PANORAMA OF FOREST FIRES IN THE MUNICIPALITY OF HUMAITÁ BASED ON THE INPE HOT SPOTS DATABASES FROM 1998 TO 2022

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Abstract: Remote sensing has various applications, including the identification of hotspots and their association with forest fires in Brazilian territory. This study analyzed the data on the incidence of hotspots in the municipality of Humaitá in the state of Amazonas from 1998 to 2022. The research was based on the database of the National Institute for Space Research (INPE), on the BDQUEIMADAS web page, using monitoring data from AQUA reference satellites for the state of Amazonas during the period from 1998 to 2022. A total of 233,968 (two hundred thirty-three thousand nine hundred sixty-eight) hotspots were identified throughout the state, with ten municipalities in the state, including Lábrea, Apuí, Boca do Acre, Manicoré, Novo Aripuanã, Canutama, Humaitá, Maués, Autazes, and Tefé, standing out with 154,633 (one hundred fifty-four thousand six hundred thirty-three) hotspots, accounting for 66.09% of all hotspots in the state during the study period. Humaitá had 8,854 (eight thousand eight hundred fifty-four) hotspots and ranked as the seventh municipality in the state in terms of hotspot numbers in the historical data. However, it is a crucial municipality for the logistics of the southern region of the state, as it is intersected by two major highways, BR-319 (Manaus/Porto Velho) and BR-230 (Cabedelo/Lábrea). This study aimed to become an important tool for the prevention and combat of forest fires in Humaitá based on the hotspot data collected from 1998 to 2022. It also sought to serve as a reference in the study of the behavior of forest fires in the region.

Keywords: Hotspots, Humaitá, Forest Fire, Fire

INTRODUCTION

The Brazilian Amazon suffers every year from deforestation and forest fires that transform primary vegetation into secondary vegetation, which for NEPSTAD et al. (1999) states that most of the primary forests in the Amazon are not flammable in years of normal rain, even with seasonal drought, but deforestation and forest fires make these forests more susceptible to fire. In Amazonas, the border region with neighboring states: Acre, Mato Grosso, Pará and Rondônia, are those that suffer most from deforestation and consequently from forest fires (NEPSTAD et al.1999).

Speed and efficiency in detecting and monitoring forest fires are fundamental to enabling fire control, as they help reduce costs in combat operations and damage mitigation. Furthermore, inadequate knowledge of the location of the fire and the extent of the burned area favors the impact of the fire on the environment (BATISTA, 2004).

In this context, the National Institute for Space Research (INPE) has been improving a fire detection system since the 1980s based on images from sensors on board polar and geostationary satellites. These are the so-called "hot spots", which are geographic points captured by spatial sensors on the surface of the soil, when a temperature above 47° and a minimum area of 900 m² are detected (GONTIJO et al. 2011). Specifically speaking, the expression hot spots is used to interpret the heat record captured on the ground surface by space sensors. The AVHRR (advanced very high resolution radiometer) sensor captures and records any temperature above 47 °C and interprets it as a heat source. Although the spatial resolution is low (1.1km), fires with areas of at least 900 m2 can be detected (ANTUNES and RIBEIRO, 2000).

Currently, the information is made operationally available to users around 20 minutes after the satellites pass. The entire country and a large part of South America are covered by the images (CPTEC/INPE, 2022).

Humaitá belongs to the Southern Region of the State of Amazonas, a region that has the highest rates of hot spots and forest fires in the State. The present work therefore aimed to analyze the number of hot spots in the period from 1998 to 2022 in this municipality, identify its most critical areas and the seasonality of the occurrences of hot spots during the year.

MATERIAL AND METHODS

The municipality of Humaitá, according to the map in figure 1, is located in the south of the State of Amazonas on the left bank of the Madeira River, a tributary of the right bank of the Amazon River, approximately 200 km from Porto Velho and 675 km from Manaus via Highway BR-319, is located in the physiographic zone of the Madeira River, at the confluence of the BR 230 (Transamazônica) and BR 319 (Porto Velho/RO – Manaus/AM) highways. It is limited to the municipalities of Manicoré to the north and east, Tapauá and Canutama to the west and the State of Rondônia to the south and has an area of 33,111 km². The center of the municipality is 7°30'22"S. and 63°01'15"W.Gr.

The region's climate is Tropical Monsoon (Am), according to Kõppen, because annual precipitation varies from 2250 to 2750 mm, with a short dry season (July, August and September). The average annual temperature varies from 24°C to 26°C, the relative humidity, which is quite high, varies from 85 to 90% and the average altitude is 90 meters above sea level (MACHADO et al, 2017).
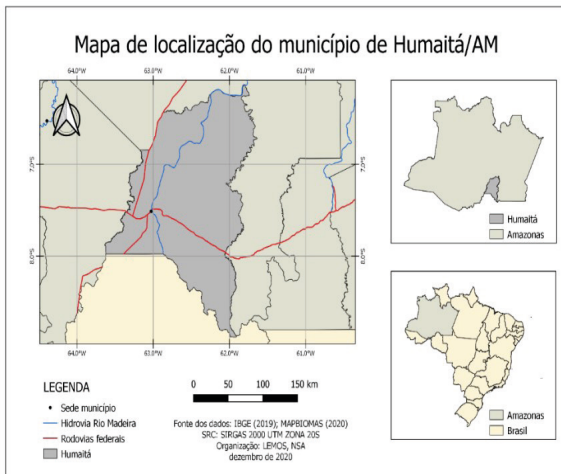
Figure 1: Location Municipality of Humaitá-AM, source: IBGE.

Figure 2: Soil Use and Coverage in the Municipality of Humaitá-AM in 2022, source INPE.

The land use and cover map was obtained by orbital image classification. The software used for classification was E-Cognition 9.2 using the Unsupervised Classification method, applying the Bottom-up (bottom to top) and Top-down (top to bottom) techniques for segmentation. The thematic information obtained by classification in the E-Cognition 9.2 software was exported and manipulated in the QGIS 3.32.2 software. The Landsat 7 and 8 images, ETM+/OLI sensor, obtained from INPE were already referenced by the Geodetic Reference System WGS84 and dated 07 and 10/08/2022. Spectral bands 3, 4 and 5 were used, referring to the wavelengths of green (0.53-0.59μm), red (0.64-0.67 μm) and near infrared (0.85-0.88 μm), respectively. As seen in Figure 2, land use and coverage in 2022 occurred as follows:

Mosaic of Occupation in Forest Area occupied 14.9 km² (0.05%), Countryside Vegetation 252.2 km² (0.79%), Managed Pasture 438.1 km² (1.32%), Forest Region 29731.9 km² (89.9%), Wet area 897.1 (2.8%), Mosaic of Occupation in Countryside Area 1186.2 km² (3.59%), Artificial Area 19 km² (0.05%), Body d 'water 501 km² (1.5%), as shown in figure 2.
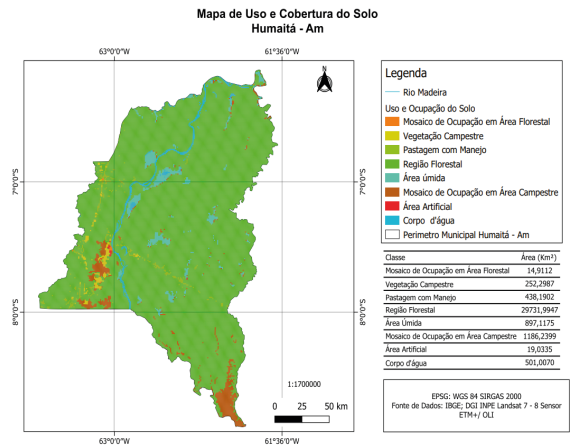
The road map of the municipality of Humaitá, as shown in figure 3, was prepared through Landsat 7 satellite image analysis, and data made available by the National Department of Transport Infrastructure (DNIT), showing a road network with two main roads, BR 230 (Transamazônica) and BR 319 (Manaus – Porto Velho), the first crosses the municipality from east to west and the second from North to South, in both we have the formation of a process called "fishbone" which, according to (FRANCE , 2016) is the appearance of local roads leaving these BRs towards areas of farms, plots of land and regions of small towns, with emphasis on the Realidade District in the northwest region on the banks of BR 319 and the Cristolândia District in the southwest region on the banks from BR 319.
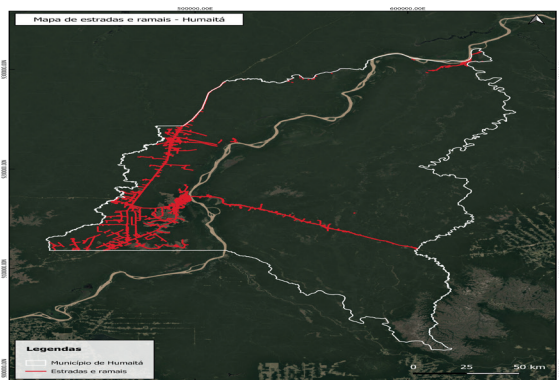
Figure 3: Road map of the Municipality of Humaitá-AM, source: INPE

To process the information on hot spots available in tables, points and polygons, a set of tools from the GIS program (Geographical Information System) was used, from the database available on the INPE website. The points representing the hot spots were grouped in Excel program tables divided by municipalities, corresponding to the years 1998 to 2022, the data was worked on year by year to form a database, and situation analysis in the form of tables and graphs generated from this data tabulated in Excel. The representations in the form of thematic maps were created from the INPE database, provided by reference satellites, which were saved in shapefire format and worked on in the Quanto Gis 3.32.2 program, using specific shapes for the Municipality of Humaitá.

RESULTS E DISCUSSION

For study purposes, a survey of hot spots was carried out throughout the State of Amazonas, data from reference satellites made available by the National Institute for Space Research (INPE) database for the years 1998 to 2022 were identified. 233,968 (two hundred and thirty-three thousand, nine hundred and sixty-eight) hot spots in the 62 municipalities of the state in the 25 years analyzed. Highlighting ten municipalities with the highest number of hot spots, as shown in

the table below.

MUNICIPALITY	Results by Municipality	%
Lábrea	36362	15,54%
Apuí	27104	11,58%
Boca do Acre	20145	8,61%
Manicoré	18230	7,79%
Novo Aripuanã	14593	6,24%
Canutama	10490	4,48%
Humaitá	8854	3,78%
Maués	7395	3,16%
Autazes	6368	2,72%
Tefé	5092	2,18%
TOTAL	**154633**	**66,09%**

Table 1. Ten municipalities with the highest rate of hot spots in the State of Amazonas from 1998 to 2022.

Table 1 shows that the ten municipalities total 154. 633 (one hundred and fifty-four thousand six hundred and thirty-three) hot spots, corresponding to 66.09% of the hot spots in Amazonas, in the period of 25 years, Humaitá and the seventh municipality with the highest rate of hot spots with 8,854 (eight thousand eight hundred and fifty-four), in the same period, corresponding to 3.78% of the state's total hot spots, as shown in figure 4:
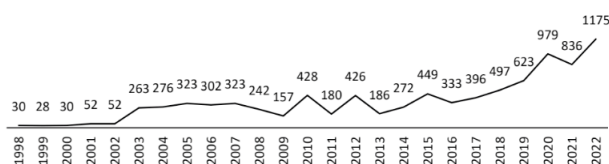

Figura 4. Focos de calor em Humaitá no período de 1998 a 2022, Fonte: INPE

In figure 4 above we have the distribution of hot spots in Humaitá in the period from 1998 to 2022, where we have a significant increase in hot spots from the year 2018 with the record number of hot spots in 2022 with 1,175 (one thousand one hundred and seventy and five), the distribution of hot spots in the municipality during the year, in the 25 years
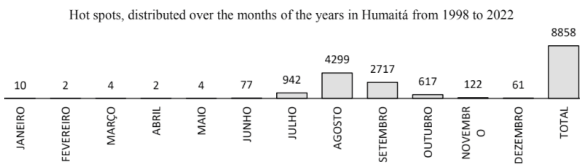
of study, can be seen in figure 5:

Figure 5. Hot spots, distributed over the months of the years in Humaitá from 1998 to 2022, Source: INPE

Figure 5 shows the distribution of hot spots distributed over the months of the year in Humaitá, during the study period, where it is observed that the months of July, August and September concentrate most of the occurrences of hot spots, with emphasis on August with almost 50% of occurrences, and the seasonality of occurrences in the municipality is evident with the concentration of occurrences in the period called Amazonian summer where we have high temperatures, low rainfall and consequently low relative air humidity, leading to the incidence of forest fires, fueled by the culture of fire in the region, used to clear land, open pastures and complement deforestation in the region, removing the primary forest creating secondary vegetation more susceptible to fire.

The spatial distribution of hot spots in the municipality is concentrated in the most anthropic regions as seen in figure 6:
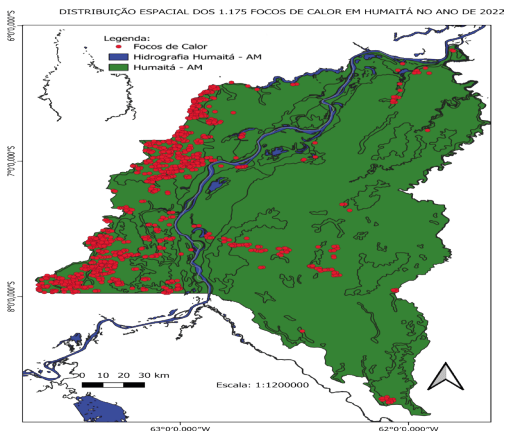

Figure 6. Spatial distribution of the 1,175 hot spots in Humaitá in 2022, Source: INPE

The outbreaks are concentrated on the banks of the municipality's highways and side roads, with emphasis on the district of Realidade, on the banks of BR 319, located to the northwest, and the community of Cristolândia on the banks of BR 319, located to the southwest of the municipality, close to the border with the State of Rondônia, as seen in figure 6, where we have the distribution map of hot spots in Humaitá in the year 2022, which concentrated the largest accumulation of hot spots in the 25-year period of study.

As a way of demonstrating the concentration of occurrences of hot spots, in specific areas of the municipality, the Kernel density technique was used for the accumulation of 7,769 hot spots in the period from 1998 to 2021, as shown in figure 7:
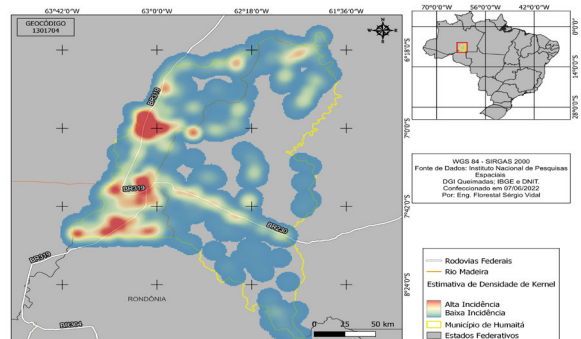

Figura 7. Mapa Densidade do acumulado de 7.769 focos de calor em Humaitá, no período de 1998 a 2022, Fonte: INPE

A high incidence of outbreaks is observed on the banks of the BR 230 and 319 highways, with an accumulation of outbreaks close to the municipality's headquarters, Realidade district and Cristolândia community. The areas with low incidences correspond to forested regions with a low rate of anthropization.

CONCLUSIONS

The Municipality of Humaitá located in the southern region of the state of Amazonas and at the confluence of two important highways in the region Brs 230 and 319, the left bank of the Madeira river, and an important hub in the southern region of the state, the study found that in the period of For 25 years, the municipality has been considerably increasing the number of hot spots within its municipal limits, with emphasis on the year 2022, the only year in which Humaitá surpassed a thousand hot spots with a total of 1,175 hot spots, the spatial distribution of hot spots in the municipality has not and homogeneous, concentrated in the regions with the greatest human presence, the banks of highways, side streets, districts and communities, with emphasis on the district of Realidade and the community of Cristolândia with large accumulations of outbreaks in the period, the distribution of outbreaks during the year It has a strong seasonality with a concentration in the months of July, August and September, the Amazonian summer period, with the scale of forest fires in the southern region of the state.

Humaita is being the basis for several governmental actions at the federal and state level, examples: operation guardians of the biome at the federal level and Aceiro at the state level, this work aimed to support public authorities to combat forest fires more effectively, which are increasing in the region, studying the hot spots that are the parameter used to monitor forest fires in the region.

The soot from the fires in Humaitá and neighboring municipalities contributes to air pollution in the capital of Amazonas, as was seen in an exacerbated manner in the months of August, September, October and November 2023. These occurrences increase the respiratory problems of the local population.

REFERENCES

ANTUNES, M. A. H.& RIBEIRO. **Uso de satélites para detecção de queimadas e para avaliação do risco de fogo**. *Ação Ambiental*, 12:24-27, 2000.

BATISTA, A. C. Detecção de incêndios florestais por satélites. Floresta, Curitiba, v. 34, n. 2, p. 237-241, 2004.

FRANÇA, G. F. Avaliação dos padrões de desmatamento na região de influência da UHE Belo Monte, Pará. 27 f. Monografia (Especialização em Geoprocessamento Ambiental). Instituto de Geociências da Universidade de Brasília, Brasília, 2016.

GONTIJO, G. A. B., ALLAN A. P., EVERTON D. S. O., FAUSTO W. A. J. Detecção de queimadas e validação de focos de calor utilizando produtos de Sensoriamento Remoto. Anais XV Simpósio Brasileiro de Sensoriamento Remoto – SBSR, Curitiba, PR, Brasil, 30 de abril a 05 de maio de 2011, INPE, 7966 p.

INPE – Instituto Nacional de Pesquisas Espaciais, 2021. Portal do Monitoramento de Queimadas e Incêndios. Disponível em http:<//queimadas.cptec.inpe.br>. Acesso: 20 de out. de 2023.

CPTEC/INPE – Instituto Nacional de Pesquisas Espaciais, 2022. Portal do Monitoramento de Queimadas e Incêndios. Disponível em http:<//queimadas.cptec.inpe.br>. Acesso: 12 de jul. de 2022.

NEPSTAD, D. C., A. Moreira & A. A. Alencar. 1999. A Floresta em Chamas: Origens, Impactos e Prevenção de Fogo na Amazônia. Programa Piloto para a Proteção das Florestas Tropicais do Brasil, Brasília, Brasil.