Potential fire risk in forest fire prevention: A case study in the Serra da Canastra National Park – MG

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ABSTRACT
Conservation Units (UCs) are natural areas subject to protection at the federal, state or municipal level (MMA, 2019). Due to their peculiar characteristics, due to the maintenance and conservation of biodiversity, they guarantee the sustainable use of natural resources by current populations, providing the communities that live in their surroundings with the development of sustainable economic activities and ensuring the conservation of the environmental services provided by that unit (COSTA, 2020).

Keywords: UCs, Federal level.

1 INTRODUCTION

Conservation Units (UCs) are natural areas subject to protection at the federal, state or municipal level (MMA, 2019). Due to their peculiar characteristics, due to the maintenance and conservation of biodiversity, they guarantee the sustainable use of natural resources by current populations, providing the communities that live in their surroundings with the development of sustainable economic activities and ensuring the conservation of the environmental services provided by that unit (COSTA, 2020).

The study area, Serra da Canastra National Park (PNSC) and Buffer Zone, is located in the Cerrado biome, in the southwestern region of Minas Gerais, housing important species of Brazilian fauna, some of them endangered, in addition to a biological diversity of flora, including endemic species (ICMBIO, 2019).

Parna Canastra is an example of a conservation unit, where fire is seen as a conflicting activity, however, fires and burnings cause damage to biodiversity, threatening the preservation of the Park, and also harming the maintenance of ecological processes, in view of the vulnerability of the areas affected by fire (MESSIAS & FERREIRA, 2017).

Some Integrated Fire Management (IFM) techniques have been used in the PNSC in recent years as a management strategy, and the work is widely done by the fire management team of ICMBio (Chico Mendes Institute for Biodiversity Conservation). Among them are: firebreaks in the extension of the Park's roads, controlled burning, environmental education and integration work with the residents surrounding the PNSC, authorization of controlled burning, scientific research and management of people in the prevention and fighting of fires, in addition to monitoring through Geographic Information Systems (ICMBIO, 2019).

Gigovićet *al*., (2018), point out that geospatial data and Geographic Information Systems that apply the interaction of environmental as well as anthropogenic variables, simulating the possibility of ignition and propagation of forest fires, have been used in order to analyze the susceptibility to the occurrence of fires, through spatial-temporal models, characterizing the dynamics of natural and anthropogenic factors.

Lacerda *et al.*, (2022), point out that spatial models of forest fires have contributed to the management of PAs, enabling prevention and combat planning.

Among the alternatives of instruments for the prevention and control of forest fires, there are the Fire Risk Indexes, which are important tools that, if applied together with management techniques, can serve as an aid to the PAs in Brazil, in the work of management, management and combat of forest fires (COSTA, 2020).

The environmental impacts caused by wildfires are highlighted in issues involving global warming and future climate change. The burning of biomass represents a significant part of CO2 emissions into the atmosphere. Several fire risk indices are used to investigate the susceptibility to the occurrence of fires (COSTA, 2020).

Silva *et al.*, (2016), define fire risk as the probability of occurrence or start of a fire, as a result of the presence of causative agents.

On days with high temperatures not in line with low relative humidity and strong winds, there is an increase in the potential to activate the start of a forest fire, which can lead to the degradation of thousands of hectares of forest. Fires usually occur during periods of rising temperatures and drought. The fire risk indices should serve to provide climate information to forest agents in prevention work, and it is important to review the conditions of the biomass for burning (TATLI AND TURKES, 2014).

An important step in forest fire prevention work is the analysis of the environment, investigating the susceptibility that a given place has, so that hot spots can spread and become forest fires (fire risk). In the countries of the Northern Hemisphere, especially the United States and Canada, the Indices are widely used (COSTA, 2020).

In the present work, the fire risk analysis was carried out, through the Fire Potential Index (PFIv2), which is an adaptation of Silva (2019), of the PFI Index (*Potential Fire Index*), developed internally at the Center for Weather Forecasting and Climate Studies (CPTEC), based on the observation of the occurrence of fires and fires in the biomes of Brazil, as a result of "the meteorological conditions and histories in the area of each event" (SETZER, 2002), to which the *Haines Index* was implemented, a Haines logistical function, considering the days of drought, a latitude correction factor, the basic risk of fire and vegetation conditions (SILVA, 2019).

It is believed that the Potential Fire Risk Index is an important tool to be implemented in the UC of the PNSC, in order to, together with the prevention measures already used in the area, constitute an efficient alternative in the work of preventing the occurrence and spread of forest fires, since the PFIv2 does not aim at the ignition point, but the susceptibility of atmospheric and vegetational conditions to the risk of fire.

2 OBJECTIVE

The general objective of the research was to analyze the susceptibility to the occurrence of forest fires in the area of the PNSC and Buffer Zone, using the PFIv2, as a tool for management, management and prevention of development and spread of forest fires, in order to propose a new method to be added to the work of prevention and combat of forest fires in the Conservation Unit.

3 METHODOLOGY

The research methodology initially consisted of the analysis and study of scientific works for a better understanding of the local climatological and meteorological conditions, for the purpose of using the Potential Fire Risk Index (PFIv2), and also for the analysis and discussion of forest fires in the PNSC, making a diagnosis of the atmospheric conditions favorable to the occurrence of fires.

Dynamic and synoptic analyses of the region were necessary, covering the area of the PNSC.As synoptic analyses are related to the analysis and weather forecasting of large-scale meteorological systems, relating to the duration of atmospheric phenomena, their spatial and seasonal distribution.

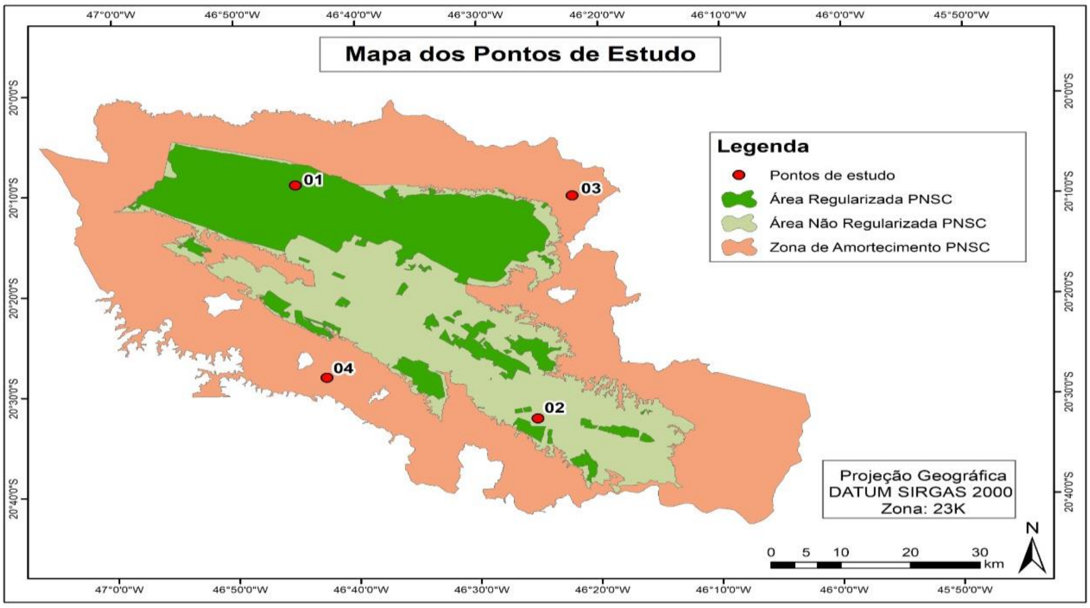
The Potential Fire Risk Index (PFIv2) was applied, implemented with the Haines logistic growth equation , an index that uses the atmospheric conditions susceptible to the occurrence and propagation of fires, requiring knowledge and understanding of the climatic conditions, as well as the vegetation favorable to the propagation of hot spots in the Serra da Canastra region.

The Serra da Canastra National Park, located in the southwest region of Minas Gerais, was created in 1972, covering the municipalities of São Roque de Minas, Vargem Bonita, Sacramento, Delfinópolis, São João Batista do Glória and Capitólio, with a total area of 200,000 (two hundred thousand hectares). At its creation, 71525 hectares had their land tenure regularized, including the Chapadão da Canastra. Over the years, other areas have been expropriated and there are currently approximately 89,000 hectares regularized (ICMBIO, 2020), the research was carried out in the regularized, non-regularized area and buffer zone, north and south faces (Figure 1).

The Park is located in a region called Planalto da Canastra, which in its composition is made up of crests, bars and valleys, adapted in direction structuring NO-SE (SILVA & BERNARDES, 2019).

The relief is characterized by an "alternation of plateaus, steep slopes and embedded valleys. Two major segments can be distinguished: Chapadão da Canastra, with grassland formations, and Chapadão da Babilônia, with the busiest relief, in addition to the valley that forms between the plateaus. The altitude varies between 900 and 1496 meters, with the highest point being the top of Serra Brava, in Chapadão da Canastra (IBAMA, 2007).

Figure 1: Study area of the Serra da Canastra National Park, Minas Gerais



Source: Costa, E. G.; Lemos, (2022).

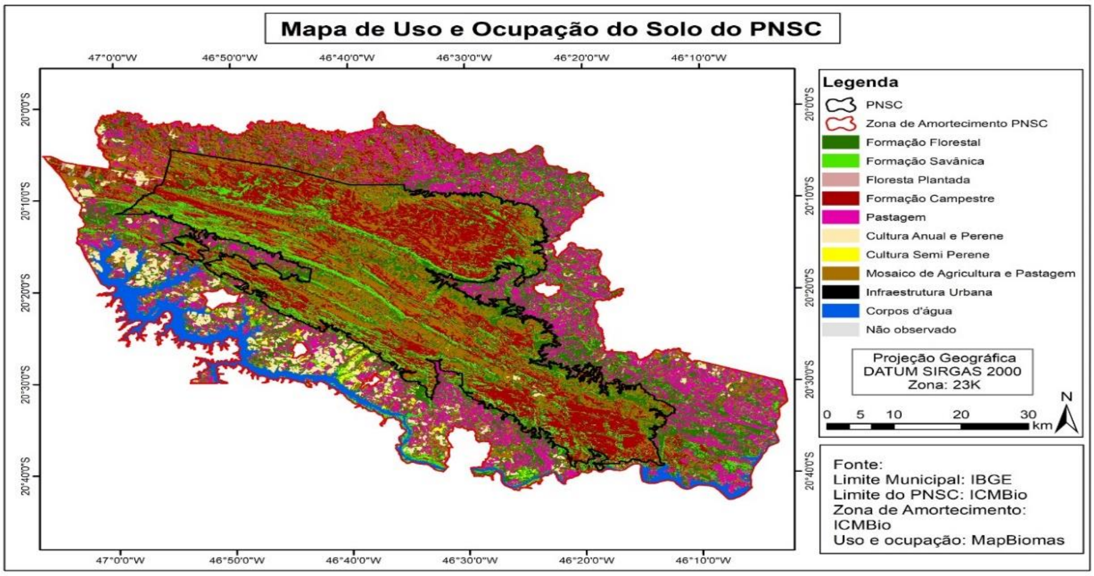
The climate in the region is subtropical moderate humid, with average temperatures between 16º and 23º C, being characterized by two very distinct seasons, dry between May to September and rainy between October and April, during the dry season the humidity levels reach 15% in the late afternoon. The months of July, August and September are the driest and, consequently, the ones with the highest occurrence of fire outbreaks in the PNSC. In the mountains, temperatures are milder, and in winter the minimum is close to zero, allowing frost and the maximum recorded reached 38º C in the months of December and January. The area has rainfall between 1000 and 1500 mm per year, (SILVA & BERNARDES, 2019).

The prevailing winds in the region are north-south, but there are oscillations, with the afternoon being more stable. This factor, together with other variables, such as relief, topography, vegetation, make forest fires spread rapidly.

The PNSC Buffer Zone is located in 11 municipalities around of Parna Canastra having an area of 269,513 ha. The economy consists of agriculture and livestock, part of the local income is linked to the cultivation of coffee, soybeans, corn and the production of canastra cheese. Figure 2 shows the use and occupation of the land.

It can be seen that on the north face of the Buffer Zone, pastures, little grassland formation and agricultural mosaic stand out. In the regularized area, the grassland formation stands out and the non-regularized area points of savannah, grassland and forest formation.

Figure 2: Land Use and Occupation of the Serra da Canastra National Park – MG and Buffer Zone



Source: Costa, E. G.; Lemos, (2022).

In the northern portion of the PNSC, there are also quartzite mining activities, in addition to several research permits for diamond exploration, registered with the National Mining Agency (ANP). The Ecological Zoning of Minas Gerais establishes the areas cited as priorities for conservation (REIS & MELO, 2014).

For the calculation of the Index, the following data were calculated: i) precipitation, ii) relative humidity, iii) maximum temperature, iv) atmospheric conditions to calculate the Haines log function, v) days of dryness, vi) latitude and vii) determination of vegetation type.

The variables relative humidity and air temperature were obtained by means of the ERA-Interim reanalysis, a recent version, produced by the *European Centre for Medium-Range Weather Forecasts*(ECMWF).

Precipitation was obtained through the *Climate Prediction Center* (CPC/NOAA), which uses the records of approximately 30,000 stations controlled by various agencies. For data quality control, historical records are still used, as well as independent observations from neighboring stations, radars, satellites, and numerical models (SILVA, 2019).

The period from January 1, 2001 to December 31, 2018 was defined for the research, and this is the range of data available through the Terra/MODIS (*Moderate Imaging Spectroradiometer*) satellite.

Terra/MODIS, captures every point of 1 – 2 days, in 36 spectral bands, the sensor tracks an extensive series of vital signs from the earth, larger than other sensors, measuring for example the surface of the earth that is covered by clouds.

The research was carried out in different stages, for the purpose of comparing the efficiency and validation of PFIv2, namely:

i) Daily calculations using the Potential Fire Risk (PFIv2) formulas, for the purpose of producing monthly and annual averages;

ii) Survey and tabulation of data on hot spots that occurred in the study area. This step was important for the validation of the previous step, making it possible to compare the results with the calculations of the Index.

iii) Survey of climatological data, by the National Institute of Meteorology (INMET), climatological station of Bambuí - MG with the purpose of corroborating them with the hot spots and periods in which they occurred, analyzing the meteorological conditions and what are their influences on the occurrence of hot spots and propagation of forest fires in the study region, in Serra da Canastra.

iv) Analysis and diagnosis of burned areas in hectares and percentage, of the Regularized and Non-Regularized Areas and Buffer Zone, through the survey carried out by researchers Messias & Ferreira (2019), an essential step for validating the data indicated by PFIv2.

The principle of fire risk is directly related to the number of days without precipitation, called drought days (DS), the more days without rain, the greater and more critical the risk. In the PFIv2 calculation, the effects and influence of vegetation type, phenological cycle, maximum temperature, air humidity, as well as the presence of fire in the study area are used (SILVA, 2019).The *Potential Fire Index* (PFI) is based on the principle that vegetation type increases the fire risk factor in periods of drought. Dry days are a hypothetical number of days without precipitation prior to 120 days prior to the date analyzed. To calculate the fire risk, 4 points were defined, as shown in Table 1.

Table 1: Points in the study area of the Serra da Canastra National Park - MG

Point	Area	Latitude	Longitude
01	Regularized	20º,15´S	46th,75´W
02	Not regularized	20th,54´S	46th,42´W
03	For face norte	20th,17´S	46th,37´W
04	FOR face sul	20th,47´S	46th,71´W

Source: Costa, E. G.; Lemos, (2022).

To calculate the fire risk, the PFIv2 formula (equation 1), adapted by Silva (2019), was used. the index is a PFI enhancement quest.

It is important to note that PFIv2 is an index of intermediate complexity.

$$PFIv2 = BR * (a2 * LF + b) * RT * Forb \qquad (eq.\ 1)$$

Where:

BR – Basic fire hazard

A2 - constant = 0.006

LF – Haines log function

b - constant = 1.3

$$Forb = (0{,}003 * |let| + 1) \text{ (aq. 2)}$$

Where:

$|Lat|$ – Modulus of latitude

Whereas:

*(a2 * LF + b),* this is the impact factor of the Hai *log* function .

Table 2 shows the PFIv2 categories, according to the values found.

Table 2: PFIv2 Risk Rating Categories

Risk	PFIv2
Minimal	< 0,15
Low	0,15 < 0,40
Medium	0,40 < 0,70
Alto	**0,70 < 0,9**
Critical	**0,9 <**

Source: Silva (2019).

The survey of hot spots, which occurred in the study area, was carried out for the period January 1, 2001 to December 31, 2018, using the images (*MODerateResolution Imaging Spectroradiometer*) MODIS, Earth satellite, with a resolution of 1 Km x 1 Km, sensor in polar orbit, and the data were made available in the public domain, from the database of the *FireInformation For Resource Management System* (FIRMS) platform.

The information was based on the coordinates of occurrence of the outbreaks, date, time and satellites used for the survey. From then on, the data were managed, performing the monthly sum of the hot spots, and then the monthly and annual averages were calculated, to validate the fire risk calculations, for the study period.

Subsequently, the climatological conditions were surveyed, in order to relate the climatic factors and the development of hot spots, considering that the PFIv2, in its formula, implemented by the *Hai log function* , considers the climatological factors and the conditions for the occurrence of fire, through the temperature of the layers of the atmosphere, the dew point and the relative humidity of the air.

Between the climatic conditions, the precipitation factor considered for the 120 days prior to the calculation and the days of dryness is directly related to the vegetation conditions, which influence the risk of fire.

For data analysis, the results of the daily fire risk calculations were verified, performing the monthly and annual averages of the 4 points evaluated, seeking to compare with the climatological conditions for the periods studied and the variation of results between the points.

Then, to validate the index, the occurrence of hot spots was analyzed, comparing the data found in the calculations with the climatological data and finally with the burned areas in hectares and percentage.

4 DEVELOPMENT

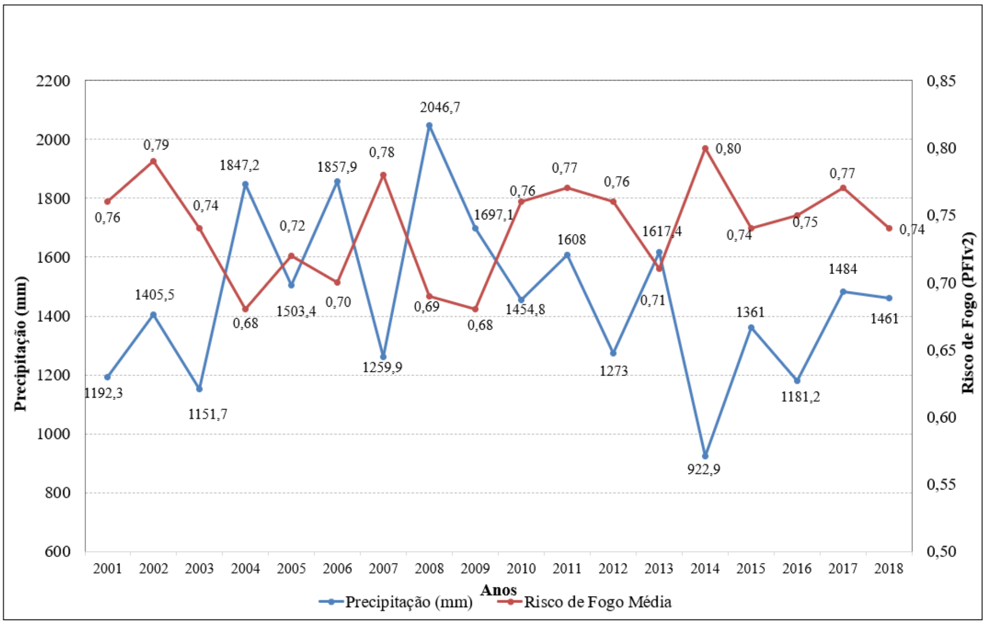
Climatological and atmospheric conditions influence the spread of hot spots and the occurrence of fires, given the importance of evaluating all factors and variables. In the Serra da Canastra region, the situation is no different. It was observed that in periods with high temperatures, where as a consequence there is low relative humidity of the air, these factors provided an increase in PFIv2. These conditions, when associated with the accumulation of biomass, wind and local topography, are determining factors for the occurrence and spread of forest fires.

Another important climatic condition to be observed are the days without precipitation or accumulated precipitation, as this condition directly alters the relative humidity of the air, the moisture of the soil and vegetation, as well as the calculation for the days of drought.

Figure 3 shows the annual averages of the PFIv2 index and precipitation for point 01.

It was decided to demonstrate the results in points 01 and 02, considering that point 01 is the Regularized Area of the PNSC and point 02 the Non-Regularized Area, which are considered the most vulnerable areas.

Figure 3: Precipitation and Risk of Rogo PFIv2 - Point 01 – PNSC Regularized Area



Source: Costa, E. G.; Lemos, (2022).

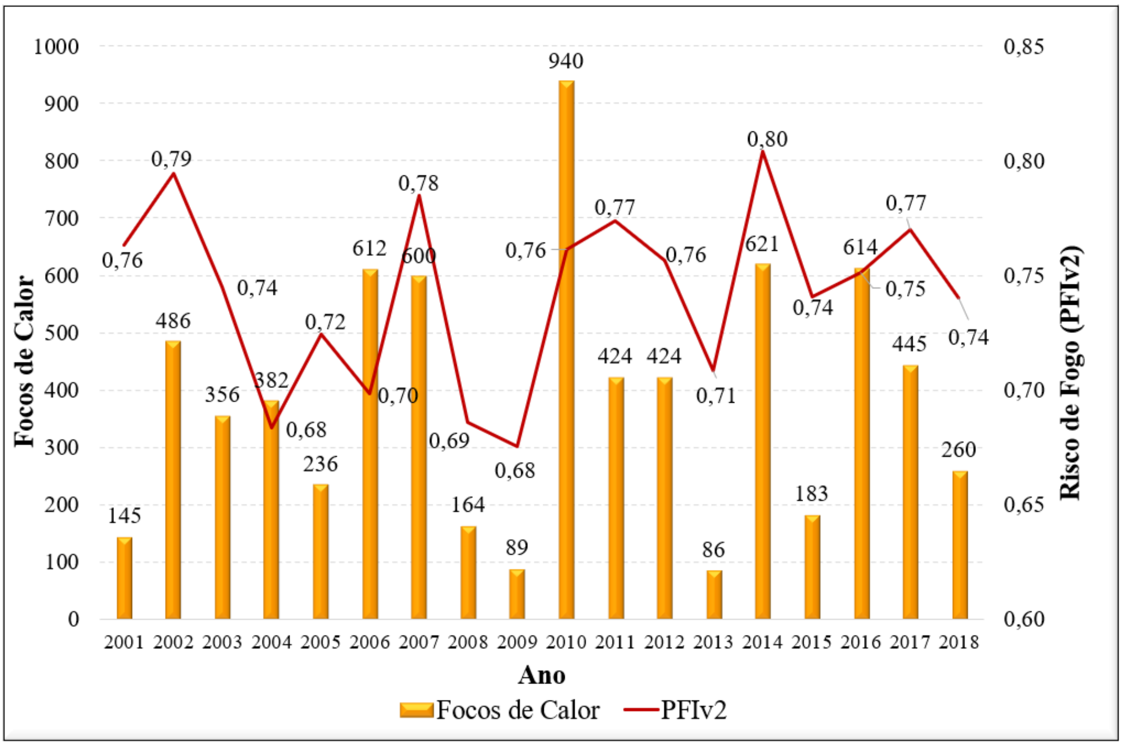
It can be seen, then, that there is a relationship between the values indicated by the PFIv2 and the average annual rainfall. In years with low precipitation values, there is an increase in PFIv2 values. Justino (2013) points out that the risk of fire increases as the duration of drought periods increases.

The years 2004, 2005, 2006, 2008 and 2013 had rainfall values well above average, in fact, the values indicated by the index decreased.

In contrast to the years 2007, 2012, 2014, 2015 and 2016 where the annual rainfall averages were very low, the values indicated by PFIv2 were high, and these were the years that had the highest number of burned areas.

Figure 4 shows the hot spots and the values indicated by PFIv2 for point 01.

Figure 4: Annual average of Hot Spots and PFIv2 point 01 - PNSC

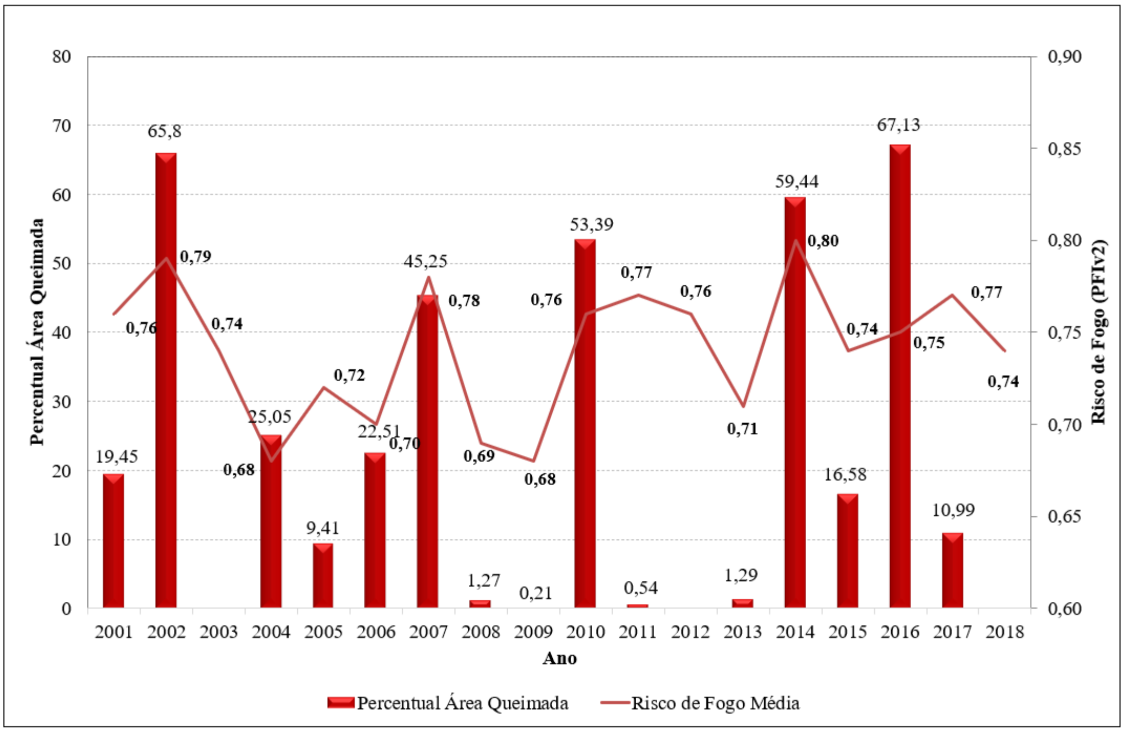


Source: Costa, E. G.; Lemos, (2022).

It is noted that there is a correlation in the results of PFIv2 with the occurrence of hot spots in the study area, which demonstrates that the index corroborates and can be used in the management, prevention and fighting of forest fires in the PNSC.

Emphasizing the importance of always correlating the values indicated by the index with the other variables and factors that can alter the behavior of fire. The PFIv2 should be worked on, in line with the various fire management tools, observing the conditions of the biomass, an important component in the fire triangle. Figure 5 shows the PFIv2 values and the burned areas for point 1.

Figure 5: PFIV2 Values and Burned Area - Point 01 - PNSC



Source: Costa, E. G.; Lemos, C.F., (2022).
Note: For the years 2003, 2012 and 2018 we do not have the values of burned area.

The highest occurrences of burned areas were in 2016, 2002, 2014, 2010 and 2007, being years with high values indicated by PFIv2.

In 2011 and 2012, they had averages of 0.77 and 0.76, high values that indicate susceptibility to the occurrence of hot spots and the spread of forest fires. However, it should be considered that in 2010, an area equivalent to 53.39% of the PNSC was burned, however, the biomass factor is considered, because as a component of the fire triangle, the decrease in biomass contributed to the low occurrence of fires, even though the PFIv2 value indicates susceptibility.

The years 2009, 2008 and 2013 were the years with the lowest burned areas. It is noted that these are years after burning of large areas in previous years, thus reducing the biomass, a condition for the values to be lower. In addition, above-average rainfall values were recorded for the region.

To address the issue of fire, all variables must always be taken into account, in order to have an efficient management. The indication of high or critical PFIv2 values should be improved considering local conditions, climatic conditions, biomass, temperature, relative humidity and precipitation.

The year 2010 was a year of occurrence of*El Niño*, in the moderate category, a factor that intensifies the number of hot spots, increasing the area of incidence of fires, due to local climatic conditions. Fires occur as a result of heat waves, prolonged periods of drought, and weather patterns associated with *El Niño* (INPE, 2019).

Clement; Junior & Louzada (2017), showed in their research that the years with the highest numbers of records of hot spots coincide with the El *Niño* and *La Niña cycles* in the strong and weak categories, according to the authors, La *Niña* in 2010 (strong), caused influences on the entire climate of Brazil, with changes in rainfall and air temperature.

Silva (2019) mentions that on a global scale, the *El Niño* phenomenon contributes to the occurrence of fires, given that climate change episodes increase the potential for fire risk.

Regarding the amount of biomass, it is noted that in the previous years, 2008 and 2009 were years of low occurrence of fires, which indicates that there was an accumulation of plant biomass, thus, in line with climatic factors and interference of *El Niño*, there was a peak of hot spots in 2010.

In the years 2011, 2012 and 2013, after the occurrence of fires in 2010, there was a decrease in the number of hot spots, justified by the decrease in biomass. The average rainfall for these years ranged from 1270 mm to 1400 mm.

In 2014, four years after major fires in the PNSC and after 3 years with little occurrence of fires, it is marked as the second largest year in number of hot spots and the third year in burned area, it was a period of drought, where the average annual rainfall was approximately 900 mm of rain. The climatic conditions for the fires were favorable, with higher temperatures (INMET 2019).

Coelho *et al*., (2015), cite that as a result of a combination of factors, the summer of 2014 was anomalously dry, due to an intensification of the South Atlantic Subtropical Anticyclone (ASAS), between southeastern Brazil and the Atlantic Ocean, as a result, there was a decrease in upward movements in the atmosphere and cloud formation, decreasing precipitation rates.

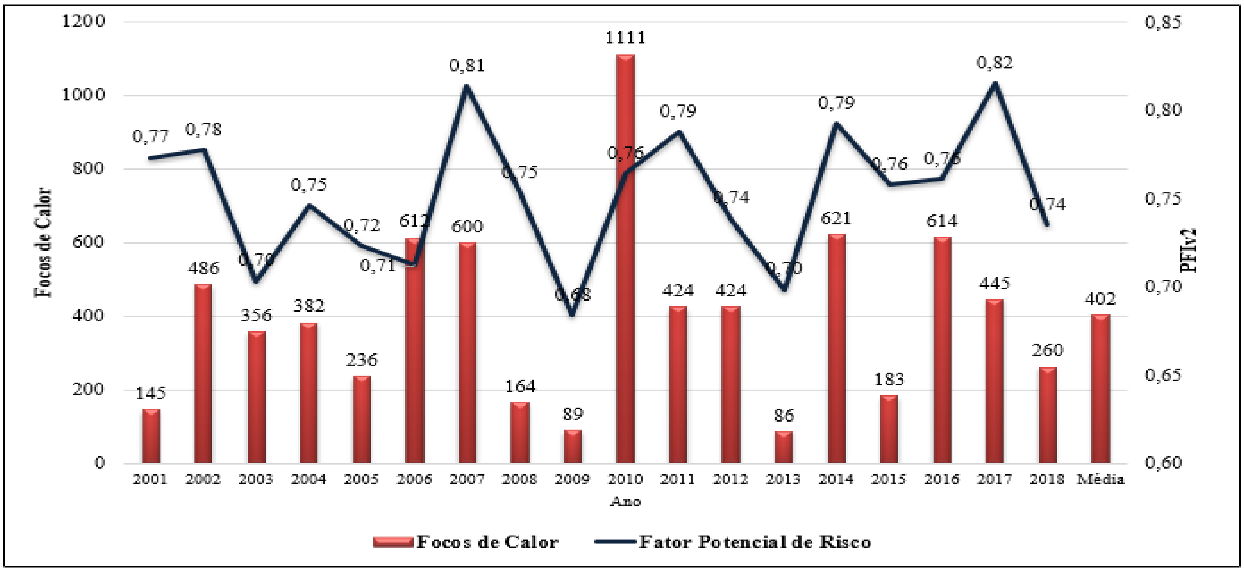
According to Coelho *et al*. (2016) was a period with a deficit of precipitation in the southeastern region of the country, the drought of this year arose due to anomalous convective activities that occurred in the north of Australia. As a result, an anomalous high pressure system was established over the Atlantic Ocean and the southeastern region of Brazil, this occurrence disfavored the formation of events such as the South Atlantic Convergence Zone, which is a mechanism for the production of rainfall over the southeastern region of Brazil, decreasing precipitation values due to frontal systems being forced to travel oceanic trajectories, warming the ocean through the incidence of solar radiation.

In 2002, 2007 and 2016 were years of occurrence of the *La Niña phenomenon*, in the moderate category, (INPE, 2019). It is observed that these were years with a high percentage of burned areas.

Sodré *et al*., (2018), cite in a research carried out in the Eastern Amazon, that La *Niña* influences the concentration and occurrence of hot spots, despite presenting a greater predominance in rainfall days in the first half of the year, in the second half of the year, there is an increase in hot spots, justifying that, due to the increase in rainfall in the first half of the year, the areas that were not burned in this period, They burn in the dry season. The authors point out that in *La Niña years*, the second half of the year needs more attention from law enforcement agencies.

Figure 6 shows the hot spots and PFIv2 values.

Figure 6: Hot Spots and PFIv2 point 02 - PNSC

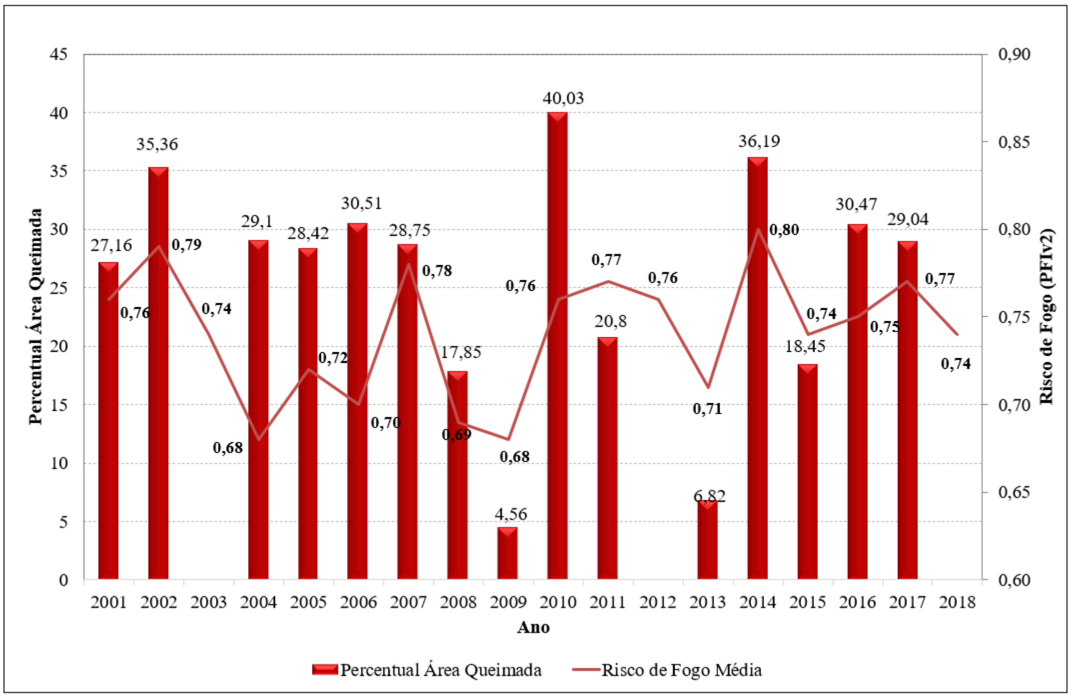


Source: Costa, E. G.; Lemos, C.F (2022).

In Figure 7, the PFIv2 and the burned areas, for point 02, Non-Regularized Area of the Park.

Figures 6 and 7 show that there was consonance between PFIv2 values, hot spots and burned areas. In 2006, there was a greater burning in point 2, compared to 2007, when compared to the Regularized Area of the PNSC, the year 2007 was the 6th year with the largest extension of burned area in point 02.

Figure 7: PFIv2 Values and Burned Area - Point 02 PNSC



Source: Costa, E. G.; Lemos, C.F, (2022).
Note: For the years 2003, 2012 and 2018 we do not have the values of burned area.

It is important to analyze the values for this area, considering that it is anthropized. The index indicates the atmospheric, climatic and vegetational conditions for fire propagation, but the anthropic factor is not taken into account, being an important point, as it can aggravate the fire situation.

In this case, it is suggested to use the values indicated by the index in environmental education work with the population that lives in these areas, called canastreiros, so that they can collaborate in the work of preventing and fighting fires.

The Fire Risk Potential Index PFIv2 proved to be efficient to be used as a complementary tool in the actions of management of the spread and occurrence of forest fires in the study area.

The calculations carried out in the research, when compared to the hot spots obtained by FIRMS and burned areas, showed that the values indicated by the index corroborate the occurrence of hot spots and forest fires in the analyzed interval.

PFIv2 can be used by ICMBio in its monitoring, control and prevention of forest fires, which are problems faced by the UC since its creation in 1971.

The subsidy data for index estimates can be downloaded on free platforms, and daily and monthly projections can be made and the PFIv2 values calculated, using the model to be provided to the municipality.

The PFIv2, which can be applied to any data set, is a model of intermediate complexity, with one of the main characteristics being generic, and can be used in different groups of data, with different spatial and temporal resolutions (SILVA, 2019), giving greater reliability in smaller areas when better resolutions are used, such as those used in this research.

Considering that the non-Regularized area is an anthropized and non-monitored area, it is necessary to integrate the residents with ICMBio, for an efficient fire management and possible use of the index.

A management seeking this integration through environmental education can be evaluated and discussed on how to bring the information to the residents, so that they can collaborate in an efficient management, considering that forest fires most of the time end up causing damage to rural properties, damaging fences among other material goods.

There are two types of firefighter contracts in the PNSC. The fire brigade that operates through PREVIFOGO is hired for 6 months a year, from May to October, with 32 people. And there is also a 3-year contract with a total of 10 people who work all year round. Outside of this period, only ICMBio employees and third parties who are hired through companies that provide services to the municipality, with a total of 38 people, work in the area all year round (ICMBIO, 2019).

In the period before winter, the brigade, together with other ICMBio employees and third parties, implement fire prevention work, carrying out firebreaks on the sides of the roads and integrated fire management.

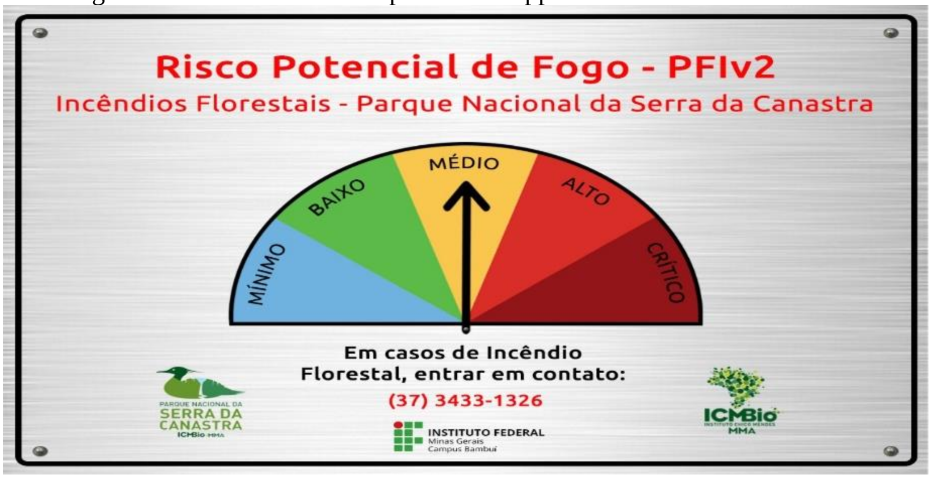
For this situation, the PFIv2 projection will be useful in choosing the best days or months to carry out this work, that is, when the index points to low risk values, which would be days less susceptible to the occurrence or spread of fires, with favorable climatological conditions for this type of activity.

In the critical period, when there are more fires, the index can also be proficient in conjunction with other tools for controlling and fighting forest fires.

Also taking into account that the area is home to several tourist attractions, the use of the index can be useful in environmental education work, through fire risk warning panels (Figure 8), to be placed at entrances and tourist spots, indicating and alerting tourists and other people who enter the limits of the PNSC, for the risk of daily fire. Some conservation units and several private companies use this type of alert for society.

According to Oliveira *et al*. (2017), some countries in Europe have created techniques for the production of forest fire risk maps, thus fostering the management bodies for the elaboration of forest fire prevention plans.

Figure 8: Model of the PFIv2 panel to be applied in the Conservation Unit



Source: Costa, E. G.; Lemos, C.F., (2022).

5 FINAL THOUGHTS

The results showed that PFIv2 can be a tool to be used in the management of forest fires in Parna Canastra. In the comparisons of the values indicated by the PFIv2 with the burned areas and hot spots, satisfactory results were obtained, demonstrating that by using a better resolution in *pixels* (0.125 x 0.125), in obtaining data from the variables to promote the index, it can be applied in smaller areas, achieving more accurate results.

However, it should be noted that PFIv2 indicates susceptibility to the development of hot spots and the occurrence of forest fires. It is necessary to analyze other factors in order to work with a better prevention management. The biomass factor is a condition for the occurrence of fires, thus, among the prevention tools to be aligned with the index, the Integrated Fire Management stands out, which has already been used in the Conservation Unit.

The purpose of using the Index is to point out the days that are susceptible to fire, in which climatological conditions favorable to the spread of fires occur, both in the performance of prevention work and in the fight against fires.

Another important point to be highlighted is that the PFIv2 points out the natural conditions for the spread of fires, and the anthropic factor is not taken into account. It is important to highlight the need to analyze whether regional adjustments are necessary for the use of the fire risk index in different areas where it was generated and validated.

Therefore, it is emphasized that preventive and corrective work for cases of forest fires are part of a set of tools, which together become more effective, that is, the PFIv2 index is a complementary tool that can more effectively assist the work aimed at managing forest fires in the Conservation Unit.

The PFIv2 has proven to be efficient to be applied in the area, it is important for ICMBio, in the implementation of programs, in the database, *software*, for the projections of daily, weekly or monthly calculations, to train employees for the use and application of it, so that the risk panels can be changed daily, as indicated by the index, as well as before the execution of controlled burns and firebreaks, check the conditions pointed out by PFIv2, in order to choose the best days to carry out these works, thus avoiding the occurrence of accidents, spreading fires in the execution of preventive works.

REFERENCES

CLEMENTE, S. D., JÚNIOR, J. F., & LOUZADA, M. A. (2017). Focos de Calor na Mata Atlântica do Estado do Rio de Janeiro. Revista Brasileira de Metereologia. *32*, 669-677.

COELHO, C. A. *et al*. The 2014 southeast Brazil austral summer drought: regional scale mechanisms and teleconnections. *ClimateDynamics*. V. 45. Pág. 1-16. 2015.

COSTA, E. G. da. Índice de Risco Potencial de Fogo (PFIv2) na Prevenção de Incêndios Florestais: Estudo de Caso no Parque Nacional da Serra da Canastra. Bambui, 2020. 138f.; il.; color
FIRMS. Fire Information for Resource Management System. NASA. Earth Data: HYPERLINK "https://firms.modaps.eosdis.nasa.gov/" https://firms.modaps.eosdis.nasa.gov/Acesso em 05 de fevereiro de 2019.

GIGOVIĆ, L. et al. GIS multi-criteriaanalysis for identifyingand mapping forestfirehazard: Nevesinje, Bosniaand Herzegovina. TehničkiVjesnik, [s. l.], v. 25, n. 3, p. 891-897, 2018.

IBAMA. (2007). Plano Operativo de Prevenção e Combate aos Incêndios Florestais do Parque Nacional da Serra da Canastra. São Roque de Minas - MG.

ICMBIO. (2019 e 2020). Instituto Chico Mendes de Conservação da Biodiversidade. Ministério do Meio Ambiente. Escritório Administrativo. Informações. Parque Nacional da Serra da Canastra. São Roque de Minas.

INMET. Instituto Nacional de Meteorologia. Ministério da Agricultura, Pecuária e Abastecimento. HYPERLINK "http://www.inmet.gov.br/portal/ Acesso em 15 de outubro de 2019.

INMET. Instituto Nacional de Meteorologia. Ministério da Agricultura, Pecuária e Abastecimento. Prognóstico Climático da Primavera. 15/03/2019. Hyperlink "http://www.inmet.gov.br/portal/index.php?r=noticia/visualizarNoticia&id=137".
Acesso em 10 de outubro de 2019.

JUSTINO, F. B; PELTIER, W. R. & BARBOSA, H. A. (2010) Atmospheric susceptibility to wildfire occurrence during the Last Glacial Maximum and mid-Holocene. Palaeogeography, Palaeoclimatology, Palaeoecology. Elsevier. p. 76 -88, (2010)

JUSTINO, F.; de MELO, A. S.; SETZER, A.; SISMANOGLU, R.; SEDIYAMA, G. C.; (julho de 2009). Greenhouse gas induced changes in the fire risk in Brazil in ECHAM5/MPI-OM coupled climate model. Climatic Change. p.106-285.

JUSTINO, F.; STORDAL, F.; CLEMENT, A.; COPPOLA, E.; SETZER, A.; & BRUMATTI, D. Modelling Weather and Climate Related Fire Risk in Africa. American. Journal of Climate Change. v. 2, p. 209-224, (2013).

LACERDA, H. C. et al. Susceptibilitytowildfire in a conservationunitlocated in thetransitionregionof Cerrado andAtlantic Forest Biomes, Brazil. Ci. Fl., Santa Maria, v. 32, n. 1, p. 451-473, Jan./Mar. 2022.

MMA. Ministério do Meio Ambiente. (21 de novembro de 2018). Número de incêndios florestais é o menor em 20 anos. Disponível em https://www.mma.gov.br/informma/item/15252-n%C3%BAmero-de-inc%C3%AAndios-florestais-%C3%A9-o-menor-em-20-anos.htmlAcesso em 12 de outubro de 2019.

MESSIAS, C. G., & FERREIRA, M. C. Mapeamento Temporo-Espacial das Queimadas no Parque Nacional da Serra da Canastra e suas Relações com a Zona de Planejamento. I Congresso Nacional de Geografia Física. Instituto de Geociências Unicamp.Campinas. 2017b. 15 p.

MESSIAS, C. G., & FERREIRA, M. C. Análise da distribuição espacial das queimadas no Parque Nacional da Serra da Canastra (MG), entre 1984 e 2017. Caminhos da Geografia. v. 20. n. 71. Uberlândia – MG. Setembro/2019. p. 52-71. MMA. (02 de 03 de 2019). Fonte: Ministério do Meio Ambiente: http://www.mma.gov.br/informma/itemlist/category/34-unidades-de-conservacao Acesso em 12 de outubro de 2019.

SETZER, A.; SISMANOGLU, R. A. Queimadas no Brasil. Climanálise Boletim de Monitoramento e Análise Climática, v. 7, n. 8, p. 40-53, 2002.

SILVA, A. S. da. (2019) Aplicação do Risco Potencial de Fogo da Vegetação em Escala Global. (Tese de doutorado). Viçosa – MG, 2019.

SILVA, I. *et al*. (2016) Estimativa de Risco e Perigo de Incêndios Florestais Utilizando Subconjuntos Fuzzy, k-NN Fuzzy e SubtractiveClustering. Quarto Congresso Brasileiro de Sistemas Fuzzy (IV CBSF). Novembro de 2016. Campinas. 12 p.

SILVA, P., & BERNARDES, A. (20 de março de 2019). Unidade de Conservação: Analise da Fragilidade Ambiental. Fonte: Instituto de Geografia da Universidade Federal de Uberlândia: http://observatoriogeograficoamericalatina.org.mx/egal12/Procesosambientales/Usoderecursos/01.pdf

TATLI, H., & TÜRKEŞ, M. (2014) Climatological evaluation of haines forest fire weather index over the Mediterranean Basin. Meteorological Applications, 21(3), 545–552. (2014).