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Do indigenous territories sustain the standing Amazon forest? The case of the Sete de Setembro Indigenous Land?

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A B S T R A C T

This work presents a spatiotemporal analysis of deforestation and vegetation fires in the Sete de Setembro Indigenous Land (SSIL), located between the states of Rondônia and Mato Grosso, a region known as "Arc of Deforestation" in the Brazilian Legal Amazon. The distribution of the occurrence of fires and deforestation in the SSIL and its surroundings were evaluated, considering five buffer zones in relation to its perimeter: 1) Core: the innermost area of the SSIL; 2) internal buffer 0 to 5 km; 3) internal buffer 5 – 10km; 4) external buffer 0 to 5 km; 5) external buffer 5 to 10 km. For the spatio-temporal analysis of forest fires, we considered the reference satellite data from 2000 to 2020 available at Queimadas Program. PRODES data were analyzed to quantify deforestation, considering the clear cut from 2008 onwards. Vegetation fires on SSLI occur predominantly on the borders and presented a considerable reduction since 2004, when the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAm) was created. Less than 1% of SSLI has been clear cut since 2008; however, considering the Legal Amazon, there is a trend towards an increase in forest removal since 2018. This increase is mainly associated with cattle in the municipalities where SSLI is located. SSIL has been efficient in holding deforestation and fires in its interior, although it is exposed and vulnerable to anthropization in its surroundings, mainly resulting from the dense network of highways and roads in that region.

Keywords: deforestation, forest fires, conservation, rainforest.

As terras indígenas sustentam a floresta amazônica em pé? O caso da TI Sete de Setembro

R E S U M O

Este trabalho apresenta uma análise espaço-temporal do desmatamento e das queimadas na Terra Indígena Sete de Setembro (TISS), localizada entre os estados de Rondônia e Mato Grosso, região conhecida como "Arco do Desmatamento" na Amazônia Legal Brasileira. Foi avaliada a distribuição da ocorrência de queimadas e desmatamento na TISS e seu entorno, considerando cinco zonas de amortecimento em relação ao seu perímetro: 1) Núcleo: a área mais interna da TISS; 2) buffer interno de 0 a 5 km; 3) buffer interno 5 – 10km; 4) buffer externo de 0 a 5 km; 5) buffer externo de 5 a 10 km. Para a análise espaço-temporal dos incêndios florestais, foram considerados os dados do satélite de referência de 2000 a 2020 disponíveis no Programa Queimadas. Os dados do PRODES foram analisados para quantificar o desmatamento, considerando o corte raso a partir de 2008. As queimadas na TISS ocorrem predominantemente nas fronteiras e apresentaram uma redução considerável desde 2004, quando foi criado o Plano de Ação para Prevenção e Controle do Desmatamento na Amazônia Legal (PPCDAm). Menos de 1% da TISS foi desmatado desde 2008; no entanto, considerando a Amazônia Legal, há uma tendência de aumento da remoção florestal desde 2018. Esse aumento está associado principalmente ao gado nos municípios onde a TISS está localizada. A TISS tem se mostrado eficiente na contenção de desmatamentos e queimadas em seu interior, embora esteja exposta e vulnerável à antropização em seu entorno, decorrente principalmente da densa rede de rodovias e estradas naquela região.

Palavras-chave: desmatamento, queimadas, conservação, floresta tropical.

Introduction

The Brazilian protected areas, which include, among other categories, Indigenous Lands (ILs) aim to promote environmental protection and recovery with the sustainable use of natural resources by indigenous peoples. ILs belong to the Union, although they are intended for possession

and occupation by indigenous peoples (ISA, 2021a; Brazil, 2021a; Brazil, 2021b). ILs cover 24% of the Brazilian Amazon biome, are essential strategies to contain deforestation, act as protection of traditional peoples and biodiversity, carbon stocks and offer ecosystem services. Traditional culture and way of life are dependent on forest resources and this is an incentive for indigenous people to keep the forest standing (Ferrante and Fearnside, 2020; Paiva et al., 2020; Jaffé et al., 2021; Reis et al, 2021).

According to FUNAI (Brazilian National Indian Foundation, 2021), in the 2010 census, more than half of the Brazilian indigenous population, approximately 514,564 indigenous, lived in the north and northeast region, where part of the Amazon is located, and their lands are threatened by deforestation. The demarcation of ILs started before 1988 when the Brazilian Federal Constitution entered into force, but the conservation of these demarcated areas and the rights of indigenous peoples were marked with Federal Decree No. 7,747/2012 which institutes the Brazilian Policy for Territorial and Environmental Management of Indigenous Lands (PNGATI), which in turn provides guidance on ensuring ethnic and cultural and ecosystem protection in Indigenous Lands (Silva and Pureza, 2019; Brazil, 2012).

The Sete de Setembro Indigenous Land (SSIL) is located in the Brazilian Amazon, between the states of Rondônia and Mato Grosso (Figure 1), occupying an area of 248,000 hectares, without overlapping with Conservation Units or other protected areas. Although SSIL was demarcated in 1976, its ratification took place only seven years later, by Decree n. 88,867/1983. With the arrival of immigrants in the state of Rondônia in the 1960s, part of the original territory was lost; indigenous families began to dedicate themselves to coffee growing, illegal logging, raising cattle and leasing land to sharecroppers. In the early 1980s, the creation of the Northwest Region Integrated Development Program (POLONOROESTE), for paving the BR-364, boosted the predatory exploitation of wood (ISA, 2021).

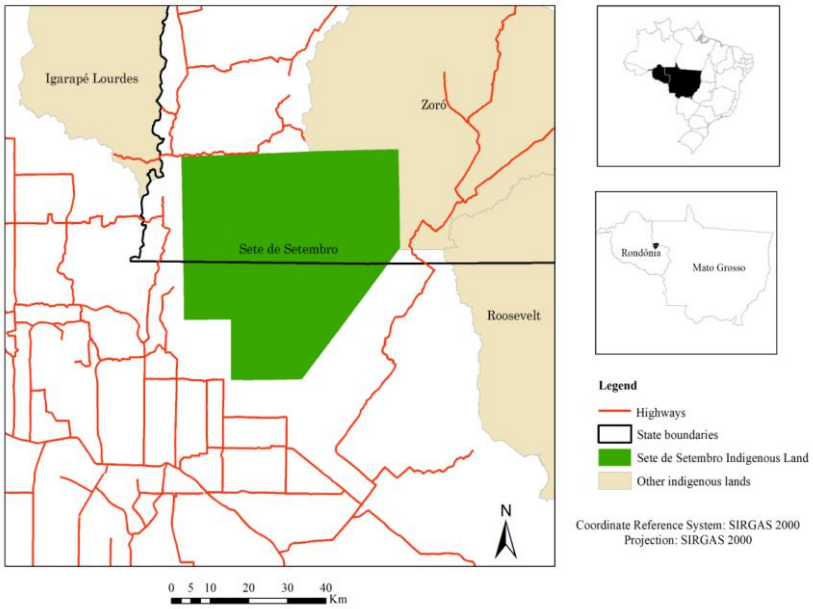

Figure 1. Location of the Sete de Setembro Indigenous Land.

The expansion of the agricultural frontier in Brazil, the migration of the workforce from the center south of the country and the increase in population density in the inner Amazon resulted in the invasion of the Paiter Suruí territory. This pressure for land implied in agrarian, ethnic, cultural and economic conflicts and in a precarious process of urbanization of the Paiter Suruí people. In the late 1960s, the Surui's involvement in the illegal timber trade was followed by a significant change in land cover with the conversion of forest to pastures and commercial agriculture. Forty years later, the indigenous people understood how the new way of life harmed their culture and the maintenance of forest resources necessary for their subsistence. The Pamine Project for reforestation of the IT was then conceived, and implemented in 2003 in line with PNGATI (Barbosa et al., 2017;

Barbosa et al., 2021). In 1987, Fearnside (1987) already showed that economic development projects and the establishment of highways stimulate population migration and accelerate deforestation in the Brazilian Amazon by the example of POLONOROESTE. The author found that deforested areas were often converted to cattle pasture to secure land claims at minimal cost; projects of this nature follow a pattern that lead to a strong impact on the region's natural ecosystems.

In 2009, the REDD+ project was implemented and contributed to a sharp reduction in deforestation during the first five years. However, the project was discontinued in 2018 as some community leaders were colluding with deforestation and illegal use of the territory by loggers and miners. The indigenous people also complained about the amount received, the regularity of payment for the carbon credit and the lack of autonomy and use of traditional activities (Silvestre et al., 2022).

The Surui coordinated the first deforestation and forest degradation mapping project managed by an indigenous community. It is a cooperation indigenous leadership has partnered with Google in 2009 to create an online map of their cultural heritage and monitor illegal logging and carbon stocks using smartphones (Fabri and Floriani, 2020; Google, 2022).

Deforestation and forest fires are one of the greatest threats to the Amazon biome (Silva Junior, et al., 2018). Carvalho et al. (2016) estimated that deforestation contributed only 0.14% to the growth of the Brazilian gross domestic product, in the years 2006 to 2011, adding in reais 75.3 thousand per km² and 5.9 billion nationally, which did not it is effective to the economy to the point of suppressing the negative effects caused by the degradation of the biome. In addition, when the internalization of the national value is observed, 55% would be destined for the Amazon itself, and the remainder would be distributed throughout the country. Thus, although exploration indicates development for the Amazon region, exploration does not significantly affect the rest of the country in a positive way.

Indigenous peoples are subject to violence instigated by the federal government's support for the agribusiness sector in the Amazon region and by the weakening of environmental control and interruption of the demarcation of indigenous territories. The economic pressure on the Brazilian Amazon rainforest intensified after the victory of the extreme right in the 2018 elections; the government then adopted authoritarian strategies to modernize the country, resulting in social and environmental devastation for indigenous communities. The government has defined a legislative agenda that weakens indigenous peoples, including the direct participation of the Armed Forces. The main changes in indigenous legislation refer to the discontinuation of the demarcation of new ILs and the revision of the limits of the existing ones, which result in the reduction of protected areas and impacts on traditional communities. Even the coordination of FUNAI, which is the agency responsible for protecting indigenous people in Brazil, has persecuted indigenous leaders and organizations. IL's are susceptible to invasion by land grabbers who manage to consolidate land ownership, which has been facilitated by the controversial reduction in the number of infractions and embargoes and the increase in deforestation/degradation alerts. Maneuvers by the Ruralist Bench in the National Congress are common practice to circumvent legislation and allow land grabbers to take over and also issue land titles that overlap potential claims to indigenous lands. This is in complete disagreement with other federal and state conservation, human rights and development policies, especially since the allocation of public lands must give priority to the creation of new conservation units and the granting of land rights to indigenous peoples and traditional communities (Brito et al., 2019; Pelicice and Castello, 2020; Conceição et al., 2021; Ferrante and Fearnside, 2021; Urzedo and Chatterjee, 2021).

In August 2019, farmers in the state of Pará organized the "Fire Day" when they would set fire to the forest to clear it and introduce livestock. The fires also occurred in other states of the Legal Amazon: Acre, Amapá, Amazonas, Rondônia, Roraima, Maranhão, Mato Grosso and Tocantins. The abrupt increase in the number of fires caused international commotion and concern on the part of leaders of countries such as Norway and Germany, main donors to the Amazon Fund, who announced the suspension of transfers of around €64 million. At the time, the Ministry of the Environment proposed the allocation of resources to indemnify landowners.[1]

[1] Fim do Fundo Amazônia pode afetar fiscalização do Ibama contra o desmatamento. Available in <https://g1.globo.com/natureza/noticia/2019/08/16/fim-do-fundo-amazonia-pode-afetar-fiscalizacao-do-

This work aims to present a spatiotemporal analysis of deforestation and fires in the Sete de Setembro Indigenous Land (SSIL), located between the states of Rondônia and Mato Grosso, a region known as the "Arc of Deforestation" in the Brazilian Legal Amazon, and to assess the importance of this protected area in holding deforestation. We assume that human disturbances such as deforestation and fires are less frequent in the inner parts of the IT than in its edges and surrounding area

Methods

The distribution of the occurrence of fires and deforestation in the SSIL and its surroundings was evaluated, considering 5 buffer zones in relation to its perimeter: 1) Core: the innermost area of the SSIL and which is more than 10 km from the limit towards its interior; 2) internal buffer 0 to 5 km (internal edge of SSIL), adjacent to the SSIL boundary; 3) internal buffer 5 – 10km: range between 5 to 10 km from the SSIL boundary towards its interior; 4) external buffer 0 to 5 km, comprising the external lane that skirts the SSIL; 5) external buffer 5 to 10 km, comprising the range 5 to 10 km from the SSIL boundary (Figure 2).

For the spatio-temporal analysis of forest fires, we considered the reference satellite (NOAA-12 until July 3, 2002 and AQUA_M-T from this date) from 2000 to 2020, published by Queimadas Program run by Brazilian National Institute for Space Research (INPE, 2021a). Daily fires data detected by the reference satellite have been used to compose the time series over the years.

To quantify deforestation, data from PRODES – Amazônia (INPE, 2021b) were analyzed, considering the clear cut from 2008 onwards. PRODES is organized by the Landsat grid; therefore, deforestation polygons identified in the path/rows 230/67, 230/68, 213/67 and 23/68 were analysed. The system currently uses imagery from LANDSAT 8/OLI, CBERS 4 and IRS-2; however, regardless of the satellite, only deforested areas of at least 6.25 hectares and that present clear cut are counted, that is, where all forest cover is removed. Selective cutting, characteristic of sustainable extractive activity, is not identified by the PRODES system (INPE, 2008).

In ArcGIS 10.5 software, runing the Identity tool, PRODES data and SSIL buffers were combined to create a new data that identifies in its attributes table in which buffer zone the deforestation polygons are located; the same procedure was done for the fire points data (Figure 3). The area of the deforestation polygons was recalculated considering the SIRGAS 2000 UTM Zone 20 S projection system..

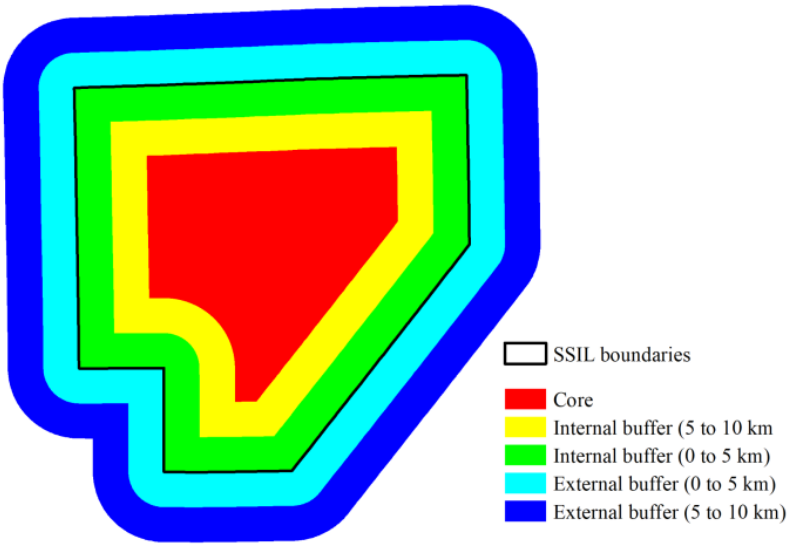

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Figure 2. Internal and external buffer zones.

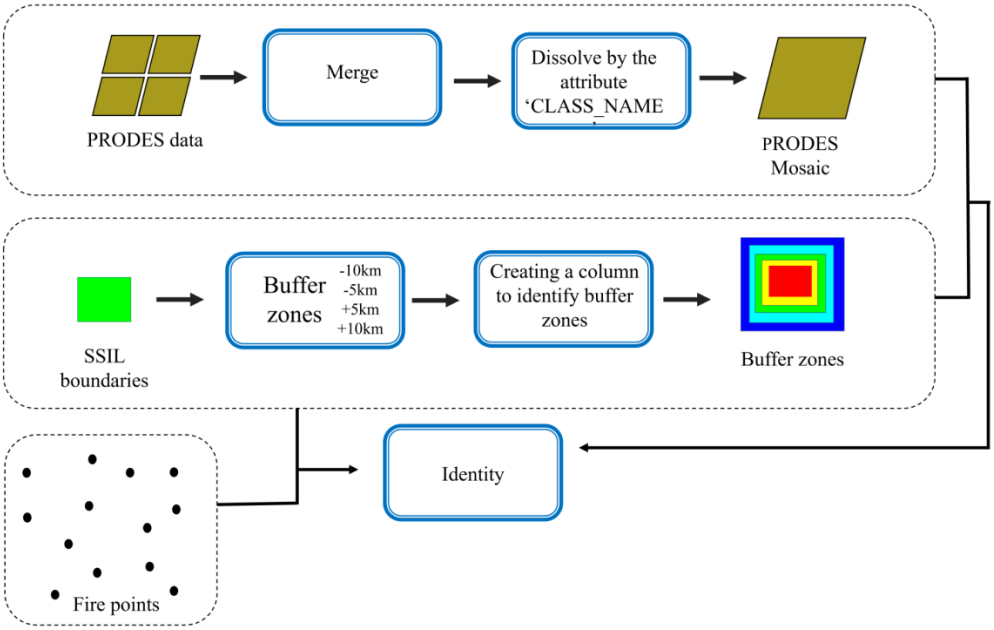

Figure 3. Internal and external buffer zones.

Results

In the entire period of analysis, 98.2% of the fire points inside the SSIL occurred in the external buffer strip adjacent to its perimeter (up to 5 km from the SSIL boundaries). This percentage can indicate two situations: 1) fires initiated on private properties adjacent to the SSIL that spread and entered the indigenous land; 2) vulnerability to logging by initiatives outside the Suruí population of Rondônia. Even though a broader spatial context is considered, that is, including up to the 10 km external buffer, the edges presented 19% of the fire occurrences throughout the analysis period (Table 1).

The extents of the buffer zones are not equal and, therefore, it is important to present the occurrence of fire points in these zones in terms of fire points density (number of fire points per thousands of square kilometers). Considering the fire points density, in 2016, fires was three times greater on the inner edge of the SSIL in relation to its neighborhood (buffer zone up to 5 km from the edge of the SSIL); from then onwards, the fire points density on the inner edge continued to be higher than the vicinity of the SSIL. This means that the inner edge of the indigenous land is as susceptible to fire as the private land surrounding it. As of 2008, fires around the SSIL began to decrease, with a tendency to increase in the interior of the indigenous land (Figure 4).

The period of fire reduction in the study area (considering the entire SSIL and extending up to 10 km from its edge to the outside) coincides with the creation of the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (PPCDAM), whose first phase occurred from 2004 to 2008. This plan consisted of corrective measures such as land and territorial ordering that created Conservation Units, prohibition of land grabbing on public lands, demarcation and approval of Indigenous Lands and promotion of the sustainable management of forest resources (Mello and Artaxo, 2017).

From 2008 the increase in deforestation in SSIL (Figure 5) ranged from 56 ha (2010) to 430 ha (2017). Considering the broader spatial context (Figure 4), up to a distance of 10 km from the perimeter of the SSIL, there were two peaks of deforestation: 1) In 2012, which coincides with the enactment of the Native Vegetation Protection Law (LPVN, Law 12.651/2012); and 2) 2018, right after a period of sharp growth in the number of heads of cattle in in the municipality of Cacoal, state of Rondonia, a large producer of cattle (56th position among Brazilian municipalities) (IBGE, 2021). Cacoal is located in the southwestern portion of the SSIL which is surrounded by private properties (SICAR, 2021) and by roads and highways, including BR-364 (Cuiabá-Porto Velho) (DNIT, 2021).

Resolution 3,545/2008 of the Brazilian Central Bank establishes the requirements of documentation proving environmental regularity for agricultural financing in the Amazon Biome. Assunção et al. (2019) concluded that this resolution contributed to the containment of deforestation, especially in municipalities where livestock is the main economic activity. This is the case when the farmer prefers to intensify production instead of extending it to new areas.

Table 1. Absolute number and density of fire points in the buffer zones.

BUFFER ZONE	FIRE POINTS IN THE PERIOD (2000 -2020)	% OF FIRE POINTS IN THE SSIL	% OF FIRE POINTS IN THE STUDY AREA	BUFFER ZONE AREA (KM^2)	DENSITY OF FIRE POINTS (Nº OF POINTS PER 10^3KM)
Core	3	0.4%	0%	1,245	2
Internal (5 to 10 km)	9	1.3%	0%	1,099	8
Internal (0 to 5 km)	659	98.2%	19%	925	713
Total fire points in the SSIL	671			3,269	205
External (0 to 5 km)	1,429		42%	723	1,977
External (5 to 10 km)	1,326		39%	843	1,573
Total fire points in the study area	3,426			4,835	709

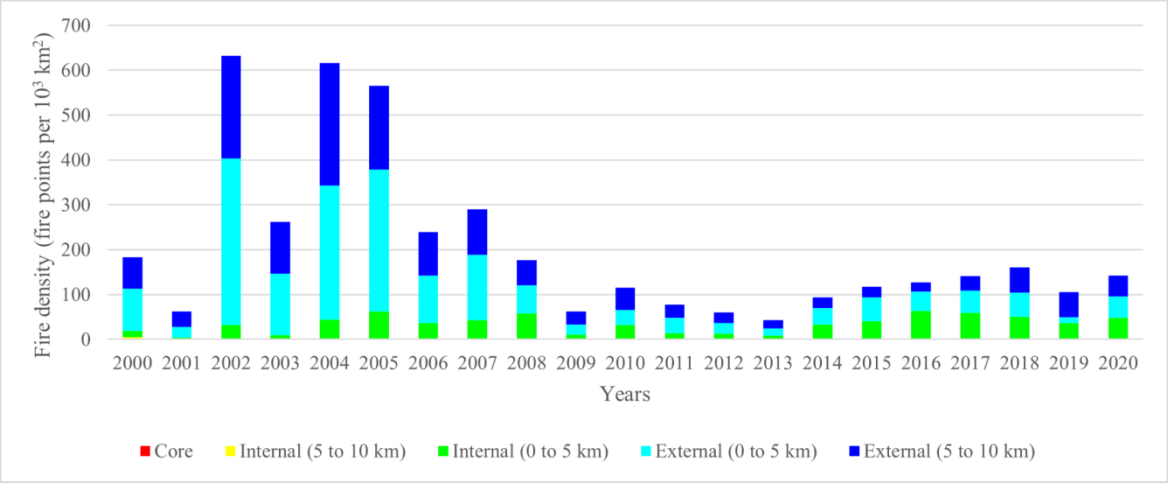

Figure 4. Vegetation fire density in the SSIL from 2000 to 2020.

Mining is a deforestation driver and causes serious damages to the environment,, such as water and soil pollution, and also results in migration and demographic growth in the mining region, threatening the integrity of indigenous societies (Villén-Pérez et al., 2020). Inside SSIL there are no mining processes; however, between 2000 and 2020 the National Mining Agency (ANM, 2021) registered 26 processes located in the vicinity of the indigenous land with extensions ranging from 0.02 to more than 9,000 hectares for industrial use or civil construction, which exposes indigenous peoples to rural violence, contamination by toxic pollutants and contagious diseases (Rorato et al., 2020).

Bill 191/2020, pending in the House of Representatives, establishes conditions for agrobusiness and mining activities in indigenous lands (Ferrante and Fernside, 2020). It amends previous laws dealing with economic activities and regulates mining, the generation of electricity and the exploration and production of oil and natural

gas in ILs. Current legislation does not disallow economic activity by indigenous people in the ILs but prohibits the leasing of land (Law 6001/1973). Rorato et al. (2020) calculated that, considering all mining license requests registered in the Brazilian National Mining Agency, 176,000 km^2 are in ILs and about 15% of the total area of Legal Amazon ILs could be directly affected by mining if the bill is passed.

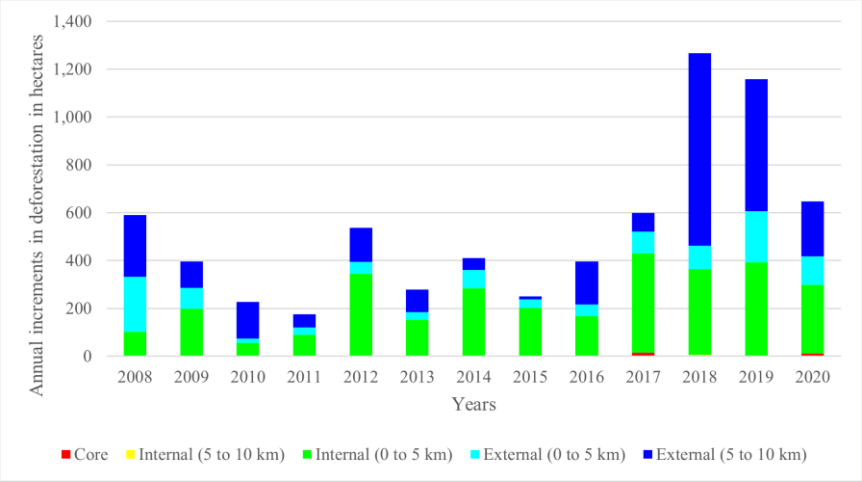

Figure 5. Deforestation in hectares in the SSLI, between 2008 and 2018.

The roads in this region were built due to public policies aimed at the development of the region, and consequently gave access to forest areas, bringing the second vector of deforestation, which are agricultural practices, which generally start with forest suppression in areas for subsistence and then were converted to practices such as livestock and logging (de Waroux, 2019). Figure 6 shows the accumulated deforestation until 2020 in the SSLI and its surroundings, highways and rural properties.

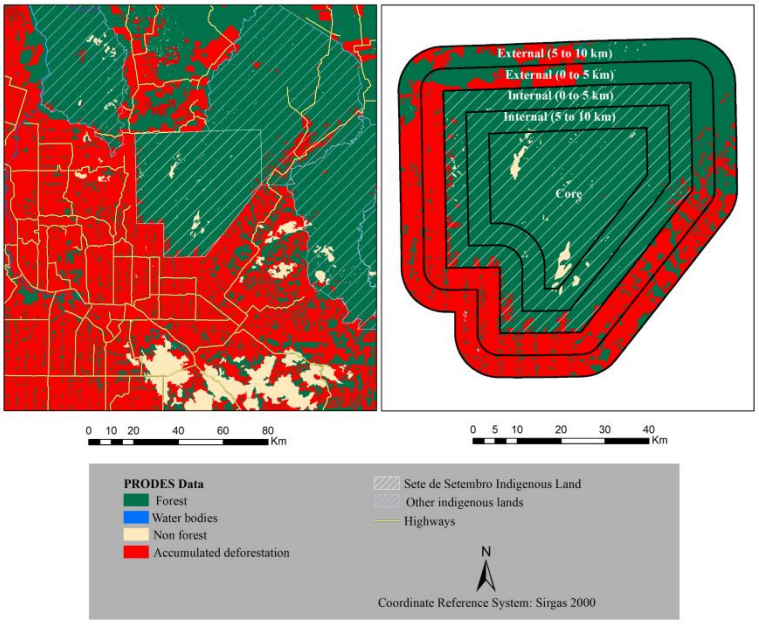

Figure 6. Accumulated deforestation until 2020 in the SSLI and its surroundings, highways and rural properties.

Despite the anthropogenic pressure in its surroundings and the possibility of increasing the deforested area in its vicinity, SSIL has had less than 1% of its area deforested since 2008. The

indigenous lands Zoró, Igarapé Lourdes and Roosevelt reinforce the protection of the forest in that region. IL Zoró which is adjacent to SSIL has prevented deforestation from advancing on its northeast edges. However, the other portions of the edge of the SILL are heavily exposed to anthropization in its surroundings and the area under indigenous protection is not supported in its entirety of its official extension. Santos et al. (2021) also concluded that ILs act as a barrier to the spread of fire, they are essential to protect native vegetation in the Amazon and, when they are close to Conservation Units, they are more protected from fire from the properties in their surroundings.

Paneque-Gálvez et al. (2018) explain that the inaccessibility and distance from towns and cities act as barriers to the movement of people and goods. Thus, in the most remote communities, traditional ecological knowledge can play a fundamental role in the conservation of forests, due to factors such as the more efficient management of their forest areasAmin et al. (2019) showed that integral protected areas and indigenous lands allow for a reduction in deforestation in the Brazilian Amazon and that protected areas have transboundary effects that depend on their size.

Deforestation outside protected areas occurs near rivers and highways (Jesus and Catojo, 2020), which are one of the main drivers of deforestation in the Amazon and contribute to a clear pattern of higher frequency of deforestation where there are roads (Bistene and Guimarães, 2019), which generally occurs in the external buffers (Figure 5).

This situation does not reflect what happens in the entire Legal Amazon. As mentioned above, the PPCDAm contributes to the reduction of fires and deforestation. According to Heilmayr et al. (2020), the Soy Moratorium in the Amazon (ASM), established in 2006 and prohibiting the production of soy in areas that were deforested after July 22, 2008 and in pastures or other cultivation areas that were deforested after clearcutting, also contributed to the reduction of deforestation. However, farmers' opposition to the ASM and the Brazilian Forest Code encouraged the end of land use restrictions. Figure 7 shows that, in fact, from 2005, deforestation in the Legal Amazon reduced considerably until 2012 (update of the Brazilian Forest Code) but started to grow again as of 2019, being 34% higher compared to the previous year. PPCDAm was extinguished in 2019 by the federal government, who reduced the budget for environmental agencies and altered the procedures for charging offenders accountable, encouraging illegal activities (Coelho-Junior et al., 2022).

Lopes and Souza (2020) evaluated SSIL deforestation on three dates with a frequency of ten years (1997-2007-2017). In the first decade of their analysis, deforestation increased on the edges of the SSIL because the surroundings (3 km from the edge to IL) were already almost completely open. For the authors, the containment of deforestation from 2007-2017 happened due to the presence of other protected areas in the northeast of the IL that prevent the advance of degradation.

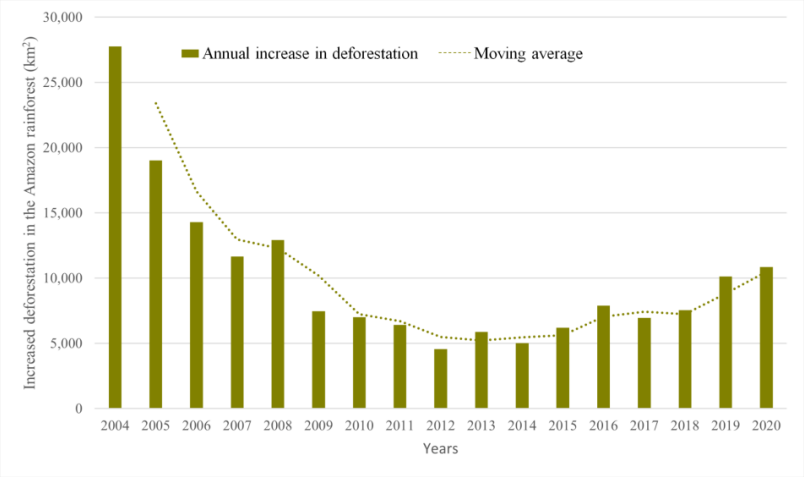

Figure 7. Deforestation in the Legal Amazon since 2004.

By 2020, with the COVID-19 pandemic, shutdowns and budget constraints by environmental agencies may have restricted field enforcement operations by government and local

communities (Brancalion et al., 2020). Deforestation in Brazil increased 72% between August 2019 and May 2020 compared to the previous year, as the federal government took advantage of the pandemic to disguise the dismantling of regulations and reduce the personnel and operating budgets of key government agencies (Daly, 2020).

Another relationship with the pandemic is that deforestation is an aggravating factor in the transmission of COVID-19 to indigenous populations, as it implies some type of human contact between indigenous and non-indigenous people (Laudares and Gagliardi, 2020). Highways connect isolated communities and also drive the spread and maintenance of diseases and health threats (Barcellos et al., 2010).

Conclusion

The Sete de Setembro Indigenous Land has been efficient in holding deforestation and fires in its interior, although it is exposed and vulnerable to anthropization in its surroundings, mainly resulting from the dense network of highways and roads in the region. Adjacent protected areas have been shown to exert a protective effect on the territory beyond their own limits and prevent the entry of degradation in the portion of the perimeter of contact between the protected areas. Hence the importance of considering a buffer zone for ILs as there is for Conservation Units.

Assuming that the opening and paving of roads leads to forest degradation, it is important to consider these results in possible future projects for the expansion of the road network in the region. While they can encourage economic growth in the region, they are potential environmental disasters. Hence the importance of demarcating these territories, strengthening indigenous policies and defining efficient agrarian reform plans to guarantee the protection of the forest. Appointments in the regional coordinators of FUNAI, for example, should consider the dialogue with the indigenous people and their representatives. The involvement of the indigenous community in the surveillance and inspection of ILs is also relevant to inhibit the invasion of loggers, miners and squatters, holding the illicit extraction of forest and fishing resources.

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