

Spatial Distribution of Hot Spots in the “Chapada dos Guimarães” National Park, Mato Grosso State, Brazil, from 2005 to 2014

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Abstract

Forest fires affect large areas around the world and Brazil is not an exception. Conservation Units, including National Parks, despite the restrictions regarding their use and occupation, are also affected by wildfires, compromising important areas in terms of environment conservation. This research was carried out in the “Chapada dos Guimarães” National Park, located in the Mato Grosso State, Brazil. The objective of the research was to analyze the hot spots spatial distribution using the Kernel density estimator and check the accuracy of forest fire detection through the AQUA satellite, in the period 2005 to 2014. Results showed that in the analyzed period 89 fires were recorded, burning a total area of 23,737.76 ha, corresponding to 72.75 % of the Park surface. The months which presented the highest number of occurrences were July (9 %), August (28.09 %) and September (38.20 %). A total of 440 focuses of heat, or hot spots, were detected. The Kernel estimator showed a high density of hot spots within the park in the years of highest fire occurrences. There was a good approximation of the Kernel estimator and the burned areas affected by the fires, imaged by the Landsat satellite. The Ripley K function rejected the complete randomness spatial distribution, indicating that the hot spots were distributed in an aggregate pattern during the 10 years temporal series, corroborating with the Kernel estimator. The AQUA satellite detected 16 of the 89 detected fires, showing an accuracy of only 18 %. Concluding, the Kernel estimator detected a high intensity of hot spots within and in the borders of the Park, the Ripley K function rejected the hypothesis of complete spatial randomness, and the AQUA satellite was a poor detector of wildfires in real time.

Keywords: Wildfire detection, conservation units, hot spots

Introduction

Forest fires affect large areas around the world and Brazil is not an exception. Conservation Units, including National Parks, despite the restrictions regarding their use and occupation, are also affected by wildfires, compromising important areas in terms of environment conservation. In Brazil, the main forest companies have efficient systems of fire control. However, most of the Conservation Units don't have any structure to prevent or fight wildfires due to the lack of financial and human resources.

The "Chapada dos Guimarães" National Park is periodically affected by wildfires, due to the local climate, with a severe dry season, the vegetation type (savanna), and the surround development areas. Besides that, the Park doesn't have any detection system, what would help to start the combat as earlier as possible. According to the Park managers since 1992 several fires have been recorded, affecting large areas of the Unit.

Satellites images, if not for real time detection, could help fire control programs indicating the most affected sites and the wildfires origins. However, this tool has not been used in this, as well as, in the majority of the Brazilian Conservation Units.

The objective of the research was to analyze the hot spots spatial distribution and check the accuracy of forest fire detection through the AQUA satellite, in the period 2005 to 2014.

Methods

This research was carried out in the "Chapada dos Guimarães" National Park (Figure 1), located in savanna region of the Mato Grosso State, Brazil, with an area of 327.70 km², between the coordinates 15°13'30" to 15°28'45"S and 55°47'20" to 55°58'40"W. Altitude ranges from 300 to 800 m above sea level in the lower and higher sites, respectively.

The climate, according Koppen's classification, is Aw in the lower site, with mean temperature of 25 °C and precipitation of 1300 to 1600 mm, and Cw in the higher sites, with mean temperature of 21.5 °C and precipitation of 2100 mm. The rainy season extends from October to March and the dry season from April to September, with relative humidity of 80 and 30 %, respectively. In August 1991 the relative humidity reached the lowest value ever recorded, 12.9 % [1].

The fire occurrence records were furnished by the Park administration, the shape file archives were obtained from the cartographic basis of the Brazilian Institute of Geography and Statistics (IBGE), and the satellites data were provided by the National Institute of Spatial Research (INPE).



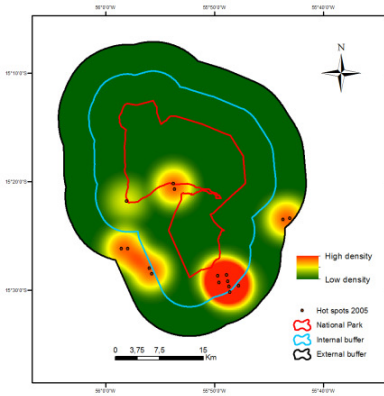
Figure 1. Partial view of the “Chapada dos Guimarães” National Park.

The hot spot distribution pattern was analyzed using the Kernel density estimator and the Ripley K function. The Kernel density estimator is part of the Spatial Analyst extension, included in the ArcGis 9.3 software [2]. It draws a circular neighborhood around each sample point, corresponding to the influence radius. Based on the Kernel's density, hot spots maps were created for each year of the analyzed period. The Ripley's K function tested the hypothesis of complete randomness spatial distribution, where the possibility of an aggregate, aleatory, or regular distribution is investigated. The Ripley's K function was calculated using the Spatstat software [3]. The statistical analyses were processed by Anderson Pedro Batista.

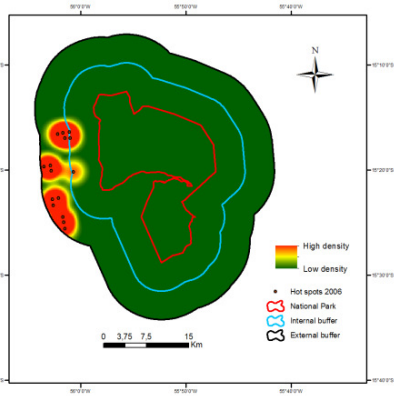
Results and Discussion

Results showed that in the analyzed period 89 fires were recorded, burning a total area of 23,737.76 ha, corresponding to 72.75 % of the Park surface. The months which presented the highest number of occurrences were July (9 %), August (28.09 %) and September (38.20 %).

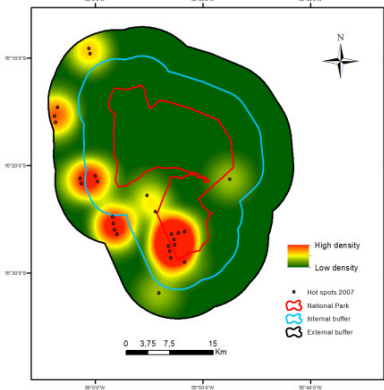
A total of 440 focuses of heat, or hot spots, were detected in the analyzed period. The Kernel estimator showed a high density of hot spots within the park in the years of highest fire occurrences (Figures 2 and 3). The Kernel density maps showed that the high density class, represented by the red color, presented a strong incidence within the Park in the years 2007, 2010, and 2012 (Figure 2), due to the higher fire occurrences in that years. In the years 2005 and 2013, the densities were media, represented by the orange color. The lower hot spots densities were observed in the years 2006, 2008, 2009, 2011, and 2014, where the fires didn't exceeded 1,000 ha in extension. It was observed that the sites which presented the higher density of heat focuses also presented the biggest fires. There was a good approximation of the Kernel estimator and the burned areas affected by the fires, imaged by the Landsat satellite.



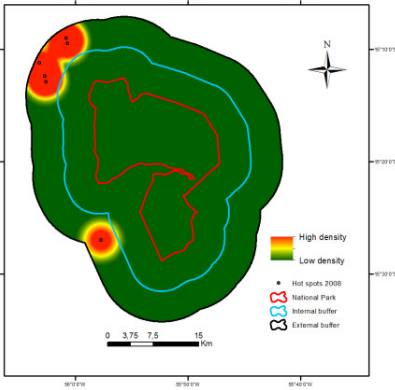
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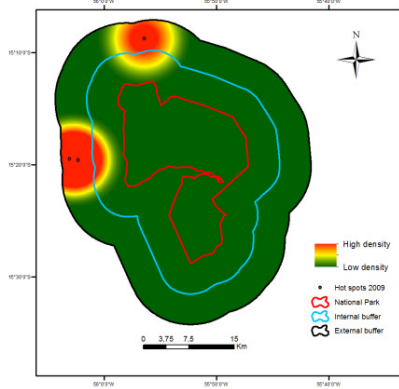
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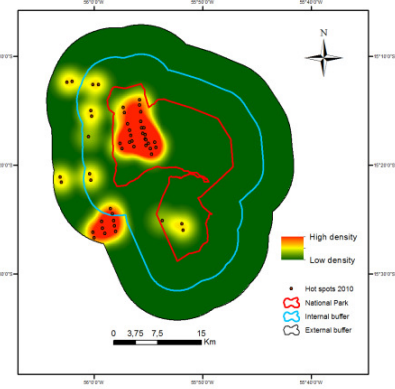
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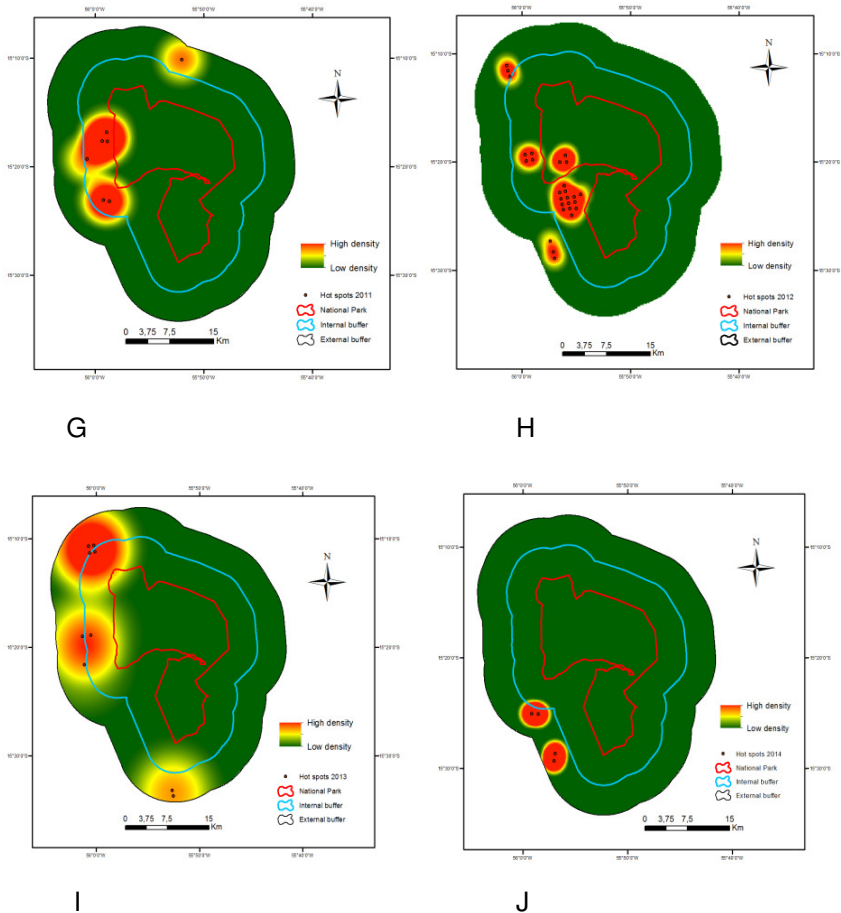


Figure 2. Kernel density map of the hot spots detected in the “Chapada dos Guimarães” National Park from 2005 to 2014 : (A) 2005; (B) 2006; (C) 2007; (D) 2008; (E) 2009; (F) 2010; (G) 2011; (H) 2012; (I) 2013; (J) 2014.

The Ripley K function rejected the complete randomness spatial distribution, indicating that the hot spots were distributed in an agregate pattern during the 10 years temporal series, corroborating with the Kernel estimator.

According to Câmara *et al* [4] A spatial distribution that differs from aleatority deserves a minutious analisys. Therefore, the research results suggests a deeper investigation that would explain the hot spots grouping in the Park. That would subside the fire control management program, inside and around the Park.

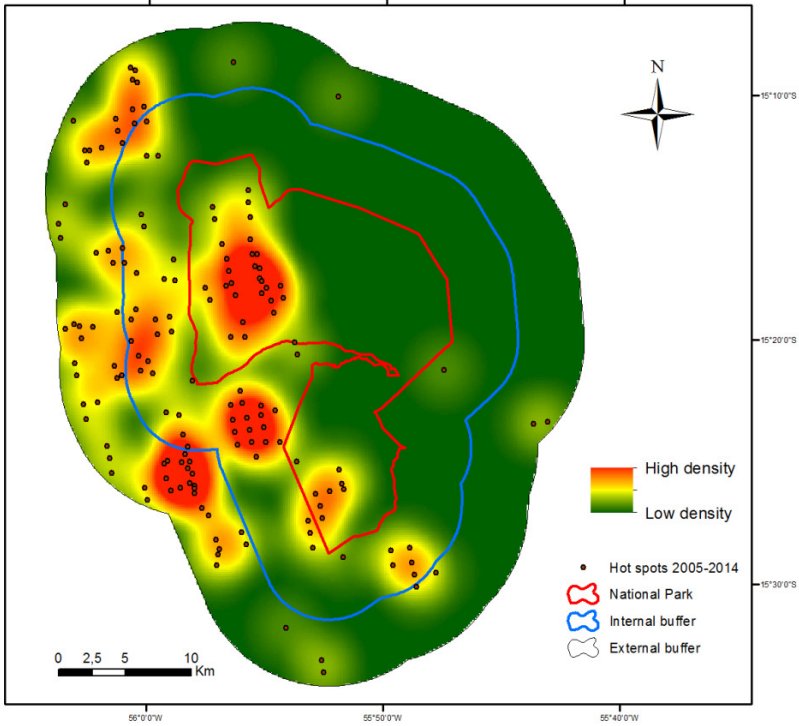


Figure 3. Kernel density map of the hot spots detected in the “Chapada dos Guimarães” National Park from 2005 to 2014.

The AQUA satellite was able to detect only 16 of the 89 recorded fires in real time in the analyzed period (Table 1), showing an accuracy of only 18 %, with an omission error of 82 %.

Cardoso *et al* [5] and Pantoja *et al* [6], working with data from the AVHRR and MODIS satellites in the Amazon region also reported the low efficiency of satellites to detect wildfires in real time.

Table 1. Recorded and detected fires by ACQUA satellite in the in the period 2005-2014.

Fires \ Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Recorded	12	17	19	6	10	8	1	6	4	6	89
Detected	0	3	10	0	0	3	0	0	0	0	16
No detected	12	14	9	6	10	5	1	6	4	6	73
Detected (%)	0	18	53	0	0	37	0	0	0	0	18

Conclusions

The Kernel estimator detected a high intensity of hot spots within and in the borders of the Park;

The Ripley K function rejected the hypothesis of complete spatial randomness;

The hot spots always appeared in grouping arrangements, i.e., not randomly distributed along the Park surface;

The AQUA satellite was a poor detector of wildfires in real time, with an accuracy of only 18%.

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