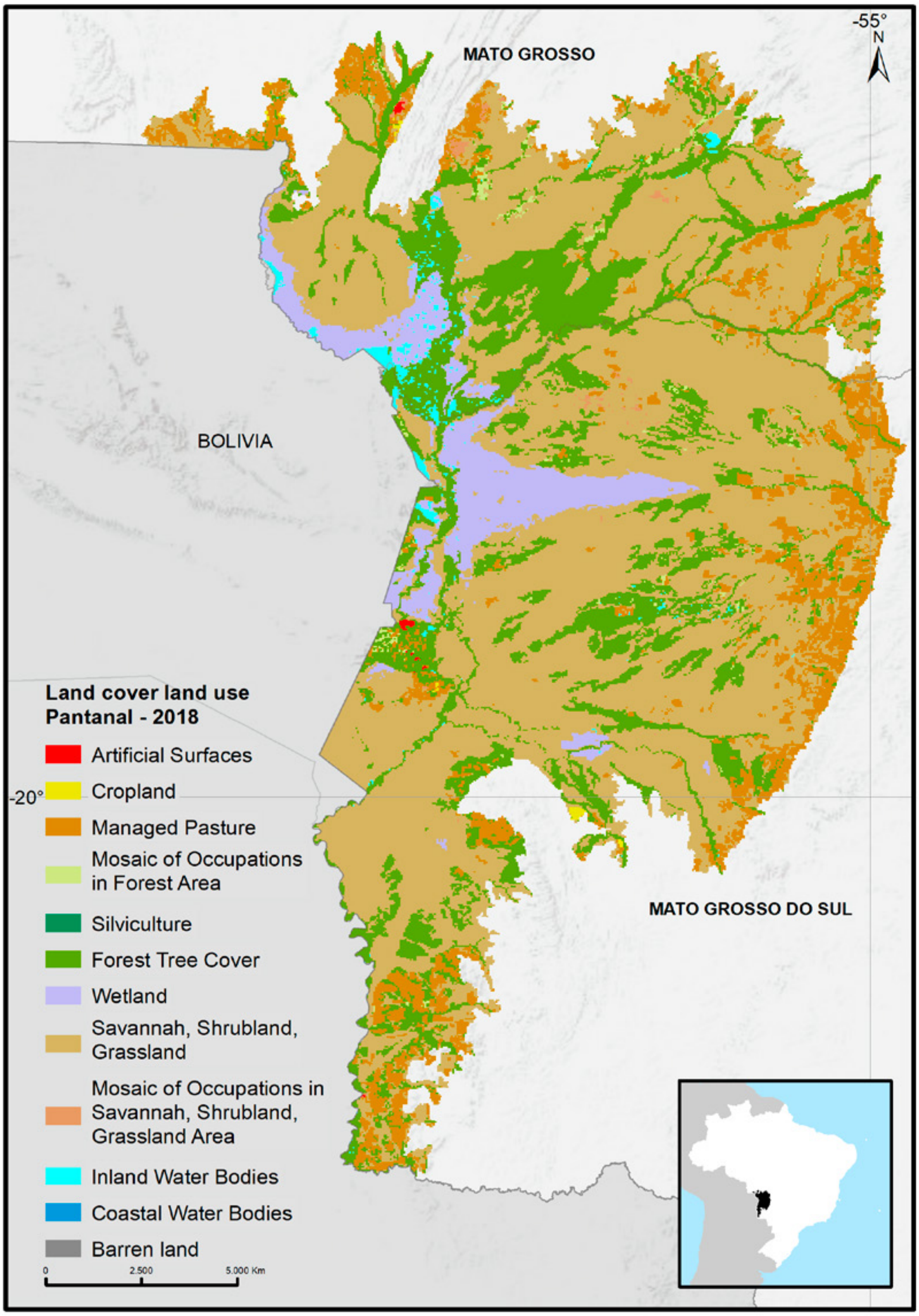
Photo: Fernando Peres Dias, 2015.

The Pantanal Biome is regarded as one of the largest continuous wetlands on the planet, according to the Ministry of the Environment (BRASIL, [2020c]), and has approximately 90% of its area formed by plains, where it encompasses 48.3% of the total wetland area in in Brazil, according to data from BDiA (IBGE, [2018]). The Pantanal Biome has predominant savannah, shrubland and grassland vegetation, totaling 91,711 km² in 2018 (Attachment 6), but it is also interesting to note the great relevance of other categories of natural cover (Map 9). In 2018, there were 31,045 km² of forest tree cover vegetation, which comprised the seasonal forests in the region, as well as 9,340 km² of wetlands, identified by IBGE Monitoring, and this diversity is exactly what makes it a unique biome.

With all its natural and exuberant beauty, this region is often sought for tourism and leisure, as noted in the report from the Program of Strategic Actions for the Integrated Management of Pantanal and the Basin of High Paraguay (*Programa de Ações Estratégicas para o Gerenciamento Integrado do Pantanal e Bacia do Alto Paraguai*) (AGÊNCIA NACIONAL DE ÁGUAS, 2004); however, it must be emphasized that in 2018, 87.5% of its territory had natural cover (forest tree cover, savannah, shrubland and grassland, as well as wetland areas) and most of the verified changes (54.9%) from 2010 correspond to the conversion to managed pasture (Photo 12), the most intense periods being from 2000 to 2012, with 56.1%, and from 2016 to 2018, with 34.5% (Attachment 6). In general terms, this conversion takes place over the natural savannah, shrubland and grassland areas (Chart 7), where a reduction of 2,090 km² in this vegetation was observed, proportional to the increase of 2,501 km² of the managed pasture areas.

[15] Regarding the protection and sustainable management of wetlands, Brazil is a party, since 1993, to the Ramsar Convention, which, although originally aimed at the preservation of the habitat of migrating species of aquatic birds, gained new priorities over time related to the sustainable use of biodiversity and the management of hydric resources.

Map 9 - Land Cover and Land Use in the Pantanal Biome - 2018

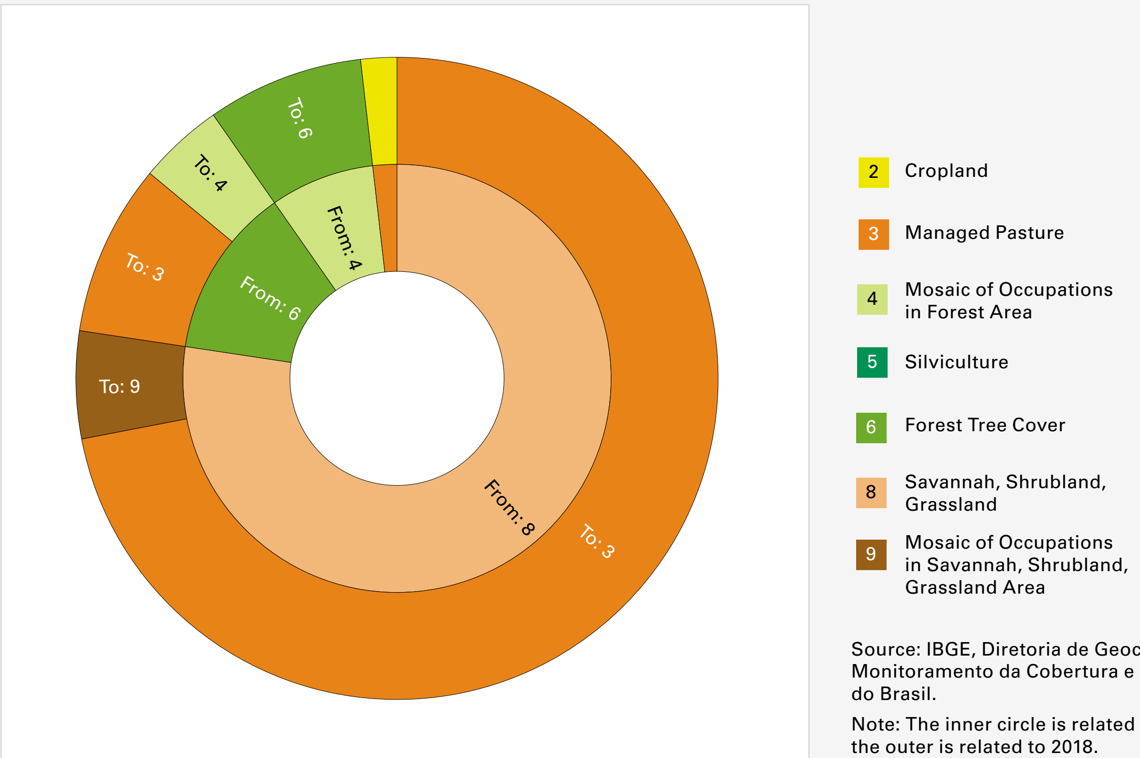


Source: MONITORAMENTO da cobertura e uso da terra do Brasil 2016-2018. Rio de Janeiro: IBGE, 2020. Available at: https://biblioteca.ibge.gov.br/index.php/biblioteca-catalogo?view=detalhes&id=2101703. Accessed: August 2020.

Photo 12 - Managed Pasture in dry and flooded area in the Pantanal landscape

Photo: Ana Clara Alencar Lambert, 2018.

Chart 7 - Conversions of land cover and land use in the Pantanal Biome - 2000/2018



Source: IBGE, Diretoria de Geociências, Monitoramento da Cobertura e Uso da Terra do Brasil.

Note: The inner circle is related to 2000, while the outer is related to 2018.

Pasture in the savannah, shrubland and grassland vegetation areas is the traditional use of the region in the Pantanal Biome, for over two centuries, with little intense management and the maintenance of cattle following the floods and ebbs, as well as the expansion of pastures through controlled fires. The investment in managed pasture, with the planting of several species of exotic foraging plants and the formation of delimited pastures, seems to present greater profitability and has been replacing this traditional form of farming in the region in order to gain competitiveness in the global market, as pointed out in studies by Embrapa (SANTOS et. al, 2005). However, the greatest impacts of human action are mainly resulting from the cropland activity developed in the uplands that surround the Pantanal Biome, which belong to the Hydrographic Basin of High Paraguay (Bacia Hidrográfica do Alto Paraguai), and which provide water and sediments to the biome (BRAZIL, 2006).

The wetland category has remained stable over time, but it is important to note that it occupies grassland and forest areas at times and is occupied by natural pasture, meaning that although its area is preserved, its transformations are dynamic. Finally, it is important to state that these areas provide essential ecosystem services not only for the fauna and the flora, but also for the well-being of human populations; as well as regulating the hydric regime of large regions, these areas also function as a source of biodiversity on all levels, thus fulfilling a relevant role of an economic, cultural, and recreational nature. Simultaneously, it meets the needs of water and food for a large variety of species and human communities, both rural and urban alike.

Another important character in this biome to be emphasized is that it has the ecologic purpose of serving as a feeding location to many migratory birds, such as the Tuiuiú, the bird that is the symbol of Pantanal, providing an environment of extreme importance to the preservation and maintenance of such species, as noted in the study by Embrapa (NUNES; TOMAS; 2004). Additionally, this biome also holds some of the endangered species in the National Territory, such as the jaguar and the tapir (BRAZIL, 2014b), the latter being the largest terrestrial mammal in South America. And, despite being the smallest biome in terms of its territorial extent in Brazil, its nature holds a wealth of flora, which according to a study from Embrapa Pantanal (JORGE; BORSATO, 2009), includes approximately 2,000 species of plants, as well as presenting medicinal potential.

The current status of land cover and land use changes: highlights from 2016 to 2018

The calculation of the Change Intensity Indicator - IIM for the Brazilian territory and its spatialization allowed a strong demonstration of the distribution of locations, or regions, where the main changes in land cover and land use took place, based on the IIM calculation methodology (Map 10). In this map, the color shades range from the IIM with the lowest intensity of change (1) to the highest (3), and where the boundaries of the terrestrial biomes are listed, allowing the analysis of their territorial arrangement. For the spatial information to be able to provide an appropriate visualization in the cartographic scale presented herein, the representation by punctual implementation with exaggerated geometric symbols was chosen, with each dot corresponding to 1 km^2.

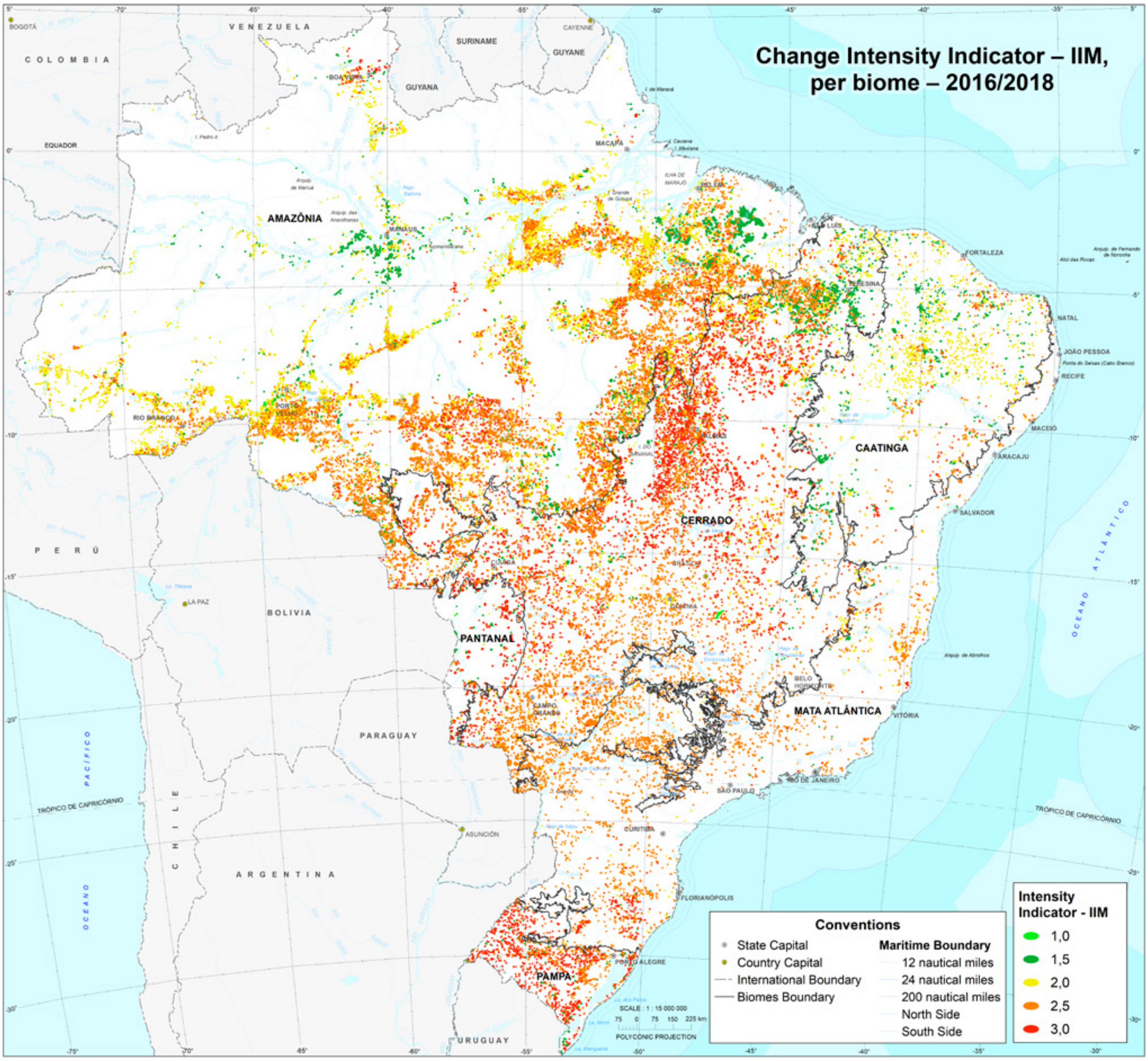
The map shows an overall trend of the land use dynamic in Brazil in relation to the current expansion of agricultural activities in the territory. This allows a great concentration of points of change to be observed between the Amazônia and Cerrado Biomes, many of them with high IIMs (2.5 and 3.0), which indicates intense changes in the landscape of those regions. The Pampa Biome was also highlighted with a relatively elevated number of high-intensity points of change (3.0) in its reduced area, pointing to an intense transformation of that spatial unit in the considered period.

The other biomes are characterized by less intense dynamics when compared to those previously mentioned. The Mata Atlântica Biome presented points of change mainly on its borders with the Cerrado Biome, most of them classified with an IIM of 2.5, which represents high intensity of change in these areas. The Caatinga Biome presented points of change scattered throughout its area, but without high intensity, mainly with an IIM of 1.5 and 2.0. The Pantanal Biome did not present high numbers of points of change, but some with high IIM (3.0) on the border with the Cerrado Biome, indicating a rapid increase in the dynamism on the eastern border of the biome.

In a quantitative analysis, it was detected that between 2016 and 2018, there were 87,242 km^2 of changes in the land cover and land use in Brazil, which corresponds to approximately 1% of the National Territory (Attachment 7). These transformations show key developments and define spatial patterns that allow better comprehension of the Brazilian territorial dynamic. Thus, the use of an IIM associated to an analysis on the absolute areas of the types and proportions of those changes in the Brazilian biomes helps in understanding the relevant events that occurred in the analyzed period.

First, it is important to evaluate the concentration of the total changes, according to those spatial units. The biomes showing the greatest changed areas were the Amazônia, with changes of 46,799 km^2, and the Cerrado, with changes of 28,289 km^2, encompassing approximately 90% of the total changes. Smaller changes took place in the Mata Atlântica, with 4,615 km^2; Caatinga, with 3,925 km^2; Pampa, with 2,465 km^2; and Pantanal, with 1,149 km^2. Despite the discrepancy in absolute figures among the modified areas, it is emphasized that the quantitative order of change follows the differences among the territorial areas of the biomes, ranging from 0.4% to 1.4% of changes in each of them.

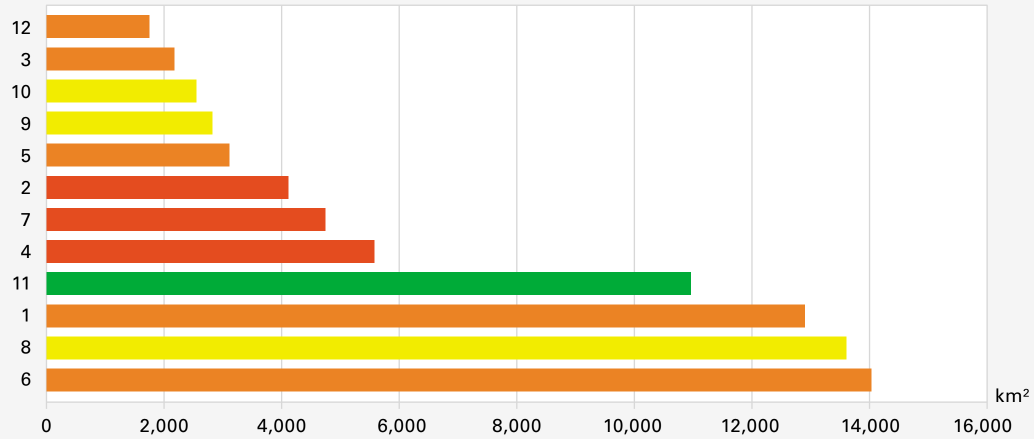
Map 10 - Spatialization of the Change Intensity Indicator - IIM in the land use and land cover in Brazil in 2016 and 2018



Source: IBGE, Diretoria de Geociências, Coordenação de Recursos Naturais e Estudos Ambientais.

In order to understand these types of changes, a detailed analysis must be performed on the category conversions that most frequently took place in Brazil between 2016 and 2018, using the classification according to the IIM as a reference (Chart 8). In this period, it can be noted that most of the changes taking place in the land cover and land use have an IIM of 2.5 (approximately 40% of the total), that is, it points to a variation among the categories of strict anthropogenic uses. The main change consisted of 14,039 km² of managed pasture that was transformed in cropland area. In 2,172 km² of the country, the opposite occurred – cropland gave way to managed pasture.

Chart 8 - Intensity of the main types of changes in land cover and land use in Brazil (Area in km² - 2016-2018)



Change Intensity Indicator - IIM

1.0 1.5 2.0 2.5 3.0

Type of change

	From	To
1	Mosaic of Occupations in Forest Area	Managed Pasture
2	Forest Tree Cover	Managed Pasture
3	Cropland	Managed Pasture
4	Savannah, Shrubland, Grassland	Managed Pasture
5	Mosaic of Occupations in Forest Area	Cropland
6	Managed Pasture	Cropland
7	Savannah, Shrubland, Grassland	Cropland
8	Forest Tree Cover	Mosaic of Occupations in Forest Area
9	Managed Pasture	Mosaic of Occupations in Forest Area
10	Savannah, Shrubland, Grassland	Mosaic of Occupations in Savannah, Shrubland, Grassland Area
11	Mosaic of Occupations in Forest Area	Forest Tree Cover
12	Managed Pasture	Silviculture

Source: IBGE, Diretoria de Geociências, Coordenação de Recursos Naturais e Estudos Ambientais.

Other transitions indicated by an IIM of 2.5, but from the broader and more diverse uses, were the areas of mosaic of occupations in forest or savannah, shrubland and grassland areas, which were converted in managed pasture or cropland areas, characterizing an increase in anthropogenic use of 18,376 km² of the territory. Still worthy of note is the conversion of 1,751 km² of managed pasture in silviculture. Regarding the areas that became mosaics in 2018, with an IIM of 2.0, there is an indication of processes that point to degradation or fragmentation of the landscape, referring to natural forest tree cover or savannah, shrubland and grassland cover that became their corresponding mosaics of occupations, for a total of 16,149 km², or approximately 20% of all changes.

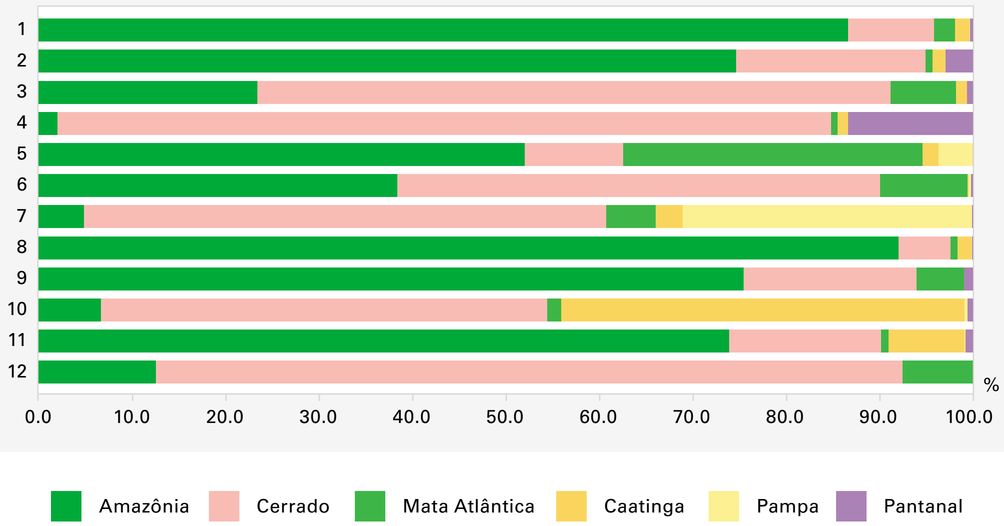
From an opposite perspective, that of categories of strict anthropogenic uses that were converted into mosaics, emphasis must be added to the managed pastures that became mosaics of occupations in forest areas, with 2,818 km² detected between 2016 and 2018. It is important to emphasize that the categories involving changes to mosaics have an IIM of 2.0 since they indicate some type of gradual transition in a period of two years, which may or may not be consolidated in the following periods. It is possible for the category to return to its previous state, pointing at some atypical phenomenon, or natural process, which is difficult to understand given the spatial resolution of the analysis.

Among the most intense changes, with an IIM of 3.0, it is important to emphasize the one that represents natural vegetation, whether savannah, shrubland and grassland or forest tree cover, which became category of strict anthropogenic use in this two-year interval, with a total of 15,852 km^2 of changes in Brazil, or 18.1% of the total. Within this conversion, the most remarkable change was the one observed in the vegetation category (9,690 km^2 consisting of savannah, shrubland and grassland and forest combined), which became managed pasture. From the remnants of those areas, 4,744 km^2 of savannah, shrubland and grassland vegetation became cropland, which shows the advance of this economic activity over the natural areas in the country.

Finally, the IIM of 1.5 represents a change in broad or strict uses for natural cover, which can be interpreted as regeneration, as long as its permanence in the historical series is evaluated. This is the type of change with less presence in the National Territory in the analyzed period, and it can be noted that there is a predominance of the category of mosaics of occupations in forest areas which became forest tree cover vegetation, with 10,956 km^2. The mosaics of occupations in savannah, shrubland and grassland areas that were converted into savannah, shrubland and grassland vegetation took place in a smaller area (1,381 km^2), indicating that the regeneration of the natural cover is seen as a gradual and/or fragmented change process in the territory.

In order to understand the distribution of those types of changes in the Brazilian territory, an analysis through the biome profile may clarify a series of territorial patterns (Chart 9). In the Amazônia Biome, there is a large predominance of changes related to forest tree cover, with processes that point to its reduction. In the case of forest tree cover areas converted into mosaics of occupations (change 10 in Chart 9), it can be observed that over 90% took place in that biome. The other transformations demonstrate the maintenance of the dynamic of transitions between forest tree cover, mosaic of occupations in forest areas, managed pasture and cropland area, typical of the process of occupation and exploitation in the Amazonian region.

Chart 9 - Intensity of the main types of changes in land cover and land use in Brazil, per biome - 2016/2018



Type of change

	From	To
1	Mosaic of Occupations in Forest Area	Managed Pasture
2	Forest Tree Cover	Managed Pasture
3	Cropland	Managed Pasture
4	Savannah, Shrubland, Grassland	Managed Pasture
5	Mosaic of Occupations in Forest Area	Cropland
6	Managed Pasture	Cropland
7	Savannah, Shrubland, Grassland	Cropland
8	Forest Tree Cover	Mosaic of Occupations in Forest Area
9	Managed Pasture	Mosaic of Occupations in Forest Area
10	Savannah, Shrubland, Grassland	Mosaic of Occupations in Savannah, Shrubland, Grassland Area
11	Mosaic of Occupations in Forest Area	Forest Tree Cover
12	Managed Pasture	Silviculture

Source: IBGE, Diretoria de Geociências, Coordenação de Recursos Naturais e Estudos Ambientais.

The distribution pattern of those changes is reiterated in what is referred to as "consolidated settlement arc", as observed in Map 10, extended in the east of the state of Pará and north of the state of Mato Grosso, to the states of Rondônia and Acre, with great dynamism, and also driving inland, accompanying the roads, such as BR-230 (Trans-amazon highway), BR-163 (Cuiabá-Santarém), and BR-174 (Manaus-Boa Vista). In addition, regarding the period from 2016 to 2018 specifically, it is important to note that the previously mentioned areas of mosaic of occupations in forest areas that became forest tree cover vegetation (change 8 in Chart 9) are concentrated in over 70% of the Amazônia Biome.

However, it is reiterated that it is early to state that it is a regeneration process, especially due to it being an atypical change in the northeastern region of the state of Pará (Map 10), which may or may not be related to natural processes, according to INPE (INFOQUEIMA, 2016). In that region, considering the entire historical series in IBGE Monitoring, which covers the period from 2000 to 2018, the categories of mosaics are present only in 2016, with forest coverage in all other years. Therefore, it seems there has not been actual deforestation in these areas in 2016, but probably a specific focal point of wildfire, as observed by IBGE (MONITORAMENTO..., 2020).

For the Cerrado Biome, the greatest relevance lies in the changes involving savannah, shrubland and grassland areas, due to their own natural characteristics, being the biome where most of the savannah, shrubland and grassland vegetation areas were converted into managed pasture and cropland areas in the country (changes 4 and 7 in Chart 9). It can also be noted that the dynamic between the categories of strict anthropogenic use - from cropland areas that were converted into managed pasture and from managed pasture that was converted in cropland area - mostly takes place in this natural environment (changes 3 and 6 in Chart 9). It is important to remember that the conversion from managed pasture to cropland area was the most frequent change in the period from 2016 to 2018, lending great emphasis to the biome.

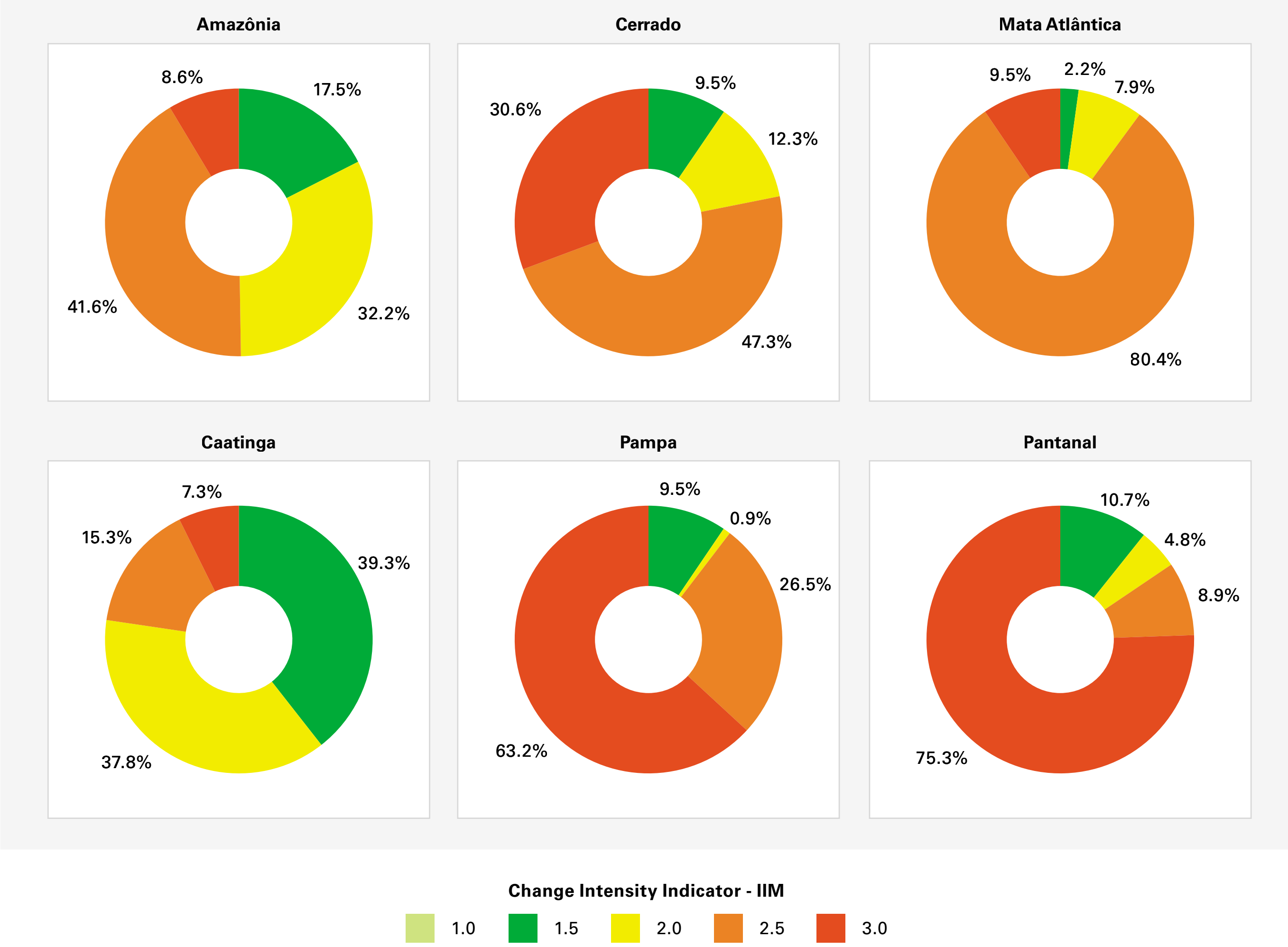
Such change is concentrated in the Center-South axis in Brazil, and is related to the favorable natural conditions, especially in red oxisol and flat landscape, according to data from BDiA (IBGE, [2018]), and also due to the high capacity of investment of the economic agents in the most profitable commodities, according to the market scenario, which is represented in the highest production and income values of rural properties in the country in the region, as identified by the Agricultural Census 2017 (CENSO..., [2020]).The conversions of savannah, shrubland and grassland vegetation to cropland areas, in turn, were concentrated in the region referred to as Matopiba, which shows, in the period under analysis, a rapid expansion of agribusiness to the North, dominating large areas in the states of Tocantins and Maranhão.

The other biomes did not present predominance in the transformations pointed out in Chart 9. However, a few important changes must be discussed.The Mata Atlântica Biome is relevant in the transitions of areas of mosaic of forest occupation and managed pasture to cropland areas, and vice versa.The characteristic transformations in that area with a historically consolidated use, and which is contemplated by programs for the preservation of native vegetation, present fewer changes when compared to the other biomes.The changes among strict anthropogenic uses in the biome are also concentrated in the Center-South region, accompanying the dynamic on the border of the Cerrado Biome, notably in western São Paulo, northern Paraná, and the south of Mato Grosso do Sul.

The Caatinga Biome stands out regarding the conversion of savannah, shrubland and grassland vegetation into mosaics, indicating a pattern of land use with a large number of rural enterprises with small areas, according to data from the Agricultural Census 2017 (CENSO..., [2020]), which renders the interpretation of the mapping scale quite complex in the categories of mosaics of occupation.The Pampa Biome presents a considerable proportion of change in the areas of savannah, shrubland and grassland vegetation that became cropland areas.This fact is relevant, since it means a probable degradation of the biome at an accelerated rate, due to the greater concentration of investments by credit cooperatives (CENSO..., [2020]).

Similarly, an important change can also be observed in the Pantanal Biome: the replacement of savannah, shrubland and grassland vegetation, traditionally used as native pasture, by managed pasture, indicating the maintenance of the economic predominance of cattle raising, but with new techniques, substituting the traditional farming patterns in the region. Given the differences of proportion in the areas of change in the biomes, by analyzing them by type of change, important processes can be observed, and when analyzed by the IIM, the relevance of the internal dynamic of the changes in each biome can be assessed (Chart 10).

Chart 10 - Change Intensity Indicator - IIM, per biome - 2016/2018



Source: IBGE, Diretoria de Geociências, Coordenação de Recursos Naturais e Estudos Ambientais.
Note: The IIM values = 1.0 are less than 0.4% and are not visible in the charts.

The Pampa and Pantanal biomes combined experienced only 4.1% of the changes in land cover and land use in the country; however, they are predominantly intense (highest internal proportion of IIM with value 3.0), which represents the conversion of large areas of natural, savannah, shrubland and grassland or forest vegetation into cropland areas in the Pampa biome, and to managed pasture in the Pantanal Biome. The proportion of changes with IIM of 3.0 in the Cerrado Biome is 30.7% and refers to the aforementioned transition from savannah, shrubland and grassland vegetation to cropland between 2016 and 2018, which makes it the biome with the highest absolute quantity of intense changes in Brazil. Of the Amazônia Biome 8.6% of its territory falls in that category, mainly resulting from the expansion of the cropland areas in the uplands in the north of the state of Mato Grosso and east of the state of Pará, and from the conversion of forest tree cover into managed pasture in the vicinity of the city of Boa Vista, in the state of Roraima.

In the Cerrado and Mata Atlântica Biomes there is a predominance of an IIM of 2.5 with change among anthropogenic uses, notably cropland and pasture, which demonstrates the great influence of such areas in the dynamic of those regions. Add to that the changes in areas of managed pasture into silviculture, often present in those biomes, representing the regional concentration of the paper and pulp industries. The IIM of 2.0, which points to changes of intermediate intensity, related to mosaics, is relevant in the Caatinga and Amazônia Biomes for different reasons: in the former, in savannah, shrubland and grassland areas, due to its disperse land structure with diverse uses; and, in the latter, for its continuous dynamic of transition of uses between forest tree cover vegetation, mosaics of occupations, managed pasture, and cropland area, a pattern of the 'pioneer front'.

An IIM of 1.5 may indicate regeneration of the vegetation if it is maintained in the historical series, and was more relevant in the Caatinga biome in the analyzed period, presenting a disperse spatial pattern in the biome. This conversion into savannah, shrubland and grassland vegetation may be related to the system of abandonment and roaming of the region in certain areas previously occupied by pasture or subsistence farming activities. In relation to the Amazônia and Cerrado Biomes, an analysis during the coming periods is necessary, considering that the conversion occurs in extremely dynamic areas, contiguous to several other changes, notably in the North of the state of Maranhão and Northeast of the state of Pará.

Final remarks

This first issue of the Brazilian Ecosystem Accounts presents the results, in general terms, of the state of preservation of the ecosystems in the Brazilian terrestrial environment, for the environmental profile of biomes, and an analysis of their corresponding remaining natural areas, as well as the main land use conversions present in those ecological units, in their peculiar ways, in each part of the National Territory.

From the spatial analysis, it was possible to understand the environmental territorial dynamic of the country and identify the regions where the land use conversions took place more or less intensely. Therefore, it is important to note the Amazônia and Cerrado Biomes with the highest proportion of changes, in a complex system that involves the reduction of natural areas - forest and savannah, shrubland and grassland , respectively - and the expansion of cropland use, whether intensive or not.

This study presented some of the greatest challenges in terms of accounting for a stock of natural resources as diverse in its landscapes and biodiversity, which is not always reflected in the spatial unit of the biomes. Therefore, it is essential to evolve to an environmental profile with greater detailing of the ecosystem types in the next issues, which will then be capable of presenting results on larger analysis scales.

Furthermore, in order to evaluate the extent of Brazilian ecosystems, it is important to emphasize other possible spatial analysis units that may be relevant to the environmental scenario of the country, which can also be considered within the accounting scope, such as Regions/Hydrographic Basins and Priority Areas and Conservation Units - the former, due to the note to further the research in the aquatic environment, and being an appropriate profile for the nature of its data; the latter by being in compliance with the panorama of the Brazilian legislation currently in force.

Regarding the Change Intensity Indicator - IIM, this publication presented the potential of its application to understand the key changes observed in land use conversions in the Brazilian territory; however, it was punctually calculated in time and space. Therefore, its methodological improvement to a weighting of the indicator by areas of ecosystems, as well as its interpretation throughout the time series, may present an interpretation of the environmental condition in an aggregated and regular manner.

Therefore, the authors would like to see the next issues of the Ecosystem Accounts in Brazil to include a greater diversity of relevant and priority environmental matters in the national agenda, upon the incorporation of additional databases, in addition to other national and international methodological developments, aiming at the promotion of a dynamic portrait of the country in terms of its natural resources.

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Attachments

1 - Physical accounts of land - Amazônia - 2000/2018

2 - Physical accounts of land - Cerrado - 2000/2018

3 - Physical accounts of land - Caatinga - 2000/2018

4 - Physical accounts of land – Mata Atlântica - 2000/2018

5 - Physical accounts of land - Pampa - 2000/2018

6 - Physical accounts of land - Pantanal - 2000/2018

7 - Changes of land cover and land use, by biome, according to the Change Intensity Indicator (*Indicador de Intensidade de Mudanças* - IIM) - 2016-2018

Attachment 1 - Physical accounts of land - Amazônia - 2000/2018

Accounting	Area (km²)					
	Artificial Surfaces	Cropland	Managed Pasture	Mosaic of Occupations in Forest Area	Silviculture	Forest Tree Cover
2000						
Stock	**3,781**	**17,073**	**248,794**	**172,552**	**2,438**	**3,454,052**
Additions (+)	592	18,721	155,866	70,455	1,663	1,109
Reductions (-)	0	390	5,082	50,060	25	190,660
2010						
Stock	**4,373**	**35,404**	**399,578**	**192,947**	**4,076**	**3,264,501**
Additions (+)	103	3,674	18,580	16,008	389	260
Reductions (-)	0	52	1,656	10,115	17	26,736
2012						
Stock	**4,476**	**39,026**	**416,502**	**198,840**	**4,448**	**3,238,025**
Additions (+)	336	12,897	13,441	12,261	565	1,688
Reductions (-)	0	234	8,503	11,676	9	20,176
2014						
Stock	**4,812**	**51,689**	**421,440**	**199,425**	**5,004**	**3,219,537**
Additions (+)	116	7,554	5,193	22,819	414	634
Reductions (-)	0	80	7,603	5,784	4	23,099
2016						
Stock	**4,928**	**59,163**	**419,030**	**216,460**	**5,414**	**3,197,072**
Additions (+)	181	7,800	15,189	14,865	336	8,100
Reductions (-)	29	613	7,795	21,033	205	16,233
2018						
Stock	**5,080**	**66,350**	**426,424**	**210,292**	**5,545**	**3,188,939**

Accounting	Area (km²)					
	Wetland	Savannah, Shrubland, Grassland	Mosaic of Occupations in Savannah, Shrubland, Grassland Area	Inland Water Bodies	Coastal Water Bodies	Barren Land
2000						
Stock	**21,398**	**208,928**	**6,227**	**78,422**	**1,052**	**134**
Additions (+)	10	162	1,130	0	0	1
Reductions (-)	27	2,852	613	0	0	0
2010						
Stock	**21,381**	**206,238**	**6,744**	**78,422**	**1,052**	**135**
Additions (+)	24	96	310	0	0	5
Reductions (-)	41	599	233	0	0	0
2012						
Stock	**21,364**	**205,735**	**6,821**	**78,422**	**1,052**	**140**
Additions (+)	68	287	154	0	0	0
Reductions (-)	230	717	152	0	0	0
2014						
Stock	**21,202**	**205,305**	**6,823**	**78,422**	**1,052**	**140**
Additions (+)	0	10	317	0	0	0
Reductions (-)	11	431	45	0	0	0
2016						
Stock	**21,191**	**204,884**	**7,095**	**78,422**	**1,052**	**140**
Additions (+)	0	85	195	67	0	0
Reductions (-)	1	527	382	0	0	0
2018						
Stock	**21,190**	**204,442**	**6,908**	**78,489**	**1,052**	**140**

Source: IBGE, Diretoria de Geociências, Monitoramento da Cobertura e Uso da Terra do Brasil.

Attachment 2 - Physical accounts of land - Cerrado - 2000/2018

Accounting	Area (km²)					
	Artificial Surfaces	Cropland	Managed Pasture	Mosaic of Occupations in Forest Area	Silviculture	Forest Tree Cover
2000						
Stock	**7,897**	**193,874**	**419,305**	**89,857**	**17,971**	**216,761**
Additions (+)	560	50,496	70,124	2,990	7,573	206
Reductions (-)	0	1,106	13,216	17,841	753	16,367
2010						
Stock	**8,457**	**243,264**	**476,213**	**75,006**	**24,791**	**200,600**
Additions (+)	183	14,905	13,952	903	5,286	121
Reductions (-)	0	521	5,522	5,708	717	3,130
2012						
Stock	**8,640**	**257,648**	**484,643**	**70,201**	**29,360**	**197,591**
Additions (+)	232	21,404	6,905	995	4,988	62
Reductions (-)	0	436	13,138	2,401	230	2,259
2014						
Stock	**8,872**	**278,616**	**478,410**	**68,795**	**34,118**	**195,394**
Additions (+)	97	9,071	2,729	848	1,232	158
Reductions (-)	0	275	5,249	1,494	215	1,221
2016						
Stock	**8,969**	**287,412**	**475,890**	**68,149**	**35,135**	**194,331**
Additions (+)	115	11,088	8,895	1,306	2,004	1,783
Reductions (-)	0	2,023	10,029	3,334	420	1,810
2018						
Stock	**9,084**	**296,477**	**474,756**	**66,121**	**36,719**	**194,304**

Accounting	Area (km²)					
	Wetland	Savannah, Shrubland, Grassland	Mosaic of Occupations in Savannah, Shrubland, Grassland Area	Inland Water Bodies	Coastal Water Bodies	Barren Land
2000						
Stock	**3,439**	**963,468**	**61,789**	**8,735**	**3**	**1,524**
Additions (+)	0	297	4,240	0	0	6
Reductions (-)	3	79,904	7,302	0	0	0
2010						
Stock	**3,436**	**883,861**	**58,727**	**8,735**	**3**	**1,530**
Additions (+)	0	163	2,128	0	0	0
Reductions (-)	0	19,938	2,105	0	0	0
2012						
Stock	**3,436**	**864,086**	**58,750**	**8,735**	**3**	**1,530**
Additions (+)	0	258	1,389	0	0	0
Reductions (-)	1	16,132	1,636	0	0	0
2014						
Stock	**3,435**	**848,212**	**58,503**	**8,735**	**3**	**1,530**
Additions (+)	0	156	2,622	0	0	0
Reductions (-)	2	7,194	1,263	0	0	0
2016						
Stock	**3,433**	**841,174**	**59,862**	**8,735**	**3**	**1,530**
Additions (+)	0	918	2,175	70	0	5
Reductions (-)	0	8,878	1,865	0	0	0
2018						
Stock	**3,433**	**833,214**	**60,172**	**8,805**	**3**	**1,535**

Source: IBGE, Diretoria de Geociências, Monitoramento da Cobertura e Uso da Terra do Brasil.

Attachment 3 - Physical accounts of land - Caatinga - 2000/2018

Accounting	Area (km²)					
	Artificial Surfaces	Cropland	Managed Pasture	Mosaic of Occupations in Forest Area	Silviculture	Forest Tree Cover
			2000			
Stock	**3,341**	**7,213**	**40,747**	**93,329**	**12**	**150,296**
Additions (+)	141	2,354	4,327	2,636	87	57
Reductions (-)	0	68	110	3,651	5	3,376
			2010			
Stock	**3,482**	**9,499**	**44,964**	**92,314**	**94**	**146,977**
Additions (+)	118	2,420	1,492	3,779	18	103
Reductions (-)	0	28	81	1,355	3	4,264
			2012			
Stock	**3,600**	**11,891**	**46,375**	**94,738**	**109**	**142,816**
Additions (+)	67	738	1,259	1,228	14	145
Reductions (-)	0	405	42	944	1	1,475
			2014			
Stock	**3,667**	**12,224**	**47,592**	**95,022**	**122**	**141,486**
Additions (+)	53	220	321	448	0	79
Reductions (-)	0	86	55	249	0	440
			2016			
Stock	**3,720**	**12,358**	**47,858**	**95,221**	**122**	**141,125**
Additions (+)	80	382	423	245	4	888
Reductions (-)	0	119	149	1,161	0	277
			2018			
Stock	**3,800**	**12,621**	**48,132**	**94,305**	**126**	**141,736**

Accounting	Area (km²)					
	Wetland	Savannah, Shrubland, Grassland	Mosaic of Occupations in Savannah, Shrubland, Grassland Area	Inland Water Bodies	Coastal Water Bodies	Barren Land
			2000			
Stock	**28**	**430,149**	**129,571**	**6,759**	**7**	**1,108**
Additions (+)	0	454	11,932	0	0	8
Reductions (-)	1	13,788	997	0	0	0
			2010			
Stock	**27**	**416,815**	**140,506**	**6,759**	**7**	**1,116**
Additions (+)	0	187	7,458	0	0	3
Reductions (-)	2	9,107	736	0	0	2
			2012			
Stock	**25**	**407,895**	**147,228**	**6,759**	**7**	**1,117**
Additions (+)	33	818	3,589	0	0	4
Reductions (-)	0	3,851	1,176	0	0	1
			2014			
Stock	**58**	**404,862**	**149,641**	**6,759**	**7**	**1,120**
Additions (+)	15	550	1,222	0	0	4
Reductions (-)	0	1,361	721	0	0	0
			2016			
Stock	**73**	**404,051**	**150,142**	**6,759**	**7**	**1,124**
Additions (+)	0	657	1,242	11	0	0
Reductions (-)	0	1,327	899	0	0	0
			2018			
Stock	**73**	**403,381**	**150,485**	**6,770**	**7**	**1,124**

Source: IBGE, Diretoria de Geociências, Monitoramento da Cobertura e Uso da Terra do Brasil.

Attachment 4 - Physical accounts of land - Mata Atlântica - 2000/2018

Accounting	Area (km²)					
	Artificial Surfaces	Cropland	Managed Pasture	Mosaic of Occupations in Forest Area	Silviculture	Forest Tree Cover
2000						
Stock	**18,190**	**182,865**	**161,913**	**476,523**	**27,418**	**147,504**
Additions (+)	307	21,810	5,818	5,554	9,091	174
Reductions (-)	0	546	5,273	26,324	1,450	5,462
2010						
Stock	**18,497**	**204,129**	**162,458**	**455,753**	**35,059**	**142,216**
Additions (+)	104	5,614	2,118	3,433	2,058	164
Reductions (-)	0	186	1,829	6,932	1,343	2,380
2012						
Stock	**18,601**	**209,557**	**162,747**	**452,254**	**35,774**	**140,000**
Additions (+)	91	5,043	849	709	587	44
Reductions (-)	0	363	3,158	2,705	259	247
2014						
Stock	**18,692**	**214,237**	**160,438**	**450,258**	**36,102**	**139,797**
Additions (+)	41	2,031	700	1,034	111	145
Reductions (-)	0	177	1,036	1,703	42	893
2016						
Stock	**18,733**	**216,091**	**160,102**	**449,589**	**36,171**	**139,049**
Additions (+)	154	2,848	537	316	611	88
Reductions (-)	0	283	1,600	1,743	79	193
2018						
Stock	**18,887**	**218,656**	**159,039**	**448,162**	**36,703**	**138,944**

Accounting	Area (km²)					
	Wetland	Savannah, Shrubland, Grassland	Mosaic of Occupations in Savannah, Shrubland, Grassland Area	Inland Water Bodies	Coastal Water Bodies	Barren Land
2000						
Stock	**8**	**47,980**	**29,777**	**14,346**	**91**	**122**
Additions (+)	0	83	910	0	0	0
Reductions (-)	0	3,331	1,361	0	0	0
2010						
Stock	**8**	**44,732**	**29,326**	**14,346**	**91**	**122**
Additions (+)	0	84	188	0	0	0
Reductions (-)	0	703	390	0	0	0
2012						
Stock	**8**	**44,113**	**29,124**	**14,346**	**91**	**122**
Additions (+)	0	0	83	0	0	0
Reductions (-)	0	488	186	0	0	0
2014						
Stock	**8**	**43,625**	**29,021**	**14,346**	**91**	**122**
Additions (+)	0	27	511	0	0	41
Reductions (-)	0	616	174	0	0	0
2016						
Stock	**8**	**43,036**	**29,358**	**14,346**	**91**	**163**
Additions (+)	0	14	47	1	0	0
Reductions (-)	0	384	334	0	0	0
2018						
Stock	**8**	**42,666**	**29,071**	**14,347**	**91**	**163**

Source: IBGE, Diretoria de Geociências, Monitoramento da Cobertura e Uso da Terra do Brasil.

Attachment 5 - Physical accounts of land - Pampa - 2000/2018

Accounting	Area (km²)					
	Artificial Surfaces	Cropland	Managed Pasture	Mosaic of Occupations in Forest Area	Silviculture	Forest Tree Cover
2000						
Stock	**1,093**	**57,754**	**626**	**13,746**	**2,700**	**7,294**
Additions (+)	44	5,985	16	7	3,113	2
Reductions (-)	0	22	13	561	1	324
2010						
Stock	**1,137**	**63,717**	**629**	**13,192**	**5,812**	**6,972**
Additions (+)	5	1,683	3	1	558	0
Reductions (-)	0	6	20	134	3	67
2012						
Stock	**1,142**	**65,394**	**612**	**13,059**	**6,367**	**6,905**
Additions (+)	1	2,204	5	74	406	9
Reductions (-)	0	14	4	188	2	128
2014						
Stock	**1,143**	**67,584**	**613**	**12,945**	**6,771**	**6,786**
Additions (+)	5	883	0	10	18	4
Reductions (-)	0	9	2	8	4	20
2016						
Stock	**1,148**	**68,458**	**611**	**12,947**	**6,785**	**6,770**
Additions (+)	20	2,079	4	7	108	10
Reductions (-)	0	173	35	153	55	36
2018						
Stock	**1,168**	**70,364**	**580**	**12,801**	**6,838**	**6,744**

Accounting	Area (km²)					
	Wetland	Savannah, Shrubland, Grassland	Mosaic of Occupations in Savannah, Shrubland, Grassland Area	Inland Water Bodies	Coastal Water Bodies	Barren Land
2000						
Stock	**0**	**88,188**	**6,572**	**15,289**	**0**	**712**
Additions (+)	0	4	281	0	0	4
Reductions (-)	0	8,318	213	0	0	4
2010						
Stock	**0**	**79,874**	**6,640**	**15,289**	**0**	**712**
Additions (+)	0	9	182	0	0	0
Reductions (-)	0	2,154	53	0	0	4
2012						
Stock	**0**	**77,729**	**6,769**	**15,289**	**0**	**708**
Additions (+)	0	75	858	0	0	0
Reductions (-)	0	3,109	187	0	0	0
2014						
Stock	**0**	**74,695**	**7,440**	**15,289**	**0**	**708**
Additions (+)	0	17	21	0	0	0
Reductions (-)	0	821	94	0	0	0
2016						
Stock	**0**	**73,891**	**7,367**	**15,289**	**0**	**708**
Additions (+)	0	223	14	0	0	0
Reductions (-)	0	1,533	480	0	0	0
2018						
Stock	**0**	**72,581**	**6,901**	**15,289**	**0**	**708**

Source: IBGE, Diretoria de Geociências, Monitoramento da Cobertura e Uso da Terra do Brasil.

Attachment 6 - Physical accounts of land - Pantanal - 2000/2018

Accounting	Area (km²)					
	Artificial Surfaces	Cropland	Managed Pasture	Mosaic of Occupations in Forest Area	Silviculture	Forest Tree Cover
2000						
Stock	**83**	**92**	**13,397**	**1,121**	**0**	**31,196**
Additions (+)	4	4	1,445	118	0	65
Reductions (-)	0	8	47	195	0	185
2010						
Stock	**87**	**88**	**14,795**	**1,044**	**0**	**31,076**
Additions (+)	0	15	65	36	0	72
Reductions (-)	0	0	10	121	0	29
2012						
Stock	**87**	**103**	**14,850**	**959**	**0**	**31,119**
Additions (+)	4	25	175	29	6	0
Reductions (-)	0	12	61	23	0	23
2014						
Stock	**91**	**116**	**14,964**	**965**	**6**	**31,096**
Additions (+)	0	2	71	0	0	2
Reductions (-)	0	0	0	17	0	5
2016						
Stock	**91**	**118**	**15,035**	**948**	**6**	**31,093**
Additions (+)	0	33	938	39	0	87
Reductions (-)	0	13	75	128	1	135
2018						
Stock	**91**	**138**	**15,898**	**859**	**5**	**31,045**

Accounting	Area (km²)					
	Wetland	Savannah, Shrubland, Grassland	Mosaic of Occupations in Savannah, Shrubland, Grassland Area	Inland Water Bodies	Coastal Water Bodies	Barren Land
2000						
Stock	**9,208**	**93,801**	**665**	**1,426**	**0**	**0**
Additions (+)	94	219	136	0	0	0
Reductions (-)	84	1,380	186	0	0	0
2010						
Stock	**9,218**	**92,640**	**615**	**1,426**	**0**	**0**
Additions (+)	34	184	18	0	0	0
Reductions (-)	97	63	104	0	0	0
2012						
Stock	**9,155**	**92,761**	**529**	**1,426**	**0**	**0**
Additions (+)	92	9	4	0	0	0
Reductions (-)	1	192	32	0	0	0
2014						
Stock	**9,246**	**92,578**	**501**	**1,426**	**0**	**0**
Additions (+)	187	89	1	0	0	0
Reductions (-)	89	232	9	0	0	0
2016						
Stock	**9,344**	**92,435**	**493**	**1,426**	**0**	**0**
Additions (+)	0	36	16	4	0	0
Reductions (-)	4	760	37	0	0	0
2018						
Stock	**9,340**	**91,711**	**472**	**1,430**	**0**	**0**

Source: IBGE, Diretoria de Geociências, Monitoramento da Cobertura e Uso da Terra do Brasil.

Attachment 7 - Changes in land cover and land use, by biome, according to the Change Intensity Indicator - IIM - 2016/2018

Types of change in land cove and land use (to/from)	Change Intensity Indicator	Area (km²)						
		Total	Amazônia	Cerrado	Mata Atlântica	Caatinga	Pampa	Pantanal
Total	-	**87,242**	**46,799**	**28,289**	**4,615**	**3,925**	**2,465**	**1,149**
Managed Pasture / Cropland	2.5	14,031	5,391	7,246	1,317	18	33	26
Forest Tree Cover / Mosaic of Occupations in Forest Area	2.0	13,600	12,523	754	100	207	3	13
Mosaic of Occupations in Forest Area / Managed Pasture	2.5	12,894	11,173	1,186	291	201	2	41
Mosaic of Occupations in Forest Area / Forest Tree Cover	1.5	10,956	8,100	1,783	88	888	10	87
Savannah, Shrubland, Grassland / Managed Pasture	3.0	5,575	113	4,616	40	63	0	743
Savannah, Shrubland, Grassland / Cropland	3.0	4,744	231	2,653	249	139	1,469	3
Forest Tree Cover / Managed Pasture	3.0	4,115	3,074	833	30	57	0	121
Mosaic of Occupations in Forest Area / Cropland	2.5	3,110	1,619	328	996	53	114	0
Managed Pasture / Mosaic of Occupations in Forest Area	2.0	2,818	2,126	523	143	0	0	26
Savannah, Shrubland, Grassland / Mosaic of Occupations in Savannah, Shrubland, Grassland Area	2.0	2,549	171	1,217	38	1,100	9	14
Cropland / Managed Pasture	2.5	2,172	509	1,472	152	25	1	13
Managed Pasture / Silviculture	2.5	1,751	220	1,399	132	0	0	0
Mosaic of Occupations in Savannah, Shrubland, Grassland Area / Savannah, Shrubland, Grassland	1.5	1,381	76	607	6	619	58	15
Mosaic of Occupations in Savannah, Shrubland, Grassland Area / Cropland	2.5	1,330	17	505	249	167	390	2
Mosaic of Occupations in Savannah, Shrubland, Grassland Area / Managed Pasture	2.5	1,038	288	631	21	77	1	20
Forest Tree Cover / Cropland	3.0	758	500	209	12	5	31	1
Managed Pasture / Mosaic of Occupations in Savannah, Shrubland, Grassland Area	2.0	695	23	570	5	95	0	2
Savannah, Shrubland, Grassland / Silviculture	3.0	442	8	325	57	0	52	0
Mosaic of Occupations in Forest Area / Silviculture	2.5	373	64	30	255	0	24	0
Cropland / Mosaic of Occupations in Savannah, Shrubland, Grassland Area	2.0	369	1	314	2	47	5	0
Managed Pasture / Savannah, Shrubland, Grassland	1.5	319	8	255	0	33	2	21
Cropland / Silviculture	2.5	298	37	164	84	3	10	0
Silviculture / Cropland	2.5	257	42	147	25	0	42	1
Mosaic of Occupations in Forest Area / Artificial Surfaces	2.5	206	65	7	112	19	3	0
Silviculture / Mosaic of Occupations in Forest Area	2.0	192	132	16	41	0	3	0
Cropland / Savannah, Shrubland, Grassland	1.5	191	1	30	0	5	155	0
Silviculture / Managed Pasture	2.5	191	31	157	3	0	0	0
Cropland / Mosaic of Occupations in Forest Area	2.0	144	60	13	32	38	1	0
Mosaic of Occupations in Savannah, Shrubland, Grassland Area / Silviculture	2.5	129	0	74	35	0	20	0
Mosaic of Occupations in Savannah, Shrubland, Grassland Area / Artificial Surfaces	2.5	118	1	47	23	36	11	0
Forest Tree Cover / Artificial Surfaces	3.0	89	81	2	3	3	0	0
Silviculture / Mosaic of Occupations in Savannah, Shrubland, Grassland Area	2.0	76	0	74	2	0	0	0
Forest Tree Cover / Silviculture	3.0	70	7	12	48	1	2	0
Savannah, Shrubland, Grassland / Artificial Surfaces	3.0	58	4	33	0	18	3	0
Savannah, Shrubland, Grassland / Artificial Surfaces	1.0	52	48	0	0	4	0	0
Managed Pasture / Artificial Surfaces	2.5	49	25	18	3	3	0	0
Silviculture / Savannah, Shrubland, Grassland	1.5	42	0	26	8	0	8	0
Cropland / Artificial Surfaces	2.5	28	5	8	13	1	1	0
Artificial surfaces / Mosaic of Occupations in Forest Area	2.0	24	24	0	0	0	0	0
Savannah, Shrubland, Grassland / Barren Land	1.0	5	0	5	0	0	0	0
Silviculture / Artificial Surfaces	2.5	2	0	0	0	0	2	0
Wet area / Managed Pasture	3.0	1	1	0	0	0	0	0

Source: IBGE, Diretoria de Geociências, Coordenação de Recursos Naturais e Estudos Ambientais.

Glossary

This item provides definitions and descriptions of the main terms and concepts described in the System of Economic Environmental-Economic Accounting (*Sistema de Contas Econômicas Ambientais* - SCEA) both in the Central Framework (CF), and in the Experimental Ecosystem Accounting (EEA) manual. In some cases, it provides external references, transverse comments among the terms and/or a small note after the descriptions.

basic spatial unit Geometrical unit that provides a disaggregated level in which different pieces of information can be attributed. The basic spatial unit can be formed by a reference grid or through the delimitation of polygons. It must be stated that, in the ecosystem accounting, this unit is not a subjacent conceptual unit; it comprises the approach of measuring of spatial data.

benefits not related to the System of National Accounts Benefits that reach individuals or society in general that are not produced by economic units.

benefits Goods and services that are used and enjoyed by people, and that contribute towards individual and social well-being. Two types of benefits are described in the ecosystem accounting: SNA and non-SNA benefits.

biodiversity Variability among living organisms, including those in terrestrial, marine and aquatic ecosystems, as well as the diversity within the species, among the species and ecosystems, according to provision in Art. 2 in the Convention on Biological Diversity - CBD. The diversity of ecosystems is also an important analysis, and in the

Ecosystem Experimental Accounts, it is derived from the measuring of changes in the ecosystem extents and condition.

cultural services Qualities perceived or accomplished in the ecosystems that provide cultural benefits.

depletion Reduction, in physical terms, of the quantity of the stock of a natural resource over an accounting period that is due to its extraction by economic units occurring at a level greater than that of regeneration.

depreciation Reduction, in economic terms, of the value of an investment during its useful life.

ecosystem Dynamic complex of plant, animal, and micro-organism communities and their non-living means, interacting as a functional unit, as provided in Art. 2 in the Convention on Biological Diversity - CBD. Ecosystems can be identified on different scales; for accounting purposes, the ecosystem assets are defined upon the delimitation of unique and contiguous spatial areas.

ecosystem accounting area Geographic area for which an Ecosystem Account is compiled. The System of Environmental-Economic Accounting 2012 - Experimental Ecosystem Accounting Manual, referred to as the UN SEEA-EEA, defines which assets from the ecosystems are included in an account. Usually, these accounting areas are: national jurisdictions/groups of countries, subnational administrative areas, environmentally defined areas within a country, among other areas of political or analytical interest.

ecosystem assets Contiguous spatial areas of a single type of ecosystem that comprise a set of biotic and abiotic components and other elements of nature that work together in a homogeneous way. For the purposes of ecosystem accounting, this unit of analysis is considered as a statistic reference.

ecosystem characteristics Properties related to the operation of the ecosystem, the main ones related to its structure, composition, processes and functions, and its location (extent, configuration, forms of landscape, and climate associated to seasonal patterns). The ecosystem characteristics are also strongly related to the biodiversity at several levels.

ecosystem condition General quality of an ecosystem asset measured in terms of its characteristics. It is the condition that holds the ecologic integrity and that sustains the capacity of an asset to generate ecosystem services. Therefore, changes in the ecosystem conditions impact the expected flow of their services.

ecosystem conversion Situation regarded as significant or irreversible, where there are changes in the ecologic structure, composition, or role of an asset in the ecosystem that, in turn, are reflected on a different set of services provided by the ecosystem.

ecosystem degradation Decrease in the value of an ecosystem asset over a given accounting period due to economic or other human activities. It usually reflects on the decrease of the condition of the ecosystem or on the expected flow of ecosystem services. The measures of ecosystem degradation are influenced by the scale of the analysis and the characteristics of the ecosystem asset. The degradation of the ecosystem can be measured in both physical and monetary terms, and is connected to the capacity of the ecosystem to offer benefits to people.

ecosystem extent Size of an ecosystem asset in terms of spatial area, many times accounted in terms of ecosystem types.

ecosystem functional groups Third level of classification by the International Union for Conservation of Nature (IUCN) for functionally distinctive groups of ecosystems within a biome. Ecosystem types within the same functional group share common ecologic factors that promote the convergence of biotic characteristics that characterize the group.

ecosystem improvement Increase or improvement of an ecosystem asset due to human interferences or even the economic activity itself.

ecosystem services Contributions of ecosystems to human benefits, including their well-being and economic activities; therefore, they exclude the set of flows usually referred to as supporting or intermediary services that contribute to the intra- and inter-ecosystem processes. In Brazilian literature, references are found to the terms ecosystem services or environmental services.

ecosystem type Specific category in which the ecosystem assets are ecologically comparable. The ecosystem type can be interpreted as aggregations of ecosystem assets of a similar type or with contiguous areas of a specific ecosystem type; in practical terms, the classification of ecosystem types must be started in order to define the ecosystem assets.

ecosystem useful life Time during which it is expected that an ecosystem asset generates ecosystem services.

EFG *See* ecosystem functional groups

environmental assets Living and non-living components of the Earth that occur naturally and, thus, constitute the biophysical environment, which may provide benefits to humanity. The scope of environmental assets is not equal to that of ecosystem assets, since the former includes mineral and energy resources as individual components to economic activities. In addition, the broad scope of environmental assets is extended beyond natural resources, since it includes produced assets, such as crops; cultivated plants, including timber, cattle and fish. The measuring of environmental assets is broader in physical terms than in monetary ones, since it is limited to the ones that hold economic value, following the principles of market evaluation from the System of National Accounts.

environmental indicator Quantitative or qualitative factor or variable that, upon a measurable method, provides an objective and communicable answer of a change in the condition, process, or function of ecosystems.

environmental services *See* ecosystem services

exchange value Value in which goods, services, labor, or assets are in fact exchanged, or could be exchanged, for cash.

land cover Physical and biological cover observed on the surface of the Earth; including natural vegetation, abiotic (non-living) surfaces, and inland bodies of water, such as rivers, lakes and reservoirs.

land use Human use performed in a specific spatial area for a given purpose (residential, farming, among others). The change in the land use is related to a change in the use or management of the land by human beings.

market price Amount, in cash, that willing buyers pay to acquire something from willing vendors.

mitigation Intervention for the reduction of negative or non-sustainable uses of the ecosystems.

natural capital Term used to describe the inventory of renewable and non-renewable natural resources that combine to generate a flow of benefits to people.

natural resources All biological, mineral, energy, soil, and hydric resources. In the System of Environmental-Economic Accounting 2012 - Experimental Ecosystem Accounting Manual, also referred to as the UN SEEA-EEA, natural resources are defined to include not only the environmental assets produced, that is, those that are not considered as having existed as a result of processes that fit in the limit of production of the System of National Accounts. Therefore, a differentiation is made between natural and harvested environmental assets.

Non-SNA benefits *See* benefits not related to the System of National Accounts

protected area Geographic space clearly defined and managed by legal means, or other efficient means, to reach the objectives of preservation of nature, with associated ecosystem services as well as cultural values.

provisioning services Broad range of products in matter and energy, such as food, freshwater, fuel, medications, genetic resources, and others, that are directly obtained from the ecosystems. Therefore, the provisioning services represent the material and energy contributions generated by an asset in the ecosystem in terms of spatial area.

regulating and maintenance services All the ways by which the ecosystems control or change biotic or abiotic parameters that define the environment. The regulating and maintenance services are results of the ecosystem that are not consumed, but affect the performance of human activities; therefore, they are resulting from the ability of ecosystems to regulate the climate, hydrological and biochemical cycles, the surface processes of the Earth, as well as a range of biological processes.

resilience Magnitude of the disturbance an ecosystem can suffer without overcoming the critical threshold, with its structure and functions, to a different state. Resilience depends on factors in the physical and ecologic dynamic, but also in the organizational capacity to generate and respond to that dynamic.

restoration Any intentional activity that starts or accelerates the recovery of an ecosystem in a degraded state.

revaluations Changes in the value of ecosystem assets over an accounting period that are solely due to movements in the unit prices of ecosystem services.

SDG *See* sustainable development goals

SNA benefits *See* System of National Accounts benefits

sustainability Characteristic or state through which the needs of the current and local population can be met without compromising the capacity of meeting the needs of future generations and populations in other locations.

sustainable development goals Set of goals adopted by the United Nations in 2015 to end poverty, protect the planet, and ensure prosperity to humanity, as part of Agenda 2030 for Sustainable Development.

System of National Accounts benefits Goods and services (products) produced by economic units, such as food, clothing, shelter, entertainment, among others, currently included in the economic production boundary of the System of National Accounts.

well-being value Value that reflects the utility associated to an exchange, most commonly measured as the sum of the surplus from the consumer and producer.

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Ecosystem Accounts

Land Use in the Brazilian Biomes

2000 - 2018

Natural Capital Accounting is an accounting framework that allows measuring and comparing, through time, the contribution of natural resources and ecosystems to the social and economic aspects of a given territory, as well as providing dynamic and standardized statistics for planning and decision-making in order to promote more efficient and sustainable choices in resource management.

By recognizing the importance of integrating environmental data to the System of National Accounts - SNA, in order to account for ecosystem services and register how the use flow of these services by the economic system interferes with environmental assets, IBGE presents in this publication the results of the Ecosystem Extent Account, in the context of the System of Environmental Economic Accounting - SEEA.

The main objective of this first edition is to offer an analysis of the extension of natural areas of ecosystems in the National Territory and an approximation of their conservation status based on the changes observed in the period from 2000 to 2018.

In order to accomplish this, Brazilian Terrestrial Biomes where adopted as the official environmental approach compatible with the ecological concept of spatial units foreseen in the methodology of the Experimental Ecosystem Accounting of the United Nations. In the Brazilian case, the Amazônia, Cerrado, Mata Atlântica, Caatinga, Pampa and Pantanal Biomes were considered. As a starting point for future editions, a summary of the data from the Monitoring of Land Cover and Land Use of Brazil is presented, also prepared by IBGE, based on the interpretation of the natural and anthropic areas identified in this mapping and the changes that occurred throughout the historical timeline, thus evidencing the evolution of the territorial environmental dynamics.

In addition, analyses of the main land use conversions circumscribed to each biome are also implemented, where the vectors of change responsible for the transformations of each portion of the National Territory can be interpreted.

This study contributes to the application of the international recommendations contained in the *System of Environmental-Economic Accounting 2012: Experimental Ecosystem Accounting*, SEEA-EEA, developed by the United Nations in the context of the Natural Capital Accounting and Valuation of Ecosystem Services - NCAVES project, in partnership with the European Union.

The results presented constitute a starting point for future research in Ecosystem Accounting, encompassing other scales of analysis and ecosystem condition indicators that reflect the diversity of landscapes in Brazil. Therefore, it is expected to embrace the variety of relevant and priority environmental issues on the national and international agenda in order to promote a dynamic portrait of the country in terms of natural resources.

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