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CÂMPUS UNIVERSITÁRIO DE SINOP
INSTITUTO DE CIÊNCIAS NATURAIS, HUMANAS E SOCIAIS
PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS AMBIENTAIS

Wendel Buêno Morinigo.

Espaço-temporalidade dos focos de incêndios e a sua relação com a ação antrópica na transição dos biomas Cerrado-Amazônia

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Orientador(a): Prof.(a) Dr. Carlos Antonio da Silva Junior.

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RESUMO

A área de transição dos biomas Cerrado-Amazônia apresenta-se como uma importante área de rendimentos inerentes ao agronegócio global, concomitantemente estimula mudanças significativas no uso dos solos sobre a ação do desmatamento e do fogo. A utilização de queimadas controladas esteve associada ao desenvolvimento humano e à evolução de algumas espécies intrínsecas aos biomas Cerrado e o Pantanal. Porém, incêndios florestais estão relacionados à diminuição de sumidouros de carbono, doenças cardiorrespiratórias e mudanças climáticas. Para a análise de extensas áreas e longas séries temporais de alguns atributos ambientais, o uso de sensores orbitais é imprescindível, pois possibilita o monitoramento de forma sistematizada por meio da assimilação de ondas eletromagnéticas dos seus alvos. Ao processar esses dados por meio de técnicas de geoprocessamento é possível quantificar os reflexos das ações antrópicas para o melhor planejamento e tomada de decisões. Para tanto, os objetivos desta pesquisa foram quantificar e correlacionar a área queimada, Produção Primária Bruta (sigla em inglês GPP), Uso e Ocupação do solo (sigla em inglês LULC), focos de incêndios e material particulado menor que 2.5 micrometros ($PM_{2.5}$), além de observar a possibilidade de tendências temporais na transição Cerrado-Amazônia entre 2008-2020. Utilizou-se a linguagem Java Script na plataforma do *Google Earth Engine* para obter os produtos do sensor MODIS (*Moderate Resolution Imaging Spectroradiometer*) de áreas queimadas, GPP e LULC. Dados de focos de incêndios e $PM_{2.5}$ foram adquiridos respectivamente das plataformas do FIRMS (*Fire Information for Resourch Management*) *e* ECMWF *(European Centre for Medium-Range Weather Forecasts)*. Os processamentos dos dados foram realizados no programa QGIS 3.24.1 para posteriormente elaborar os gráficos e estatísticas no programa R. O ano de 2010 concentrou a maior área queimada (226 073,79 km²), o que corresponde à 11,5 % de toda área da transição Cerrado-Amazônia. O $PM_{2.5}$ manteve-se acima do limite de segurança (10 µm m^{-3}) estabelecido pela OMS/CONAMA ao longo da série temporal incluindo o período de pandemia. A GPP é inversamente proporcional influenciada pelas queimadas (R^2 = 0,65 P<0,05) e relata valores mínimos no terceiro trimestre. Ao relacionar as áreas queimadas com o $PM_{2.5}$, encontrou-se alto coeficiente de determinação positivo (R^2 = 0,83 P<0,05). Savanas (WSV) e Campos (SV) representam 52,5% e 26,47% da área queimada, porém os maiores valores de $PM_{2.5}$ ocorrem sobre a Amazônia em classes de florestas. Grandes áreas queimadas quando associadas às anomalias climáticas influenciaram na diminuição da GPP e estão associadas às maiores emissões de $PM_{2.5}$ sobre a transição Cerrado-Amazônia.

Palavras-chave: área-queimada, material particulado**,** GPP, LULC e focos de incêndios.

ABSTRACT

The transition area between the Cerrado and Amazon biomes is an important area of income for global agribusiness, while at the same time stimulating significant changes in land use through deforestation and fire. The use of controlled burns has been associated with human development and the evolution of some species intrinsic to the Cerrado and Pantanal biomes. However, forest fires are related to the reduction of carbon sinks, cardiorespiratory diseases and climate change. When it comes to analyzing large areas and long time series, the use of orbital sensors becomes indispensable, as they enable systematized monitoring through the assimilation of electromagnetic waves from their targets. By processing this data using geoprocessing techniques, it is possible to quantify the effects of anthropogenic actions for better planning and decision-making. To this end, the objectives of this research were to quantify and correlate the burned area, Gross Primary Production (GPP), Land Use and Land Cover (LULC), fire foci and particulate matter smaller than 2.5 micrometers ($PM_{2.5}$), as well as to observe the possibility of temporal trends in the Cerrado-Amazon transition between 2008-2020. The Java Script language was used on the Google Earth Engine platform to obtain products from the MODIS (Moderate Resolution Imaging Spectroradiometer) sensor for burnt areas, GPP and LULC. Fire foci and $PM_{2.5}$, data were acquired respectively from the FIRMS (Fire Information for Resource Management) and ECMWF (European Centre for Medium-Range Weather Forecasts) platforms. The data was processed in the QGIS 3.24.1 program and then graphs and statistics were produced in the R program. The year 2010 saw the largest area burned (226,073.79 km²), which corresponds to 11.5% of the entire Cerrado-Amazon transition area. $PM_{2.5}$, remained above the safety limit(10 µm m^{-3}) established by WHO/CONAMA throughout the time series, including the pandemic period. The GPP is inversely proportionally influenced by fires (R^2 = 0.65 P<0.05) and reports minimum values in the third quarter. When linearly correlating burned areas with $PM_{2.5}$,, a high positive correlation of (R^2 = 0.83 P<0.05) was found. Savannas (WSV) and grasslands (SV) represent 52.5% and 26.47% of the burnt area, but the highest $PM_{2.5}$, values occur over the Amazon in forest classes. Large burnt areas when associated with climate anomalies have influenced the decrease in GPP and are associated with higher $PM_{2.5}$, emissions over the Cerrado-Amazon transition.

Keywords: Burned area, MODIS, GPP , LULC, $PM_{2.5}$ e biomes.

LISTA DE ABREVIAÇÕES E SIGLAS

BN – Barren

CAMSRA - Copernicus Atmospheric Monitoring Service Reanalysis

CE - Ceará

CS - Closed Shrublands

CL - Croplands

DNF - Deciduous Needleleaf Forests

DBF - Deciduous Broadleaf Forests

EBF - Evergreen Broadleaf Forests

ECMWF - European Centre for Medium-Range Weather Forecast

ENF - Evergreen Needleleaf Forests

GL - Grasslands

GO - Goiás

GPP - Gross Primary Product

IBGE - Instituto Brasileiro de Geografia Estatística

LULC - Land Use Land Cover

MA - Maranhão

MF - Mixed Forests

MODIS - Moderate Resolution Imaging Spectroradiometer

MT - Mato Grosso

MS - Mato Grosso do Sul

NVM - Cropland/Natural Vegetation Mosaics

PA - Pará

$PM_{2.5}$ - Particulate Material (Material Particulado menor que 2.5 micrometros)

PSI - Permanent Snow and Ice

PW - Permanent Wetlands

PI - Piauí

TO - Tocantins

RO - Rondônia

OS - Open Shrublands

WB - Water Bodies

WSV - Woody Savannas

SV – Savannas

UBL - Urban and Built-up Lands

UFMT – Universidade Federal de Mato Grosso

SUMMARY

INTRODUÇÃO GERAL DA DISSERTAÇÃO

A área de transição Cerrado-Amazônia apresenta um alto índice de ocupação populacional associada às significativas mudanças no uso e ocupação do solo (CARR, D. 2004). Consideráveis alterações ocorrem por meio da urbanização (VENTER et al., 2016a), construção de usinas hidrelétricas (MORETTO et al., 2012), inserção da agropecuária e estão diretamente correlacionadas ao desflorestamento (DA SILVA JUNIOR et al., 2022). Mesmo com tentativas de redimir os impactos através de acordos comercias que mitigam o desmatamento ilegal (Moratória da Soja), expressivas produções de soja impulsionam o agronegócio, mas, desafiam a sustentabilidade dos biomas ("SOJAMAPS - Monitoramento de áreas de soja por meio de imagens de satélite", 2018). No Cerrado brasileiro 20% das espécies em processo de extinção habitam fora de áreas protegidas, pois apenas 2,2% desse bioma estão regulamentados como áreas de proteção ambiental (KLINK et al., 2005a). Na Amazônia as interações do fogo e áreas florestadas emitem partículas finas na atmosfera menor que 2.5 micrometros ($PM_{2.5}$) que alteram a dinâmica climática do planeta (CHUNG; RAMANATHAN; DECREMER, 2012)(HANSEN; NAZARENKO, 2004)(MOTOS et al., 2019), além de reduzir a capacidade de estocar carbono que instigam mudanças no balanço hídrico (MARENGO et al., 2022)(MARENGO et al., 2018)(ROSSI et al., 2022)

O uso do fogo como técnica agrícola para limpeza de pasto ou queima de leiras de biomassa pós desmatamento é um método barato e eficiente utilizado há anos no processo de uso e ocupação dos solos (KLINK et al., 2005a). Nesse contexto, é importante entender que existem as queimas controladas (ou prescritas) e os incêndios florestais. Queimas controladas contribuíram ao longo do tempo para a evolução de algumas espécies do Cerrado (SIMON et al., 2009) e na idade contemporânea são decisivas para controlar o volume de carga de biomassa com a finalidade de reduzir os riscos de grandes áreas queimadas (CORREA et al., 2022). Entretanto, os incêndios florestais ocorrem quando sem o devido controle grandes áreas são queimadas e promovem perdas substanciais na fauna e na flora, seja ele por ignição antrópico ou por causas naturais (ROEBROEKS; VILL, 2011)(LIBONATI et al., 2020).

Na sua parcialidade os biomas Pantanal, Cerrado, Amazônia e Caatinga integram a área de transição Cerrado-Amazônia com limites que devido as alterações antrópicas não respeitam as demarcações estabelecidas pelo o Instituto Brasileiro de Geografia e Estatística (IBGE) (DA SILVA JUNIOR et al., 2022). Contudo, devido a diversidade ecossistêmica remanescente é notável um alto endemismo sobre a maior área de floresta seca do Brasil, fato que potencializa a possibilidade de incêndios de grandes proporções catastróficos à biodiversidade (DE SOUZA MENDES et al., 2019).

As anomalias climáticas promovem secas e constantes aumentos da temperatura nas últimas décadas, fato que potencializa os incêndios florestais (DOUGHTY et al., 2015)(MARENGO; ESPINOZA, 2016)(CORREA et al., 2022)(MARENGO et al., 2018). Na Amazônia tais anomalias ocorrem junto às significativas mudanças do uso do solo que modificam o fluxo hidrológico e do carbono à um passo de sua inflexão, fato que especula um possível colapso no ecossistema tropical (BULLOCK et al., 2020). No sul da Amazônia, divisa com o Cerrado, é notado na última década um aumento na temperatura média junto a um maior prolongamento do período das secas sobre uma área de constante alterações antrópicas (MARENGO et al., 2022). Cenários perfeitos aos incêndios são criados na presença do aquecimento superficial do oceano Pacífico oriental (El Niño) ou por meio do *North Atlantic Oscillation* (NAO), pois as alterações nos centros de pressão atmosférica são geradas sobre seus epicentros iniciais em alto mar e alteram a o padrão de chuvas na Amazônia (FERNANDES et al., 2011).

Políticas de combate aos incêndios precisam estar aliadas ao desenvolvimento da ciência para concretizar a sua eficácia, porém, tal situação por vezes é negligenciada no Brasil. No ano de 2019 o governo proibiu o uso do fogo por sessenta dias em todo o território brasileiro (Decreto nº 9.997, de 30 de agosto de 2019). Tal medida desesperada do governo brasileiro inibiu a necessária queima prescrita e estimulou o aumento da carga combustível para o próximo ano, além de impedir o ciclo natural da germinação de plantas que dependem do fogo no Cerrado e no Pantanal (DURIGAN, 2020). Diminuições de repasses financeiros aos órgãos de proteção ao meio ambiente refletem na diminuição do número de inspetores efetivos nos últimos anos e estimula a queda no número de registros de infrações ao meio ambiente (LEAL FILHO et al., 2021).

Queimas de biomassa estão associados a emissão de $PM_{2.5}$ (material particulado menor que 2.5 micrometros) e entre 2018-2019 foram correlacionados à mortes prematuras na região da Amazônia (NAWAZ; HENZE, 2020), além de aumentarem significativamente o número de internações no Brasil (YU et al., 2021). O bioma amazônico apesar de ser considerado um sumidouro de carbono, torna-se um grande emissor de partículas finas na atmosfera na presença do fogo, visto que apresenta alta carga de biomassa devido principalmente a disponibilidade de floresta latifoliada (DE OLIVEIRA et al., 2020). As emissões de partículas finas carbonáceas não exercem apenas intervenções locais, pois ao entrarem em correntes atmosféricas podem ser transportadas à quilômetros de distância, ampliando a sua escala de influência (LOGE;

FONSECA; SILVEIRA, 2021). Nas regiões polares foram detectadas alterações na escala de albedo do gelo devido a precipitação de $PM_{2.5}$, fato que motiva alterações climáticas globais (HANSEN; NAZARENKO, 2004).

A Produção primária bruta (GPP – sigla em inglês) – que é a conversão total de energia solar convertida em biomassa pelos seres autotróficos, refletem a influência tanto de fatores antrópicos (CRIVELARI-COSTA et al., 2023) quanto a de perturbações climáticas (MARENGO; ESPINOZA, 2016). Mudanças nos usos do solo na região do Mato Grosso entre 2015-2018 promoveram alterações da GPP e motivaram a redução do fluxo de absorção do carbono (ROSSI et al., 2022). O acúmulo de chuvas na bacia Amazônica no ano de 2017 associado ao fenômeno *La Niña* aumentou a GPP para o mesmo período, porém, pode ter influenciado nos catastróficos incêndios ocorridos para os anos subsequentes de 2019 e 2020 devido ao acúmulo de biomassa (DOUGHTY et al., 2021).

O uso do sensoriamento remoto é fundamental para quantificar e entender a dinâmica das áreas queimadas e suas respectivas influências em extensas áreas e na presença de grandes temporalidades. Para tanto, o objetivo desse trabalho foi quantificar a área queimada entre 2008-2020 na transição Cerrado-Amazônia e relacioná-la com a GPP, LULC, focos de incêndios e $PM_{2.5}$ analisando a possibilidade de tendências temporais. Entender a abrangência das alterações antrópicas e suas consequências relacionadas ao uso do fogo em uma área de interesse internacional, é de grande importância para melhorar o planejamento e a fiscalização do combate aos incêndios, pois trata-se de um problema ambiental, econômico e de saúde pública.

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Spatio-temporality of fire foci and their relationship with anthropogenic action in the transition between the Cerrado and Amazonia biomes

The present manuscript will follow the standards adopted by the jornal *Science of the total Enviromental*, to which the present work will be submitted.

Spatio-temporality of fire foci and their relationship with anthropogenic action in the transition between the Cerrado and Amazonia biomes

Abstract

Cerrado-Amazonia transition area is of vital importance both to the environment and agribusiness. It is home to a wide range of endemic biodiversity that is crucial for maintaining ecosystem services, while at the same time boosting global agribusiness and making Brazil one of the major commodity producers worldwide. However, the use of fire to clear areas after deforestation or post-production causes numerous problems when burning is not properly controlled, as are accidental burn-offs. Here we quantify the relationship between the area burned and the Gross Primary Production (GPP), particulate matter smaller than 2.5 µm ($PM_{2.5}$), fire foci and land use and land cover (LULC) in the entire Cerrado-Amazonia transition area. Using orbital remote sensing products, our quarterly/annual analyses showed complex spatial relationships between anthropogenic use and the influence of climate anomalies in the study area between 2008-2020. Total burned area over the time series is 1,317,912.6 km², equivalent to 67% of the entire study area. In 2010, an area of 226,073.79 km² was burned under the influence of climate anomalies and LULC changes. We found that $PM_{2.5}$ remained above the safety limit (10 µm m^{-3}) throughout the time series, including the COVID-19 pandemic period, when respiratory problems were more pronounced. By linearly correlating the burned areas with the $PM_{2.5}$, a high positive correlation ($R^2 = 0.83$ $P<0.05$) was observed. Savannas (WSV) and grasslands (SV) represent 52.5% and 26.47% of the burned area, respectively, but the highest $PM_{2.5}$ values occur over the Amazonia in forest classes. The GPP is inversely proportional to the burned areas ($R^2 = 0.65$ $P<0.05$) and reports minimum values in the third quarter. Forest class (EBF) showed a significant downward trend in 2012, a fact that may be correlated with public policies and changes in the Brazilian forest code for the same period.

1 – Introduction

Cerrado-Amazonia transition area is a region that has been exploited for decades, altering the original properties of nature (SILVA JUNIOR et al., 2019). In this part of the territory, migration and the high fertility rate play a driving role in transforming land use and cover (LULC) when combined with political and economic factors (CARR, D, 2004).

In this context, Brazil is a major supplier of commodities for the growing demand, being one of the largest grain producers in the world ("SOJAMAPS - Monitoramento de áreas de soja por meio de imagens de satélite", 2018). The search for new farming areas highlights the controversial relationship between man and nature. Even with attempts to contain the advance of deforestation through political agreements in the Amazonia (the Soy Moratorium), native vegetation has been replaced by soybean plantations (LIMA et al., 2019)(PIVELLO, 2011)[5](LOURENÇONI et al., 2021), urbanization (VENTER et al., 2016b), and hydroelectric plants, for example (LATRUBESSE et al., 2017). In the Cerrado, Brazil's second largest biome after the Amazonia, crop fields and pastures account for half of this biodiversity hotspot (MATAVELI et al., 2019).

Fires have been burning for millions of years due to ignition by lightning or volcanoes (ROEBROEKS; VILL, 2011). This characteristic of natural fire by lightning in Brazilian biomes is observed in the Cerrado, the tropical savannah that has generated the capacity for species to adapt and diversify to fire over the course of geological eras (SIMON et al., 2009)(ABREU et al., 2017). However, the environmental legislation in force under the Brazilian Forest Code ratifies the preservation of 35% of legal reserves in the Legal Amazon and 20% in other areas, which encourages deforestation associated with fires in this biome. Associated with incipient environmental monitoring, 4,800 species of endemic plants and vertebrates are threatened with extinction (STRASSBURG et al., 2017).

In the Amazon, changes in the pattern of incident radiation flux are notable due to the emission of particulate matter associated with biomass burning, an effect that represents significant changes in the global climate (CHUNG; RAMANATHAN; DECREMER, 2012). Fire alters the Gross Primary Production (GPP) in the southern (S), southeastern (SE), southwestern (SW), western (W), and northwestern (NW) regions of the Amazonia and counteracts the capacity to be a carbon sink, a circumstance that changes the drought periods in the region (MARENGO et al., 2022)(MARENGO et al., 2018)(DA SILVA JUNIOR et al., 2022).

Allied to economic development, burning biomass is still the cheapest way to generate new agricultural land, pasture for livestock, and clean up after planting (KLINK et al., 2005b). Despite being an efficient tool for such practices, anthropogenic or natural fire increases the potential for problems such as loss of biomass and species (TRUMBORE; BRANDO; HARTMANN, 2015), stimulates the emission of greenhouse gases (DA SILVA JUNIOR et al., 2020), cause deaths related to particulate matter emissions (JOHNSTON et al., 2012a; YE et al., 2022a), and encourages climate change on the planet (LASHOF, 1991).

Using remote sensors is essential for quantifying degradation in large areas that are difficult to access over a long period of time. The large number of orbital sensors makes it possible to monitor the burned area (GIGLIO et al., 2009), fire foci (GIGLIO et al., 2003), fine particulate matter less than 2.5 micrograms ($PM_{2.5}$) (INNESS et al., 2019), LULC (FRIEDL; SULLA-MENASHE, 2019), and Gross Primary Production (GPP) (MONTEITH, 1972; RUNNING; ZHAO, 2015). To this purpose, the objectives of this investigation were to: (i) quantify the burned area between 2008-2020 and relate it to GPP, LULC, fire foci and $PM_{2.5}$; (ii) to sizing the LULC and observe the possibility of temporal trends in the Cerrado-Amazonia transition, and (iii) measure and spatially analyze the $PM_{2.5}$ over the study area.

2- *Material and Methods*

2.1 *Study area*

Based on the proposal to update the borders between the Cerrado and Brazilian Amazonia biomes (SILVA JUNIOR et al., 2019), a buffer of 300 km either side of the official boundary between the Cerrado and Amazonia biomes proposed by the Brazilian Institute of Geography and Statistics (IBGE) was built. The total area is 1,965,511.45 km², corresponding to 23.09% of Brazil's territory, partially comprising the Cerrado, Amazonia, Pantanal and Caatinga biomes (IBGE - INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA., 2021).

Figure 1. Cerrado-Amazonia Transition Area (SILVA JUNIOR et al., 2019) and their respective land use and land cover in 2020 (FRIEDL; SULLA-MENASHE, 2019)

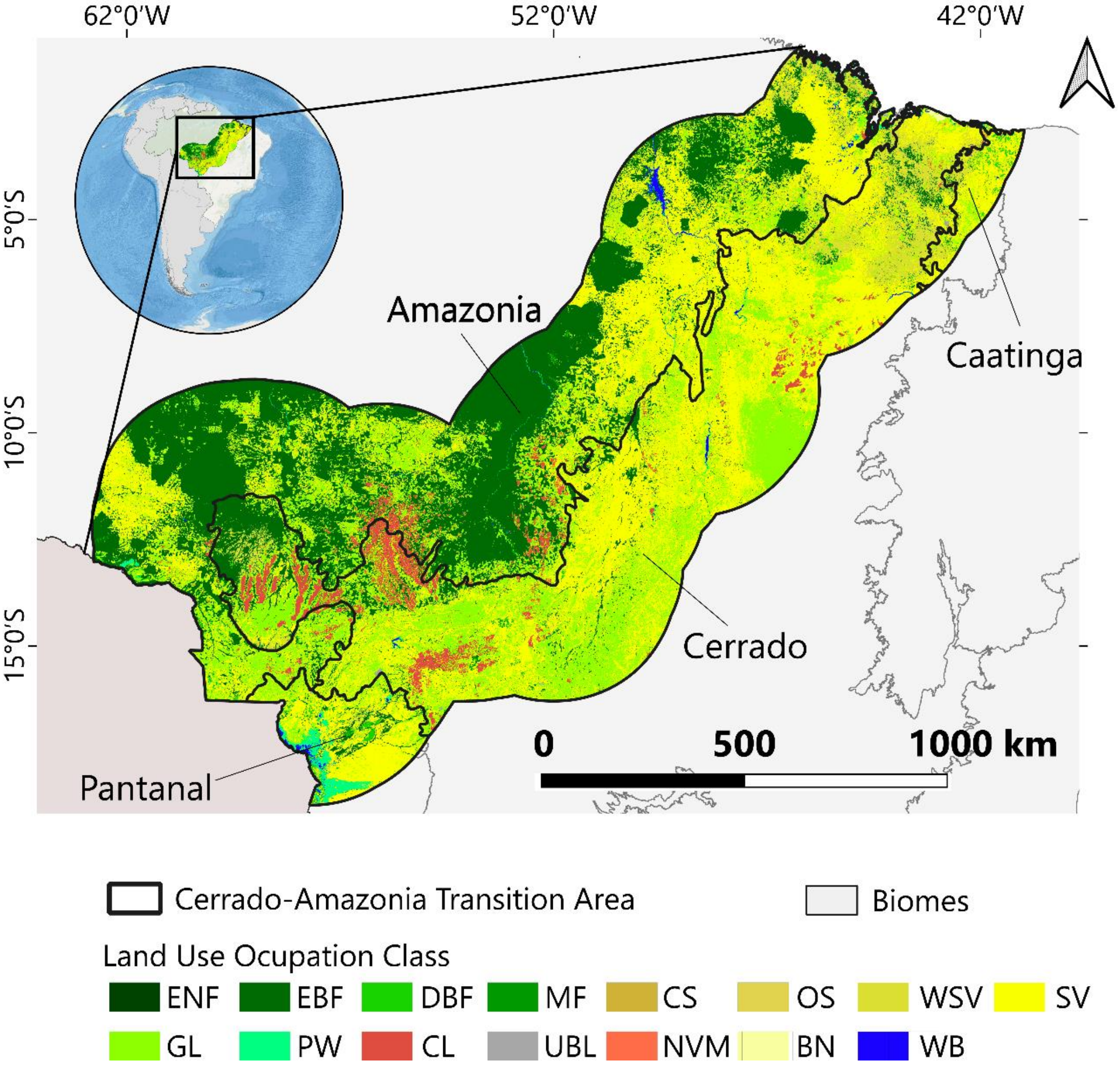


Figure 1 – Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Savannah climate (Aw) - with a dry season in winter and a rainy season in summer - is predominant (91.4% of the area) throughout the Cerrado, Pantanal, Caatinga and most of the southern (S) and eastern (E) portions of the Amazonia. The average temperature of the coldest month is above 18ºC with annual rainfall between 750-1800 mm. The Sub-humid Tropical

(Am) and Humid Tropical (Af) climates account for 5.0% and 3.6% of the study area in the Southwest (SW) and Northwest (NW) portions, respectively (DUBREUIL et al., 2018).

3.0. Data acquisition and processing

Data were acquired from the 2008-2020 time series. Burned area (MCD64A1) (GIGLIO et al., 2009), GPP (MYD17A2H) (MONTEITH, 1972) (RUNNING; ZHAO, 2015), and LULC (MCD12Q1) (FRIEDL; SULLA-MENASHE, 2019) products were acquired from the Google Earth Engine platform via export to drive in TIFF format using Java script. Fire foci data (MOD14/MYD14) (GIGLIO et al., 2003) were obtained from the FIRMS-NASA Platform (NASA FIRMS, 2020) in shapefile format, while $PM_{2.5}$ product (INNESS et al., 2019) was acquired from the *Atmosphere Copernicus* website (ECMWF, [s.d.]) in TIFF format. Data for the federal units was acquired from the website of the Brazilian Institute of Geography and Statistics (IBGE) (IBGE, 2020).

Burned area (quarterly), GPP (every 8 days), $PM_{2.5}$(Monthly), and fire foci (monthly) products were reorganized using the "raster calculator" tool (or "intersection" function in the case of fire foci) for quarterly/annual periods using the Qgis 3.24 software (QGIS DEVELOPMENT TEAM. QGIS ASSOCIATION, 2018). After grouping the data, all products (including LULC) were vectorized into shapefile format using the "raster pixels for polygons" option, (or "raster pixel for points" in the case of the $PM_{2.5}$). Using the "intersection" tool, we correlated all the products to the area burned, Federative Units, LULC and total area, creating a new table of attributes.

Aiming at obtaining better results in the intersection between the products, we applied the Inverse Distance Weighting (IDW) interpolator to the vectors of $PM_{2.5}$, because the distance of ~ 80 km between the centroids of $PM_{2.5}$ pixels could interfere with the results of the analysis. IDW interpolator can be used to mitigate discrepancies in spatial resolution found between different models and helps to infer areas between larger spacings (BARTIER; KELLER, 1996). After a new vectorization on the Qgis 3.24 software using the "pixels from raster to points" function, data were correlated with the other variables using the attribute table.

Kernel Density (KD) estimator was applied to the fire data to identify the highest foci densities over the area obtained by the Eq. (1):

$$\mathfrak{f}_h(x) = \frac{1}{nh} \sum_{i=1}^{n} \mathcal{K} \left(\frac{x - \chi_i}{h}\right) \tag{1}$$

Wherein $\mathcal{K}$ is the Kernel function $\int \mathcal{K}$ (s) ds = 1; h is the search radius; x is the position of the center of each cell in the output raster; χ_i is the position of point i from the centroid of each polygon; and n is the total number of fire foci.

The graphs were drawn up using the R (R CORE TEAM, 2023) using the ggplot2 package (WICKHAM, 2016) to construct the boxplots and bar charts. In the case of the violin plot, in addition to the ggplott2 package, we also used the *dplyr* (WICKHAM et al., 2023) and *tidyr* packages (WICKHAM; VAUGHAN; GIRLICH, 2023).

4.0. *Land Use and Land Cover Data*

The MCD12Q1 product version 06 of the Moderate Resolution Imaging Spectroradiometer sensor (MODIS) was used to quantify and analyze spatial and temporal trends in LULC over the Cerrado-Amazonia transition area. The algorithm processes the product (V006 Global 500 m Land Cover Type Product) based on supervised decision tree classifications processing reflectance data from the MODIS sensor on the Terra and Aqua satellites. Raster data is made available with a spatial resolution of 500 meters at an annual time scale with the categorization and identification of the different types of land use and land cover (FRIEDL; SULLA-MENASHE, 2019). The product has 5 different classifications proposed by: University of Maryland (UMD), International Geosphere-Biosphere Program (IGBP), Plant Functional Types (PFT) classification schemes, Leaf Area Index (LAI) and BIOME-Biogeochemical Cycles (BGC). Due to the extension of the area and the diversification of biomes in the region studied, the IGBP class 1 model (Table 1) was adopted as it is more complete and meets the objectives of this study (SILVA et al., 2021a; VAN DER WERF et al., 2010).

Table 1. Type 1 classification of MCD12Q1 product.

Class	Color	Acronym	Description
1	05450[a]	ENF	Evergreen Needleleaf Forests: dominated by evergreen conifer trees (canopy >2 m). Tree cover >60%.
2	086a10	EBF	Evergreen Broadleaf Forests: dominated by evergreen broadleaf and palmate trees (canopy >2 m). Tree cover >60%.
3	54a708	DNF	Deciduous Needleleaf Forests: dominated by deciduous needleleaf (larch) trees (canopy >2 m). Tree cover >60%.
4	78d203	DBF	Deciduous Broadleaf Forests: dominated by deciduous broadleaf trees (canopy >2 m). Tree cover >60%.
5	009900	MF	Mixed Forests: dominated by neither deciduous nor evergreen (40–60% of each) tree type (canopy >2 m). Tree cover >60%.
6	c6b044	CS	Closed Shrublands: dominated by woody perennials (1–2 m height) >60% cover.
7	dcd159	OS	Open Shrublands: dominated by woody perennials (1–2 m height) 10–60% cover.
8	dade48	WSV	Woody Savannas: tree cover 30–60% (canopy >2 m).
9	fbff13	SV	Savannas: tree cover 10–30% (canopy >2 m).
10	b6ff05	GL	Grasslands: dominated by herbaceous annuals (<2 m).
11	27ff87	PW	Permanent Wetlands: permanently inundated lands with 30–60% water cover and >10% vegetated cover.
12	c24f44	CL	Croplands: at least 60% of area is cultivated cropland.
13	a5a5a5	UBL	Urban and Built-up Lands: at least 30% impervious surface area including building materials, asphalt and vehicles.
14	ff6d4c	NVM	Cropland/Natural Vegetation Mosaics: mosaics of small-scale cultivation 40–60% with natural tree, shrub, or herbaceous vegetation.
15	69fff8	PSI	Permanent Snow and Ice: at least 60% of area is covered by snow and ice for at least 10 months of the year.
16	f9ffa4	BN	Barren: at least 60% of area is non-vegetated barren (sand, rock, soil) areas with less than 10% vegetation.
17	1c0dff	WB	Water Bodies: at least 60% of area is covered by permanent water bodies.

MCD12Q1 product (FRIEDL; SULLA-MENASHE, 2019).

***5.0** – Data analyses*

Mann Kendall (MK) (MANN, 1945) and Pettitt (PETTITT, 1979) tests were used to verify the possibility of trends in changes in LULC, burned areas and fire foci over the analyzed time series. MK test allows for determining whether the values of the time series are inclined to increase or decrease over time, or whether there is a significant change in the central distribution point of the time series data. Meanwhile, the Pettitt test indicates when this trend has occurred or checks whether the time series is stationary. This latter, which is non-parametric test, is a variation of the Mann-Whitney test, which assesses whether two samples, χ_1,... , χ_t, and χ_{t+1},..., χ_t belong to the same population. The statistic U_t counts how many times an element from the first sample is larger than an element from the second sample, as expressed in Equation (2). $U_{t,T}$, is calculated for values 1 < t < T, and $\mathcal{K}$(t) is defined according to Eq. (2):

$$U_{t,T} = U_{t,T-1,T+} \sum_{j=1}^{T} sgn\ (\chi_{i-} \chi_j), \qquad (2)$$

$$\mathcal{K}(\mathrm{t}) = \mathrm{MAX}_{1 \leq t \leq T} |, \mathrm{U}_{\mathrm{t,T}}\ | \qquad (3)$$

Wherein sgn (x) = 1 for x > 0; sgn (x) = 0 for x = 0; and sgn (x) = −1 for x < 0.

The Pettitt test locates the point at which there was an abrupt change in the historical series, the t where the maximum $\mathcal{K}$(t), resulting in $\mathcal{K}_{cri}$, or critical values (Equation (4)) on the average of a time series. Their significance was calculated using the Equation (5).

$$\mathcal{K}_{cri} = \pm \sqrt{\frac{\ln\left(\frac{p}{2}\right)(\mathrm{T}^3 + \mathrm{T}^2)}{6}} \qquad (4)$$

$$p = -value \cong 2\ exp\left\{\frac{-6\ \mathcal{K}(t)^2}{(T^3 - T^2)}\right\}, \qquad (5)$$

The Mann-Kendall and Pettitt tests were run using the "trend" and "ManKendall" packages in R software version 4.1.2 (R CORE TEAM, 2018).

5.1. *Burned Area*

The burned area was detected using the MCD64A1 product Version 6 Burned Area (GIGLIO et al., 2009), which examines the mid-infrared bands in order to verify the intense radiation emitted by fires (DOZIER, 1981; MATSON; DOZIER, 1981) . The algorithm calculates the area of fires based on an automatic method using the MODIS sensor with an image resolution of 500 m and active fires of 1 km on the Aqua and Terra satellites. First, the algorithm performs a daily temporal analysis in spectral bands 5 and 7, composing reflectance for each pixel. Subsequently, a normalized index is applied (VI = (B5 − B7) / (B5 + B7)), which shows greater sensitivity for identifying burned areas when VI drops sharply. When the algorithm identifies pixels with the possibility of a burnt area, a temporal scan (10 days before and 10 days after) is initialized in order to define a temporal isolation of the burned area using descriptive statistics. A set of burned/unburned pixel separation mechanisms are applied to a mask layer to subsequently calculate the probability density according to each MODIS vegetation class. This information is recorded in a single data layer, representing the day of the calendar year on which the burn occurred. Zero values (0) are assigned to unburned land pixels, while special values are reserved for missing data and grid cells corresponding to water areas. The final data is made available monthly with a 500-meter spatial resolution (GIGLIO, L.; JUSTICE, C.; BOSCHETTI, L.; ROY, 2015; ZHOU et al., 2019).

5.2 *- Fire foci*

Monthly fire foci data was quantified using the MODIS MCD14DL (TERRA/AQUA) sensor product processed by NASA's Land, Atmosphere Near real-time Capability for the Fire Information for Resource Management System (FIRMS), using swath products (MOD14/MYD14) instead of the modular MOD14A1 and MYD14A1 products. Thermal anomalies such as active fires, volcanoes and gas flares are represented in the center of a 1 km pixel that has been flagged by the MODIS MOD14/MYD14 Fire and Thermal Anomalies algorithm. NRT fire data is available within approximately 3 hours of the satellite passing over and images are available within 4 to 5 hours (GIGLIO et al., 2003).

5.3 *Gross Primary Production (GPP)*

To analyze the GPP over the burned area and total area, we used the MYD17A2H product, which quantifies the cumulative composition through the solar radiation use efficiency of the vegetation (MONTEITH, 1972; RUNNING; ZHAO, 2015). Using a conversion efficiency lookup table, the MODIS algorithm converts the absorbed photosynthetically active radiation related to the total amount of leaf area into carbon absorption (ALMEIDA et al., 2018; FELTON; GOLDSMITH, 2023). The pixel values with reference to the digital numbers of the MODIS image were transformed into biophysical values (kg C m -2) via multiplication with a scale factor (0.0001) (RUNNING; ZHAO, 2015).

5.4 - Particulate matter ($PM_{2.5}$)

The $PM_{2.5}$ data (μm m^{-3}) were quantified using the Copernicus Atmospheric Monitoring Service Reanalysis product (CAMSRA) (INNESS et al., 2019), produced in cycle 42R1 of the Integrated Weather Forecasting System of European Centre for Medium-Range Weather Forecast (ECMWF), which is assimilated to 4DVar data from satellite measurements, including O3, NO2, CO and Aerosol Optical Depth (AOD). A set of sensors attached to the Envisat, TERRA, Aura, MetOp and POES platforms provide data from 2003 to 2021 with horizontal resolutions of approximately 80 x 80 km (similar to a regular latitude/longitude grid of 0.75º x 0.75º) and temporal resolutions of 3 hours for the composition of the product. Its vertical resolution consists of 60 hybrid sigma/pressure model levels, with the top level located at 0.1 hPa. This algorithm uses inventoried data from partner institutions in the following sectors: anthropogenic emissions ((MACC), 2014; REGIONAL CLIMATE CONSORTIUM FOR ASIA AND THE PACIFIC, 2010); biomass burning (COPERNICUS ATMOSPHERE MONITORING SERVICE, 2023); weather (CLIMATE DATA GUIDE PIS AND STAFF, 2023) and volatile organic compounds in its composition (GUENTHER et al., 2012). Black carbon (BC), organic carbon (OC), organic matter (OM), sulphates (SO_4), sea salt and dust are observed in the final composition of your model (INNESS et al., 2019).

5.5 *–PM2.5 Spatial Grouping*

Spatial and temporal assessment of PM2.5 through fire foci was analyzed using the Getis-Ord method [65]:

$$G_i = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \bar{X}\sum_{j=1}^{n} w_{i,j}}{\sqrt{\left[\frac{n\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{i=0}^{n} w_{i,j}\right)^2}{n-1}\right]}} \tag{6}$$

wherein G_i é the spatial dependence of incident i in all events *n*; x_j is the magnitude of variable X at incident location j in the observations (n) (j can be equal to *i)*; and $w_{i,j}$ is the weight value between events i and j representing the spatial interrelationship.

The G_i statistics identifies significant spatial clusters of high (hot spots) or low values (cold spots) in the observations and was developed for datasets in which there is no global spatial self-correction [65]. The hotspot analysis was performed on Qgis 3.24(QGIS DEVELOPMENT TEAM. QGIS ASSOCIATION, 2018), and the points were transformed into a raster to enable better visualization.

6. Results

6.1. Changes in land use and land cover

The smallest extent classes were observed in SO, ENF, CS and BN from 52.19 km² to 1151.72 km², while the largest classes were observed in SV, EBF, GL and WSV with an area larger than 198,000 km² (Table 1). The CL, DBF, PW, WB, MF, UBL and NVM classes represent amplitudes below 60 000 km² and greater than 1 200 km². The DNF and PSI classes were not observed in the study area (Table 2).

Table 2 - Area, in km², occupied by each land use and land cover classes in the Cerrado-Amazonia Transition between 2008 and 2020.

Class	ENF	EBF	DBF	MF	CS	OS	WSV	SV
2008	216.162	555832	12313.6	4940.26	662.08	774.295	187853	760190
2009	177.622	552971	11147	3532.17	474.856	495.014	197350	775772
2010	145.566	543714	14949.9	4961.17	335.399	388.558	193558	764716
2011	115.4	544018	14268.8	4727.23	297.2	313.828	198475	762631
2012	88.8143	540609	16338.6	5205.55	240.292	183.199	190322	785071
2013	101.326	537652	15068.7	4220.23	209.096	93.7205	195216	797836
2014	134.568	538888	16019.6	4071.39	221.655	116.217	194692	804472
2015	154.544	531864	18813.6	4439.29	235.708	111.178	188763	801608
2016	142.484	519209	18972	3731.81	321.794	116.735	183733	785175
2017	134.686	521238	21079.2	3817.76	316.914	114.269	174181	777987
2018	129.563	522327	20241.8	2507.66	375.474	91.8342	171190	763067
2019	107.837	521833	21628.7	2336.75	354.754	52.1932	171753	755724
2020	177.622	552971	11147	3532.17	474.856	495.014	197350	775772
Minimum	88.8143	519209	11147	2336.75	209.096	52.1932	171190	755724
Maximum	216.162	555832	21628.7	5205.55	662.08	774.295	198475	804472
Mean	140.477	537164	16306.8	4001.8	347.698	257.389	188034	777694

Class	GL	PW	CL	UBL	NVM	BN	WB	
2008	370081	19370.7	41356.7	2054.38	1116.78	1139.41	7606.55	
2009	351011	18252.5	42410.9	2054.38	1103.29	1120.7	7635.64	
2010	370646	18499	41880.2	2055.12	969.713	1134.72	7555.65	
2011	364560	18633.2	45747.7	2056.6	989.975	1121.62	7553.2	
2012	349391	17520.7	48795.2	2057.83	1019.71	1109.93	7555.25	
2013	335429	17393.3	50464.9	2058.57	1055.51	1088.61	7620.66	
2014	325384	17811.8	51723.3	2059.06	1187.86	1085.27	7642.49	
2015	335781	18121.3	53560.9	2059.8	1240.76	1095.16	7660.01	
2016	370167	18199.6	53657.8	2060.53	1258.98	1133.28	7629.59	
2017	380263	18440.4	55900.2	2061.51	1198.76	1151.73	7623.6	
2018	396747	19616.2	57220.1	2061.76	1119.36	1140.2	7673.23	
2019	401113	19309.5	59512.2	2061.76	910.708	1114.89	7696.69	
2020	351011	18252.5	42410.9	2061.90	1103.29	1120.7	7635.64	
Minimum	325384	17393.3	41356.7	2054.38	910.708	1085.27	7553.2	
Maximum	401113	19616.2	59512.2	2061.76	1258.98	1151.73	7696.69	
Mean	361660	18417	49587.8	2058.13	1098.05	1119.71	7622.17	

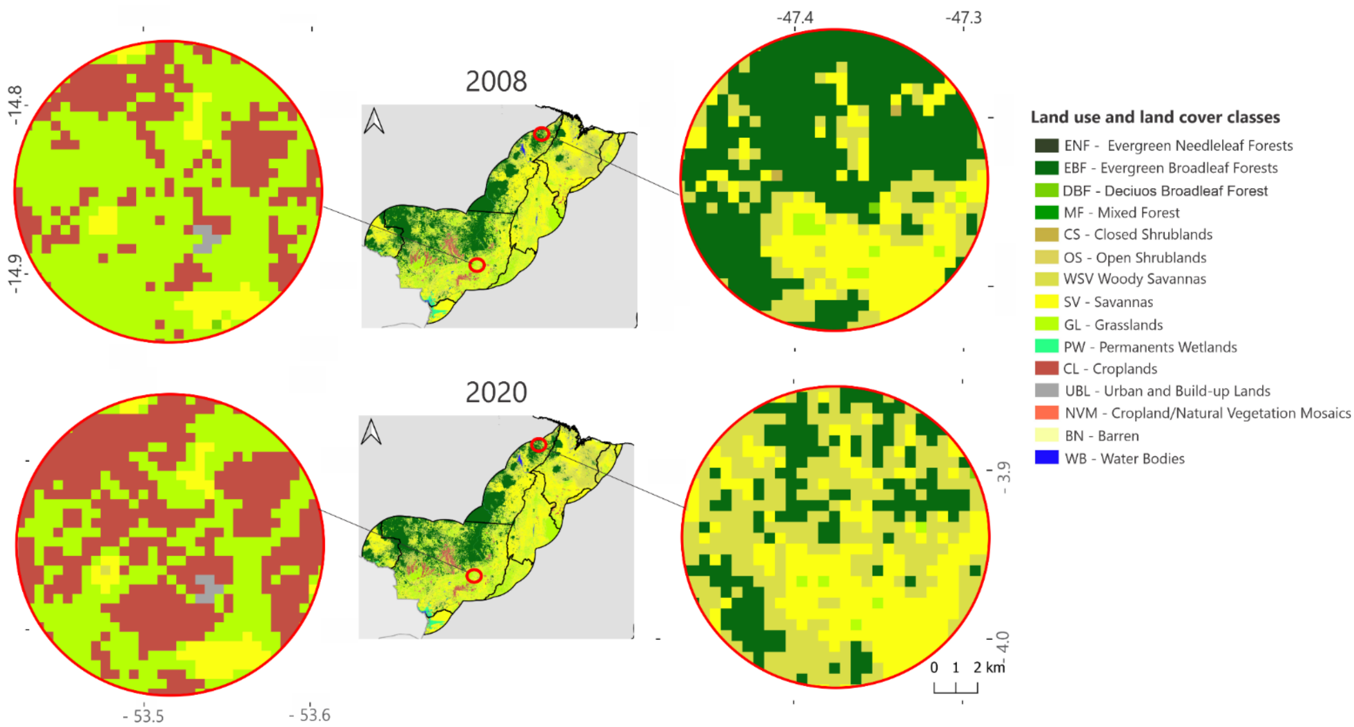
Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrublands (CS); Open Shrublands (OS); Wooded Savannas (WSV); Savannas (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built Soils (UBL); Farmland/natural vegetation mosaics (NVM); Barren (BN); Water bodies (WB).

In the period 2008-2020, there was a decrease in the areas of ENF (38.53 km²), EBF (2,861.07 km²), DBF (1,166.56 km²), MF (1,408.09 km²), CS (1,87.22 km²), SO (279.28 km²), GL (19,070.08 km²), PW (1. The increases were observed in the WSV (9,496.74 km²), SV (15,581.2 km²), CL (1,054.25 km²), WB (29.09 km²), and UBL (7.51 km²) classes.

In the time comparison between 2008-2020, the classes that suffered the greatest losses were GL located in the southern and eastern Cerrado, EBF mainly in the north and western Amazonia (Figure 2, Table 2), MF in the western Amazonia and southeastern Cerrado, and DBF in the northeastern Cerrado and southern Pantanal. Their losses impacted on the reduction of 5.15%, 0.5%, 28.5% and 9.47%, respectively, compared to their area in the first year of the study.

The most representative class SV (39.47%) is found in the Cerrado and the northern and western parts of the Amazonia, while the second largest class EBF (28.13%) is found in the north and west of the study area. The GL (17.86%), WSV (10.04%) and CL (2.16%) classes are identified in the east/south, north/southwest and south/west portions respectively of the transition area. DBF (0.57%) is predominantly found in the federal units of Tocantins, Mato Grosso and Goiás, especially in the Cerrado area. Classes PW (0.93%), WB (0.39%) are found significantly in the Pantanal and northern Amazonia biomes. To a lesser extent, the MF class (0.18%) is observed in the northern Amazonia and the southern Cerrado. UBL (0.10%) is notable in all federal unions, with greater expression in the capitals. The NVM class (0.06) is detected in the southwest of the transition area and is visibly associated with the occurrence of the CL class (Figure 1, Table 2).

Figure 2.0 - Changes in land use and land cover and their expanded area over the federal units of Mato Grosso and Pará.

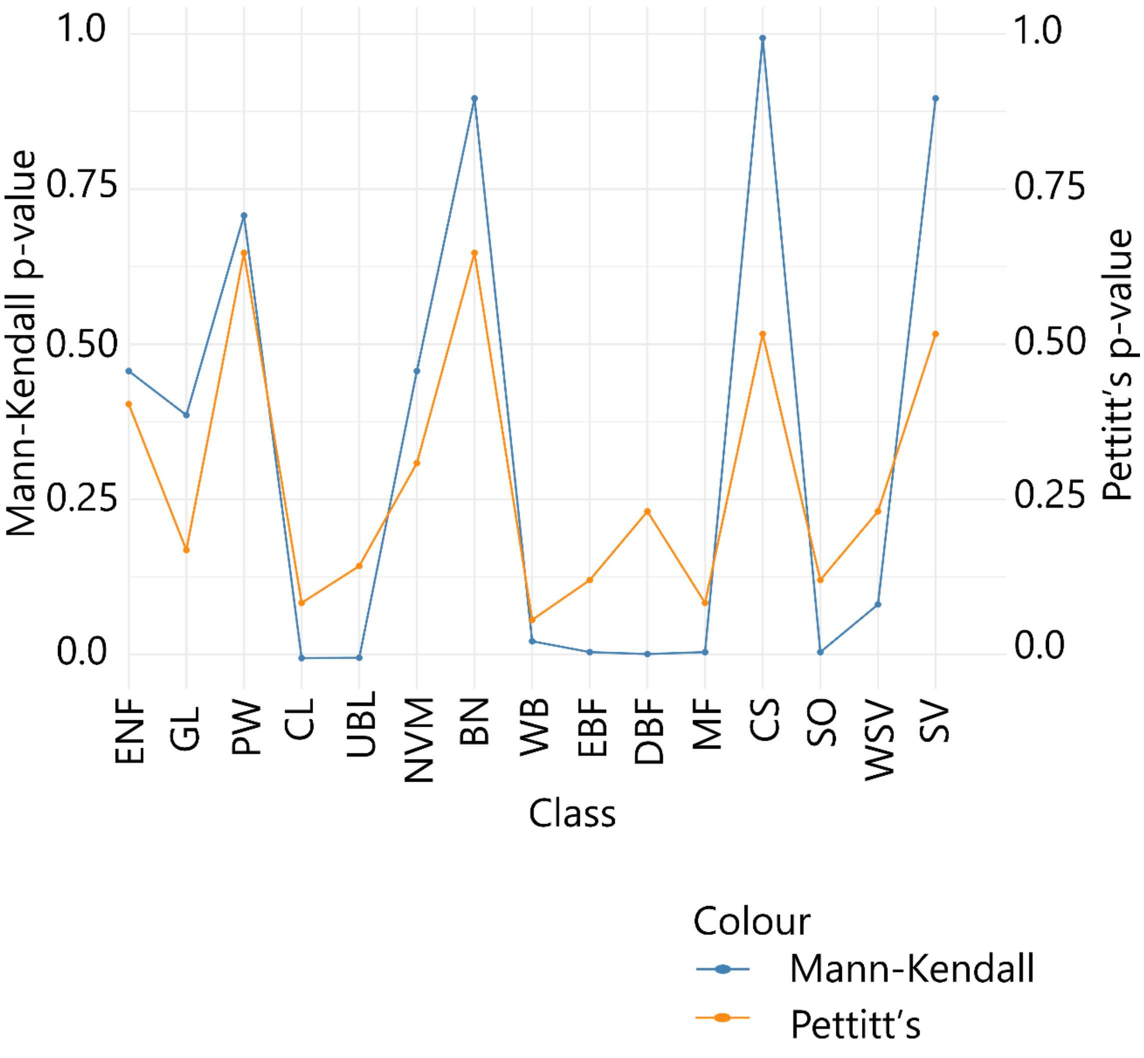


The areas in evidence represent changes in LULC between 2008 and 2020. The brown color on the left side of the map highlights the increase in the crop class (CL) in the federal unit of Mato Grosso. The green color on the right shows the decrease in the evergreen broadleaf forest class in the federal unit of Pará (EBF).

6.2. Pettitt and Mann-Kendall tests on land use and land cover

Increasing trends ($p < 0.05$) were detected by the Z value in the Mann-Kendall test for the DBF (0.007), WB (0.028), CL (0.0006) and UBL (0.0012) over the entire time series.

Figure 1 – Mann Kendall Test and Pettitt Test analysis of land use and land cover classes: 2008-2020.



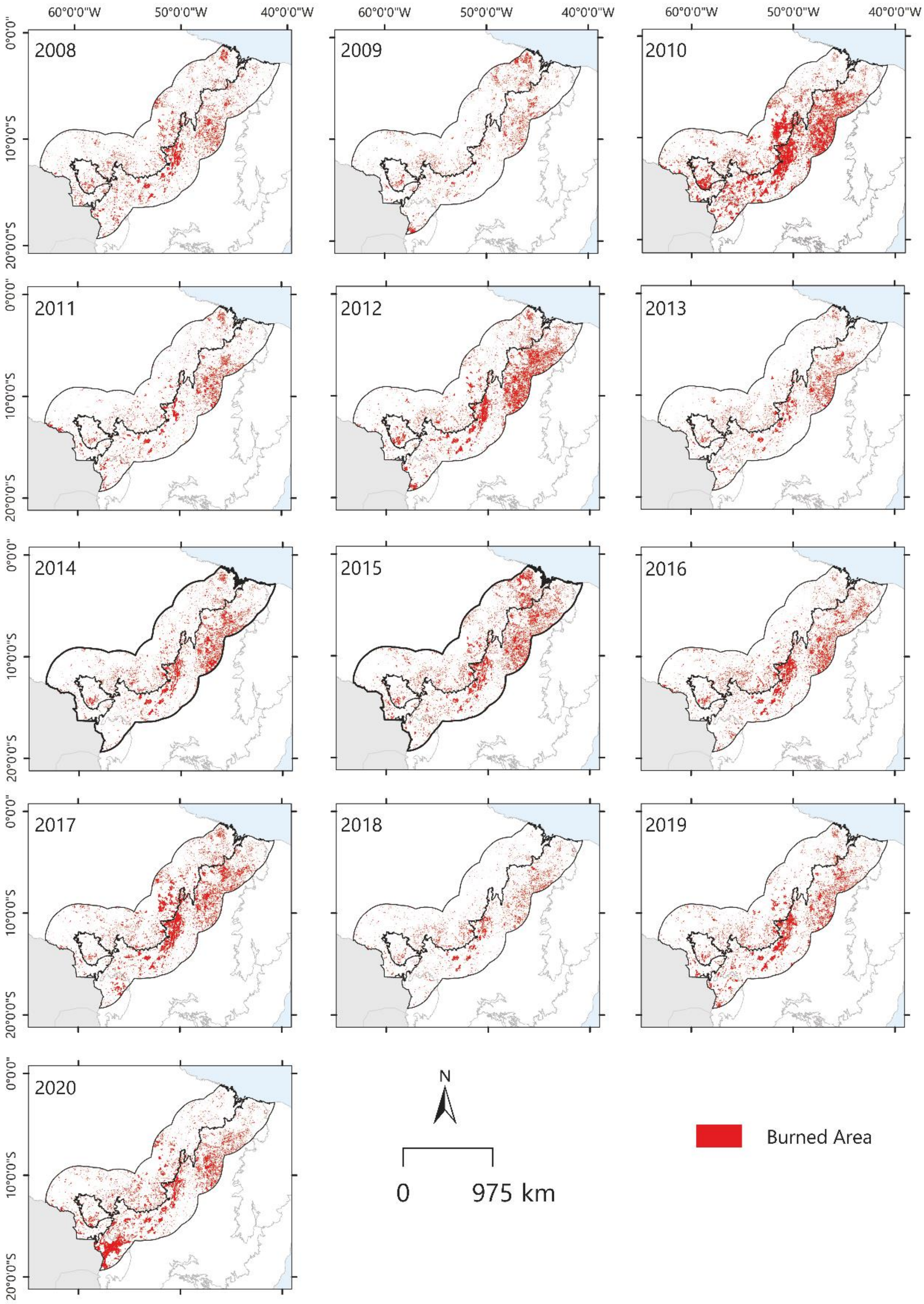
Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrublands (CS); Open Shrublands (OS); Wooded Savannas (WSV); Savannas (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built Soils (UBL); Farmland/natural vegetation mosaics (NVM); Barren (BN); Water bodies (WB). **: significant at 5% by Mann-Kendall test

Significant decreasing trends were detected for the EBF (0.0011) and SO (0.0102) classes, but the Pettitt test was not significant at 95% (Graph 1).

6.3 Burned areas/fire foci.

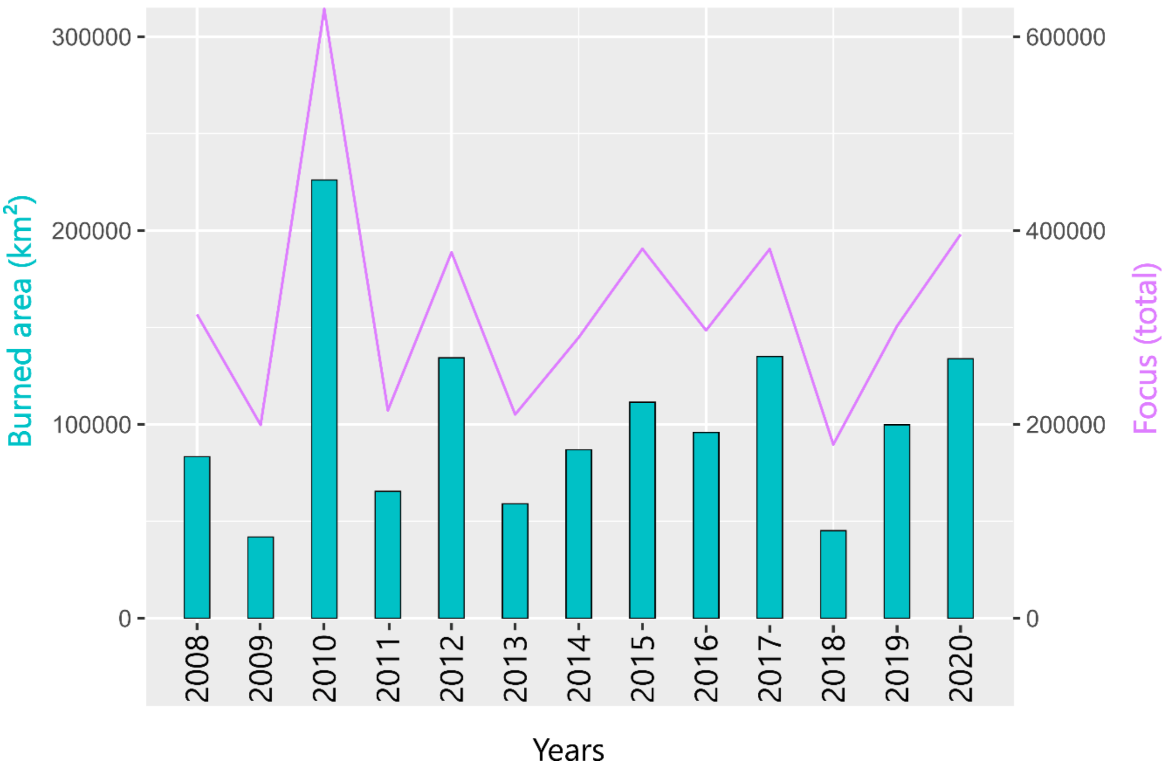
During the entire time series evaluated, a total of 1,317,912.6 km² was burned, equivalent to 67% of the study area. The year 2010 saw the largest area burned in the 2008-2020 time series, with a percentage increase of 439.6% compared to 2009. A predominance of burned areas and fire foci were detected in the central and eastern areas of the Cerrado-Amazonia transition, where part of the area of the last agricultural frontier is located, known as MAPITOBA (acronyms for the federal units of Maranhão, Piauí, Tocantins and Bahia) (Figure 3).

Figure 3 – Burned area in the Cerrado-Amazonia transition: 2008-2020. The black line in the middle refers to the Cerrado-Amazonia boundary (IBGE).



In addition to 2010, the years 2012, 2015, 2017, and 2020 stand out above the mean (101,377.8 km²) in terms of the area burned and together account for 56.19% of the area burned in the entire time series (Table S.1.2). The year 2012 saw a 76% increase in fire foci compared to the previous year, followed by 2019 (69%) and 2014 (37.8%). Fire foci followed a similar metric in relation to the area burned and recorded a percentage increase of 215.1% between 2009 and 2010 (Graph 1.2).

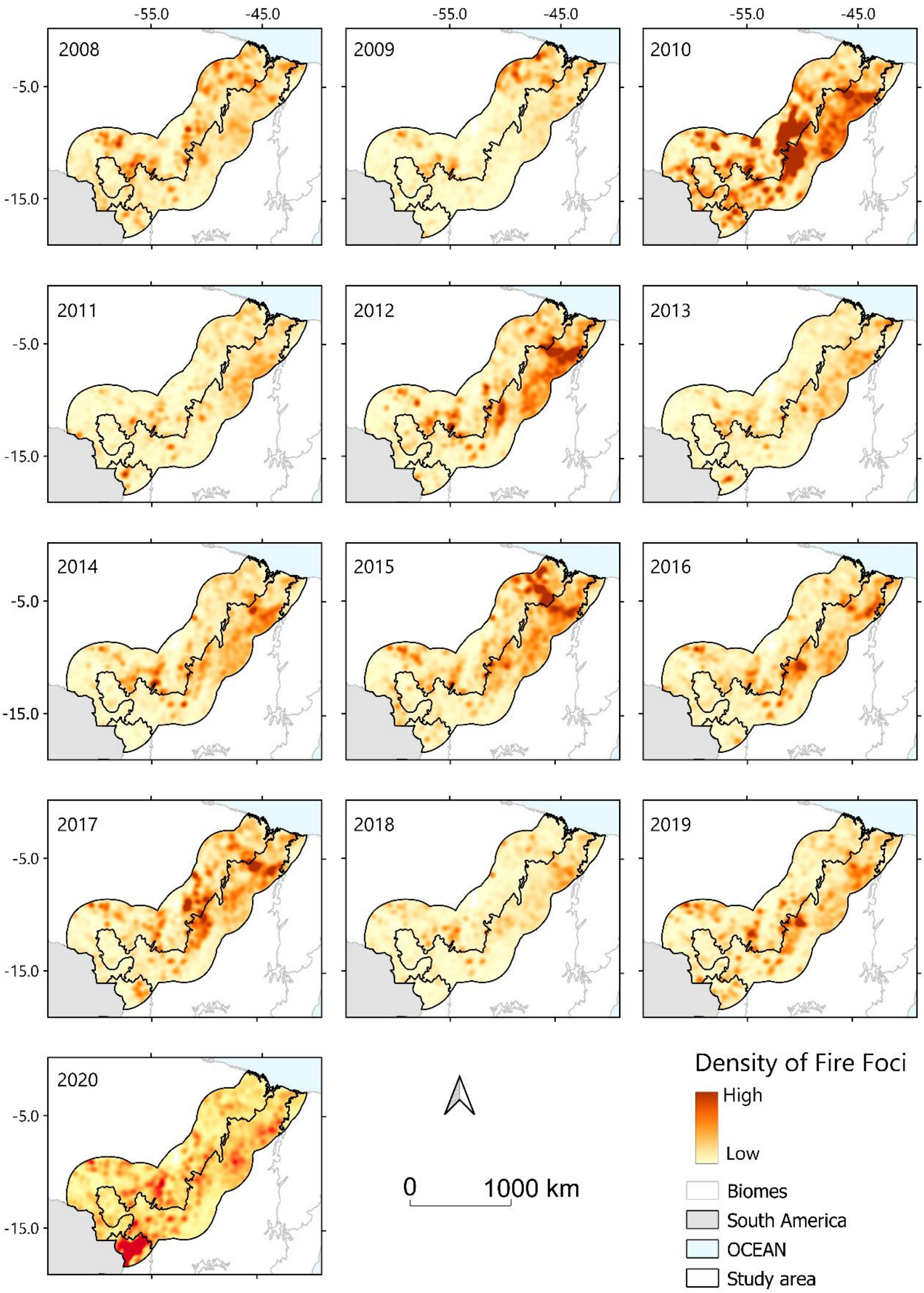
Graph 1.2 – Burned area and total number of fires in the Cerrado-Amazonia transition area: 2008-2020.



The smallest areas burned occurred in the years 2009, 2018, and 2011 and respectively account for 3.17 %, 3.42 % and 4.96 % of the burned area. The years 2008, 2013, 2014, 2016, and 2019 represent 32.23 % of the total burning area and 21.6% of the total area (Graph 1.2, Figure 3). The largest fires occur predominantly in the third quarter, a period of high dry biomass load stimulated by the drought (Graph S 1.0).

In the 2008-2020 time series, we found a balance of 2,084,366 fire foci and the lowest records were seen in 2018, with a 53% decrease in growth compared to 2017 (Graph 1.2). However, in 2020 there was a considerable increase in fires and burned areas in the southwestern portion of the transition, something unprecedented in the timeframe evaluated (Figure 3, Figure 4).

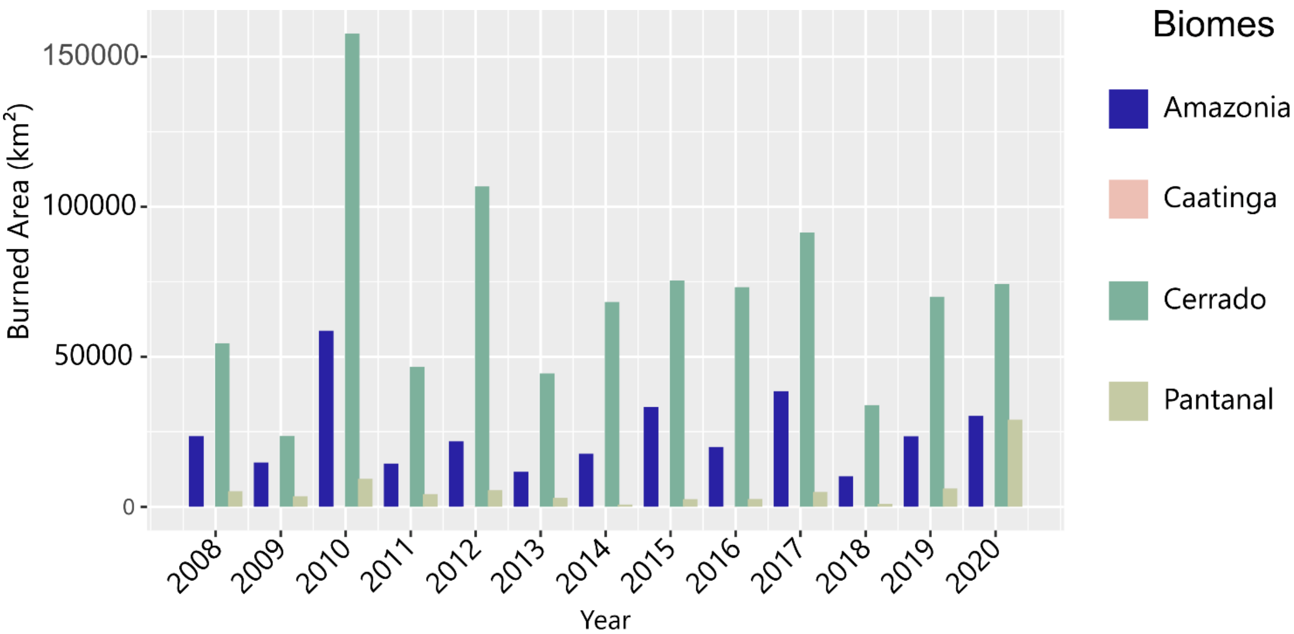
Figure 4 – Fire foci density in the Cerrado-Amazonia transition: 2008-2020



Although the Amazonia biome accounted for the largest number of fire foci in 2008 (57.7%) and 2009 (55.2%), the Cerrado accounts for the largest number of foci in the time series (48.8%), with 15.5% of the occurrences concentrated in 2010 (Graph S. 1.0, Figure 4). The largest burned areas also occur in the Cerrado (55.5% to 79.5%), followed by the Amazonia

(16.2% to 35.2%), Pantanal (0.89% to 21.7%), and Caatinga (0.0% to 0.14%). In 2010, an area of 46,670.1 km² was burned in the Cerrado biome, around 69.8% of the burning among the region's biomes (Graph 1.3).

Graph 1.3 – Burned Area in the Cerrado-Amazonia Transition Biomes: 2008-2020



Amazonia, the largest biome in the study area (Table S - 1.0), burned 58,671.1 km² in 2010, an influence equivalent to 25.9% of the total area burned and a proportional increase of 297.8% over the previous year. The central and northwestern portions of this biome were the most affected (Figure 3). For the same year, Pantanal and Caatinga burned 4.1% and 0.01% respectively, representing the smallest areas burned. Although the Pantanal biome represents the second smallest biome in the Cerrado-Amazonia transition (Table S - 1.0), an area of 29,018.5 km² burned in 2020, which corresponds to 21.7% of the entire burned area and a proportional increase of 378.1% in burning compared to 2019 (Graph 1.3).

The Caatinga has the smallest area (0.6%) in the Cerrado-Amazonia transition (Table S1.0) and 0.49% of the fires in the time series analyzed. In the 13 years analyzed, this biome accumulated a deficit in the percentage growth of fire foci in 8 years of the study period and the Mann-Kendall test identified a significant decreasing trend (**0.012). However, the Pettitt test failed to indicate with 95% accuracy the exact year of this change (Table 3).

Table 3.0 – Mann-Kendall and Pettitt test for the variables fire foci and burned area, in the total area of the Cerrado-Amazonia transition and by biome: 2008-2020

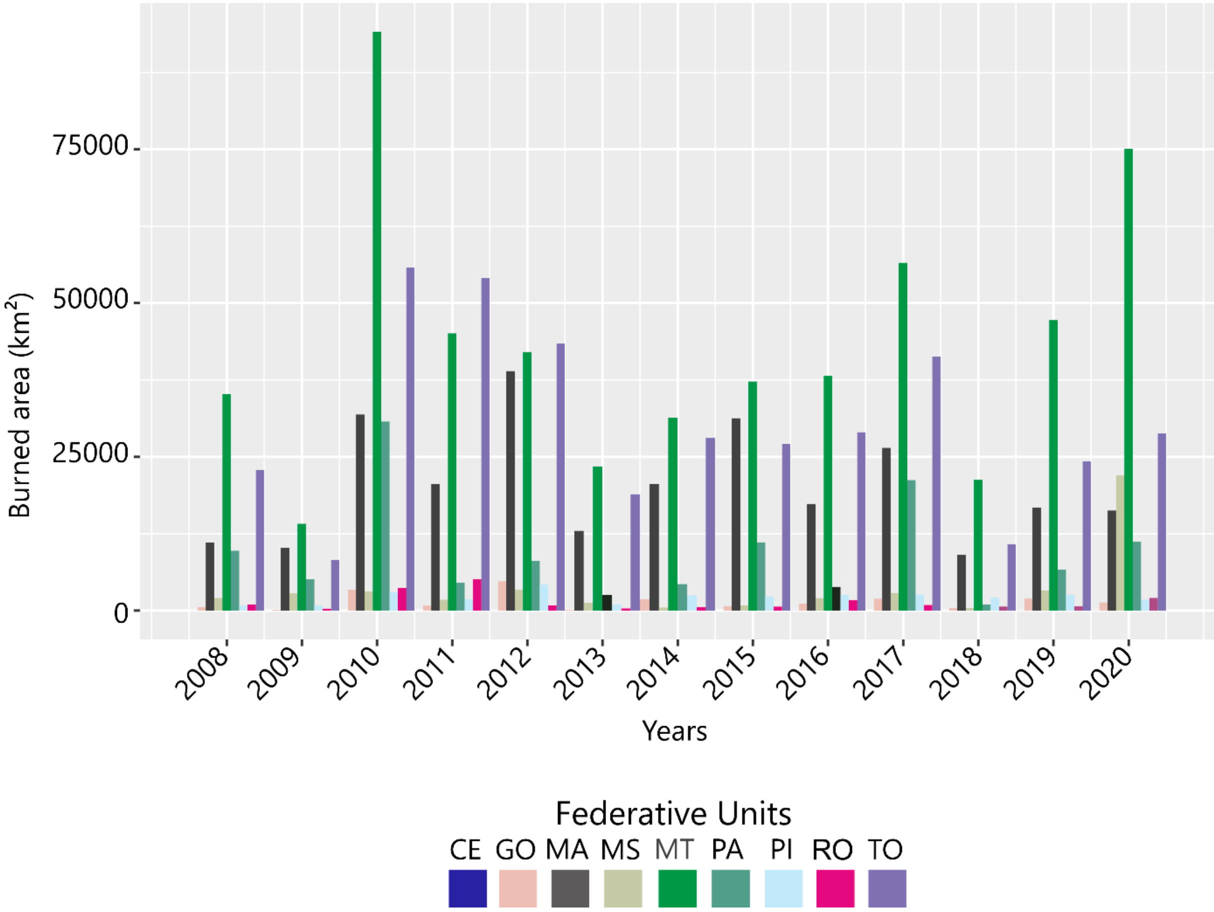
Area	Burned Area				Fire Foci				
Cerrado-Amazonia Transition	Mann-Kendall	Z	Pettitt	S	Mann-Kendall	Z	Pettitt	S	YEAR
	0.43	0.79	1.00	43	0.583	0.549	1.00	34	_
Biomes	Burned Area				Fire Foci				
	Mann-Kendall	Z	Pettitt	S	Mann-Kendall	Z	Pettitt	S	YEAR
Amazonia	0.85	0.18	1	4	0.85	0.18	1	-4	_
Caatinga	0.16	1.4	0.14	24	0.08	2.5	0.14	-42	2011
Cerrado	0.66	0.42	1	8	0.76	0.3	1	6	_
Pantanal	0.95	-0.06	0.72	-2	1	0	0.72	0	_

Although there were significant percentage increases in burned area and fire foci from one year to the next, the Mann Kendall test did not identify a significant trend for the total area of the Cerrado-Amazonia transition or for the other biomes (Table 3).

The highest numbers of fires occur in the states of MT, PA and TO, respectively, and together they account for 67.9% of the total number of fires over the time series analyzed. On the other hand, when we divide the number of fire foci by the area of the federal units, MA, TO and MS represent the highest densities of fire foci in their respective territories (Table S1.3, Figure 4).

The State of Mato Grosso has the largest territory in the Cerrado-Amazonia transition (Table S - 1.1) and also consolidates the largest burned area among the states (39.2%) in the time series analyzed (Graph 1.4). In 2010, the peak year for fires, this federal unit burned something equivalent to 41.6% of the area burned among the states and a percentage increase of 566.5% compared to 2009. However, when we consider the proportion of each federal unit's area, the state of TO has the largest burnt area (0.23% of its territory burnt), followed by MT (0.11%), and PA (0.09%) (Figure 3, Table S1.1, Graph 1.3, Graph 1.4).

Graph 1.4 – Burned Area by Federative Unit in the Cerrado-Amazonia transition: 2008-2020



Federal Units: Ceará (CE), Goiás (GO), Maranhão (MA), Mato Grosso do Sul (MS), Mato Grosso (MT) Pará (PA), Piauí (PI), Rondônia (RO), and Tocantins (TO).

The State of Mato Grosso do Sul was the third most expensive federal unit in terms of area burned in 2020 (13.8% in relation to the amount of the states). However, it had a proportional growth of 568.8% in the area burned compared to 2019. The state of TO burned an area of 54,096.9 km² in 2011, which corresponds to 40.4% of all the burned area among the federations for that year. The states of MA and PA accounted for 18.1% and 8.2%, respectively, of the total burned area in the 2008-2020 time series, and in 2017 there was an increase of 52.7% and 448.7%, respectively, in the burned area compared to 2016 (Graph 1.4, Figure 3).

The federal units of RO, PI, GO, and CE (11.3% of the total area) account for the smallest burned areas and together account for 4.5% of the total burned area in the Cerrado-Amazonia transition (Graph 1.4, Figure 3). The lowest number of fires occurred in the States of CE, GO and MS, which accounted for 3.5% of the total fire foci over the time series (Figure 2.2, Table S1.3).

In the total time series analyzed, the LULC class with the largest burned area is SV (52.4%), followed by GL (26.4%) and WSV (7.6%). The ENF, CS, OS, NVN, BN, WB and UBL species had the smallest burned areas and accounted for 0.1% of the total burned area. The EBF, WSV, SV and GL classes had above-average burns and accounted for 93.9% of the total burned area (Table 4).

Table 4 – Burned area (km²) of land use and land cover in the Cerrado-Amazonia transition: 2008-2020.

Class	ENF	EBF	DBF	MF	CS	OS	WSV	SV
2008	0.24	4289.00	1601.03	797.10	38.20	33.46	4097.71	45995.29
2009	3.30	1726.56	208.29	229.57	8.83	1.45	2754.75	20367.62
2010	7.74	21599.63	4337.50	1919.98	49.54	44.40	17742.41	119522.54
2011	5.52	2964.29	1510.11	633.30	6.56	4.84	2703.47	35263.98
2012	1.89	7415.79	3052.11	1141.57	7.83	18.71	13915.51	74014.17
2013	0.24	1982.20	969.10	542.63	4.63	3.67	3172.59	30172.84
2014	0.00	4003.43	1954.50	619.85	6.62	6.60	5773.49	47817.20
2015	0.48	8661.42	2533.19	836.83	5.65	5.37	12006.27	56445.40
2016	0.96	5256.95	2628.09	683.72	7.56	8.30	7457.68	48086.11
2017	1.20	12367.86	3326.63	1084.92	12.04	5.38	11279.99	74154.55
2018	0.00	1482.85	1274.81	241.92	3.70	2.19	2545.56	21610.02
2019	2.37	6003.86	2397.64	551.51	7.29	0.97	5277.41	53712.88
2020	42.94	19261.19	1766.41	703.15	42.43	52.96	11749.86	64103.02
Total	66.88	97015.04	27559.42	9986.06	200.87	188.30	100476.68	691265.60
Minimum	0.00	1482.85	208.29	229.57	3.70	0.97	2545.56	20367.62
Maximum	42.94	21599.63	4337.50	1919.98	49.54	52.96	17742.41	119522.54
Mean	5.14	7462.70	2119.96	768.16	15.45	14.48	7728.98	53174.28

Class	GL	PW	CL	UBL	NVM	BN	WB	
2008	24249.05	389.46	1735.87	4.34	28.41	2.46	18.92	
2009	13659.93	369.25	2455.78	0.49	7.94	1.23	34.16	
2010	56864.31	839.98	2878.41	5.57	30.71	2.45	45.21	
2011	19533.28	821.04	1843.16	1.70	13.09	0.98	32.27	
2012	31974.37	360.08	2248.04	5.60	8.67	1.48	43.31	
2013	19546.36	282.55	2281.13	1.69	6.71	1.47	9.59	
2014	24775.20	52.78	1727.04	2.92	12.69	1.72	17.23	
2015	27825.63	118.06	2777.44	1.70	24.48	4.43	17.24	
2016	28247.65	46.23	3340.89	4.62	13.50	1.72	12.31	
2017	30038.06	178.19	2479.01	2.66	4.10	2.70	15.69	
2018	14613.68	20.52	3278.07	0.72	3.87	0.99	4.41	

2019	27027.05	575.41	4056.38	3.63	15.69	2.70	27.88	[redacted]
2020	30224.00	3470.14	1892.12	9.55	17.76	2.22	367.49	
Total	348578.57	7523.70	32993.33	45.18	187.61	26.55	645.72	
Minimum	13659.93	20.52	1727.04	0.49	3.87	0.98	4.41	
Maximum	56864.31	3470.14	4056.38	9.55	30.71	4.43	367.49	
Mean	26813.74	578.75	2537.95	3.48	14.43	2.04	49.67	

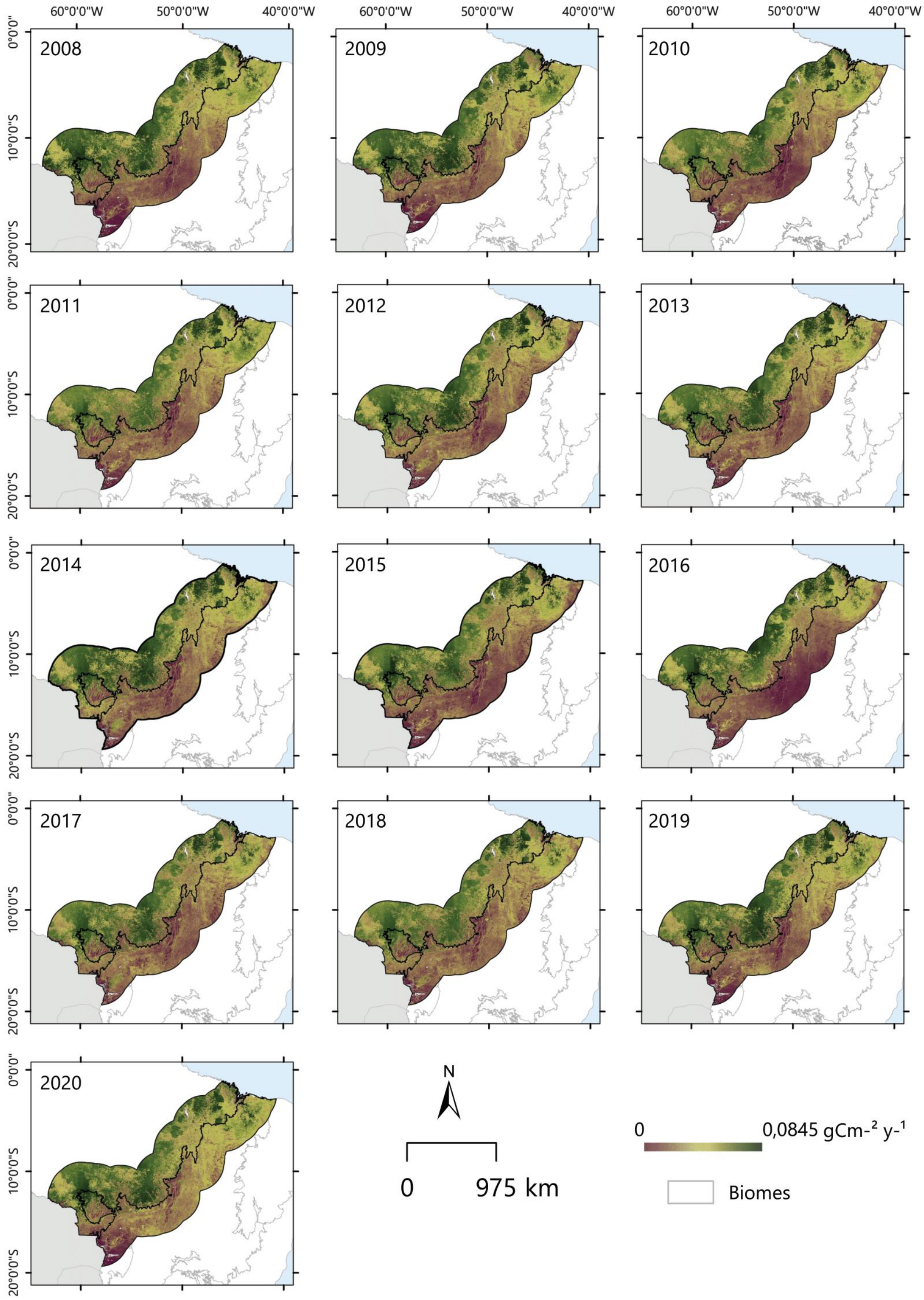
Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrublands (CS); Open Shrublands (OS); Wooded Savannas (WSV); Savannas (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built Soils (UBL); Farmland/natural vegetation mosaics (NVM); Barren (BN); Water bodies (WB).

In 2010, the most significant year for burned areas, the OS class had the highest growth in percentage of burned areas (2,956.3%), followed by the DBF (1,982.4%) and UBL (1,046.8%) classes. In 2012, the WSV, OS and EBF varieties showed a proportional increase of 414.7%, 286.8% and 150.1% in burned areas, respectively, compared to 2011. However, in 2020, the third year with the highest accumulation of burned area, the OS class recorded a percentage growth of 5,344.8% followed by WB (1,842.01%), ENF (1,714.37%), and CS (482.47%) and together they accounted for 1,077.8 km² of burned area (Table 4).

6.4 – Gross Primary Production - Total Area

The highest GPP values were detected in the first quarter of 2010 (0.802 gC$m^{-2}y^{-1}$), 2019 (0.076 gC$m^{-2}y^{-1}$) and 2017 (0.074 gC$m^{-2}y^{-1}$), all over the northwestern Amazonia region. When analyzing the mean GPP in the time series, the years 2008, 2009, 2010, 2011, 2012, and 2016 accounted for below-average values and the year 2016 showed the lowest index (0.023 gC$m^{-2}y^{-1}$) especially the Cerrado biome (Figure 5).

Figure 5 – The Temporal Spatiality of the GPP in the Cerrado-Amazonia transition: 2008-2020



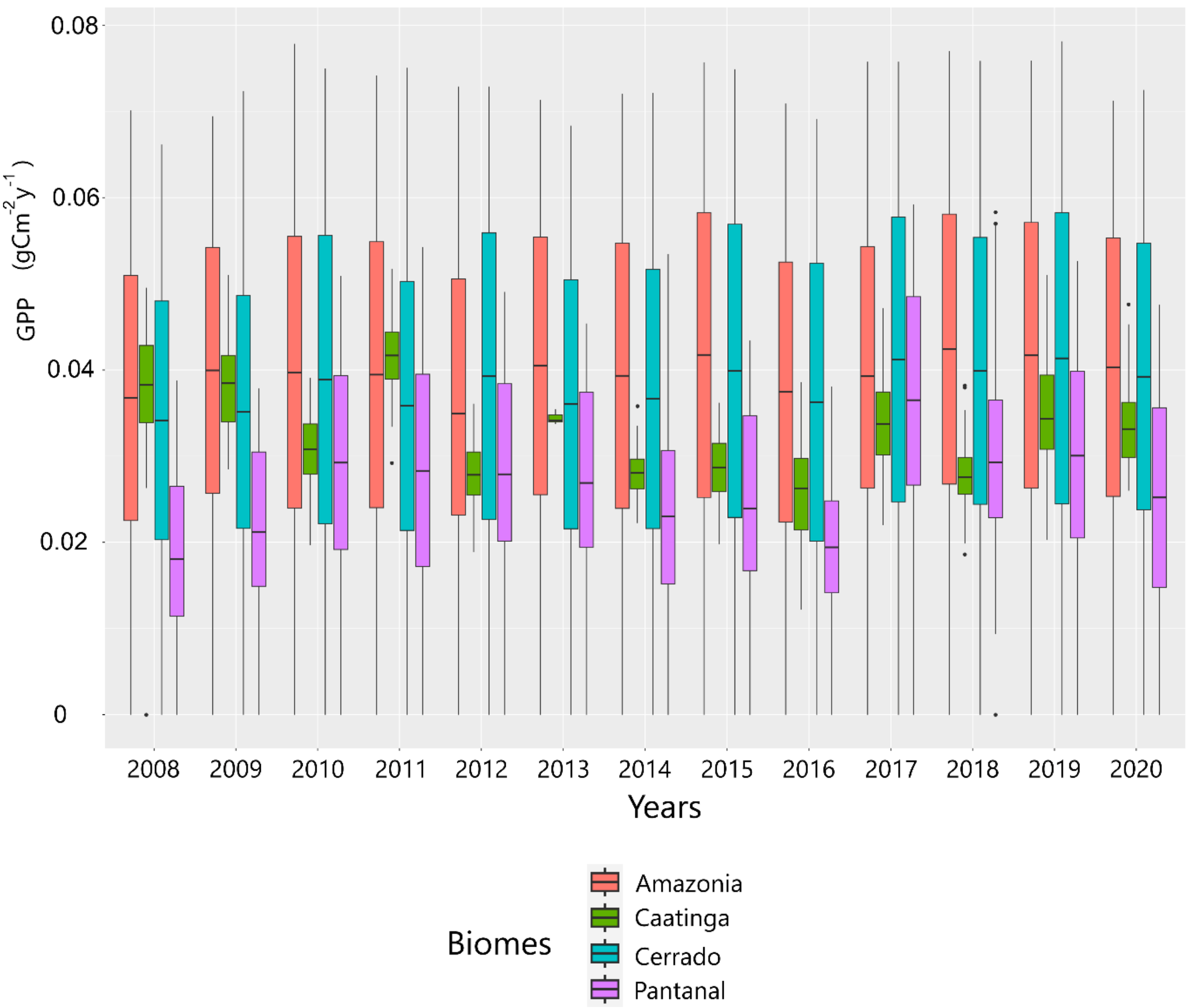
Results of annual GPP (Gross Primary Production) between 2008-2020 in the Cerrado-Amazonia Transition area in grams of carbon per m² per year. The black line in the middle refers to the boundary (IBGE) between the Cerrado and the Amazonia.

In 2009, there was a higher spatial dispersion of high GPP values in Amazonia, in the northeastern Cerrado and in the northwestern Caatinga. As a result, the accumulation of biomass in 2009 may have boosted burning in 2010, the period with the largest area burned. In the years following the largest burned areas, 2011 and 2017 show high GPP values in the northeastern and southwestern portions of the Cerrado, a fact correlated with the period of regrowth and less burning of this vegetation in these years (Figure 5).

6.5 – Gross Primary Production over burned area

In the Amazonia, the years 2008, 2011, 2012, 2014 and 2016 had below-average GPP, in which the lowest value was recorded in 2008 (0.036 g$Cm^{-2}y^{-1}$). The highest mean GPP values were detected in 2018, 2015 and 2019, respectively. Due to the different LULC classes and the presence of burning and regrowth in the same year, the greatest dispersions are seen in the Amazonia and Cerrado (Graph 1.5).

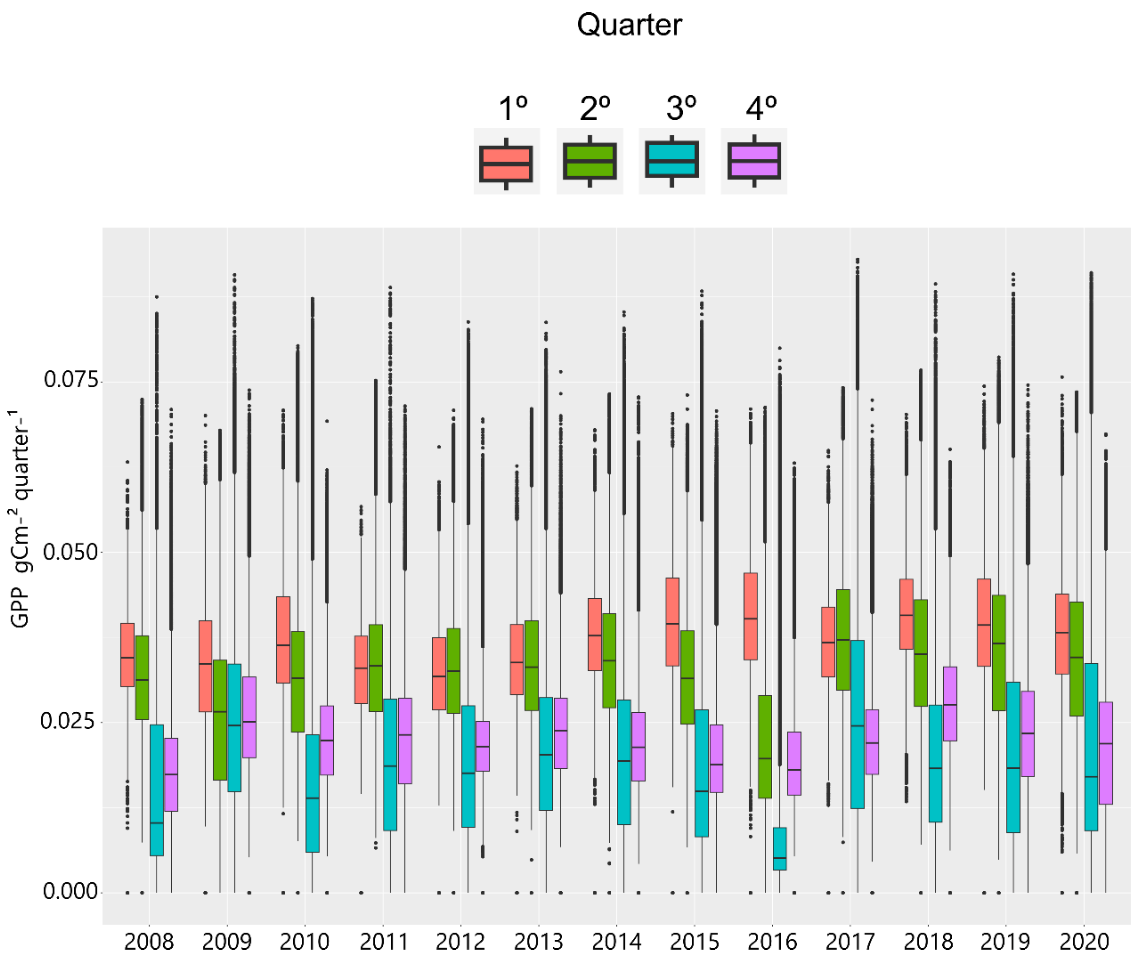
Graph 1.5 - Gross Primary Production over the burned area of the Biomes in the Cerrado-Amazonia transition: 2008-2020.



The lowest burned area values in the years 2011, 2009 and 2008 in the Caatinga biome resulted in the highest median GPP values in the northwestern part of its territory (Figure 5). The lowest mean GPP value was consolidated in 2016 and this is correlated with the highest value of burned area (16.7%) in this biome. The lowest dispersion is observed in 2013, the year with the lowest concentration of fire foci (Graph S.1.1, Graph 1.5).

The third quarter concentrates the longest period of drought, sunlight and fires (Graph S.1.0), so in the time series (2008-2020), the lowest GPP values also occurred in this quarter. As more than 90% of the territory has a tropical climate, the fourth quarter exceeds the third quarter in GPP values, which is correlated with the arrival of the rainy season and the start of post-burn regrowth. The years 2016, 2008 and 2010 each had the lowest GPP values in the time series (Graph 1.6).

Graph 1.6- Gross Primary Production per quarter over the entire burned area in the Cerrado-Amazonia transition: 2008-2020



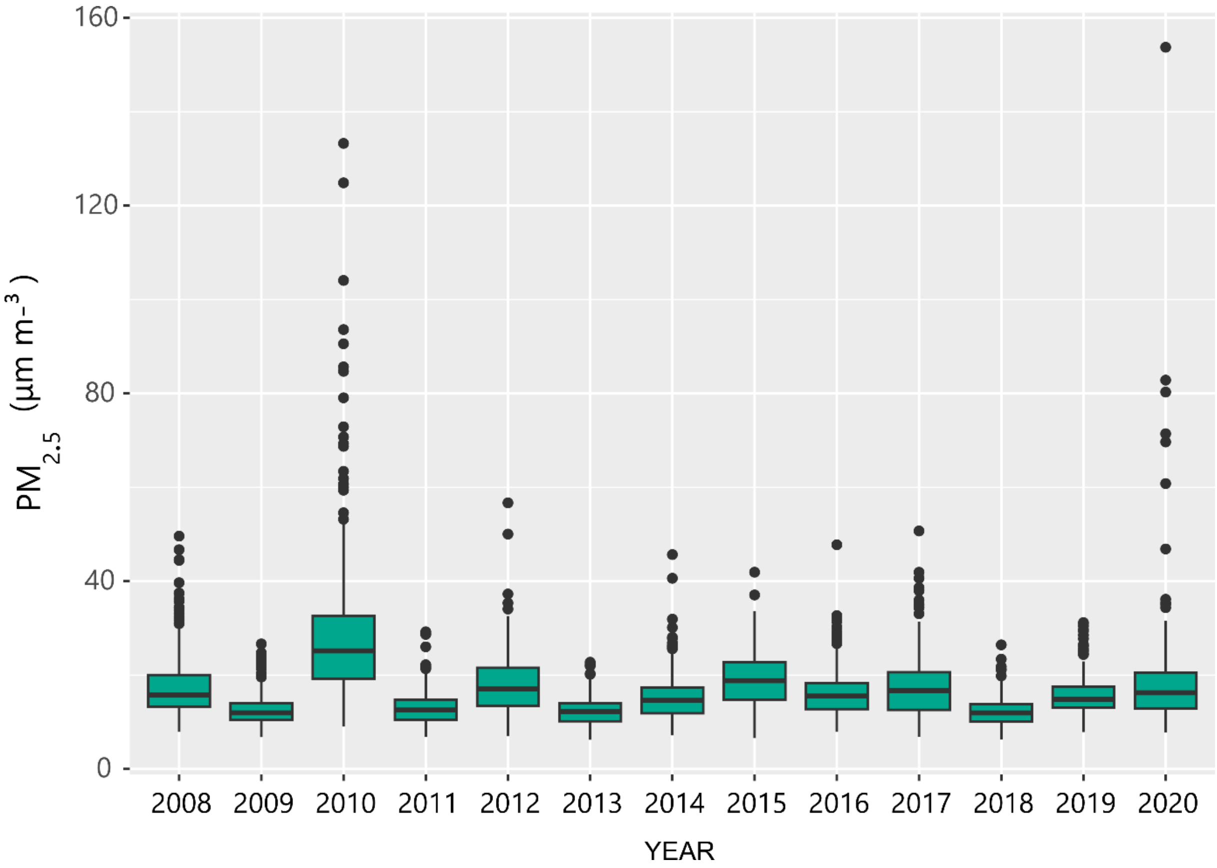
In the Cerrado biome, the years 2019 and 2017 showed the highest median annual GPP values (Graph 1.5), both identified in the northeastern portion of the Cerrado-Amazonia transition (Figure 5). These values reflect smaller burned areas (Graph S1.0) and rainier periods equivalent to the first and second quarters of the respective years (Graph 1.6). The highest dispersion of GPP data in the Cerrado occurs in 2010 (Graph 1.5). This is due to the increase in biomass from the previous year until the first quarter of 2010, combined with the intensification of fires in the third quarter of the same year (Graph 1.6).

Due to the natural seasonality of floods and ebbs in the Pantanal, this biome had the lowest GPP means throughout the time series (Graph 1.5). In 2008, the lowest value was detected in the southern portion of its territory (0.018 gC$m^{-2}y^{-1}$) over temporarily flooded areas. Its highest mean was observed in 2017 (0.037 gC$m^{-2}y^{-1}$) in the northern portion, an area less affected by the seasonal water cycle of this biome (Figure 5). In 2017 and 2019, mean GPP values accumulated above the time mean analyzed. As a result of this biomass accumulation, there was an intensification of burned areas detected in the State of Mato Grosso do Sul in 2020 (Graph 1.4) and the Pantanal recorded the highest number of fire foci among the biomes (Graph S.1.1) and significant reductions in GPP for the same year (Graph 1.5).

6.6 - $PM_{2.5}$ (µm m^{-3})

All the years had an annual mean of $PM_{2.5}$ above the safety limit (10 µm m^{-3}) established by the World Health Organization (WHO)(ORGANIZATION, 2021)(UNIÃO, [s.d.]) and National Environment Council. The year 2010 accumulated the highest mean (28,8 µm m^{-3}) between the mean $PM_{2.5}$ pixels with the highest percentage growth (130.15%), and this is compatible with the period of highest burned area/fires in the time series analyzed (Graph 1.2). The years 2015 (19.0 µm m^{-3}), 2020 (18.5 µm m^{-3}) had the second and third highest mean $PM_{2.5}$ pixel accumulations. The lowest values were detected respectively in the years 2018 (12.0 µm m^{-3}) and 2013 (12.3 µm m^{-3}) (Graph 1.7).

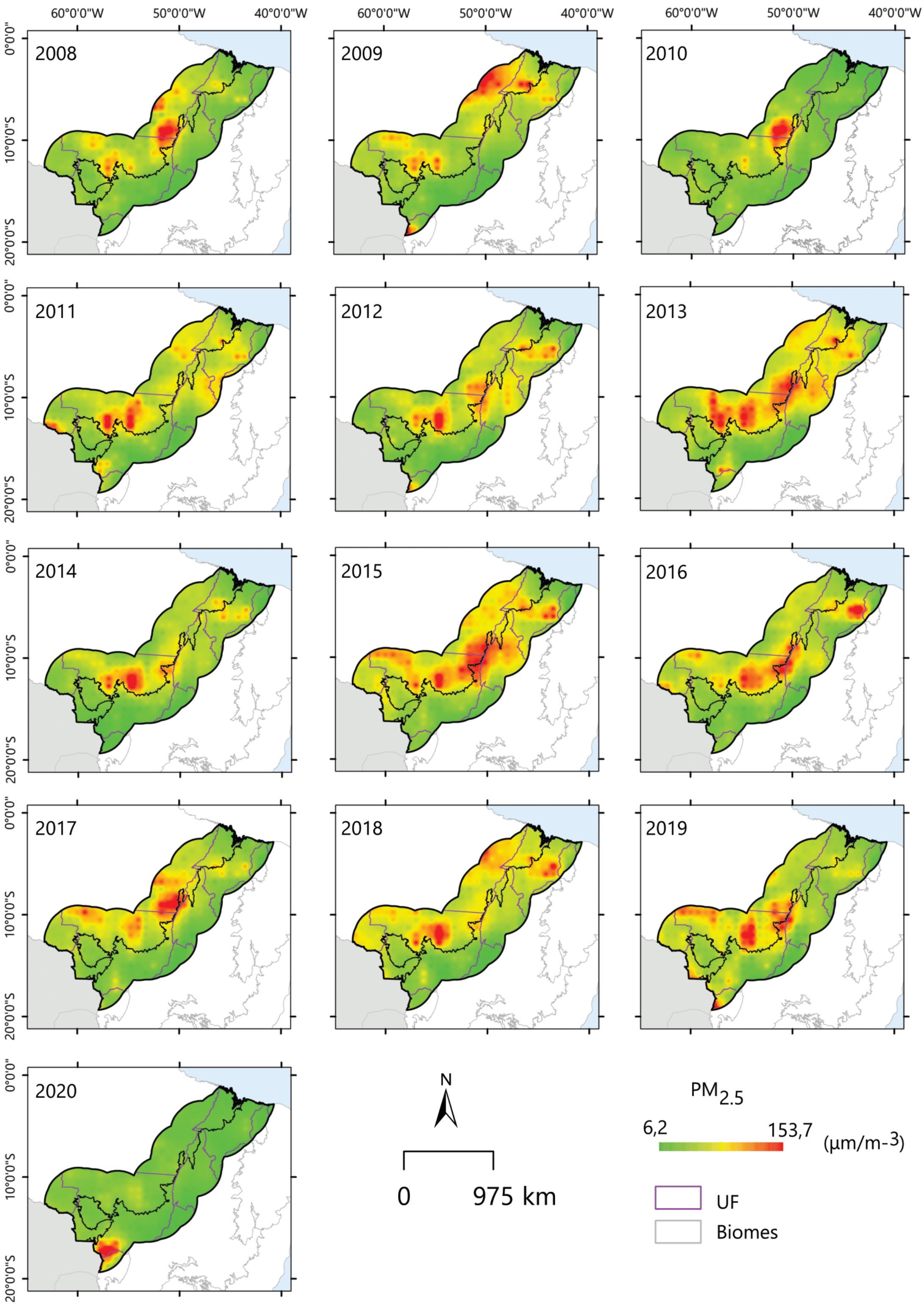
Graph 1.7 – $PM_{2.5}$ in the Cerrado-Amazonia transition: 2008-2020



In the annual graph of $PM_{2.5}$ (Gráfico 1.7), it is possible to see a higher dispersion of the interquartile range associated with a lower data density near the median when the values of the fine particles exceed the mean (16.7 µm m^{-3}) of the time series. This occurs in the presence of large burned areas that emit significant quantities of particles and become clear in the highest values andoutliers. The highest annual mean of $PM_{2.5}$ occurred in 2020 (153.7 µm m^{-3}) over the Pantanal, which concentrated the lowest spatial dispersion of fine particles in the time series (Graph 1.7, figure 4).

Spatial concentrations vary over the years, but there is a certain constancy in the central and eastern portions of the study area over Amazonia and Cerrado territories, respectively. The northern region of the State of Mato Grosso also has considerable concentrations in the Amazon biome. The year 2015 showed the highest spatial dispersion of $PM_{2.5}$ and its highest concentration is observed in the Amazonia (Figure 6).

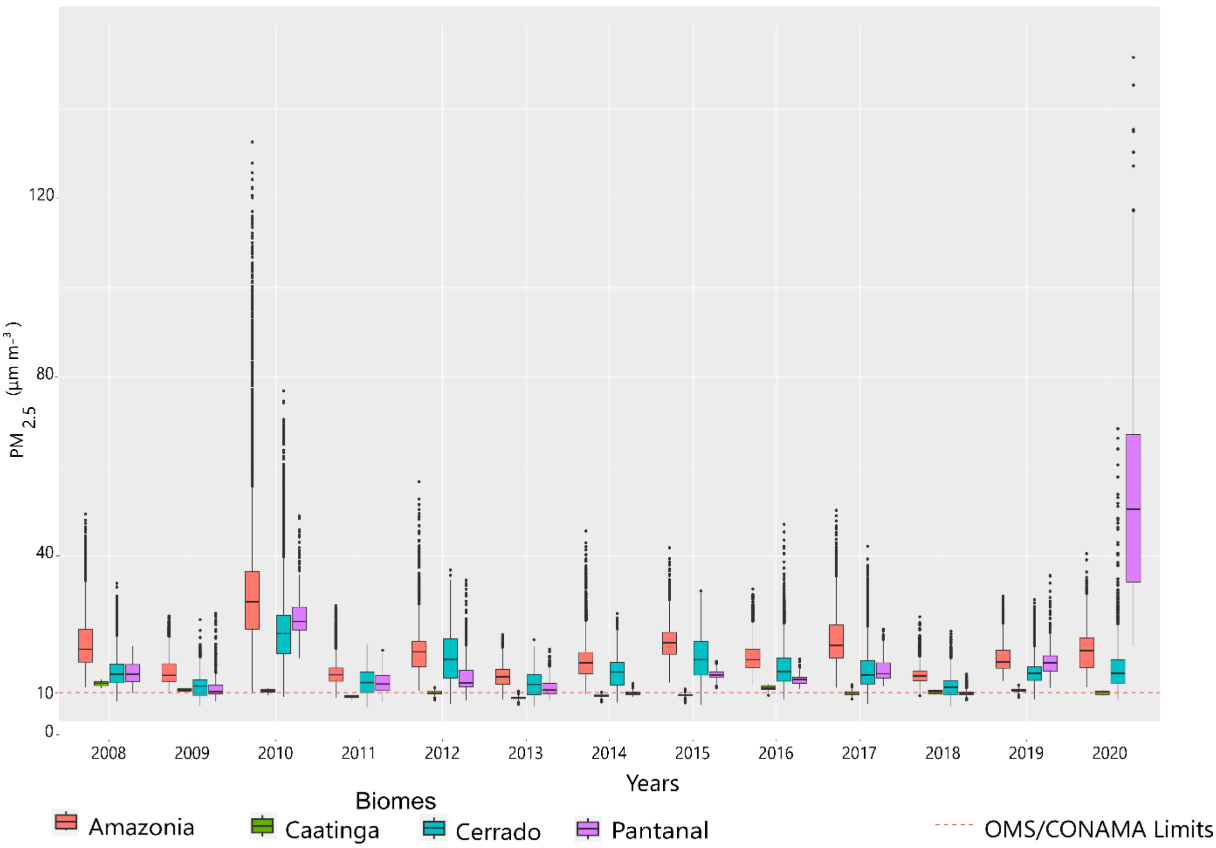
Figure 6 – Annual mean of $PM_{2.5}$ in the Cerrado-Amazonia transition: 2008-2020



Annual Particulate Matter Concentration ($PM_{2.5}$ µm m^{-3}) on their respective Federative Units between 2008-2020, in the Cerrado-Amazonia transition area. The black line in the middle refers to the boundary (IBGE) between the Cerrado and the Amazonia.

Amazonia showed mean values of fine particles above all the biomes in the time series analyzed, except for 2020, which due to the intense fires in the Pantanal biome, emitted significant amounts of $PM_{2.5}$ to the atmosphere The lowest mean value for fine particles was observed in the Caatinga biome (8, 3 µm m^{-3}) in 2013, followed by the Pantanal (9,3 µm m^{-3}) in 2014. Cerrado ranks second among the biomes with the highest annual means of $PM_{2.5}$ in 2016. Isolated points in this biome exceeded the values for the Amazonia and this can be seen in the outliers for the year in question (Figure 1.8).

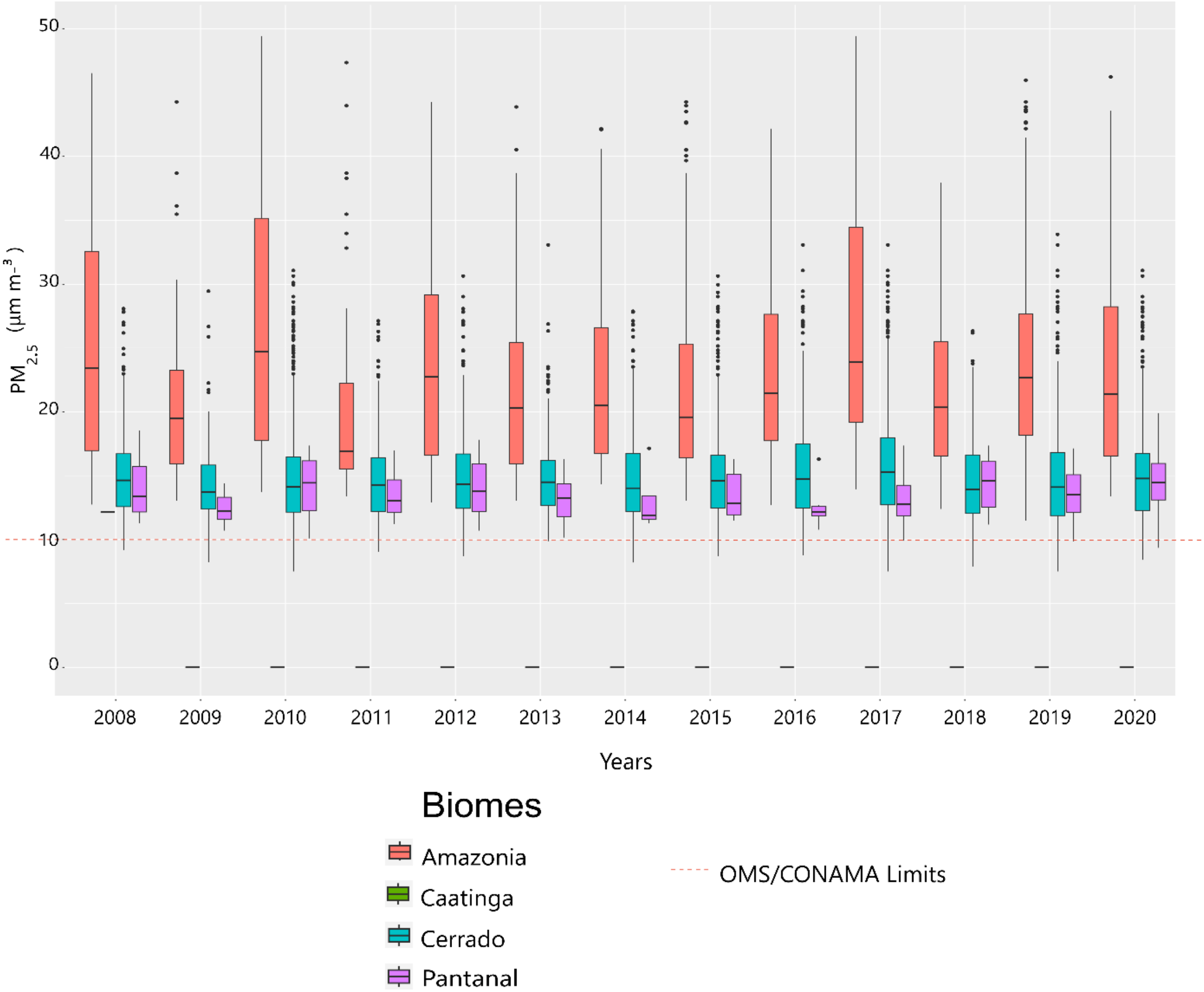
Graph 1.8 - Annual $PM_{2.5}$ in the Cerrado-Amazonia transition biomes: 2008-2020



Amazonia showed the highest percentage growth (135%) of $PM_{2.5}$ followed by the Cerrado biome (118%) in 2010 and the lowest growths were observed the following year in the Amazonia (-58%) and Pantanal (-56%) biomes (Graph 1.8).

The highest emissions of $PM_{2.5}$ as well as large fires occur in the third quarter of the year (Graph S1.2) and this demonstrates the influence of fire on the atmosphere associated with the dry season. When we analyze the $PM_{2.5}$ over the burned area, it becomes clear that the Amazonia biome emits a greater amount of fine particulate matter in the air over the entire time series evaluated (Graph 1.9).

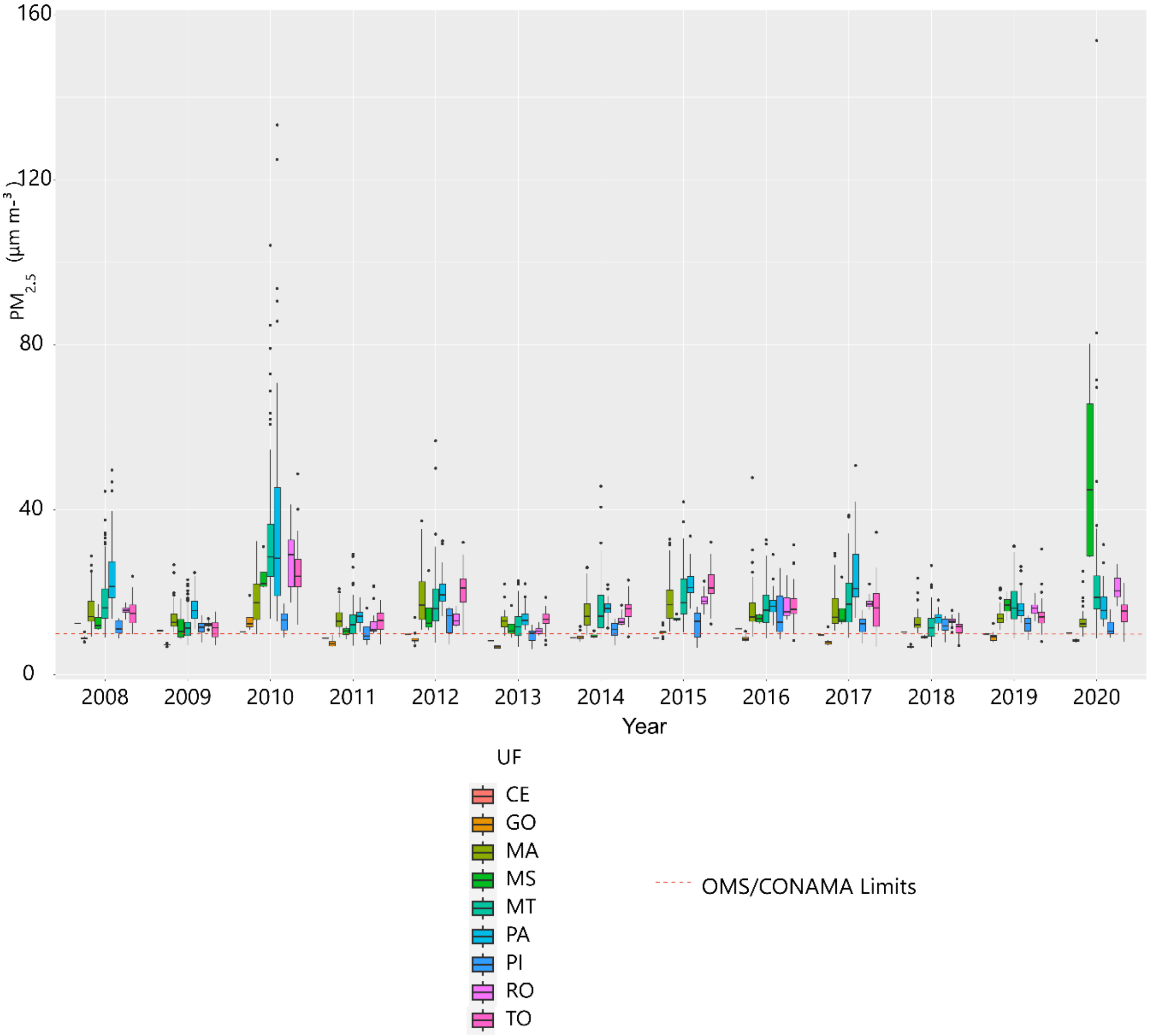
Graph 1.9 - Annual $PM_{2.5}$ on the burned area of biomes in the Cerrado-Amazonia transition: 2008-2020



We found that the highest $PM_{2.5}$ values do not occur exactly over the burned areas, but around them. This shows that atmospheric instability can interfere with the spatiality of fine particle data and has the potential to influence adjacent biomes or federal units. As an example of this process, we note that the Pantanal did not record the highest $PM_{2.5}$ values over its burned area in 2010 (Graph 1.9). This condition was reported in the same biome, but outside its burned area (Graph 1.8). However, all biomes showed means higher than the safety limits established by WHO/CONAMA (UNIÃO, [s.d.])(ORGANIZATION, 2021).

The highest mean $PM_{2.5}$ values in the time series were observed in the States of PA (19.5 µm m^{-3}), MT (17.38 µm m^{-3}) and MS (16.47 µm m^{-3}). However, we detected the highest annual pixel values in the States of MS (49.5 µm m^{-3} in 2020), followed by PA (39.1 µm m^{-3}) and MT (32.7 µm m^{-3}) in 2010. The States of CE, GO and PI were the only federative units in the 2008-2020 time series with mean annual pixels of $PM_{2.5}$ below the safety limit established by WHO/CONAMA (Graph 2.0).

Graph 2.0 – Annual mean of $PM_{2.5}$ on the Federal Units in the Cerrado-Amazonia transition: 2008-2020.

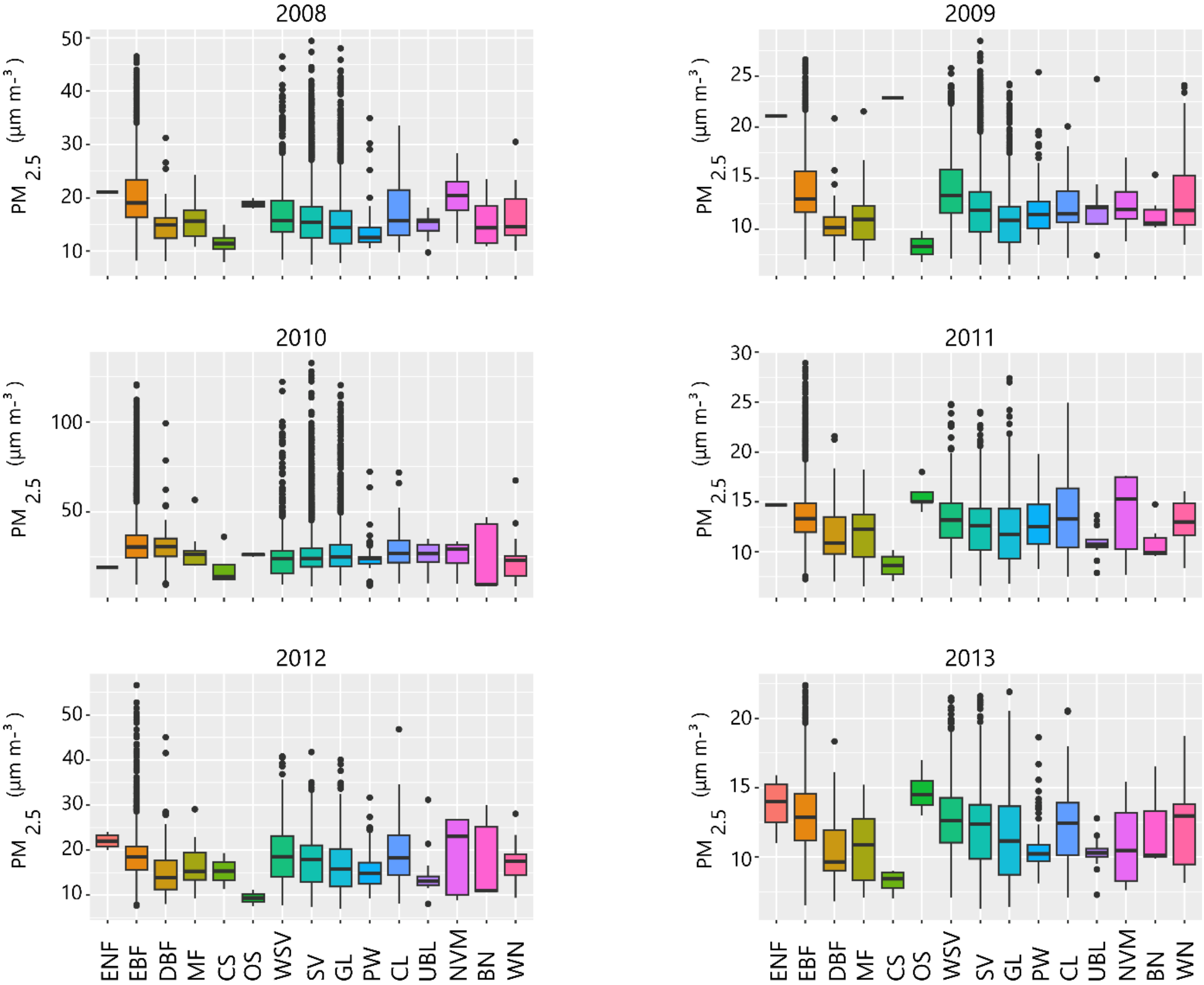


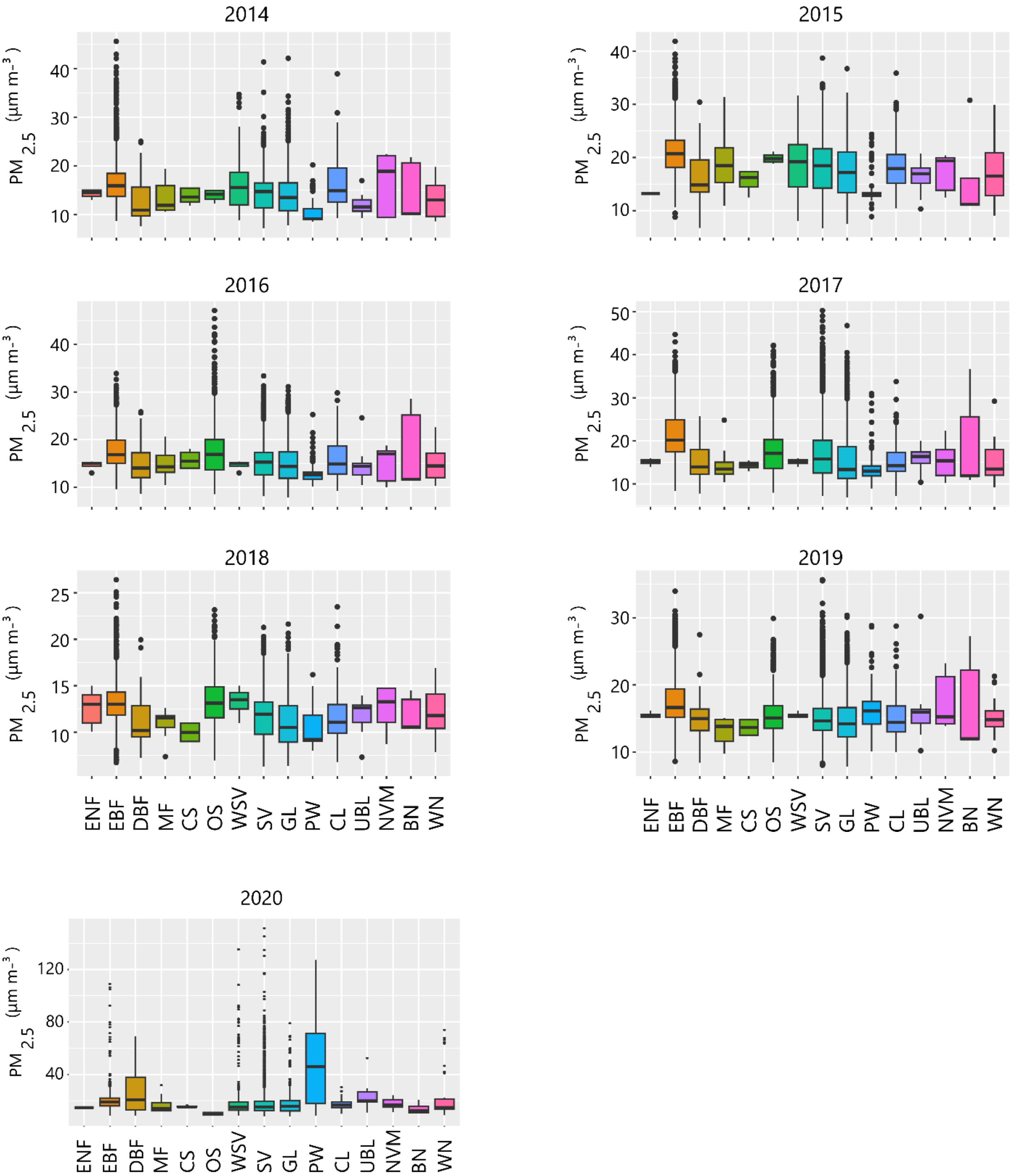
Federative units contained in the Cerrado-Amazonia transition: Ceará (CE), Goiás (GO), Maranhão (MA), Mato-Grosso (MT), Pará (PA), Piauí (PI), Rondônia (RO), Tocantins (TO).

The highest percentage growth (196%) was observed in Mato Grosso do Sul in 2020 and is associated with the largest burned area in this federal unit in the time series evaluated. The States of MT and PA had a percentage increase of 179% and 142%, respectively, for the year 2010, and together accounted for 58.4% of fire fires in the Cerrado-Amazonia transition for the same period.

The highest mean $PM_{2.5}$ was recorded in 2020 (151.55 µm m^{-3}) over the savannah class (SV). However, the forest class (EBF) concentrated the highest mean values over the time series evaluated in 6 years. The years 2010 (132.644 µm m^{-3}) and 2012 (56.62 µm m^{-3}) showed the highest means in the SV and EBF classes, respectively. Except for 2011 and 2012, all the minimum $PM_{2.5}$ values were identified in the SV class, with 2013 (6.27 µm m^{-3}) standing out as the lowest (Graph 2.1).

Graph 2.1 – Annual mean of $PM_{2.5}$ on land use and land cover classes in the Cerrado-Amazonia transition: 2008-2020



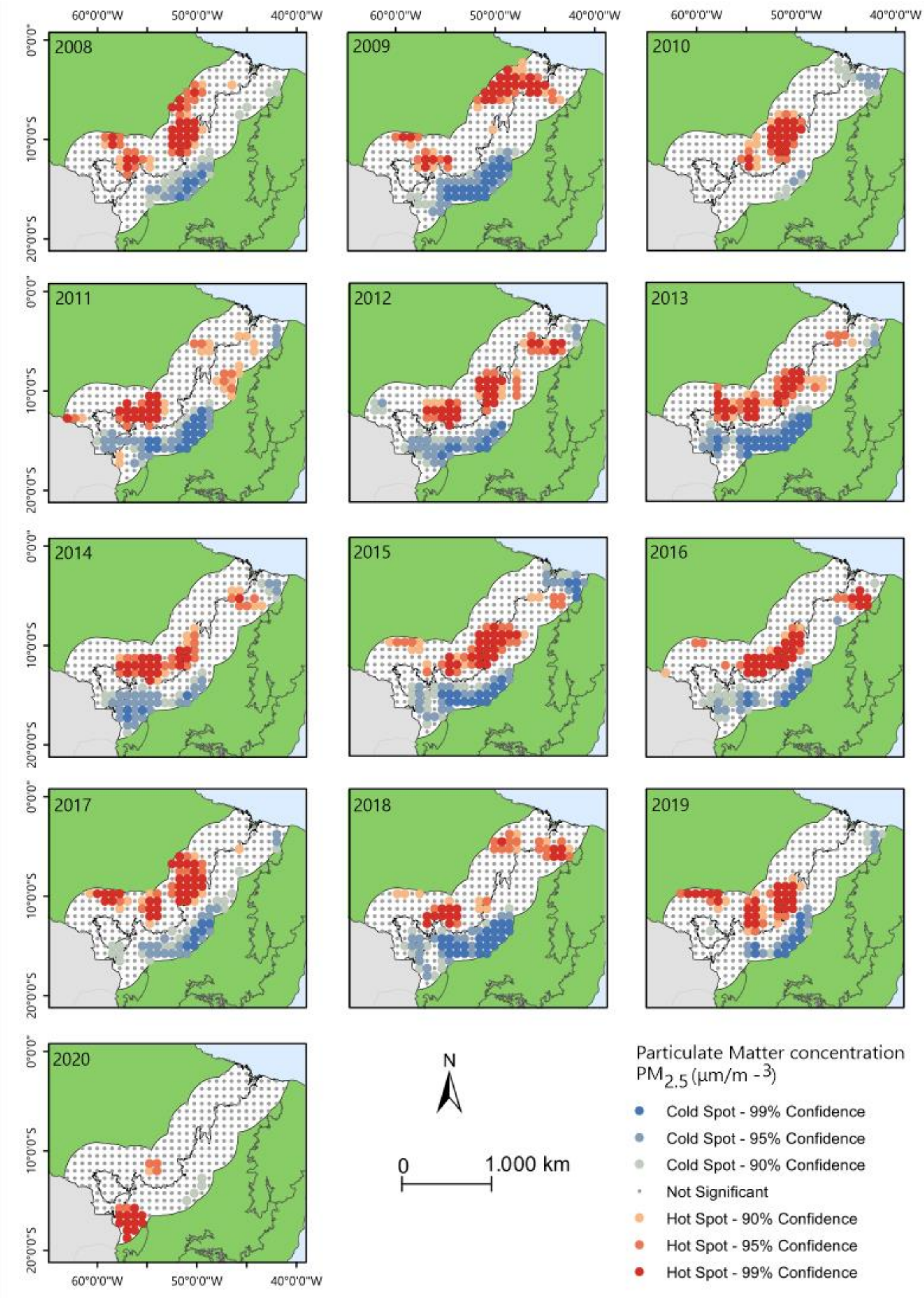


Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrublands (CS); Open Shrublands (OS); Wooded Savannas (WSV); Savannas (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built Soils (UBL); Farmland/natural vegetation mosaics (NVM); Barren (BN); Water bodies (WB). Obs.: When the LULC classes and $PM_{2.5}$ were intersected, some LULC classes, because they were small, did not show any data due to the post-vectorization pixel centroid of the $PM_{2.5}$ not exactly overlapping that particular class.

When looking at the pixel means by LULC class, the permanent wetlands (PK) class had the highest mean $PM_{2.5}$ value (46.36 µm m^{-3}) in the Pantanal biome region. The forest classes EBF (33.55 µm m^{-3}) and DBF (31.27 µm m^{-3}) concentrated the highest mean values in 2010. The lowest $PM_{2.5}$ were recorded in the open shrub class (OS – 8.27 µm m^{-3}) in 2009 nd in the urban class in 2013 (UBL; 10.29 µm m^{-3}) (Graph 2.1). There is also a higher dispersion (Graph 2.1) along with a large number of outliers in the years 2010, 2015, 2016 and 2020. This is correlated with the period of major fires, which locally have high pixel values of $PM_{2.5}$ and decrease the concentration near the median. Despite the large variations in values, no significant trends of $PM_{2.5}$ were observed over the LULC classes in the burned area (Table S 1.4) or over the Federative units (Table S1.5).

Significant clusters of the highest $PM_{2.5}$ values were observed for the hotspots in the northern Amazonia in 2012. It was also significant in the northeastern portion of MT, bordering the State of PA in 2010, 2012, 2015, 2016, and 2019. These conglomerates are arranged together or close to the locations of the large burned areas (Figure 3), mainly over the forest classes (DBF and EBF) of the Amazonia region in the central portion of the study area. In 2020, greater confidences were observed over the Pantanal area on the border between the States of MT and MS, a biome that stood out in terms of fire foci for this period (Figure 7).

Figure 7- Hotspot for atmospheric concentrations of $PM_{2.5}$ in the Cerrado-Amazonia transition: 2008-2020.

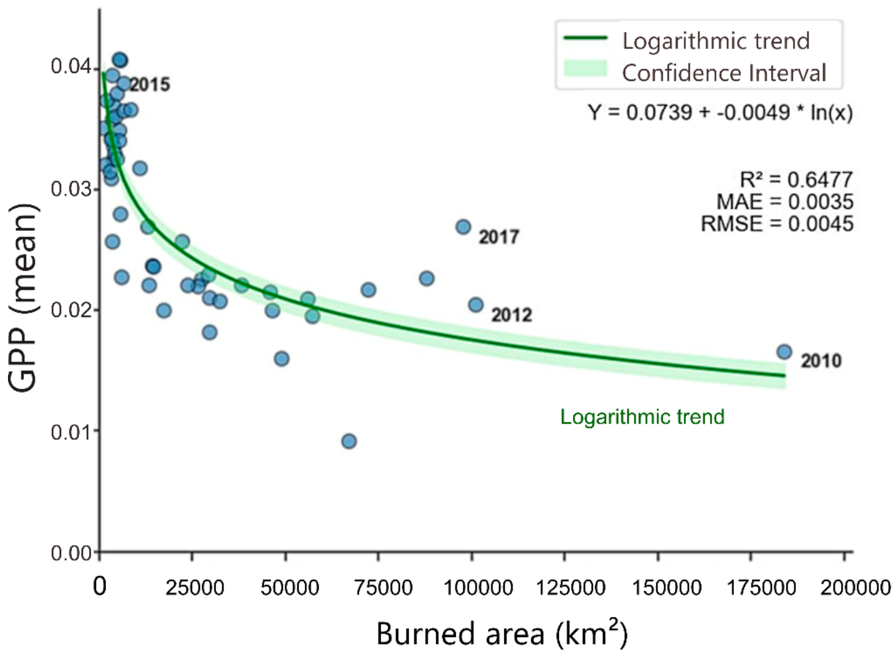


Conversely, the lowest spatially-confident values (coldspots) were observed in the south and southeast of the Cerrado over the savannah class (SV) in the States of MT and GO. In 2010 and 2015, coldspots were also found in the northeast of the Cerrado-Amazonia transition area in the Caatinga biome over the GL and SV classes.

7- Correlation between variables

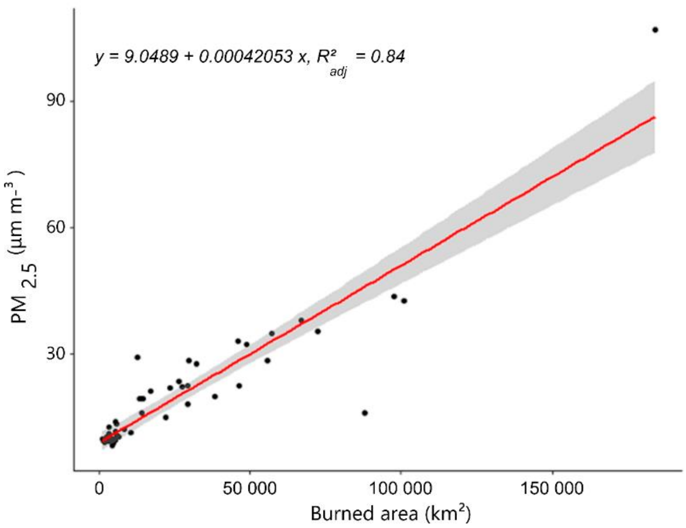
When we relate the burned area to the GPP by using logarithmic regression, the results show a high correlation and a inversely proportional relationship between burned area andd GPP (R^2 = 0.64.7 $P<0.05$).

Graph 2.2 – Dispersion between burned area and quarterly GPP in the Cerrado-Amazonia transition: 2008-2020.



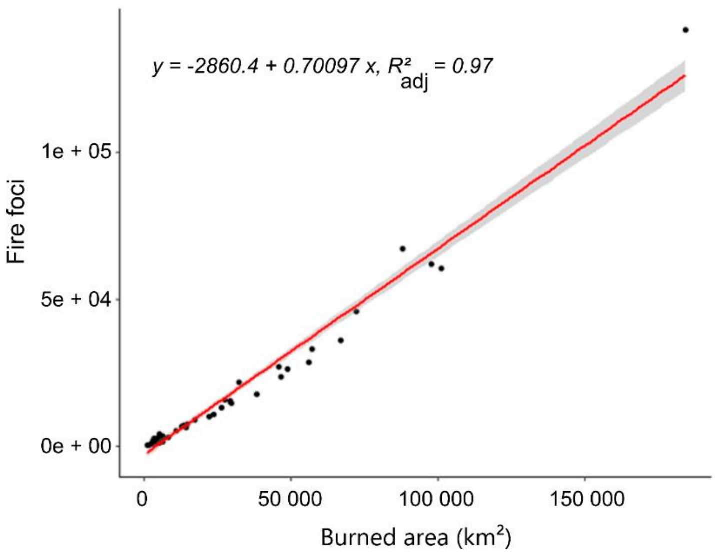
When we analyzed the dispersion by linear regression between burned area and $PM_{2.5}$, we found a high coefficient of determination (R^2 = 0.84 $P<0.05$).

Graph 2.3 – Dispersion between burned area and $PM_{2.5}$ in the Cerrado-Amazonia transition: 2008-2020.



A high positive correlation ($R^2 = 0.97$ $P<0.05$) was observed between the area burned and the number of fire foci.

Graph 2.4 – Dispersion between burned area and fire foci in the Cerrado-Amazonia transition: 2008-2020



8. Discussion

8.1. Characterizing changes in land use and land cover

Our results show significant forest loss in the Cerrado-Amazonia Transition, especially in the Amazonia biome. MF and EBF suppressed 1,408.09 km² and 2,861.07 km² between 2008-2020 (Table 2). We observed a downward trend for the forest class EBF and an upward trend for the cropland class (CL) in 2012 over the time series with the Pettitt test at 10% over the entire study area (Table 3). Environmental and social challenges were introduced in March 2012 through the legislative amendment to the Brazilian Forest Code (Law 4.771/1965) by Law 12.651/2012, which ratified an amnesty for areas that had been illegally deforested before 2008, as well as a package of reduced environmental restrictions (BRANCALION et al., 2016). This may have contributed to the significant changes at LULC.

In this context, when we evaluated only the Amazonia biome in the Cerrado-Amazonia transition, our findings revealed a downward trend in mixed forests (MF) and an increase in the savannah class (DBF) in 2012 with Pettitt at 5% and 10% respectively (Table S 3.9). An increase in fire trends was noted in the Legal Amazonia at the beginning of 2013 and patterns were observed that were mainly associated with the expansion of international market mechanisms for cattle meat and soybean along with governance (VALENTE; LAURINI, 2023). However, studies on land use and change have identified that municipalities with a higher proportion of soy production in the State of Mato Grosso do Sul that is not destined for international markets also have statistically significant associations with deforestation (DA SILVA et al., 2023). Brazil exports 19% of its beef production and consolidates its position as the world's largest exporter (ZU ERMGASSEN et al., 2020). However, its grassland areas are the main driver of deforestation, followed by soybean plantations in recent decades (MACEDO et al., 2012). The Cerrado-Amazonia transition area encompasses a large part of this troubled human-nature relationship, as it partially makes up the federal units that stand out in agribusiness, along with portions of the biomes (Pantanal, Cerrado, Amazonia and Caatinga) with great biodiversity and complex ecosystems (Figure 1).

The grasslands - Gl class showed the highest loss (19,070.08 km²) among the LULC classes. Although it is common for native grasslands to be replaced by crops in the Cerrado region, the MCD12Q1 version 06 product guide points out that in tropical regions the grassland class can be wrongly classified as savannah, and that in low latitude regions where the dimensions of agricultural fields are significantly smaller than a MODIS pixel, agricultural activity is occasionally not properly represented, i.e. it is wrongly identified as natural vegetation (SULLA-MENASHE; FRIEDL, 2018). As an example of this condition, a 15% difference was observed in the savannah class when comparing the MCD12Q1 with the classification obtained from LANDSAT (predominance of 30 meters in most of its bands) in 2013 for the Cerrado (MATAVELI et al., 2019). In this study, we have chosen the MCD12Q1 version 06 product due to the greater compatibility of resolutions with other products using the same sensor. Despite being a global product, it represents 75% accuracy in its classification (SULLA-MENASHE; FRIEDL, 2018).

We observed a significant increase in the savannah class - SV (15,581.2 km^2) which cannot only be correlated with the inaccuracies of the MCD12Q1 product, as we detected a change in the forest class (EBF) for open shrubs (SO) and savannahs (SV) (figure 2). These facts may be associated with the anthropogenic actions that predominantly occur in the Amazonia biome. A proposal to reclassify tropical forests drawn up in 2013 raises the hypothesis of "savannization" in tropical areas and this would be directly correlated to structural changes in the vegetation (TORELLO-RAVENTOS et al., 2013).

The change in LULC use aimed at expanding the agricultural sector, combined with underlying climate change, has the potential to increase the occurrence of extreme weather events (BULLOCK et al., 2020)(ARVOR et al., 2021)(MARENGO et al., 2018). Trends of rising temperatures and a delay in the rainy season with the expectation of longer droughts have been observed over the eastern and southern transition areas between the Amazonia and the Cerrado in the last decade (MARENGO et al., 2022)(NOBRE et al., 2016). Changes in the water balance associated with increased temperature and decreased evapotranspiration have been influenced by the substitution of the forest-crop and forest-pasture class in southeastern Amazonia (SILVÉRIO et al., 2015). Besides anthropogenic factors, climatic extremes associated with anomalies in the warming of the surface waters in the North Atlantic and Eastern Pacific (El Niño) promote prolonged droughts across the Cerrado-Amazonia transition, combining perfect conditions for large forest fires (FERNANDES et al., 2011). Therefore, the constant changes in the LULC, conditioned by human-intensified climate change, could lead the Cerrado-Amazonia transition area to face major challenges in relation to agribusiness losses and damage to ecosystems, whoch hence compromise the global food security.

Mann-Kendall's test identified an upward trend in the water bodies (WB) class and Pettitt at 10% probability showed 2013 as the change point (Graph 1). When we carried out the same tests on each biome included in the transition area, we found that this same class showed a significant upward trend in the Cerrado biome in 2012 (Table S 4.1). This situation is correlated with the increased number of hydroelectric plants in the study region. The Cerrado has a large watershed known as the Brazilian Central Plateau and this relief feature is conducive to the formation of rivers with high gravitational potential energy (AB'SABER, 2003), a fact that has stimulated the construction of hydroelectric plants on its territory, which includes the large Amazon basin (LATRUBESSE et al., 2017). Due to the 2001 crisis in the Brazilian energy sector (the blackout), the federal government concentrated its efforts on the construction of hydroelectric plants during that decade, with a total of 30 plants being built, 10 of them in the Amazon basin between the years 2000-2010 (MORETTO et al., 2012). In the State of Mato Grosso alone, another 5 power plants were set up later on the Teles Pires river: UHE São Manoel (747 MW) in the municipality of Paranaíta (2017), Teles Pires (1820 MW) in the municipality of Apiacás (2015), Colíder (342 MW) in the municipality of Colíder (2021), Sinop (461 MW) in the municipality of Itaúba (2019), and Foz do Apiacás in the municipality of Apiacás (275 MW). All these developments present serious ecological problems inherent in the inefficiency of their environmental planning (FEARNSIDE, 2019). This situation demonstrates the growing need for energy associated with population growth and, as a consequence, promotes major changes in the land use and land occupation. Energy attracts new investments, new occupations, new needs and land speculation, while at the same time placing a heavy burden on the environment.

8.2. Characterizing burned areas/fire foci

Our results show that the year 2010 concentrated the largest number of fires/burned areas (Graph 1.2). In a study carried out by MATAVELI et al. (2018), the authors found that below-average rainfall encouraged large areas of burning in the Cerrado for the same period and the fires converged in the months of May to September during the dry season in the transition region with the Amazonia. Our study confirms the same condition in the Cerrado-Amazonia transition area and highlights the third quarter of each year with the largest burned areas (Table 1.0 S). The year 2010 saw an intensification of droughts in the Amazon basin, with marked epicentres in the States of MT and PA. This is correlated with the El Niño and North Atlantic Oscillation anomalies (DOUGHTY et al., 2015)(MARENGO; ESPINOZA, 2016). A study carried out on the entire Amazon basin between 2001-2019 showed the influence of droughts on the number of spatially concentrated fire foci (76.91%) in the Cerrado-Amazonia transition, a fact that contributed to the deficit in the carbon absorption flow during the period evaluated (DA SILVA JUNIOR et al., 2022).

We observed that the largest areas burned between 2008-2020 in the Cerrado-Amazonia transition occurred in the Cerrado biome over the Savannah (SV) class. Controlled fire in the Cerrado is vital for this biome, as in addition to inhibiting accumulations of combustible materials and preventing large-scale fires (SILVA-JUNIOR et al., 2022), plant species in this morphoclimatic domain acquired the ability to adapt to fire in the recent geological past (ABREU et al., 2017; SIMON et al., 2009). The action of controlled fire in the Cerrado is a major incentive for this ecosystem (ARAGÃO et al., 2023), but large forest fires are a constant concern, as they are associated with significant impacts on natural resources and society (DA SILVA JUNIOR et al., 2020, 2022; JOHNSTON et al., 2012a; LASHOF, 1991; MARENGO et al., 2018, 2022; TRUMBORE; BRANDO; HARTMANN, 2015; YE et al., 2022a). The government's desperate response to the growing number of wildfires in Brazil in 2019 saw ineffective policies put in place through a decree that reinforced the idea of "zero fire". This resulted in a reduction in fires in the Amazonia, but catastrophic losses in the biodiversity of the Cerrado along with the accumulation of biomass as a fuel load for this biome (DURIGAN, 2020). This reality demonstrates the difficulty of implementing homogeneous public policies in different biomes. This problem is accentuated in the Cerrado-Amazonia transition, because in addition to bringing together 4 different biomes, this ecotone has often undergone changes in the LULC and does not obey the boundary line established by the IBGE (SILVA JUNIOR et al., 2019). The Cerrado-Amazonia ecotone has great endemism and is home to the largest dry forest in Brazil, a fact that increases the incidence of forest fires in the largest area of contact between savannah and forest in the world (DE SOUZA MENDES et al., 2019).

The year 2020 saw the second highest number of fires (Graph 1.2), concentrated mainly in the Pantanal region (Graph S1.1) over the State of Mato Grosso (Table S1.3) in the savannah class (SV) (Table 4.2). The lack of monitoring could intensify anthropogenic action on deforestation and increase the number of fires. In recent years, there have been losses of half the number of environmental inspectors at the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA), associated with several appointments to management positions without any experience, a fact that has stimulated a drop in the number of infractions for the same period in the Pantanal region (LEAL FILHO et al., 2021). In response to the major fires in 2020, the government cut 20% of its funding to the Ministry of the Environment and questioned the reliability of satellite fire detection, raising doubts among its population. (LIBONATI et al., 2020). Associated with this process, high-pressure systems that promote droughts influenced by the El Niño-Southern Oscillation anomaly, together with the constant increases in maximum temperatures observed in recent decades, have promoted perfect conditions for large fires in the Pantanal in 2020 (LIBONATI et al., 2022). Among the consequences of government negligence associated with climatic events in the Pantanal were an exponential increase in soil erosion, water contamination by fire ash, the death of thousands of species and large emissions of particulate matter that even impacted Brazil's most densely populated region, the Southeast, in the middle of the COVID-19 pandemic (LIBONATI et al., 2020).

In 2020, there was also a 28.88% increase in the number of areas burned in Amazonia (Graph 1.3) over the Cerrado-Amazonia transition when compared to 2019. In a comparative study (2010-2018/2019-2020) carried out on the Amazonia biome, there was a decline of 82% and 77% in the number of infractions in the region, and as a consequence of this more lenient legislation towards anthropic actions, there was greater deforestation, an increase in the number of biomass burnings, higher CO_2 emissions and less capacity for the forest to act as carbon sinks (GATTI et al., 2023). The Cerrado had the largest burned area in 2020 (Graph 1.3), but this can be explained by the larger area of this biome over the Cerrado-Amazonia transition when correlated with the Pantanal (Table S1.0).

The year 2015 had the third highest number of fires (Graph 1.2, Figure 4) and the fifth highest number of burned areas (Graph 1.2, Figure 3), which is correlated to the effects of climate anomalies. The greatest droughts and maximum temperatures of the last 40 years were recorded under the influence of super El Niño in 2015 and 2016, mainly affecting the Amazonia region (MARENGO et al., 2018). Although dry organic matter serves as a fuel load for large forest fires (DA SILVA JUNIOR et al., 2022), the warming anomaly of the eastern Pacific Ocean was not the factor that most influenced the peak of fires (2010) in the Cerrado-Amazonia transition between 2008-2020. This shows the predominance of anthropogenic influence on fire. Our statistical tests show that there was an upward trend in the number of fires, but it was not possible to detect the exact year in which this occurred. This shows that regardless of political party, fire-fighting actions have not been successful in Brazil.

The second year with the largest burned area (Graph 1.2, Figure 3) and the fourth largest number of fires (Graph 1.2) was 2017. The State of MT had the largest burned area (Graph 1.4) and the largest number of fires (Table S 1.3) due to its larger area in the Cerrado-Amazonia transition (Table S 1.1). However, the States of MA and TO, which are included in the MATOPIBA region (acronym for the states of Maranhão, Tocantins, Piauí and Bahia) represent the highest density of fires when we take their respective areas into account. The concentrations of these fire foci can also be seen on the Kernel density map (Figure 4). The soy moratorium agreement relieved the Amazonia by not allowing purchases of soy from deforested areas after 2006 (later renegotiated for 2008), but it burdened the Cerrado with the greatest impact in the MATOPIBA region, a region known as the new agricultural frontier (LIMA et al., 2019). For the 2017-2018 crop year, 33.347 million hectares (Mha) of soybeans were produced in Brazil, making it the second largest producer of this commodity in the world ("SOJAMAPS - Monitoramento de áreas de soja por meio de imagens de satélite", 2018). In contrast to this process, 54 endemic species were identified for this same region, 38 of which are threatened with extinction due to the anthropogenic changes promoted by the advance of agribusiness in 2022 (DE OLIVEIRA SANTANA; SIMON, 2022). In contrast to this process, 54 endemic species were identified for this same region, 38 of which are threatened with extinction due to the anthropogenic changes promoted by the advance of agribusiness in 2022 (AGOSTINHO et al., 2023).

8.3. Characterizing GPP

The lowest mean GPP was identified in 2016 (0.023 gC$m^{-2}y^{-1}$) with significant reductions for all biomes in the Cerrado-Amazonia transition area (Figure 5). These results are correlated with the influence of climate anomalies and anthropogenic interventions. Despite the heterogeneity in the volume of rainfall in tropical regions, the El Niño phenomenon (2015-2016) caused an increase in temperature, promoting below-average rainfall and consequently a reduction in GPP along with anomalous emissions of carbon dioxide into the atmosphere (ZENG; MARIOTTI; WETZEL, 2005). In the South American region over tropical areas, fire contributed to increased carbon release (0.4 ± 0.08 gigatonnes C) (LIU et al., 2017). Our results show similar conditions and below-average GPP values for the area burned for all biomes in 2016 (Graph 1.5). However, it is important to note that the El Niño phenomenon began at the end of 2014, peaked at the end of 2015 and ended in May 2016 (LIU et al., 2017). Our findings show that the lowest GPP values occurred in the third quarter of 2016 in the burned area (Graph 1.6), which is outside the period of the climate anomaly. This shows that after extreme climatic conditions, vegetation that is still weakened when instigated by fire can lead to even more catastrophic conditions and negatively influence the carbon cycle. This circumstance can also be understood by looking at the outliers above the average in the boxplot, which represent much of the regrowth in the third quarter. The year 2016 shows the lowest GPP outlier values above average when compared to the third quarter of the other years, a situation that confirms the difficulties of recomposing the biota after extreme events (Graph 1.6). An analysis of sun-induced fluorescence (SIF) using orbital sensing in the Amazonia showed that the effects of El Niño (2015-2016) were more intense over the eastern Amazonia, an area that coincides with the Cerrado-Amazonia transition (KOREN et al., 2018). This context supports these reductions in GPP values and also justifies the difficulty of regrowth.

Both 2008 and 2010 showed below-average GPP in the Cerrado-Amazonia transition (Figure 5, Graph 1.5). The year 2008 was susceptible to a post-drought period (2005-2007) influenced by the El Niño Southern Oscillation (ENSO) and North Atlantic Oscillation (NAO) phenomena (MARENGO; ESPINOZA, 2016). Low GPP values may be associated with the period of biota recovery. However, as 2008 did not show significant fire foci or burned areas (Graph 1.2, Figure 4, Figure 5), the outliers above the average were higher than in 2016, demonstrating more efficient recovery for this period under reduced burning conditions. The mapping of ecoregions identified a long drought period in 2007 and 2010 associated with higher fire intensity in the northern region of the Cerrado, predominantly in the MATOPIBA area (SILVA et al., 2021b). Our results converge with similarity and show a reduction in GPP in 2010 (Figure 5), especially in the third quarter of the year (Graph 1.6). This reduction was also noted for all biomes in the area burned (Graph 1.5). Increasing temperature trends have been noted over the decades and influence the loss of biomass due to anomalous droughts, encouraging a decrease in carbon absorption capacity and making vegetation more vulnerable to large forest fires (MARENGO et al., 2018). We found that 2011, despite not having a high number of fires/burned area (Figure 1.2), still reflected conditions from the previous year and represented GPP below the temporal mean for the area burned between 2008-2020. A study carried out in Iran using the MODIS product showed that the GPP after a period of prolonged drought recovers more quickly in the forest class than in the rainfed agriculture class (FATHI-TAPERASHT et al., 2023). This demonstrates the importance of the forest for water balance services, together with the vulnerability of agricultural LULC associated with its inability to replace a native ecosystem.

In 2012, in the middle of the La Niña period and the warm anomalies of the Tropical South Atlantic (TSA) that caused flooding in the western Amazonia (MARENGO; ESPINOZA, 2016), there was a decrease in GPP below the mean for the time series analyzed between 2008-2020 (Figure 5). During this same period, we noticed a downward anthropogenic trend for the forest class - EBF and an upward trend for the crop land class (CL) (Graph 1), discussed here under LULC. Studies carried out in the State of Mato Grosso have shown that, between 2015-2018, areas converted from forest to another type of land use emitted more CO_2 into the atmosphere than areas of unaltered native forest, so maintaining forests mitigates climate change (ROSSI et al., 2022). When evaluating the changes in the carbon dioxide balance associated with land use and land cover in the Brazilian Legal Amazon between 2009-2019, a reduction in GPP and twice as much carbon flux emission from the agriculture class when compared to the forest class in the southeast of the Cerrad0o-Amazonia transition was noted over the time series (CRIVELARI-COSTA et al., 2023). Our findings also show decreases in GPP associated with land use change for the year 2012 in the Amazonia and Caatinga biomes, both with GPP below the mean for the same period (Graph 1.5). Probably due to the significant anthropogenic and climatic influence in the Cerrado transition, combined with the wide variability of species, we did not find any downward or upward trends in GPP (Table S1.4).

In 2017, the GPP was above average in the Cerrado-Amazonia transition (Figure 5). This circumstance may be correlated with the influence of the La Niña climate anomaly, which recorded above-average rainfall compared to the neutral period in the Amazon basin for the same period (DOUGHTY et al., 2021). The high volumes of rainfall in 2017 may have accumulated biomass as fuel for the coming years of drought. At the end of 2018 until 2020, prolonged droughts were detected using data from the *Climate Hazards Group InfraRed Precipitation with Station* (CHIRPS), a situation that created conditions conducive to the historic burning of the Pantanal (MARENGO et al., 2021). Also in 2017, we detected the highest GPP values (outliers) over the burned area of the 2008-2020 time series in the third quarter (Graph 1.6). There is a predominance of tropical climates over the Cerrado-Amazonia transition area, with the rains starting in September (DUBREUIL et al., 2018). Conversely, the highest concentrations of fires occur during the dry season (DA SILVA JUNIOR et al., 2022), and specifically in the Cerrado biome, 90% of these occur between June and October (SILVA et al., 2021b). Therefore, the high outlier GPP values at the end of the dry season and predominant in the third and fourth quarters are related to regrowth, as they are consequences of the initial post-fire rains visualized in isolated pixels due to the different days of burning and different levels of regrowth given the heterogeneity of the vegetation. Regrowth of tree species from different phenological groups shows divergent values even when they belong to the same biome (SARTORELLI et al., 2007).

8.4. Characterizing $PM_{2.5}$

Highest $PM_{2.5}$ concentrations occur in the Amazonia biome (Graph 1.5, Figure 4, Figure 5), specifically in the EBF class (Graph 2.1). However, the largest fire foci and burned areas occur in the Cerrado biome (Graph 1.3) in the savannah-SV class (Table 4.2). Similar findings were identified in the correlation study between fire foci density and $PM_{2.5}$ over Brazil between 2008 and 2018 (REQUIA et al., 2021). This can be explained by the different LULC classes in the Amazonia biome, which tend to have phytogeographic characteristics of evergreen and broadleaved plants with a higher volume of biomass for burning (MATAVELI et al., 2019). This also shows that the impact of fire is significantly higher in the Amazonia, while the emission of fine material triggers a range of social impacts. Carbon absorption capacity is being altered as a result of land use, leading to climate change (BRIENEN et al., 2015). In synchrony with this situation, in 2010, large fires compatible with the period of prolonged droughts increased the number of hospitalizations of children under 5 years old with respiratory problems in the Amazonia by 267% (SMITH et al., 2014).

It is important to note that our findings do not only reflect the $PM_{2.5}$ from fire, but from all kinds of fine particles detected by the CAMSRA product database. A recent study carried out in the Amazonia during the rainy season with flux towers also showed that part of the particulate matter in the forest is anthropogenic (elemental carbon), ammonium sulphate, and nitrate come from the forest itself, while the aged mineral dust mixed with salts is probably from transatlantic transport from the Sahara desert (WU et al., 2019). Northeasterly winds predominate over the Amazonia region during the rainy season and show the influence of the intercontinental trade winds during this period (FERNANDES et al., 2021). These findings may explain that, besides the higher biomass volumes emitting maximum values of particulate matter in the Amazonia, the biogenic factor and wind direction may interfere with the final $PM_{2.5}$ concentration. However, in 2012, an assessment was made of three types of databases that calculate particulate matter over the Amazonia and correlated them with airborne data from aircraft. The results showed that the models not only underestimated emissions from biomass burning, ~54%-78% of which comes from burning local vegetation (REDDINGTON et al., 2019). Our study supports these results previously reported and demonstrates a high coefficient of determination ($R^2 = 0.83$, $P < 0.05$) (Graph 2.3) of the burned area and $PM_{2.5}$ A direct correlation ($R^2 = 0.68$ to 0.97 $P < 0.05$) was also seen in the reduction of deforestation and $PM_{2.5}$ emissions from fires in the dry seasons between 2001 and 2012 in the Brazilian Amazonia (REDDINGTON et al., 2015).

The years and locations with the highest densities of fire foci (Figure 4) and burned areas (Figure 3) show high spatial coexistence with $PM_{2.5}$ The years and locations with the highest densities of fire foci (Figure 4) and burned areas (Figure 3) show high spatial coexistence with $PM_{2.5}$ (Figure 6, Figure 7), especially on a macro scale. However, when correlating fine particles with burned areas, the highest values do not always coincide. These circumstances may be related to atmospheric mechanisms. On August 19, 2019, the sky over the city of São Paulo darkened at 3:00 p.m. under the effect of particulate matter from the Amazonia carried by Low-Level Jets (LLJ) in atmospheric systems passing over the Midwest, South, and Southeast of Brazil (LOGE; FONSECA; SILVEIRA, 2021). The black carbon included in $PM_{2.5}$ is difficult to attract by gravity, which allows wind currents to deposit it in colder regions such as the Arctic, consequently altering the ice albedo and influencing climate forcings of +0.3 W/m² in the northern hemisphere and hence instigating global warming (HANSEN; NAZARENKO, 2004). Furthermore, black carbon directly influences meteorological conditions as cloud condensing nuclei, and therefore can influence climate change when correlated to regions with high annual emissions (MOTOS et al., 2019).

The highest mean $PM_{2.5}$ values the 2008-2020 time series were observed over the States of Pará (19.5 µm m^{-3}), Mato Grosso (17.38 47 µm m^{-3}), and Mato Grosso do Sul (16.47 µm m^{-3}). However, we found that the highest annual pixel values occurred in the federal units of Mato Grosso do Sul (49.5 µm m^{-3} in 2020), followed by Pará (39.1 µm m^{-3}) and MT (32.7 µm m^{-3}), both in 2010 (Figure 6, Figure 7, Graph 1.7, Graph 2.0). Forest losses were found in Amazonia over the Apyterewa indigenous area in the municipality of São Félix do Xingu, Pará, and found an increase in $PM_{2.5}$ emissions associated with fire between 2004 and 2019 (DE OLIVEIRA et al., 2020). At a global level, a study carried out between 1997-2006 estimated the emission of 2 pentagrams of carbon into the atmosphere associated with 339,000 annual deaths caused by exposure to $PM_{2.5}$ from fires, and pointed to the El Niño phenomenon as an intensifying cause (JOHNSTON et al., 2012b). In Brazil, a study carried out between 2000 and 2016 showed that short-term exposure to $PM_{2.5}$related to forest fires caused 121,351 deaths due to cardiorespiratory failure and the largest risk groups were women and adults over 60 years old (YE et al., 2022b). Our data shows that the value of $PM_{2.5}$ (153.7 µm m^{-3}) in 2020 exceeds the safety limit by more than 15 times (10 µm m^{-3}) established by the World Health Organization (WHO) (ORGANIZATION, 2021) and the National Environment Council (CONAMA) (UNIÃO, [s.d.]). Government negligence, coupled with the droughts discussed here, have caused losses in the Pantanal biome. Synchronously, in 2020, 230,452 deaths were recorded as a result of the respiratory crisis caused by COVID-19 (FIOCRUZ, 2021). The possible worsening of this health crisis was associated with scientific denialism, biopolitical strategies linked to neoliberal reason and the lack of beds with respirators (CAPONI, 2020).

Faced with the critical scenario facing the transition regions between the Cerrado and the Amazonia, it is imperative that effective measures are adopted to mitigate the devastating impacts of fires. The intersection of these unique biomes is not only home to unparalleled biological diversity, but also plays a crucial role in the global climate balance. In this context, our data shows that the Amazonia and the Pantanal are the areas with the highest $PM_{2.5}$ concentration associated with forest fires. This suggests that the implementation of public policies aimed at fighting fires in priority areas is a pressing need. These policies should be designed based on a holistic approach, integrating prevention, monitoring and rapid response actions. Investing in advanced detection technologies, promoting sustainable land management practices and establishing collaborative partnerships between government agencies, local communities, and environmental organizations are essential measures to preserve the integrity of these critical zones. By focusing efforts and resources on priority areas, public policies can play a key role in protecting these vital ecosystems, ensuring not only the survival of the diverse life forms that inhabit them, but also the long-term sustainability of our planet.

9. Conclusion

Although fire is aligned with economic development, the constant changes in land use and land cover in the Cerrado-Amazonia transition have led to environmental problems. Our findings show that during periods of post-fire climate anomalies, vegetation has more difficulty in recovering, as the water availability and ideal conditions for growth have been affected and have compromised the natural resilience of species. Large burned areas, when associated with climatic extremes, influenced the decrease in GPP and are associated with higher $PM_{2.5}$ emissions. These facts show that the fire impacts on the study area contribute to decrease the carbon sinks and alter the atmospheric dynamics. .

10 - References

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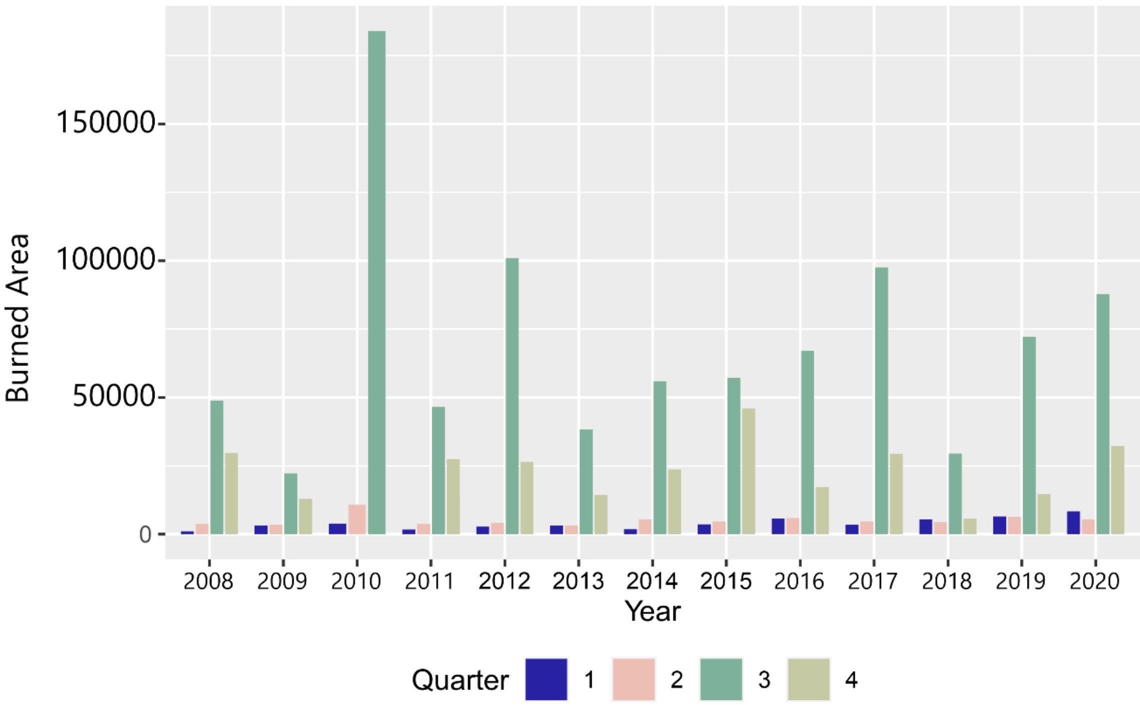
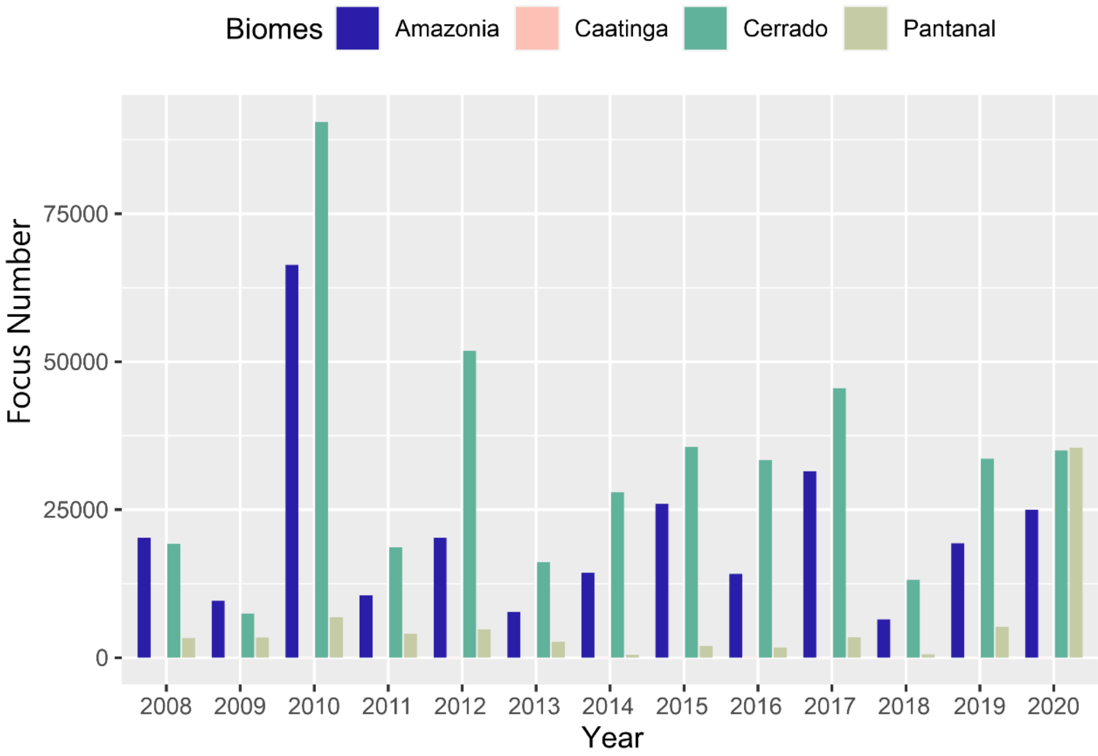
ATTACHMENT

Graph S - 1.0 – Areas Burned per Quarter in the Cerrado-Amazon Transition between 2008-2020



Graph - S - 1.1 - Number of fire outbreaks by biome over the area burned in the Cerrado-Amazon Transition between 2008-2020



Graph S 1.3 - quarterly $PM_{2.5}$ on the burned area of the Cerrado-Amazonia transition: 2008-2020

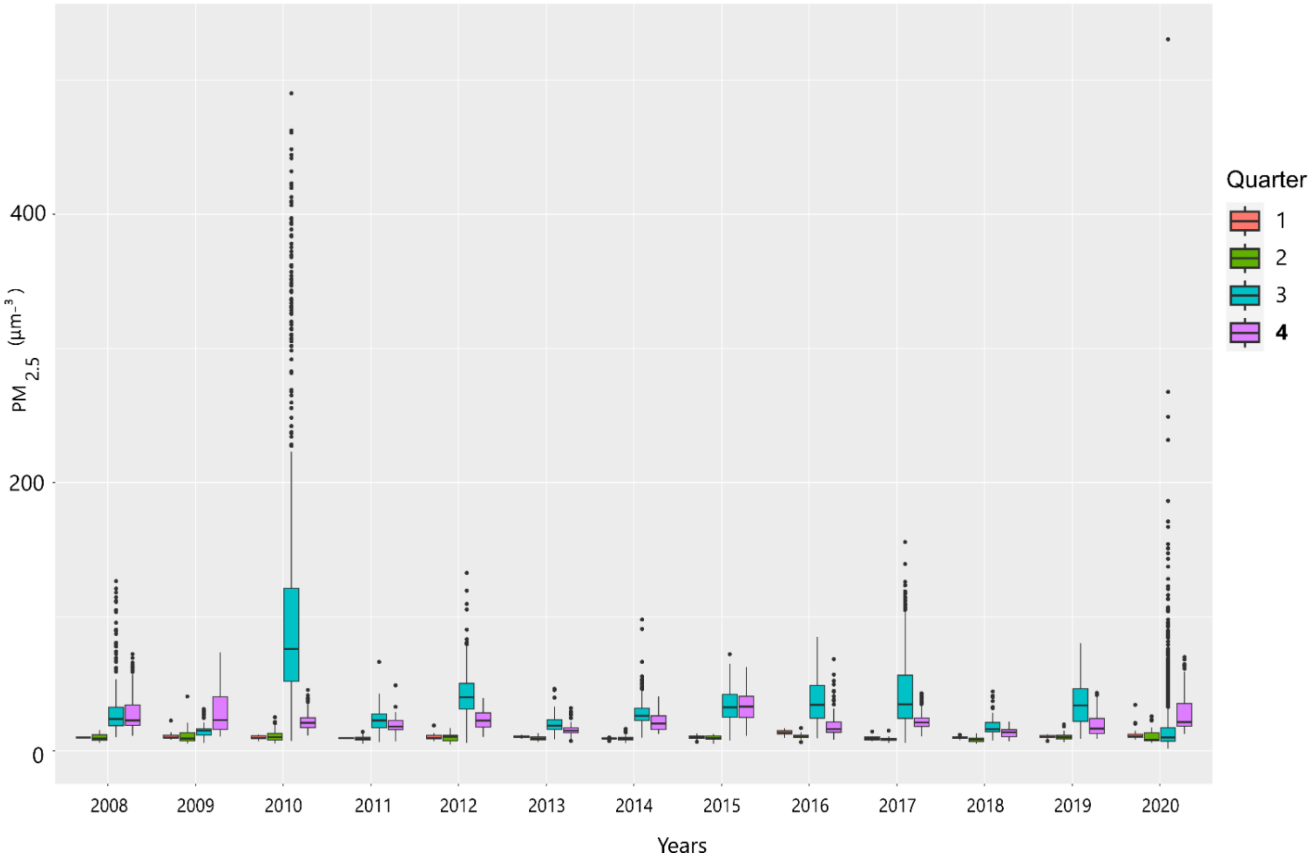


Table S - 1.0 – Area of Biomes and their respective percentages in relation to the Cerrado-Amazon transition.

Biomes	Cerrado	Amazonia	Caatinga	Pantanal	Total
Area (km²)	859482,7	1008063	11819	86147,3	1965511,5
Percentage (%)	43,7	51,3	0,6	4,4	100,0

Fonte: IBGE [25].

Table S -1.1 – Area of Federative Units in the Cerrado-Amazonia Transition: 2008-2020

UF	Area (km^2)	Percentage (%)
CE	5427,3	0,3
GO	63293,9	3,2
MA	323030,0	16,4
MS	33766,7	1,7
MT	837933,1	42,7
PA	310164,3	15,8
PI	54376,0	2,8
RO	98710,3	5,0
TO	237016,2	12,1
Total	1963717,718	100

Fonte: IBGE[25]

Table S .1.2 Annual Descriptive Statistics of Burnt Area and Fire Spots: 2008-2020

Variable	Mean	Standart Error	Median	Standart Deviation	Sample variance	Curtosis	Assimetria	Interval	Minimum	Máximum	Sum	Score	Year
	20836,5	11334,7	16728	22669,369	513900301,4	-2,7113	0,56606	47715	1087,23	48802,6	83346,1	4	2008
	10473,2	4511,7	8222,1	9023,3974	81421700,13	-1,4164	0,829048	18955	3246,9	22201,7	41892,8	4	2009
	56518,4	42781	19108	85561,961	7320849130	3,72116	1,921462	180139	3859,78	183999	226074	4	2010
	16353,8	10375	8583,7	20749,987	430561979,3	2,68151	1,6655	44807	1720,11	46527,5	65415,1	4	2011
	33582,9	23116,6	15274	46233,215	2137510203	2,77812	1,695034	98215	2784,82	100999	134332	4	2012
	14756,8	8275,84	8799,7	16551,683	273958216,9	1,71605	1,460269	35152	3137,61	38290,1	59027	4	2013
Burned Area	21712,5	12368,5	14552	24736,909	611914659,4	0,7007	1,223747	54076	1835,01	55910,6	86849,9	4	2014
	27838,3	13879,7	25307	27759,33	770580389,2	-5,198	0,137411	53542	3598,33	57140,5	111353	4	2015
	23964,3	14600,4	11553	29200,884	852691635,2	3,26053	1,809256	61293	5728,98	67021,8	95857,2	4	2016
	33760,6	22085,4	17005	44170,705	1951051168	2,36414	1,601345	94066	3482,88	97548,8	135043	4	2017
	11279,5	6083,08	5568,8	12166,161	148015484,1	3,96344	1,988628	25043	4468,78	29511,6	45117,9	4	2018
	11279,5	6083,08	5568,8	12166,161	148015484,1	3,96344	1,988628	25043	4468,78	29511,6	45117,9	4	2019
	33455,3	19069	20312	38138,033	1454509597	1,79348	1,470883	82320	5438,11	87758,5	133821	4	2020

Varable	Mean	Standart Error	Median	Standart Deviation	Sample variance	Curtosis	Assimetria	Interval	Minimum	Máximum	Sum	Score	Year
	10739	6088,73	8169,5	12177,454	148290388,7	-1,8001	0,734538	26011	303	26314	42956	4	2008
	5134,5	2065,98	4594,5	4131,9592	17073087	-2,2681	0,501211	9099	1125	10224	20538	4	2009
	40995	33642,5	10644	67285,044	4527277141	3,82529	1,950279	140299	1197	141496	163980	4	2010
	8319	5361,78	4546,5	10723,569	114994926	2,35428	1,583457	23385	399	23784	33276	4	2011
	19270	13974	7880	27947,914	781085907,3	3,17188	1,785652	59460	930	60390	77080	4	2012
	6645	3818,34	4121	7636,6715	58318752	1,94786	1,486599	16752	793	17545	26580	4	2013
Fire Foci	10722,3	6373,97	6854	12747,949	162510214,3	1,40943	1,35896	28135	523	28658	42889	4	2014
	15898,8	8284,77	14754	16569,531	274549360,9	-5,2973	0,108411	32153	967	33120	63595	4	2015
	12341,8	8068,79	5747	16137,587	260421722,3	3,13233	1,777104	34257	1808	36065	49367	4	2016
	20147,5	14277,7	8909,5	28555,435	815412861,7	2,85242	1,710715	60937	917	61854	80590	4	2017
	5061,75	3262,45	2249	6524,9019	42574344,25	3,83297	1,945087	13861	944	14805	20247	4	2018
	14568	10480,6	5442	20961,261	439374481,3	3,70278	1,916515	44182	1603	45785	58272	4	2019
	23926	15004,4	12917	30008,836	900530256,7	2,13988	1,550738	64187	2842	67029	95704	4	2020

Table S1.3 – Fire foci by Federative Unit in the Cerrado-Amazonia transition area: 2008-2020

Ano	CE	GO	MA	MS	MT	PA	PI	RO	TO	TOTAL
2008	619	1668	31471	2274	60297	33991	3377	4628	18328	156653
2009	404	787	27190	4719	29291	22439	3379	2000	9410	99619
2010	376	5083	55336	3416	120878	62872	5588	9668	50933	314150
2011	377	1490	27238	2385	37030	14578	3671	3476	16924	107169
2012	442	2030	58329	5179	56161	23828	6846	2689	33151	188655
2013	316	1187	26859	1631	39019	11511	3447	1908	19180	105058
2014	201	2028	37868	835	51208	18651	4695	2612	26739	144837
2015	253	2140	57342	1546	57440	33515	5095	3647	29580	190558
2016	430	2033	35553	2769	54633	15202	5488	4775	27558	148441
2017	281	2093	46038	2912	60927	39480	4715	3247	30681	190374
2018	174	960	22499	749	34103	10868	3815	2959	13467	89594
2019	271	2514	30937	4689	62567	17450	4828	3635	23649	150540
2020	303	1531	28678	11835	102794	22125	3107	4791	22612	197776
MÁXIMO	619	5083	58329	11835	120878	62872	6846	9668	50933	
MÍNIMO	174	787	22499	749	29291	10868	3107	1908	9410	
MÉDIA	349,3333	2094,267	37744,4	3834,867	61101,13	26683,33	4533,6	4107,4	25503,67	
TOTAL	4447	25544	485338	44939	766348	326510	58051	50035	322212	2083424

Table S1.4 Trend Analysis of Burned Area in the Cerrado-Amazonia Transition.

Class	$PM_{2.5}$			GPP					Fire Foci			Burned Area		
	Mann-Kendall	**Z**	**Pettitt**	**Mann-Kendall**	**Z**	**Pettitt**	**S**	**year**	**Mann-Kendall**	**Z**	**Pettitt**	**Mann-Kendall**	**Z**	**Pettitt**
ENF	0,07	-1,81	0,07	0,89	-0,13	0,73	_	_	0,64	-0,47	0,73	1,00	0,00	0,88
AME	0,95	0,06	1,00	0,20	1,28	0,73	_	_	0,25	1,16	1,00	0,36	0,92	1,00
DBF	0,58	0,55	1,00	0,16	1,40	0,59	_	_	0,67	0,43	1,00	0,67	0,43	1,00
MF	0,95	-0,06	1,00	0,16	1,40	0,27	_	_	0,85	0,18	1,00	0,76	-0,31	1,00
CS	0,33	0,98	0,88	0,95	0,06	1,00	_	_	0,42	0,80	0,96	0,50	-0,67	0,46
SO	0,28	-1,07	0,27	0,20	1,28	0,73	_	_	0,90	0,12	1,00	0,58	-0,55	1,00
WSV	0,95	-0,06	1,00	0,09	1,65	0,88	28	2011	0,50	0,67	1,00	0,85	0,18	1,00
SV	0,95	0,06	1,00	0,36	0,91	0,36	_	_	0,30	1,04	1,00	0,43	0,79	1,00
GK	0,95	0,06	1,00	0,07	1,77	0,07	30	2015	0,67	0,43	1,00	0,36	0,92	1,00
PW	0,58	0,55	0,7	0,09	1,65	0,46	28	2012	0,50	-0,67	0,59	0,25	-1,16	0,46
CL	0,50	0,67	1,0	0,09	1,65	0,07	28	2015	0,16	1,40	0,36	0,13	1,53	0,20
UBL	0,43	0,79	0,9	0,94	-0,070	1,00	_	_	0,75	0,32	0,88	0,58	0,55	1,00
NVM	0,76	-0,31	1,0	0,43	0,79	0,27	_	_	0,24	-1,17	0,46	0,58	-0,55	1,00
BN	0,67	0,43	1,0	0,39	0,86	0,27	_	_	NA	NA	NA	0,43	0,79	0,73

WB	0,85	0,18	1,0	0,35	0,94	1,00	_	_	0,75	-0,32	0,43	-0,79	0,27

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S1.5 -Trend Test of $PM_{2.5}$ by Federative Unit in the Integral Area of the Cerrado-Amazonia Transition: 2008-2020

UF	$MP_{2.5}$				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**YEAR**
CE	0,99	-0,42	0,36	-8	_
GO	0,95	-0,06	1,00	-2,00	_
MA	0,29	-1,03	0,58	-18,00	_
MS	0,42	0,79	0,72	14,00	_
MT	0,58	0,54	1,00	10,00	_
PA	0,58	-0,54	1,00	-10,00	_
PI	0,76	0,30	0,58	6,00	_
RO	0,29	1,00	0,46	18,00	_
TO	0,95	-0,06	1,00	-2,00	_

Teste de Mann Kendall e Pettit's para a verificação de tendência de $MP_{2.5}$ por Unidade Federativa na Áre de Transição Cerrado-Amazônia. **: valor de "p" significativo à 5%.

Table S1.6 - Descriptive Statistics of the Burned Area and Fire Foci (over the burned area) calculated from quarterly data in the Cerrado-Amazonia Transition between 2008-2020.

Annual Descriptive Statistics of $PM_{2.5}$ and GPP on the Burned Area: 2008-2020

Variable	Mean	Standart Error	Median	Standart Deviation	Sample variance	Curtosis	Assimetria	Interval	Minimum	Máximum	Sum	Score	Year
	29,90	1,07	23,21	20,72	429,50	5,68	2,29	120,44	6,18	126,63	11211,26	375	2008
	18,97	0,88	15,38	12,21	149,06	4,68	2,15	67,70	5,66	73,36	3642,23	192	2009
	89,51	2,65	63,94	86,85	7543,58	4,63	2,14	484,51	5,69	490,20	95959,10	1072	2010
	20,99	0,46	20,36	8,06	64,95	2,89	0,88	60,88	5,46	66,34	6380,02	304	2011
	36,84	0,70	34,39	17,81	317,28	2,00	0,95	127,92	4,80	132,71	23796,98	646	2012
	17,81	0,40	16,72	6,62	43,80	2,62	1,20	39,42	6,87	46,29	4790,61	269	2013
$PM_{2.5}$	24,94	0,54	24,00	10,77	116,09	8,32	1,75	92,22	5,75	97,97	9952,29	399	2014
	32,43	0,57	31,29	13,21	174,42	-0,30	0,30	66,77	5,36	72,13	17383,95	536	2015
	32,43	0,57	31,29	13,21	174,42	-0,30	0,30	66,77	5,36	72,13	17383,95	536	2016
	36,78	1,09	27,50	27,04	731,12	2,19	1,59	149,76	5,96	155,72	22730,58	618	2017
	15,34	0,43	14,58	6,52	42,48	2,90	1,38	38,95	5,39	44,34	3513,74	229	2018
	29,47	0,75	25,43	16,70	279,01	-0,43	0,69	73,66	6,76	80,42	14470,70	491	2019
	16,53	0,37	10,53	20,33	413,47	160,50	8,81	528,64	1,84	530,48	49844,27	3015	2020

Variable	Mean	Standart Error	Median	Standart Deviation	Sample variance	Curtosis	Assimetria	Interval	Minimum	Máximum	Sum	Score	Year
	0,018	0,000	0,015	0,012	0,000	0,875	1,022	0,088	0,000	0,088	6096,011	342050	2008
	0,027	0,000	0,026	0,013	0,000	0,878	0,632	0,091	0,000	0,091	4554,803	171548	2009
	0,018	0,000	0,017	0,013	0,000	0,902	0,998	0,087	0,000	0,087	17119,716	927719	2010
	0,022	0,000	0,021	0,012	0,000	-0,018	0,446	0,089	0,000	0,089	5777,527	268139	2011
	0,021	0,000	0,020	0,013	0,000	1,362	1,061	0,084	0,000	0,084	11777,177	549688	2012
	0,024	0,000	0,023	0,012	0,000	0,946	0,780	0,084	0,000	0,084	5762,039	242051	2013
GPP	0,023	0,000	0,021	0,012	0,000	0,771	0,821	0,085	0,000	0,085	8014,741	355588	2014
	0,022	0,000	0,018	0,013	0,000	0,986	1,118	0,088	0,000	0,088	9838,086	455158	2015
	0,014	0,000	0,008	0,013	0,000	1,552	1,440	0,080	0,000	0,080	5443,581	392944	2016
	0,027	0,000	0,024	0,015	0,000	0,050	0,783	0,093	0,000	0,093	14758,779	552573	2017
	0,026	0,000	0,025	0,014	0,000	-0,168	0,584	0,089	0,000	0,089	4788,316	185066	2018
	0,024	0,000	0,022	0,015	0,000	-0,187	0,658	0,091	0,000	0,091	9880,941	409584	2019
	0,024	0,000	0,022	0,016	0,000	-0,204	0,621	0,091	0,000	0,091	12963,320	549014	2020

Estatística Descritiva de $PM_{2.5}$ e GPP sobre a área queimada calculadas a partir dos dados trimestrais na Transição Cerrado-Amazônia entre 2008-2020.

Table S1.7 - Area, in km², of the land use and cover classes of the Federative Unit of Goiás over the Integral Area of the Cerrado-Amazonia Transition between 2008 and 2020.

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	0,48381	1336,63	137,098	112,023	6,70588	44,1999	815,481	27478,9
2009	0,48381	1455,57	140,757	60,6578	4,79636	29,2128	879,193	29430,5
2010	0,48381	1353,43	181,463	103,164	6,23545	29,4615	860,646	27746,2
2011	0,48381	1393,65	177,258	100,872	4,79343	24,6588	885,983	27951,4
2012	0,48381	1325,48	179,676	115,422	2,15843	28,0018	917,325	29279,2
2013	0,48381	1360,39	175,264	63,3309	2,15978	16,2744	958,811	29969,1
2014	0,48381	1406,84	213,165	78,0808	0,72216	18,6699	1028,84	31136,9
2015	0,48381	1387,16	275,28	101,061	0,24092	15,5601	1009,8	31238,8
2016	0,48381	1191,18	280,004	69,5853	0,48276	15,5621	1060,49	27639,6
2017	0,72518	1123,35	390,904	73,8834	0,48129	10,2976	994,511	27043,6
2018	0,48381	1298,79	316,755	34,4649	0,24055	7,1887	1062,67	26015,1
2019	0,24191	1321,26	359,203	37,9156	0,48065	4,31372	1145,17	25392,1
2020	0,48381	1455,57	140,757	60,6578	4,79636	29,2128	879,193	29430,5
Minimum	0,24191	1123,35	137,098	34,4649	0,24055	4,31372	815,481	25392,1
Maximum	0,72518	1455,57	390,904	115,422	6,70588	44,1999	1145,17	31238,8
Mean	0,48377	1339,18	228,276	77,7783	2,638	20,9703	961,394	28442,5
Class	**GK**	**PW**	**CL**	**UBL**	**NVM**	**BN**	**WB**	
2008	33203,9	11,8931	35,6628	71,3648	0	0	2,90565	
2009	31125	14,4727	42,3736	71,3649	0	0	2,90565	
2010	32839,9	13,692	47,9407	71,3648	0	0,24092	2,90565	
2011	32574,4	13,8559	55,0455	71,3649	0	0,48184	2,90565	
2012	31248,6	13,0481	73,0514	71,3649	0	0,48184	2,90565	
2013	30529,7	13,9907	92,4653	71,3649	0	1,20458	2,66482	
2014	29176,7	13,0173	108,54	71,3649	0	1,68638	2,1803	
2015	29028,5	13,9306	110,62	71,3649	0	2,16818	2,18031	
2016	32803,7	15,395	104,468	71,3649	0	2,64999	2,1803	
2017	33407	14,7989	121,205	71,3649	0	2,89089	2,1803	
2018	34297,2	15,5509	132,506	71,3649	0	2,64997	2,18031	
2019	34759,4	14,4578	145,936	71,3649	0	2,89087	2,42114	
2020	31125	14,4727	42,3736	71,3649	0	0	2,90565	
Minimum	29028,5	11,8931	35,6628	71,3648	0	0	2,1803	
Maximum	34759,4	15,5509	145,936	71,3649	0	2,89089	2,90565	
Mean	32009,2	14,0443	85,553	71,3649	0	1,33427	2,57087	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands

(PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S1.8 - Trend Analysis on Land Use and Occupation in the Federative Unit of Goiás over the Integral Area of the Cerrado-Amazon Transition: 2008-2020

Class	LULC				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**Year**
ENF	0,840	0,190	1,000	-3,000	_
AME	0,460	-0,730	0,400	-13,000	_
DBF	**0,01	2,560	0,120	43,000	2012
MF	**0,03	-2,070	0,170	-35,000	2014
CS	*0,004	-2,810	0,080	-47,000	2012
SO	**0,002	-3,050	0,080	-51,000	2011
WSV	**0,003	2,933	0,089	49,000	2011
SV	0,624	0,488	0,237	-9,000	_
GL	0,713	0,366	0,314	7,000	_
PW	**0,037	2,078	0,060	35,000	2014
CL	**0,0014	3,178	0,126	53,000	2011
UBL	0,080	1,735	0,237	29,000	_
NVM	<NA>	<NA>	<NA>	<NA>	_
BN	**0,003	2,948	0,149	49,000	2012
WB	0,090	-1,693	0,089	-27,000	_

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S1.9 - Area, in km², of the land use and cover classes of the Federative Unit of Ceará over the Integral Area of the Cerrado-Amazon Transition between 2008 and 2020.

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	0,49592	21,016	673,217	7,43688	0	0,09089	86,7163	4035,53
2009	0	31,0916	863,713	6,94131	0	0,09089	130,992	3869,47
2010	0	26,0267	577,975	15,0513	0	0	135,273	4078,06
2011	0	35,6787	726,168	10,5896	0	0	226,134	3870,86
2012	0	27,957	421,214	3,96647	0	0,09089	131,927	4245,72
2013	0	17,5459	357,918	4,70991	0,09089	131,788	4261,08	467,233
2014	0	5,70148	306,244	8,87043	0,24779	0,14258	120,811	4218,19
2015	0	3,44331	337,798	8,375	1,48663	0,09089	213,828	3944,14
2016	0	3,69111	374,08	5,89617	41,8762	0,09089	212,792	3702,27
2017	0	7,65699	511,143	4,21401	18,5588	0,05729	160,161	3692,77
2018	0	14,3496	526,991	0,49592	0,49556	0	111,571	3816,49
2019	0	31,3214	703,818	1,23961	0	0	99,2957	3799,31
2020	0	31,0916	863,713	6,94131	0	0,09089	130,992	3869,47
Minimum	0	3,44331	306,244	0,49592	0	0	86,7163	467,233
Maximum	0,49592	35,6787	863,713	15,0513	41,8762	131,788	4261,08	4245,72
Mean	0,03815	19,7363	557,23	6,51753	4,82737	10,1948	463,198	3662,27

Class	GL	PW	CL	UBL	NVM	BN	WB	
2008	399,618	68,9776	41,4361	10,4134	15,4838	29,266	27,3111	
2009	329,816	73,131	38,4927	10,4134	6,4442	28,3646	28,055	
2010	406,707	71,6426	34,4905	10,4134	4,70942	29,1085	27,5591	
2011	370,849	72,3868	34,391	10,4134	3,47022	28,5122	27,5591	
2012	411,852	70,466	33,6478	10,4134	2,47871	30,21	27,0633	
2013	68,2352	35,8916	10,4134	4,73598	0	30,5574	26,8155	
2014	572,68	65,5502	45,3265	10,4134	5,08297	30,9398	26,8155	
2015	706,945	64,3114	54,6156	10,4134	11,2701	33,4834	26,8155	
2016	869,282	65,335	58,2155	10,4134	12,9013	33,3517	26,8155	
2017	804,158	65,7994	69,8186	10,4134	13,7575	30,9438	27,5594	
2018	737,499	65,8309	61,0259	10,4134	12,7663	31,5212	27,5594	
2019	589,3	70,2937	48,3305	10,4134	5,45256	30,6742	27,5594	
2020	329,816	73,131	38,4927	10,4134	6,4442	28,3646	28,055	
Minimum	68,2352	35,8916	10,4134	4,73598	0	28,3646	26,8155	
Maximum	869,282	73,131	69,8186	10,4134	15,4838	33,4834	28,055	
Mean	507,443	66,3652	43,7459	9,9767	7,7124	30,4075	27,3495	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 2 - Trend Analysis on Land Use and Occupation in the Federative Unit of Ceará over the Integral Area of the Cerrado-Amazon Transition: 2008-2020

Class	**LULC**				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**Year**
ENF	0,14	-1,47	1,00	12,00	_
AME	0,60	-0,48	0,40	-9,00	_
DBF	1,00	0,00	0,40	-1,00	_
MF	0,07	-1,83	0,24	-31,00	_
CS	0.1	1,60	0,20	25,00	_
SO	0,51	0,65	0,80	-11,00	_
WSV	0,70	-0,36	0,65	-7,00	_
SV	0,22	-1,22	0,23	-21,00	_
GL	0,11	1,58	0,12	27,00	_
PW	0,80	0,24	0,23	-5,00	_
CL	0,17	1,34	0,04	23,00	_
UBL	0,80	0,13	1,00	3,00	_
NVM	0,62	0,48	0,31	9,00	_
BN	0,11	1,58	0,17	27,00	_
WB	0,71	0,36	0,23	7,00	_

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 2.1 - Area, in km², of the land use and cover classes of the Federative Unit of Maranhão over the Integral Area of the Cerrado-Amazonia Transition between 2008 and 2020.

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	0	32906,4	832,171	848,745	154,911	20,1367	89889,1	157358
2009	0	32972,8	522,776	458,763	104,806	11,7795	92562,8	156678
2010	0	32369,6	1348,53	607,027	77,9305	14,7202	90882,6	156926
2011	0	34338,1	958,588	519,296	59,9385	16,9267	91637,1	154780
2012	0	31651,1	2779,66	548,123	39,5688	12,4969	88538,8	157847
2013	0	30097,2	1826,63	428,875	29,2677	13,4779	90354,2	158861
2014	0,24804	29879,1	1927,14	526,85	38,2906	18,1534	90436,1	159111
2015	0	28837,7	3480,11	808,268	31,4084	16,9404	87710,4	158288
2016	0	25981,3	3396,29	702,883	32,3859	25,0237	84851,5	157890
2017	0	27353	3690,02	806,26	30,3664	24,8024	82017,4	156804
2018	0	29139,8	2990,82	426,704	42,5039	17,1839	79023,2	156221
2019	0	31982,1	3365,66	327,109	34,3748	11,8372	78052,5	154657
2020	0	32972,8	522,776	458,763	104,806	11,7795	92562,8	156678
Minimum	0	25981,3	522,776	327,109	29,2677	11,7795	78052,5	154657
Maximum	0,24804	34338,1	3690,02	848,745	154,911	25,0237	92562,8	159111
Mean	0,01908	30806,2	2126,24	574,436	60,043	16,5583	87578,3	157085

Class	GK	PW	CL	UBL	NVM	BN	WB	
2008	31431,4	3210,18	3607,94	396,86	59,4694	902,491	1295,9	
2009	29941,6	3229,23	3783,25	396,86	52,0367	901,473	1297,81	
2010	30982	3217,42	3839,06	397,108	53,7143	901,034	1296,5	
2011	30548,1	3303,78	4093,1	397,356	62,8638	899,58	1298,87	
2012	31353,7	3200,1	4267,21	398,1	61,1979	898,391	1317,98	
2013	31012,2	3184,19	4402,72	398,596	61,8613	897,479	1345,64	
2014	30593	3190,59	4475,74	398,596	61,6345	905,114	1351,92	
2015	33134	3165,02	4707,77	398,844	68,3389	914,359	1352,91	
2016	39764,9	3143,06	4381,71	398,844	72,0805	921,228	1352,28	
2017	41571,2	3141,06	4725,62	399,588	67,8631	926,465	1355,9	
2018	43877,8	3236,22	5179,87	399,588	68,5489	928,881	1361,31	
2019	43337,5	3345,48	5053,84	399,588	57,9928	925,439	1363,21	
2020	29941,6	3229,23	3783,25	396,86	52,0367	901,473	1297,81	
Minimum	29941,6	3141,06	3607,94	396,86	52,0367	897,479	1295,9	
Maximum	43877,8	3345,48	5179,87	399,588	72,0805	928,881	1363,21	
Mean	34422,2	3215,04	4330,85	398,214	61,5107	909,493	1329,85	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands

(PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 2.2 - Trend Analysis on Land Use and Occupation in the Federal Unit of Maranhão in the Integral Area of the Cerrado-Amazon Transition: 2008-2020

Class	**LULC**				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**Year**
ENF	1,00	0,00	1,00	0,00	_
AME	0,11	-1,59	0,17	-27,00	_
DBF	0,05	1,96	0,24	33,00	2011
MF	0,27	-1,10	0,31	-19,00	_
CS	0,11	-1,59	0,17	-27,00	_
SO	1,00	0,00	0,80	1,00	_
WSV	**0,027	-2,20	0,23	-37,00	2013
SV	0,46	-0,73	0,31	-13,00	_
GL	0,06	1,83	0,24	31,00	_
PW	0,62	-0,48	0,40	-9,00	_
CL	**0,003	2,93	0,13	49,00	2011
UBL	**0,0033	2,93	0,13	49,00	2011
NVM	0,27	1,10	0,52	19,00	_
BN	0,09	1,71	0,04	29,00	_
WB	0,00	3,30	0,09	55,00	2011

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 2.3 - Area, in km², of land use and land cover classes of the Federative Unit of Mato Grosso do Sul over the Integral Area of the Cerrado-Amazonia Transition between 2008 and 2020.

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	53,3017	1274,99	933,126	7,09145	0	0	615,578	22838,6
2009	18,9181	1067,55	847,875	8,9838	0	0	669,677	24333,1
2010	13,0266	806,889	844,888	7,33629	0	0	705,964	24373,7
2011	18,4365	1030,15	912,201	5,91595	0	0	613,17	24238,7
2012	9,43236	901,033	930,057	4,96865	0	0	602,974	24805,8
2013	10,6137	945,908	901,113	4,49337	0	0	585,362	24802
2014	16,7386	1499,2	931,469	1,89017	0	0	650,974	24142,7
2015	29,3399	1557,33	816,904	1,41897	0	0	644,835	23915
2016	26,8351	1308,37	781,16	1,65586	0	0	715,655	23888,2
2017	20,5001	1286,89	821,286	1,41989	0	0	806,687	23291,9
2018	35,5029	1443,38	838,338	1,65656	0	0	786,913	22911,8
2019	24,9807	1262,56	893,555	2,83989	0	0	803,996	23329
2020	18,9181	1067,55	847,875	8,9838	0	0	669,677	24333,1
Minimum	9,43236	806,889	781,16	1,41897	0	0	585,362	22838,6
Maximum	53,3017	1557,33	933,126	8,9838	0	0	806,687	24805,8
Mean	22,8111	1188,6	869,219	4,51189	0	0	682,42	23938,7
Class	**GK**	**PW**	**CL**	**UBL**	**NVM**	**BN**	**WB**	
2008	889,123	6640,9	0,47083	50,4078	0	0	439,804	
2009	598,942	5709,46	0,23573	50,4079	0	0	438,151	
2010	697,273	5805,02	0,70594	50,4079	0	0	438,151	
2011	518,003	5918,26	0,70594	50,4079	0	0	437,442	
2012	576,607	5423,94	0,94104	50,4079	0	0	437,205	
2013	605,287	5400,5	0,70594	50,4079	0	0	436,968	
2014	471,565	5540,94	0,23573	50,4079	0	0	437,204	
2015	649,229	5636,22	0,23573	50,4079	0	0	442,397	
2016	794,271	5732,92	0,23573	50,4079	0	0	443,579	
2017	1223,79	5799,52	0,23573	50,4079	0	0	440,746	
2018	1046,86	6185,12	0,23573	50,4078	0	0	443,107	
2019	1088,22	5843,51	0,2351	50,4078	0	0	444,05	
2020	598,942	5709,46	0,23573	50,4079	0	0	438,151	
Minimum	471,565	5400,5	0,2351	50,4078	0	0	436,968	
Maximum	1223,79	6640,9	0,94104	50,4079	0	0	444,05	
Mean	750,624	5795,83	0,41653	50,4079	0	0	439,766	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 2.4 -Trend Analysis on Land Use and Occupation in the Federative Unit of Mato Grosso do Sul over the Integral Area of the Cerrado-Amazon Transition: 2008-2020

Class	LULC				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**Year**
ENF	0,54	0,61	0,24	11,00	_
AME	0,39	0,86	0,06	15,00	_
DBF	0,22	-1,22	0,09	-21,00	_
MF	0,07	-1,83	0,17	-31,00	_
CS	<NA>	<NA>	<NA>	<NA>	_
SO	<NA>	<NA>	<NA>	<NA>	_
WSV	0,09	1,71	0,06	29,00	_
SV	0,22	-1,22	0,41	-21,00	_
GL	0,27	1,10	0,24	19,00	_
PW	0,90	0,12	0,65	3,00	_
CL	**0,0369	-2,08	0,07	-32,00	_
UBL	0,80	0,24	0,31	5,00	_
NVM	<NA>	<NA>	<NA>	<NA>	_
BN	<NA>	<NA>	<NA>	<NA>	_
WB	0,27	1,10	0,04	19,00	_

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Tabela S 2.5 Área, em km², das classes de uso e cobertura do solo da Unidade Federativa do Mato Grosso sobre a Área Integral da Transição do Cerrado-Amazônia entre 2008 a 2020.

Class	**ENF**	**AME**	**DBF**	**MF**	**CS**	**SO**	**WSV**	**SV**
2008	20,0329	306814	6535,51	2821,19	217,508	674,965	54255,5	218053
2009	19,5203	306252	5656,81	2067,01	164,129	429,797	55936,4	226864
2010	19,5132	301408	8418,47	2984,08	160,531	321,385	53735,6	219570
2011	19,2754	300460	8356,85	2993,15	168,589	251,144	54028,3	220215
2012	20,013	302152	8642,58	3173,84	144,371	117,735	50942	230281
2013	23,8748	302312	8420,19	2611,66	126,723	40,2232	50769,1	237725
2014	31,3524	303542	8969,35	2271,48	125,901	54,4207	49487	241112
2015	35,2493	299806	9759,94	2184,21	155,2	52,9515	48697	240456
2016	29,4328	294634	9801,09	1822,33	178,485	46,1892	47651,7	234683
2017	28,4831	295418	10564,8	1785,58	217,921	50,6965	44600,5	231193
2018	27,5016	295792	10849,6	1308,94	266,251	46,8097	43699,5	225131
2019	26,2874	292840	11262,1	1260,18	270,004	23,2835	44247,1	222899
2020	19,5203	306252	5656,81	2067,01	164,129	429,797	55936,4	226864
Minimum	19,2754	292840	5656,81	1260,18	125,901	23,2835	43699,5	218053
Maximum	35,2493	306814	11262,1	3173,84	270,004	674,965	55936,4	241112
Mean	24,6197	300591	8684,16	2257,74	181,519	195,338	50306,6	228850

Class	**GK**	**PW**	**CL**	**UBL**	**NVM**	**BN**	**WB**	
2008	202255	6440,5	36288,8	815,15	1038,23	27,8099	1599,64	
2009	193694	6183,41	37108,2	815,15	1043,33	29,7779	1592,57	
2010	205235	6249,46	36434,5	815,15	909,487	29,4658	1565,74	
2011	202058	6113,89	39865,7	815,632	920,847	30,8759	1557,87	
2012	190843	5588,33	42606,7	815,874	953,078	27,4219	1547,87	
2013	183033	5455,63	43957,9	816,116	984,926	22,2585	1557,34	
2014	178155	5660,03	44932	816,116	1117,51	19,0292	1562,51	
2015	181041	5870,12	46233,4	816,356	1156,52	18,5483	1573,62	
2016	193009	5858,86	46557,1	816,842	1170,49	21,8461	1575,97	
2017	196378	5975,53	48107,7	817,081	1113,49	24,4232	1580,73	
2018	201891	6543,17	48823,3	817,325	1033,1	23,4602	1602,76	
2019	204146	6477,05	51111,7	817,325	844,778	20,6255	1610,07	
2020	193694	6183,41	37108,2	815,15	1043,33	29,7779	1592,57	
Minimum	178155	5455,63	36288,8	815,15	844,778	18,5483	1547,87	
Maximum	205235	6543,17	51111,7	817,325	1170,49	30,8759	1610,07	
Mean	194264	6046,11	43010,4	816,097	1025,32	25,0246	1578,4	

Florestas Evergreen Needleleaf (ENF); Florestas sempre-verdes de folhas largas (AME); Florestas Caducifólias Latifoliadas (DBF); Florestas Mistas (MF); Arbustos fechados (CS); Arbustos abertos (SO); Savanas arborizadas (WSV); Savanas (SV); Pradarias (GL); Zonas Úmidas Permanentes (PW), Áreas de cultivo (CL); Solos Urbanos e Construídos (UBL); Mosaicos de terras agrícolas/vegetação natural (NVM);
Árido (BN); Corpos d'água (WB).

Table S 2.6 - Trend Analysis on Land Use and Occupation in the Federative Unit of Mato Grosso over the Integral Area of the Cerrado-Amazon Transition: 2008-2020

Class	LULC				
	Mann-Kendall	Z	Pettitt	S	Year
ENF	0,33	0,98	0,09	17,00	_
EBF	0,05	-1,96	0,17	0,17	_
DBF	**0,0033	2,93	0,17	49,00	2012
MF	**0,007	2,69	0,04	-45,00	2014
CS	0,33	0,98	0,12	17,00	_
SO	**0,01	-2,57	0,13	-43,00	2011
WSV	**0,0033	-2,93	0,17	-49,00	2012
SV	0,39	0,86	0,17	15,00	_
GL	0,81	0,24	0,40	-5,00	_
PW	0,80	0,24	0,40	5,00	_
CL	**0,0006	3,42	0,09	57,00	2012
UBL	**0,0049	2,81	0,17	47,00	2011
NVM	0,46	0,73	0,41	13,00	_
BN	0,18	-1,34	0,13	-23,00	_
WB	0,14	1,46	0,24	25,00	_

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 2.7 - Area, in km², of the land use and cover classes of the Federative Unit of Piauí over the Integral Area of the Cerrado-Amazonia Transition between 2008 and 2020.

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	0,74246	901,898	2133,81	203,45	12,6264	0,83196	12886,3	31271,3
2009	0,74246	957,972	2348,79	167,557	6,18984	0,58393	13230,1	31449,1
2010	0,49497	920,553	2265,33	191,691	1,95581	0,49607	12581,2	31345,2
2011	0,24749	1202,97	1889,04	106,626	0,46993	0,24804	13148,4	31238,4
2012	0,24749	880,882	2107,92	102,602	0,49573	0,49607	11058,4	32694,1
2013	0	725,763	2211,44	114,946	0,74296	0,24804	10413,3	32970,1
2014	0	737,028	2407,93	213,956	0,74288	0,24803	10225,7	32872,8
2015	0	629,418	2842,2	322,007	0,99052	1,29368	9993,35	31923,8
2016	0	371,473	3081,48	295,913	3,46688	2,61298	9505,83	31502,1
2017	0	469,124	3765,57	288,852	1,73364	2,36735	8979,09	31569,4
2018	0	688,983	3424,53	117,754	0,99041	2,86342	8586,5	32079,8
2019	0	931,539	3718,48	76,8688	0	2,8634	8671,98	32572,7
2020	0,74246	957,972	2348,79	167,557	6,18984	0,58393	13230,1	31449,1
Minimum	0	371,473	1889,04	76,8688	0	0,24803	8586,5	31238,4
Maximum	0,74246	1202,97	3765,57	322,007	12,6264	2,86342	13230,1	32970,1
Mean	0,24749	798,121	2657,33	182,291	2,81499	1,21053	10962,3	31918,3

Class	GK	PW	CL	UBL	NVM	BN	WB	
2008	5851,23	53,5527	565,283	183,66	1,73543	24,6814	241,888	
2009	5081,7	59,2205	579,964	183,66	0,98454	22,9824	243,472	
2010	5949,02	60,3465	564,08	183,908	0,98454	25,0042	242,732	
2011	5664,58	60,3325	569,457	184,402	1,48061	22,3564	243,959	
2012	6413,43	53,2112	569,157	184,402	1,4806	23,5796	242,622	
2013	6772,77	55,6744	619,417	184,402	1,7345	19,5968	242,853	
2014	6707,69	59,065	663,326	184,402	1,23245	18,5974	240,294	
2015	7409,97	59,5101	704,116	184,65	1,98211	19,2981	240,445	
2016	8402,84	59,865	661,64	184,65	1,48686	20,6654	238,973	
2017	7990,05	62,1312	758,802	184,65	2,72559	20,0661	238,427	
2018	8086,32	69,1835	831,947	184,65	3,21806	16,7808	239,505	
2019	7078,81	71,6781	766,356	184,65	1,73293	15,0544	240,239	
2020	5081,7	59,2205	579,964	183,66	0,98454	22,9824	243,472	
Minimum	5081,7	53,2112	564,08	183,66	0,98454	15,0544	238,427	
Maximum	8402,84	71,6781	831,947	184,65	3,21806	25,0042	243,959	
Mean	6653,08	60,2301	648,731	184,288	1,67406	20,8958	241,452	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 2.8 - Trend Analysis on Land Use and Occupation in the Federative Unit of Piauí over the Integral Area of the Cerrado-Amazon Transition: 2008-2020

Class	LULC				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**Year**
ENF	**0,03	-2,15	0,14	-33,00	2011
AME	0,27	-1,10	0,31	-19,00	_
DBF	**0,01	2,56	0,03	43,00	_
MF	1,00	0,00	0,80	-1,00	_
CS	0,62	0,48	0,40	-9,00	_
SO	0,17	1,34	0,04	23,00	_
WSV	**0,004	-2,81	0,17	-47,00	2011
SV	0,32	0,97	0,08	17,00	_
GL	**0,037	2,07	0,17	35,00	2011
PW	0,05	1,95	0,24	33,00	_
CL	**0,0049	2,81	0,04	47,00	2011
UBL	0,08	1,71	0,23	29,00	_
NVM	0,26	1,11	0,58	19,00	_
BN	**0,02	2,32	0,06	-39,00	2011
WB	0,11	-1,58	0,12	-27,00	_

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 2.9 - **Area, in km², of the land use and cover classes of the Federative Unit of Pará over the Integral Area of the Cerrado-Amazonia Transition between 2008 and 2020.**

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	6,43987	157250	337,119	430,902	52,2885	0	20350,6	104790
2009	5,20142	154703	56,0163	345,691	84,6443	0	23545,8	106283
2010	4,45827	152034	339,014	425,279	28,5474	0	24107,5	106812
2011	3,96294	151141	127,655	395,328	26,6424	0	26432,2	106376
2012	3,46759	148677	110,869	467,461	29,4114	0	26960,2	106674
2013	2,72459	147126	61,6734	424,683	34,5738	0	30003,1	107423
2014	3,96314	146471	87,2172	468,437	30,0748	0,24493	30246,9	109614
2015	3,96311	145223	118,947	479,468	25,9804	0	28463,6	112016
2016	3,22013	142638	108,923	408,978	35,8565	0,98252	28293,2	113563
2017	2,97244	142852	140,609	461,734	22,4936	0,73646	26329,4	113240
2018	0,49545	141249	119,086	379,417	40,435	0,49069	27207,8	111648
2019	0	141272	150,366	442,045	30,8921	0	27607,3	109132
2020	5,20142	154703	56,0163	345,691	84,6443	0	23545,8	106283
Minimum	0	141249	56,0163	345,691	22,4936	0	20350,6	104790
Maximum	6,43987	157250	339,014	479,468	84,6443	0,98252	30246,9	113563
Mean	3,54387	148103	139,501	421,163	40,4988	0,18881	26391,8	108758

Class	GK	PW	CL	UBL	NVM	BN	WB	
2008	22888,4	1020,4	15,5646	118,647	0	28,4351	2778,92	
2009	21056,7	1043,97	8,1596	118,647	0	21,9171	2794,57	
2010	22311,7	1070,81	7,8863	118,895	0	23,2092	2784,36	
2011	21548,1	1085,15	9,34532	119,142	0	22,363	2780,61	
2012	23101,4	1104,99	28,8073	119,389	0	20,9296	2769,63	
2013	20924,4	1127,18	45,5555	119,389	0	18,4015	2757,61	
2014	19041,9	1139,25	72,2943	119,884	0	19,0445	2753,59	
2015	19542,2	1162,33	147,288	119,884	0	15,7974	2748,93	
2016	20728	1212,91	197,042	120,131	0	23,5656	2733,68	
2017	22634,8	1243,89	265,444	120,131	0	29,4588	2724,45	
2018	25001,7	1270,97	270,159	120,131	0	26,6486	2732,89	
2019	26884,3	1284,76	388,758	120,131	0	23,483	2732,31	
2020	21056,7	1043,97	8,1596	118,647	0	21,9171	2794,57	
Minimum	19041,9	1020,4	7,8863	118,647	0	15,7974	2724,45	
Maximum	26884,3	1284,76	388,758	120,131	0	29,4588	2794,57	
Mean	22055,4	1139,28	112,651	119,465	0	22,7054	2760,47	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands

(PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 3 - Trend Analysis on Land Use and Occupation in the Federative Unit of Pará over the Integral Area of the Cerrado-Amazon Transition: 2008-2020

Class	LULC				
	Mann-Kendall	Z	Pettitt	S	Year
ENF	**0,014	-2,44	0,31	-41,00	2010
EBF	**0,0014	-3,17	0,13	-53,00	2011
DBF	0,81	0,24	1,00	-5,00	_
MF	0,90	-0,12	1,00	-3,00	_
CS	0,90	0,12	0,80	3,00	_
SO	0,20	1,27	0,46	18,00	_
WSV	0,27	1,10	0,24	19,00	_
SV	**0,037	2,07	0,12	35,00	2011
GL	80,00	0,24	0,52	5,00	_
PW	**0,0006	3,42	0,12	57,00	2011
CL	**0,003	2,93	0,12	49,00	2011
UBL	**0,003	2,93	0,12	49,00	2012
NVM	<NA>	<NA>	<NA>	<NA>	_
BN	1,00	0,00	0,31	-1,00	_
WB	**0,0071	-2,69	0,17	-45,00	2011

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 3.1 - Area, in km², of the land use and cover classes of the Federative Unit of Rondônia over the Integral Area of the Cerrado-Amazonia Transition between 2008 and 2020.

Class	**ENF**	**AME**	**DBF**	**MF**	**CS**	**SO**	**WSV**	**SV**
2008	128,6154	45614,49	439,7678	126,2374	2,674375	0	3853,045	38924,04
2009	128,6921	45504,76	431,3644	118,2286	4,624041	0	4237,457	39277,98
2010	103,0949	44816,96	582,389	143,7264	3,648701	0	4280,418	38380,07
2011	67,61909	44244,66	693,7392	160,4432	1,945203	0	4791,431	37655,62
2012	49,88229	44736,42	669,8358	179,627	1,216705	0	4581,595	37742,22
2013	57,91204	45150,93	651,406	132,0268	0,243561	0	4764,095	38256,13
2014	75,57789	45198,19	715,5589	79,13224	0,48379	0	4703,571	38476,1
2015	79,37715	44801,67	693,2331	74,77549	0	0	4540,775	39185,86
2016	75,58184	44170,34	720,1699	89,07909	0,728196	0	4334,799	39353,83
2017	73,53013	44229,7	702,9947	55,57899	0,727484	0	4076,595	38766,61
2018	58,35924	44076,41	726,3178	73,2787	0,484139	0	4118,263	37118,49
2019	49,87679	43808,22	710,5467	72,06215	0,969198	0	4115,797	36289,67
2020	128,6921	45504,76	431,3644	118,2286	4,624041	0	4237,457	39277,98
Minimum	49,8768	43808,2	431,364	55,579	0	0	3853,04	36289,7
Maximum	128,692	45614,5	726,318	179,627	4,62404	0	4791,43	39353,8
Mean	82,8316	44758,3	628,361	109,417	1,72073	0	4356,56	38361,9

Class	**GK**	**PW**	**CL**	**UBL**	**NVM**	**BN**	**WB**	
2008	8477,177	596,9534	200,0621	302,7001	0	0	2,428676	
2009	7846,473	611,9974	201,4851	302,7001	0	0	2,428676	
2010	9189,819	644,4474	218,002	302,7	0	0	2,914741	
2011	9853,913	634,3345	258,6269	302,6999	0	0	3,157769	
2012	9511,294	600,2416	288,304	302,6999	0	0	4,858645	
2013	8449,987	598,8073	292,5304	302,6998	0	0	11,41957	
2014	8200,147	600,8631	290,3503	302,6998	0	0	25,51357	
2015	8011,14	618,0506	331,2091	302,6998	0,243041	0	29,15838	
2016	8624,475	593,9054	374,157	302,6998	0	0	28,42957	
2017	9383,102	618,167	428,8424	302,6998	0	0	29,64457	
2018	11054,59	667,0819	443,306	302,6998	0	0	28,91517	
2019	12140,39	688,5211	458,3421	302,6999	0	0	31,10214	
2020	7846,473	611,9974	201,4851	302,7001	0	0	2,428676	
Minimum	7846,47	593,905	200,062	302,7	0	0	2,42868	
Maximum	12140,4	688,521	458,342	302,7	0,24304	0	31,1021	
Mean	9122,23	621,951	306,669	302,7	0,0187	0	15,5692	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands

(PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 3.2 - Trend Analysis on Land Use and Occupation in the Federative Unit of Rondônia over the Integral Area of the Cerrado-Amazon Transition: 2008-2020

Class	LULC				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**Year**
ENF	0,27	-1,10	0,40	-19,00	_
EBF	**0,037	-2,08	0,31	-35,00	2013
DBF	0,05	1,95	0,24	33,00	_
MF	**0,037	-2,07	0,03	-35,00	2012
CS	0,27	-1,10	0,17	-19,00	_
SO	<NA>	<NA>	<NA>	<NA>	_
WSV	0,46	-0,73	0,31	-13,00	_
SV	0,90	-0,12	1,00	-3,00	_
GL	0,50	0,61	1,00	11,00	_
PW	0,27	1,00	0,40	19,00	_
CL	**0,0009	3,30	0,12	55,00	2011
UBL	0,60	-2,20	0,17	-37,00	_
NVM	0,89	0,13	1,00	2,00	_
BN	<NA>	<NA>	<NA>	<NA>	_
WB	**0,003	2,94	0,14	49,00	2011

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 3.3 - Area, in km², of land use and land cover classes of the Federative Unit of Tocantins over the Integral Area of the Cerrado-Amazonia Transition between 2008 and 2020.

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	1,95073	9250,82	190,655	364,808	215,169	33,2401	5005,23	155102
2009	1,21842	9562,06	182,865	278,316	105,616	22,7362	6067,57	157201
2010	1,21512	9522,76	283,114	464,317	56,358	22,2479	6193,06	155091
2011	1,70251	9712,45	320,948	421,447	34,7067	20,5445	6629,96	155924
2012	1,45766	9802,59	391,038	592,118	23,0697	23,7259	6510,75	161089
2013	1,21512	9460,94	357,889	421,1	15,3841	22,747	7163,85	163147
2014	2,18694	9682,08	342,577	410,712	25,1914	23,4818	7720,73	163400
2015	2,37545	9156,09	375,688	447,197	20,3995	23,4874	7425,48	160257
2016	2,18963	8457,06	319,347	327,957	28,512	25,3496	7038,06	152570
2017	3,10455	8044,48	376,351	332,149	24,6068	24,5559	6152,3	152025
2018	1,88897	8168,07	330,709	159,016	23,893	16,8724	6532,4	147781
2019	1,88845	7926,24	343,401	109,745	17,9607	9,53449	6956,59	147309
2020	1,21842	9562,06	182,865	278,316	105,616	22,7362	6067,57	157201
Minimum	1,21512	7926,24	182,865	109,745	15,3841	9,53449	5005,23	147309
Maximum	3,10455	9802,59	391,038	592,118	215,169	33,2401	7720,73	163400
Mean	1,8163	9100,59	307,496	354,4	53,5756	22,4046	6574,12	156007

Class	GK	PW	CL	UBL	NVM	BN	WB	
2008	64547,7	752,748	594,113	93,2199	1,72074	106,038	729,476	
2009	61204,3	783,667	641,852	93,2199	0,49164	96,7823	747,476	
2010	62894,9	826,728	726,095	93,2199	0,73745	106,74	706,488	
2011	61281,7	882,325	854,224	93,2199	1,22911	97,5485	712,64	
2012	55797	936,329	919,737	93,2199	1,47495	89,8429	717,494	
2013	53503,1	958,716	1010,63	93,2199	1,96657	79,8596	751,892	
2014	52335,2	995,835	1128,24	93,2199	2,21244	72,4292	754,997	
2015	56125,6	967,646	1264,44	93,2199	2,45827	72,4153	755,617	
2016	65028,8	951,558	1315,9	93,2199	1,72078	90,372	739,175	
2017	66725,8	939,053	1414,73	93,2199	0,73749	97,7803	735,525	
2018	70612,9	959,608	1470,41	93,2199	1,47499	90,9711	746,507	
2019	70935,7	918,203	1531,31	93,2199	0,73747	78,7454	757,057	
2020	61204,3	783,667	641,852	93,2199	0,49164	96,7823	747,476	
Minimum	52335,2	752,748	594,113	93,2199	0,49164	72,4153	706,488	
Maximum	70935,7	995,835	1531,31	93,2199	2,45827	106,74	757,057	
Mean	61707,5	896,622	1039,5	93,2199	1,34258	90,4851	738,602	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands

(PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 3.4 - Trend Analysis on Land Use and Occupation in the Federative Unit of Tocantins over the Integral Area of the Cerrado-Amazon Transition: 2008-2020

Class	**LULC**				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**Year**
ENF	0,42	0,79	0,17	14,00	_
EBF	0,06	-1,83	0,08	-31,00	_
DBF	0,39	0,85	0,31	15,00	_
MF	0,05	-1,95	0,08	-33,00	_
CS	0,08	-1,71	0,17	-29,00	_
SO	0,54	-0,61	0,40	-11,00	_
WSV	0,39	0,85	0,40	15,00	_
SV	0,27	-1,10	0,12	-19,00	_
GL	0,32	0,97	0,12	17,00	_
PW	0,17	1,34	0,17	23,00	_
CL	*0,0006	3,42	0,12	57,00	2011
UBL	0,46	-0,73	0,65	-13,00	_
NVM	1,00	0,00	0,80	-1,00	_
BN	0,22	-1,22	0,17	-21,00	_
WB	0,06	1,83	0,12	31,00	_

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 3.5 - Fire Foci Trend Test by Federative Unit in the Integral Cerrado-Amazon Transition Area: 2008-2020

UF	Fire Foci				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**YEAR**
CE	**0,032	-2,13	0,10	-36	2011
GO	0,50	0,67	1,00	12,00	_
MA	0,66	-0,42	0,87	-8,00	_
MS	0,95	0,06	0,87	2,00	_
MT	0,24	1,15	0,87	20,00	_
PA	0,36	-0,91	0,58	-16,00	_
PI	0,70	0,30	0,87	6,00	_
RO	0,58	0,54	0,87	10,00	_
TO	0,85	0,18	0,87	4,00	_

Mann Kendall and Pettit's test to verify the trend of Fire Outbreaks by Federative Unit in the Cerrado-Amazonia Transition Area. **: "p" value significant at 5%.

Table S 3.6 - Burned Area Trend Test by Federative Unit in the Integral Area of the Cerrado-Amazonia Transition: 2008-2020

UF	Burned Area				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**YEAR**
CE	0,46	0,73	0,58	13	_
GO	0,42	0,79	0,87	14,00	_
MA	1,00	0,00	0,87	0,00	_
MS	0,95	0,06	0,72	2,00	_
MT	0,16	1,40	1,00	24,00	_
PA	0,85	-0,18	1,00	-4,00	_
PI	0,42	0,79	0,58	14,00	_
RO	0,85	0,18	1,00	4,00	_
TO	0,95	0,06	1,00	2,00	_

Mann Kendall and Pettit's test to verify the trend of Fire Outbreaks by Federative Unit in the Cerrado-Amazonia Transition Area. **: "p" value significant at 5%.

Table S 3.7 - Trend Test for Fire Spots, Burnt Area, $MP_{2.5}$ and GPP by Biomes in the Integral Area of the Cerrado-Amazonia Transition: 2008-2020

Biomes	Fire Foci					Burned Area				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**YEAR**	**Mann-Kendall**	**Z**	**Pettitt**	**S**	**YEAR**
Amazonia	0,85	0,18	1,00	-4,00	_	0,85	0,18	1,00	4,00	_
Caatinga	**0,012	2,50	0,14	-42,00	2011	0,16	1,40	0,14	24,00	_
Cerrado	0,76	0,30	1,00	6,00	_	0,66	0,42	1,00	8,00	_
Pantanal	1,00	0,00	0,72	0,00	_	0,95	-0,06	0,72	-2,00	_
Biomes	**MP2.5**					**GPP**				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**YEAR**	**Mann-Kendall**	**Z**	**Pettitt**	**S**	**YEAR**
Amazonia	0,95	-0,06	1,00	-2,00	_	0,12	1,56	0,46	26,00	_
Caatinga	0,95	-0,06	0,46	-2,00	_	0,95	0,06	0,58	2,00	_
Cerrado	0,95	-0,06	1,00	-2,00	_	0,12	1,52	0,10	26,00	_
Pantanal	0,58	0,54	0,72	10,00	_	0,76	0,30	1,00	6,00	_

Kendall and Pettit's Mann Test Test on Fire Spots, Burned Area, Particulate Matter smaller than 2.5 µm ($MP_{2.5}$) and Gross Primary Production (GPP) by Biomes in the Cerrado-Amazon Transition. **: "p" value significant at 5%.

Table S 3.8 - Area, in km², of land use and land cover classes in the Amazon during the Cerrado-Amazon Transition between 2008 and 2020.

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	144,67	495487	3479,9	1183,85	126,084	11,9831	65863,3	290488
2009	143	490857	2662,96	931,508	143,551	6,08552	72360,1	294004
2010	116,265	483082	4512	1075,88	86,7859	4,61649	72566,1	289579
2011	79,3857	481596	4022,86	1056,82	81,889	5,00128	77224,1	285068
2012	62,7885	478904	4530,62	1179,1	75,9102	3,3832	75496,2	288745
2013	71,5581	477114	4122,22	996,73	63,9136	3,63362	79799,1	293346
2014	93,1135	475527	5011,36	916,635	70,2579	3,39318	79569,8	298649
2015	96,6645	470962	5764,63	891,956	64,3301	1,69739	76177,8	303368
2016	91,1419	461988	5858,13	778,981	78,0578	3,37402	75047,1	305558
2017	91,9087	462816	6062,29	775,24	47,2484	5,53443	70800,7	301735
2018	72,8296	460366	5945,26	685,329	82,4045	4,80209	71581,2	293577
2019	64,6303	459008	6232,61	761,978	75,5486	1,91762	72511,5	286959
2020	142,653	490857	2662,96	931,508	143,551	6,08552	72360,1	294004
Minimum	62,7885	459008	2662,96	685,329	47,2484	1,69739	65863,3	285068
Maximum	144,67	495487	6232,61	1183,85	143,551	11,9831	79799,1	305558
Mean	97,7124	476043	4682,14	935,809	87,6564	4,73135	73950,5	294237
Class	**GK**	**PW**	**CL**	**UBL**	**NVM**	**BN**	**WB**	
2008	130438	5310,61	9918,97	844,453	279,151	46,9058	4140,03	
2009	125943	5368,85	10033	844,453	266,059	41,047	4157,87	
2010	135870	5464	10141,8	844,701	237,46	42,043	4140,07	
2011	136057	5526,15	11777,7	845,439	245,727	40,6216	4136,3	
2012	135275	5378,19	12850,1	846,431	261,331	35,44	4119,94	
2013	127914	5352,31	13711,3	846,927	281,492	31,7046	4107,56	
2014	122660	5375,68	14565,5	847,421	329,803	29,735	4113,51	
2015	124056	5430,32	15614,6	847,669	350,979	27,5058	4109,48	
2016	131567	5497,83	15979,3	848,402	345,879	37,2897	4084,25	
2017	137365	5548,87	17204,2	849,147	345,492	45,3123	4071,46	
2018	146333	5749,59	18071,6	849,39	304,95	40,2322	4099,51	
2019	151155	5867,73	19892	849,39	240,366	35,492	4107,96	
2020	125943	5368,85	10033	844,453	266,059	41,047	4157,87	
Minimum	122660	5310,61	9918,97	844,453	237,46	27,5058	4071,46	
Maximum	151155	5867,73	19892	849,39	350,979	46,9058	4157,87	
Mean	133121	5479,92	13830,2	846,79	288,827	38,0289	4118,91	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 3.9 - Test of Trend in Land Use and Occupation (LULC) for the Amazon on the Cerrado-Amazonia Transition: 2008-2020

Class	**LULC**				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**Year**
ENF	0,22	-1,22	0,31	-21,00	_
EBF	**0,0009	-3,30	0,12	-55,00	2011
DBF	**0,0071	2,68	0,17	45,00	2012
MF	***0,0022	-3,05	0,03	-51,00	2012
CS	0,27	-1,10	0,31	-19,00	_
SO	0,22	-1,22	0,40	-21,00	_
WSV	0,80	-0,24	0,40	-5,00	_
SV	0,32	0,97	0,24	17,00	_
GL	0,39	0,85	0,52	15,00	_
PW	**0,037	2,07	0,31	35,00	2013
CL	**0,0006	3,42	0,12	57,00	2011
UBL	**0,0009	3,30	0,12	55,00	2011
NVM	0,39	0,85	0,23	15,00	_
BN	0,32	-0,97	0,31	-17,00	_
WB	**0,03	-2,07	0,17	-35,00	2011

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 4 - Area, in km², of land use and cover classes in the Cerrado over the Cerrado-Amazon Transition between 2008 and 2020.

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	12,5822	53221,6	5340,34	3437,43	527,935	759,845	114975	413144
2009	12	54950	4679,91	2329,05	327,301	487,44	117951	422742
2010	12,5505	53862,1	6909,98	3510,1	246,712	382,959	114319	415659
2011	13,7527	55307,3	6506,96	3352,99	214,25	308,273	114809	418152
2012	13,8445	54599,1	8686,01	3722,69	163,885	178,576	108741	434219
2013	15,5301	53195,5	8036,31	2957,39	144,439	89,0935	109529	442083
2014	20,3758	54217,4	8286,87	3018,63	150,653	111,582	109049	445758
2015	24,2072	52291,9	10339,9	3413,02	169,394	107,247	106269	439240
2016	19,6662	49053,9	10431,6	2863,42	199,684	110,479	102006	421759
2017	17,6921	50132,6	11693,7	2913,49	249,65	105,32	96855,8	419935
2018	16,9434	53367,3	10748,2	1678,47	291,705	83,748	93302,3	414317
2019	14,5247	54751,3	11261,5	1428,95	279,133	47,0512	92797,4	413236
2020	11,8423	54950	4679,91	2329,05	327,301	487,44	117951	422742
Minimum	11,8423	49053,9	4679,91	1428,95	144,439	47,0512	92797,4	413144
Maximum	24,2072	55307,3	11693,7	3722,69	527,935	759,845	117951	445758
Mean	15,7965	53376,9	8277,02	2842,67	253,234	250,696	107581	424845
Class	**GK**	**PW**	**CL**	**UBL**	**NVM**	**BN**	**WB**	
2008	229521	1415,09	31359,4	1054,04	821,768	1032,47	1296,49	
2009	216431	1477,34	32310	1054,04	830,532	1021,94	1314,91	
2010	225733	1515,48	31683,7	1054,53	727,296	1033,29	1268,61	
2011	219664	1583,67	33915,4	1055,27	740,526	1022,56	1272,91	
2012	205945	1632,24	35894,7	1055,51	755,653	1014,21	1296,43	
2013	199306	1666,12	36701,9	1055,75	768,997	996,84	1371,61	
2014	194215	1707,06	37094,5	1055,75	852,536	995,71	1384,87	
2015	202190	1681,77	37862,8	1056,24	878,32	1004,93	1388,56	
2016	227864	1661,1	37584,2	1056,24	899,899	1032,08	1377,33	
2017	231467	1642,3	38583,6	1056,48	839,037	1045,03	1381,97	
2018	239097	1687,23	39044,9	1056,48	801,482	1037,77	1387,27	
2019	238782	1649,31	39531,3	1056,48	664,647	1018,84	1400,03	
2020	216431	1477,34	32310	1054,04	830,532	1021,94	1314,91	
Minimum	194215	1415,09	31359,4	1054,04	664,647	995,71	1268,61	
Maximum	239097	1707,06	39531,3	1056,48	899,899	1045,03	1400,03	
Mean	218973	1599,7	35682,8	1055,45	800,863	1021,35	1342,76	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Tabela S 4.1 - Teste de Tendência no Uso e Ocupação do Solo (LULC) para o Cerrado sobre a Transição Cerrado-Amazônia: 2008-2020

Class	**LULC**				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**Year**
ENF	0,22	1,22	0,17	21,00	_
AME	0,71	-0,37	0,65	-7,00	_
DBF	0,010	2,56	0,24	43,00	2010
MF	**0,02	-2,32	0,09	-39,00	2014
CS	0,06	0,24	0,65	5,00	_
SO	0,0049	-2,81	0,12	-47,00	2011
WSV	0,00	-2,81	0,24	-47,00	2010
SV	1,00	0,00	0,80	1,00	_
GL	0,54	0,61	0,17	11,00	_
PW	0,08	1,71	0,12	29,00	_
CL	**0,00096	3,30	0,09	55,00	2011
UBL	0,003	2,93	0,17	49,00	2011
NVM	0,46	0,73	0,40	13,00	_
BN	1,00	0,00	0,65	-1,00	_
WB	**0,014	2,44	0,04	41,00	2011

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 4.2 - Area, in km², of land use and cover classes in the Pantanal over the Cerrado-Amazon Transition between 2008-2020

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	55,0615	6664,71	1783,08	278,296	0,71343	0,71358	6257,3	48001,6
2009	21	6689,76	1693,33	230,486	0,23772	0	6250,56	50712,3
2010	14,1991	6314,61	1885,52	323,974	0	0,23895	5890,6	50798,4
2011	19,3019	6643,59	1999,93	278,402	0,47587	0	5497,74	50947,5
2012	9,43236	6649,69	1992,61	270,68	0	0	5541,05	52723,7
2013	10,8511	6895,38	1937,22	231,617	0	0	5423,46	52979
2014	17,8575	8696,7	1814,56	96,0014	0	0	5565,01	50874,7
2015	30,4263	8170,01	1775,32	97,1635	0	0	5544,41	50351,9
2016	27,9364	7735,51	1755,41	68,1615	0	0	5738,47	49705,2
2017	21,2085	7853,27	1964,58	108,304	0	0,23867	5599,43	48453
2018	35,6882	8149,13	2069,08	128,683	0	0	5540,47	47120,1
2019	25,452	7612	2186,63	130,003	0	0	5742,89	47521,5
2020	20,7375	6689,76	1693,33	230,486	0,23772	0	6250,56	50712,3
Minimum	9,43236	6314,61	1693,33	68,1615	0	0	5423,46	47120,1
Maximum	55,0615	8696,7	2186,63	323,974	0,71343	0,71358	6257,3	52979
Mean	23,7607	7289,55	1888,51	190,174	0,12806	0,09163	5757,07	50069,3

Class	GK	PW	CL	UBL	NVM	BN	WB	
2008	9011,46	12276,2	2,46925	98,2736	0	0,71666	1687,01	
2009	7677,64	11061,9	2,94578	98,2736	0	0,23903	1679,18	
2010	7947,49	11177	2,3662	98,2736	0	0,23903	1664,64	
2011	7794,67	11172,4	3,00757	98,2736	0	0,23903	1662,01	
2012	6990,78	10179,4	3,90972	98,2736	0	0,23903	1657,8	
2013	6833,84	10044,5	3,01382	98,2736	0	0	1660,43	
2014	6905,5	10385,3	0,93724	98,2736	0	0	1662,78	
2015	7717,51	10649,3	3,8172	98,2736	0	0	1679,38	
2016	8624,69	10674,4	4,77159	98,2736	0	0	1684,65	
2017	9458,55	10868,5	6,75891	98,2736	0	0	1685,38	
2018	9489,88	11778,9	5,81364	98,2735	0	0	1701,5	
2019	9692,93	11396,1	8,37003	98,2735	0	0	1703,4	
2020	7677,64	11061,9	2,94578	98,2736	0	0,23903	1679,18	
Minimum	6833,84	10044,5	0,93724	98,2735	0	0	1657,8	
Maximum	9692,93	12276,2	8,37003	98,2736	0	0,71666	1703,4	
Mean	8140,2	10978,9	3,93282	98,2736	0	0,14706	1677,49	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 4.3 - Test of Trend in Land Use and Occupation (LULC) for the Pantanal on the Cerrado-Amazon Transition: 2008-2020

Class	LULC				
	Mann-Kendall	Z	Pettitt	S	Year
ENF	0,54	0,61	0,24	11,00	_
EBF	0,11	1,58	0,04	27,00	_
DBF	0,62	0,48	1,00	9,00	_
MF	0,11	-1,58	0,02	-27,00	_
CS	0,17	-1,35	0,40	-19,00	_
SO	0,18	-1,33	0,80	-17,00	_
WSV	0,90	-0,12	0,31	-3,00	_
SV	0,22	-1,22	0,12	-21,00	_
GL	0,32	0,97	0,23	17,00	_
PW	0,90	0,12	0,52	3,00	_
CL	**0,02	2,32	0,12	39,00	2013
UBL	0,90	0,12	0,36	3,00	_
NVM	<NA>	<NA>	<NA>	<NA>	_
BN	**0,026	-2,22	0,07	-33,00	2011
WB	0,14	1,46	0,12	25,00	_

Kendall and Pettit's Mann Test on: Evergreen Needleleaf Forests (ENF); Broad-leaved evergreen forests (AME); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed shrubs (CS); Open bushes (SO); Wooded savannas (WSV); Savannas (SV); Prairies (GL); Permanent Wetlands (PW), Cultivation Areas (CL); Urban and Built Lands (UBL); Agricultural land/natural vegetation mosaics (NVM); Arid (BN); Bodies of water (WB). **: "p" value significant at 5%. <NA>: classes not found in the study area.

Table S 4.4 - Area, in km², of land use and cover classes in the Caatinga over the Cerrado-Amazonia Transition between 2008 and 2020

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	0,49592	24,4852	1572,09	21,5131	7,15036	1,48569	652,239	8193,69
2009	0	37,7811	1976,84	20,2026	3,71602	1,23766	694,732	7897
2010	0	29,001	1493,11	31,3784	1,70841	0,61323	710,05	8252,37
2011	0	41,3666	1589,79	24,7039	0,46993	0,36519	866,236	8054,15
2012	0	31,1663	978,722	15,4755	0,49573	0,98965	469,627	8942,61
2013	0	19,5175	823,931	19,661	0,74296	0,74161	394,4	8981,21
2014	0	7,17786	743,89	27,6876	0,74322	0,96089	437,48	8779,34
2015	0	4,17559	773,955	23,4276	1,98215	1,98176	712,592	8240,89
2016	0	4,17535	773,315	12,9902	44,0516	2,52137	879,103	7745,72
2017	0	8,14122	1197,27	12,3224	19,9909	2,84318	868,712	7477,46
2018	0	14,8339	1312,22	8,37256	1,18448	3,13709	714,706	7681,03
2019	0	32,5489	1776,1	8,86861	0	3,13707	659,326	7634,91
2020	0	37,7811	1976,84	20,2026	3,71602	1,23766	694,732	7897
Minimum	0	4,17535	743,89	8,37256	0	0,36519	394,4	7477,46
Maximum	0,49592	41,3666	1976,84	31,3784	44,0516	3,13709	879,103	8981,21
Mean	0,03815	22,4732	1306,77	18,9851	6,61168	1,63477	673,38	8136,72

Class	GL	PW	CL	UBL	NVM	BN	WB	
2008	991,947	96,7079	70,8062	52,1568	15,7318	41,6092	56,8137	
2009	846,39	104,025	60,106	52,1568	6,69218	40,4783	57,5576	
2010	974,514	103,529	46,613	52,1568	4,9574	41,8568	57,0617	
2011	917,949	104,318	46,087	52,1568	3,7182	40,5444	57,0617	
2012	1063,65	101,343	40,458	52,1568	2,72669	42,9338	56,5659	
2013	1259,7	99,3686	43,2763	52,1568	4,73598	43,1524	56,3182	
2014	1490,93	96,7463	56,9946	52,1568	5,33095	43,1602	56,3182	
2015	1703,14	96,7157	74,3587	52,1568	11,2701	45,9492	56,3182	
2016	1985,58	98,7312	84,224	52,1568	12,9013	47,125	56,3182	
2017	1845,5	99,4749	99,7996	52,1568	14,0424	44,1482	57,0621	
2018	1703,54	100,559	92,0039	52,1568	12,8082	45,3045	57,0621	
2019	1344,02	106,509	74,5933	52,1568	5,69557	43,9845	57,062	
2020	846,39	104,025	60,106	52,1568	6,69218	40,4783	57,5576	
Minimum	846,39	96,7079	40,458	52,1568	2,72669	40,4783	56,3182	
Maximum	1985,58	106,509	99,7996	52,1568	15,7318	47,125	57,5576	
Mean	1305,64	100,927	65,3405	52,1568	8,25407	43,1327	56,8521	

Evergreen Needleleaf Forests (ENF); Broad-leaved evergreen forests (AME); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed shrubs (CS); Open bushes (SO); Wooded savannas (WSV); Savannas (SV); Prairies (GL); Permanent Wetlands (PW), Cultivation Areas (CL); Urban and Built Lands (UBL); Agricultural land/natural vegetation mosaics (NVM);Arid (BN); Bodies of water (WB).

Table S 4.5 - Test of Trend in Land Use and Occupation (LULC) for the Caatinga on the Cerrado-Amazon Transition: 2008-2020

Class	**LULC**				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**Year**
ENF	0,14	-1,46	1,00	-12,00	_
AME	0,54	-0,61	0,31	-11,00	_
DBF	0,90	-0,12	0,52	-3,00	_
MF	**0,03	-2,07	0,08	-35,00	2014
CS	1,00	0,00	1,00	1,00	_
SO	**0,03	2,07	0,04	35,00	2013
WSV	0,46	0,73	0,31	13,00	_
SV	0,11	-1,58	0,04	-27,00	_
GL	0,06	1,83	0,17	31,00	_
PW	0,62	0,48	0,80	9,00	_
CL	0,14	1,46	0,04	25,00	_
UBL	0,95	0,06	0,40	2,00	_
NVM	0,46	0,73	0,31	13,00	_
BN	0,05	1,95	0,17	33,00	_
WB	0,71	0,36	0,23	7,00	_

Kendall and Pettit's Mann Test on: Evergreen Needleleaf Forests (ENF); Broad-leaved evergreen forests (AME); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed shrubs (CS); Open bushes (SO); Wooded savannas (WSV); Savannas (SV); Prairies (GL); Permanent Wetlands (PW), Cultivation Areas (CL); Urban and Built Lands (UBL); Agricultural land/natural vegetation mosaics (NVM); Arid (BN); Bodies of water (WB). **: "p" value significant at 5%.

Table S 4.6 - Fire Spot Trend Test, $PM_{2.5}$ and GPP by Biomes in the Burned Area in the Cerrado-Amazon Transition: 2008-2020

Biomes	**Fire Foci**				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**YEAR**
Amazonia	0,85	0,18	1,00	4,00	_
Caatinga	0,76	0,30	1,00	6,00	_
Cerrado	0,58	0,54	1,00	10,00	_
Pantanal	1,00	0,00	0,72	0,00	_
Biomes	$PM_{2.5}$				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**YEAR**
Amazônia	0,76	0,30	1,00	6,00	_
Caatinga	0,14	-1,46	1,00	-12,00	_
Cerrado	0,16	1,40	0,36	24,00	_
Pantanal	0,85	0,18	0,46	4,00	_
Biomes	**GPP**				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**YEAR**
Amazônia	0,09	1,64	0,27	28,00	_
Caatinga	0,24	-1,15	0,27	-20,00	_
Cerrado	**0,0041	2,86	0,10	48,00	2013
Pantanal	0,29	1,03	27,00	18,00	_

Kendall and Pettit's Mann Test Test on Fire foci, Burned Area, Particulate Matter smaller than 2.5 µm ($PM_{2.5}$) and Gross Primary Production (GPP) by Biomes in the Cerrado-Amazon Transition. **: "p" value significant at 5%.

Table S 4.7 - Area, in km², of land use and cover classes over the Burned area in the Amazon contained in the Cerrado-Amazonia Transition: 2008-2020

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	0,24185	3823,77	646,557	296,695	19,9747	0	2019,49	9781,71
2009	0	1551,36	115,453	102,773	2,93182	0	1884,33	6876,23
2010	7,4935	17171,4	1894,14	493,541	8,45871	0	4722,48	21257,5
2011	3,869	2390,97	555,06	166,095	2,1868	0	1078,32	6024,14
2012	0,00058	4997,36	782,24	423,843	4,6638	0	2118,95	8150,72
2013	0	1537,59	217,13	156,745	1,95738	0	884,061	3781,17
2014	0	3290,51	642,379	112,715	2,95406	0,24493	1483,06	6797,76
2015	0	7364,25	826,783	335,986	2,95616	0	4143,71	12774,9
2016	0,7252	4108,48	897,23	189,265	2,94275	0	1001,58	5210,13
2017	0,48357	10368,9	844,255	413,295	4,18127	0,24538	3462,92	15214
2018	0	1355,36	230,401	33,4123	1,47798	0,24239	361,289	2140,48
2019	0	4671,69	852,839	273,081	3,66069	0,24015	1754,43	7639,57
2020	29,7475	12589,2	230,983	196,039	9,80007	0,96112	2256,72	7084
Minimum	0	1355,36	115,453	33,4123	1,47798	0	361,289	2140,48
Maximum	29,7475	17171,4	1894,14	493,541	19,9747	0,96112	4722,48	21257,5
Mean	3,27394	5786,22	671,958	245,653	5,24201	0,14877	2090,1	8671,71

Class	GK	PW	CL	UBL	NVM	BN	WB	
2008	6390,14	9,50475	526,412	1,70237	6,97227	1,23275	9,87725	
2009	3577,69	5,14019	618,701	0	2,16481	0,24646	7,49385	
2010	12219,8	25,1451	851,718	0,97202	2,66205	0,49322	6,42875	
2011	3731,64	34,9443	410,622	1,21061	6,85928	0,49316	5,94183	
2012	4699,64	11,7691	612,916	2,16313	1,9456	0,24733	4,21111	
2013	4360,15	6,12109	666,192	0,23969	0	0,49316	2,50046	
2014	4808,35	4,58255	534,542	0,99202	1,21514	0,24658	8,8894	
2015	6531,16	7,946	1207,01	1,22273	5,82536	2,71106	14,3573	
2016	6982,73	15,3181	1493,6	1,25769	1,94635	0,49315	9,91258	
2017	7397,62	36,5783	757,456	1,68972	1,92615	0,73946	10,1528	
2018	4777,69	2,9453	1246,9	0,2403	1,45732	0,49509	1,73218	
2019	6636,83	10,2541	1640,27	0,24792	7,79645	0,49316	3,71458	
2020	7323,77	45,6616	498,447	1,45325	1,77568	0,98828	9,51498	
Minimum	3577,69	2,9453	410,622	0	0	0,24646	1,73218	
Maximum	12219,8	45,6616	1640,27	2,16313	7,79645	2,71106	14,3573	
Mean	6110,56	16,6085	851,138	1,03011	3,2728	0,72099	7,2867	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 4.8 - Test of Trend in Land Use and Occupation (LULC) for the Amazon in the Burned Area on the Cerrado-Amazonia Transition: 2008-2020

Class	**LULC**				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**Year**
ENF	0,79	-0,25	1,00	-5,00	_
AME	0,42	0,79	1,00	14,00	_
DBF	0,58	0,54	1,00	10,00	_
MF	0,76	0,30	1,00	-6,00	_
CS	0,85	-0,18	1,00	-4,00	_
SO	**0,014	2,45	0,14	36,00	2015
WSV	0,66	-0,42	1,00	-8,00	_
SV	0,50	-0,67	1,00	-12,00	_
GL	0,07	1,76	0,36	30,00	_
PW	0,58	0,54	1,00	10,00	_
CL	0,10	1,64	0,27	28,00	_
UBL	0,66	0,42	1,00	8,00	_
NVM	0,29	-1,00	0,46	-18,00	_
BN	0,50	0,67	0,72	12,00	_
WB	0,85	0,18	1,00	-4,00	_

Kendall and Pettit's Mann Test on: Evergreen Needleleaf Forests (ENF); Broad-leaved evergreen forests (AME); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed shrubs (CS); Open bushes (SO); Wooded savannas (WSV); Savannas (SV); Prairies (GL); Permanent Wetlands (PW), Cultivation Areas (CL); Urban and Built Lands (UBL); Agricultural land/natural vegetation mosaics (NVM); Arid (BN); Bodies of water (WB). **: "p" value significant at 5%.

Table S 4.9 - Area, in km², of land use and land cover classes over the burned area in the Cerrado contained in the Cerrado-Amazon Transition: 2008-2020

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	0	378,3222	865,5269	474,4513	17,48622	33,45807	1704,504	32693,19
2009	0	47,99739	65,19346	125,6024	5,896834	1,452574	802,3993	10777,84
2010	0,242345	4042,599	2317,165	1350,171	40,97871	44,39547	12190,33	91895,19
2011	0	399,4368	863,1439	442,4987	4,131928	4,837752	1421,154	26487,42
2012	0,241969	2298,031	2177,181	700,1832	3,170019	18,7137	11590,39	61586,17
2013	0,242404	376,8785	719,563	373,9011	2,671443	3,670882	2009,84	24365,35
2014	0	699,9838	1305,087	503,5965	3,663888	6,354238	4267,007	40370,72
2015	0,240354	1240,524	1619,1	497,1138	2,691971	5,367391	7692,123	41870,42
2016	0	1133,769	1704,546	492,4723	4,617679	8,299428	6347,186	40488,71
2017	0,484694	1816,705	2447,935	661,9157	7,860465	5,130365	7406,644	54928,76
2018	0	109,6329	1037,938	207,0804	2,217189	1,949871	2132,064	18670,71
2019	0,483906	1125,115	1476,231	271,2826	3,624662	0,732573	3185,572	41802,04
2020	0	2624,296	837,3799	376,4489	32,38693	52,00273	5542,938	41766,41
Minimum	0	47,99739	65,19346	125,6024	2,217189	0,732573	802,3993	10777,84
Maximum	0,484694	4042,599	2447,935	1350,171	40,97871	52,00273	12190,33	91895,19
Mean	0,148898	1253,33	1341,23	498,2091	10,10753	14,33577	5099,396	40592,53

Class	GK	PW	CL	UBL	NVM	BN	WB
2008	17059,58	7,552771	1208,801	1,688761	21,43405	1,223985	0,247688
2009	9899,953	2,697506	1836,69	0,487085	4,78741	0,980766	2,464768
2010	43716,98	22,66492	2026,011	4,362462	28,04831	1,953734	0,495148
2011	15588,59	6,100906	1431,183	0,487454	6,229362	0,491338	1,238451
2012	26718,99	13,67778	1634,672	3,435316	6,480587	1,229104	0,991766
2013	14946,12	8,312584	1614,857	1,445406	6,707562	0,9806	0,245662
2014	19871,82	11,96114	1192,465	1,925987	11,4786	1,473751	0,490874
2015	20922,73	13,13295	1567,116	0,47929	18,65603	1,716759	1,232404
2016	21135,93	11,50534	1845,069	2,181486	11,54876	1,22672	0,742592
2017	22410,72	25,60189	1720,698	0,49509	2,169574	1,964405	2,229821
2018	9694,48	2,44655	2029,851	0,239932	2,409412	0,49122	1,731443
2019	19654,18	17,02971	2412,045	3,379829	7,895994	2,211221	1,729446
2020	21503,38	12,17016	1392,897	0,727019	15,98211	1,229557	1,9671
Minimum	9694,48	2,44655	1192,465	0,239932	2,169574	0,49122	0,245662
Maximum	43716,98	25,60189	2412,045	4,362462	28,04831	2,211221	2,464768
Mean	20240,27	11,91186	1685,566	1,641163	11,06367	1,321012	1,215936

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 5 - Test of Trend in Land Use and Occupation (LULC) for Cerrado in the Burnt Area on the Cerrado-Amazon Transition: 2008-2020

Class	LULC				
	Mann-Kendall	Z	Pettitt	S	Year
ENF	0,59	0,53	1,00	9,00	_
AME	0,36	0,91	0,87	16,00	_
DBF	0,66	0,42	1,00	8,00	_
MF	0,50	-0,67	0,58	-12,00	_
CS	0,42	0,79	0,46	-14,00	_
SO	0,50	-0,67	1,00	-12,00	_
WSV	0,50	0,67	0,72	12,00	_
SV	0,66	0,42	1,00	8,00	_
GL	0,66	0,42	1,00	8,00	_
PW	0,36	0,91	1,00	16,00	_
CL	0,36	0,91	0,58	16,00	_
UBL	0,66	-0,42	1,00	-8,00	_
NVM	0,95	-0,06	1,00	-2,00	_
BN	0,29	1,03	0,72	18,00	_
WB	0,16	1,40	0,27	24,00	_

Kendall and Pettit's Mann Test on: Evergreen Needleleaf Forests (ENF); Broad-leaved evergreen forests (AME); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed shrubs (CS); Open bushes (SO); Wooded savannas (WSV); Savannas (SV); Prairies (GL); Permanent Wetlands (PW), Cultivation Areas (CL); Urban and Built Lands (UBL); Agricultural land/natural vegetation mosaics (NVM); Arid (BN); Bodies of water (WB). **: "p" value significant at 5%.

Table S 5.1 - Area, in km², of land use and cover classes over the burned area in the Caatinga contained in the Cerrado-Amazonia Transition: 2008-2020

Class	**ENF**	**AME**	**DBF**	**MF**	**CS**	**SO**	**WSV**	**SV**
2008	0	0	5,699181	0	0,743317	0	3,368885	16,70883
2009	0	0	0,24789	0	0	0	1,746859	14,51416
2010	0	0	15,36549	0	0	0	3,966077	14,05687
2011	0	0,247872	1,486213	0	0	0	0	4,439677
2012	0	0	4,215164	0	0	0	3,470829	64,19881
2013	0	0	0	0	0	0	0	0,247975
2014	0	0	0	0	0	0	0,991652	17,24817
2015	0	0	0,743755	0	0	0	0,743653	13,14208
2016	0	0	8,180402	0	0	0	7,927052	55,53541
2017	0	0	5,203091	0	0	0	4,268539	16,12435
2018	0	0	0,247968	0	0	0	0,247974	59,75833
2019	0	0	3,726496	0	0	0	1,23983	27,47442
2020	0	0	9,40308	0	0,247769	0	2,712003	30,92357
Minimum	0	0	0	0	0	0	0	0,247975
Maximum	0	0,247872	15,36549	0	0,743317	0	7,927052	64,19881
Mean	0	0,019067	4,193749	0	0,076237	0	2,360258	25,72097

Class	**GK**	**PW**	**CL**	**UBL**	**NVM**	**BN**	**WB**	
2008	0,743533	0,495911	0	0	0	0	0	
2009	0	0	0	0	0,991345	0	0	
2010	0,24775	0	0	0	0	0	0	
2011	0,496041	0	0,248015	0	0	0	0,495911	
2012	0,247905	0	0	0	0,247836	0	0	
2013	0,495953	0	0	0	0	0	0	
2014	0,991917	0	0	0	0	0	0	
2015	1,487992	0	0	0	0	0	0	
2016	2,231545	0,991923	0	0	0	0	0	
2017	9,42207	0	0	0	0	0	0	
2018	2,7259	0	0	0	0	0	0	
2019	2,338883	0	1,240099	0	0	0	0	
2020	1,487295	0	0	0	0	0	0	
Minimum	0	0	0	0	0	0	0	
Maximum	9,42207	0,991923	1,240099	0	0,991345	0	0,495911	
Mean	1,76283	0,114449	0,11447	0	0,095322	0	0,038147	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 5.2 - Test of Trend in Land Use and Occupation (LULC) for the Caatinga biome in the Burnt Area on the Cerrado-Amazon Transition: 2008-2020

Class	**LULC**				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**Year**
ENF	<NA>	<NA>	<NA>	<NA>	_
AME	0,50	-0,66	1,00	-6,00	_
DBF	0,80	0,24	1,00	5,00	_
MF	<NA>	<NA>	<NA>	<NA>	_
CS	1,00	0,00	1,00	*1	_
SO	<NA>	<NA>	<NA>	<NA>	_
WSV	1,00	0,00	1,00	1,00	_
SV	0,24	1,15	0,36	20,00	_
GL	*0,0041	2,86	0,02	48,00	2012
PW	0,55	-0,58	1,00	-7,00	_
CL	0,69	0,39	1,00	5,00	_
UBL	<NA>	<NA>	<NA>	<NA>	_
NVM	0,16	-1,37	1,00	-15,00	_
BN	<NA>	<NA>	<NA>	<NA>	_
WB	0,50	-0,66	1,00	-6,00	_

Kendall and Pettit's Mann Test on: Evergreen Needleleaf Forests (ENF); Broad-leaved evergreen forests (AME); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed shrubs (CS); Open bushes (SO); Wooded savannas (WSV); Savannas (SV); Prairies (GL); Permanent Wetlands (PW), Cultivation Areas (CL); Urban and Built Lands (UBL); Agricultural land/natural vegetation mosaics (NVM); Arid (BN); Bodies of water (WB). **: "p" value significant at 5%. <NA>: classes not found in the study area.

Table S 5.3 - Area, in km^2, of land use and cover classes over the burned area in the Pantanal contained in the Cerrado-Amazonia Transition: 2008-2020

Class	ENF	AME	DBF	MF	CS	SO	WSV	SV
2008	0	84,8466	80,05965	25,47154	0	0	362,8747	3484,17
2009	3,060336	122,1938	26,18262	0,473332	0	0	63,97983	2671,127
2010	0	372,0143	80,05563	64,50551	0	0	802,0393	6253,402
2011	1,651625	172,7807	90,42048	24,47208	0,237932	0	203,5973	2740,232
2012	1,648695	119,8428	85,95508	16,88469	0	0	199,2505	4168,267
2013	0	66,9059	29,46145	8,034396	0	0	278,607	2016,628
2014	0	8,293506	3,067551	0,00629	0	0	20,9296	604,8254
2015	0,235443	55,786	79,04142	2,858895	0	0	168,4378	1777,248
2016	0,234955	10,18868	13,47796	0,236563	0	0	100,697	2319,62
2017	0,235381	178,3069	23,0368	9,287121	0	0	405,6937	3974,888
2018	0	17,37913	5,48661	1,189133	0	0	51,84292	731,2883
2019	1,882924	204,0742	35,06846	5,930896	0	0	330,9232	4209,65
2020	12,77101	4022,316	684,3664	120,3777	0	0	3939,466	15118,11
Minimum	0	8,293506	3,067551	0,00629	0	0	20,9296	604,8254
Maximum	12,77101	4022,316	684,3664	120,3777	0,237932	0	3939,466	15118,11
Mean	1,670797	418,0714	95,05232	21,51755	0,018302	0	532,9491	3851,497

Class	GK	PW	CL	UBL	NVM	BN	WB	
2008	780,8221	360,4981	0	0,948426	0	0	8,71111	
2009	178,1108	355,9924	0	0	0	0	23,51545	
2010	912,3216	785,1154	0	0,237072	0	0	38,28656	
2011	205,5331	776,985	0	0	0	0	24,42207	
2012	548,9492	326,6388	0	0	0	0	37,43189	
2013	234,1525	267,8085	0	0	0	0	6,616357	
2014	87,02539	36,15148	0	0	0	0	7,812949	
2015	360,2677	95,66367	2,148565	0	0	0	1,654921	
2016	121,1898	17,69289	1,193656	1,185481	0	0	0,939929	
2017	211,8366	106,0879	0	0,47312	0	0	2,985076	
2018	136,0353	14,64795	0,954886	0,236563	0	0	0,944163	
2019	722,6691	528,9002	2,149186	0	0	0	22,32601	
2020	1384,316	3372,117	0	7,372003	0	0	353,653	
Minimum	87,02539	14,64795	0	0	0	0	0,939929	
Maximum	1384,316	3372,117	2,149186	7,372003	0	0	353,653	
Mean	452,5561	541,8692	0,495869	0,804051	0	0	40,71535	

Cerrado-Amazon Transition Area with its respective biomes and Land Use and Land Cover Classes according to the MCD12Q1 product version 06. Evergreen Needleleaf Forests (ENF); Evergreen Broadleaf Forests (EBF); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed Shrubs (CS); Open Shrublands (OS); Wooded Savannahs (WSV); Savannahs (SV); Grasslands (GL); Permanent Wetlands (PW), Croplands (CL); Urban and Built-up Soils (UBL); Farmland/Natural Vegetation Mosaics (NVM); Barren (BN); Bodies of Water (WB) (FRIEDL; SULLA-MENASHE, 2019).

Table S 5.4 - Test of Trend in Land Use and Occupation (LULC) for the Pantanal biome in the Burnt Area on the Cerrado-Amazon Transition: 2008-2020

Class	**LULC**				
	Mann-Kendall	**Z**	**Pettitt**	**S**	**Year**
ENF	0,48	0,69	0,72	12,00	_
AME	0,95	0,06	0,72	2,00	_
DBF	0,50	-0,67	0,46	-12,00	_
MF	0,50	-0,67	0,72	-12,00	_
CS	0,50	0,66	1,00	-6,00	_
SO	<NA>	<NA>	<NA>	<NA>	_
WSV	0,95	0,06	1,00	2,00	_
SV	0,95	0,06	0,72	2,00	_
GL	1,00	0,00	0,87	0,00	_
PW	0,24	-1,15	0,46	-20,00	_
CL	0,08	1,73	0,27	24,00	_
UBL	0,50	0,66	0,46	11,00	_
NVM	<NA>	<NA>	<NA>	<NA>	_
BN	<NA>	<NA>	<NA>	<NA>	_
WB	0,36	-0,91	0,27	-16,00	_

Kendall and Pettit's Mann Test on: Evergreen Needleleaf Forests (ENF); Broad-leaved evergreen forests (AME); Deciduous Broadleaf Forests (DBF); Mixed Forests (MF); Closed shrubs (CS); Open bushes (SO); Wooded savannas (WSV); Savannas (SV); Prairies (GL); Permanent Wetlands (PW), Cultivation Areas (CL); Urban and Built Lands (UBL); Agricultural land/natural vegetation mosaics (NVM); Arid (BN); Bodies of water (WB). **: "p" value significant at 5%. <NA>: classes not found in the study area.