

Article

Criminological Analysis of Green Delicts in the Federal District of Brazil

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ABSTRACT

Green criminology studies transgressions that cause damage to the natural environment. Spatial approaches deal with incidental conditions of every sort of crime, and they are particularly appropriate to unveil rational components of criminal activities. In the Brazilian scenario, previous studies have pointed to the need for law enforcement and further studies on green criminology. This work aimed to unveil spatial patterns of environmental crimes in the Federal District of Brazil (FDB) and their possible causes. Records of environmental crimes from 2009 to 2016 registered by the local police were subject to spatial statistics, and results showed that most occurred in urban areas. Brasília City and its surrounding counties, farms, legally protected areas, and natural habitats create a mosaic of land uses that have influenced the spatial distribution of environmental crimes recorded by the local police. Over the years, crimes have occurred repeatedly in similar areas, suggesting sensitive places for their commitment. Still, those areas were not restricted to the neighborhood boundaries, and the homogeneity among contiguous neighborhoods supported similar levels of disorder. The proximity of these places to legally protected areas, the permeability phenomenon, and some types of land use have been identified as possible explanations for those crime records.

Keywords: environmental crime, hotspot analysis, green criminology.

RESUMO

A criminologia verde estuda as transgressões que causam danos ao meio ambiente. As abordagens espaciais lidam com as condições incidentais de todo tipo de crime e são particularmente apropriadas para desvendar componentes racionais das atividades criminosas. No cenário brasileiro, estudos anteriores apontaram para a necessidade de aplicação da lei e mais estudos sobre criminologia verde. Este trabalho teve como objetivo desvelar padrões espaciais de crimes ambientais no Distrito Federal do Brasil (FDB) e suas possíveis causas. Os crimes ambientais de 2009 a 2016 registrados pela polícia local foram submetidos à estatística espacial e os resultados mostraram que a maioria deles ocorreu em áreas urbanas. A cidade de Brasília e suas regiões circunvizinhas, fazendas, áreas legalmente protegidas e habitats naturais formam um mosaico de usos do solo que tem influenciado a distribuição espacial dos crimes ambientais registrados pela polícia local. Ao longo dos anos, crimes têm ocorrido repetidamente em áreas semelhantes, sugerindo locais sensíveis para o cometimento deles. Ainda assim, essas áreas não ficaram restritas aos limites dos bairros e a homogeneidade entre bairros contíguos sustentou níveis semelhantes de desordem. A proximidade desses locais com áreas legalmente protegidas, os fenômenos de permeabilidade e alguns tipos de uso do solo foram identificados como possíveis explicações para esses registros de crimes.

Palavras-chave: crimes ambientais, análise hotspot, criminologia verde.



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Introduction

Environmental crimes emerge from complex processes made of objective and subjective elements as material and social factors (White 2008). The term green criminology was created by Lynch in 1990 and it is currently used to describe studies focused on harms, transgressions, and crimes that cause damage to the natural environment and impacts on human racial diversity and nonhuman species. Environmental criminology, on the other hand, refers to spatial and temporal analysis of crimes (White 2008).

Spatial approaches deal with incidental conditions of every sort of crime, and they are particularly appropriate to unveil rational components of criminal activities and endorse theories on crime opportunities (Beato 1998). Spatial approaches also support police and other institutions that deal with crimes and their prevention by placing the offender among the various elements of a crime event (Wortley and Mazerolle 2008).

Spatial statistics can be useful for crime prevention, from single descriptive statistics based on pie charts, histograms, and quantitative aspects of data to the most complex time-space scale analysis (Harries 1999). Methods of spatial analysis differ from conventional statistical models because they consider the spatial effects of the hypothesis. The first expected effect is the spatial dependence or the spatial autocorrelation given by the interaction of agents in space. The second effect would be spatial heterogeneity, which allows the identification of areas and groups with higher risks of suffering crimes (Anselin 2003; Anselin et al. 2000).

Identifying critical areas of criminal activity is an important factor in the spatial analysis of crimes. These areas can form either clusters or hotspots of criminal activity (Ratcliffe 2003; Eck et al. 2005). Clusters are broadly defined as events unusually aggregated in randomly distributed data. When a threshold is defined, and any area of the map reaches criminal levels above or below this threshold, it is considered a cluster. A hotspot is a particular type of cluster formed on points of excessive levels of crimes on the map. Finally, coldspots are formed on spots of below-average crime levels (Lawson 2010).

In contrast to orthodox criminological literature, much of the green criminological literature neglects quantitative research methods, which significantly contributes to the marginalization of green criminology within the discipline of criminology (Lynch et al. 2017). Spatial analysis in green criminology has focused on the spatial distribution of hazards and other land uses that negatively affect human health. Still, experts have discussed the appropriate geographic units of analysis and the proper environmental hazards to be considered as dependent variables. Environmental inequities cluster spatially according to social and racial geographically distributed logic (Zilney, McGurrin, and Zahran 2006).

The environmental scenario in Brazil is similar since the Brazilian economy has long been based on the exploitation of natural resources, and the criminalization of environmental damages has been a relatively new issue in the country. Law Nr 9,605/1998 categorizes crimes against nature in Brazil, and it is applied when civil and administrative instances of liability are no longer sufficient to restrain harmful behaviors against the environment (Brasil 1998).

There are few studies on environmental crimes in Brazil since it is a new subject in the country. One of these studies has assessed crimes against nature in the Federal District of Brazil (FDB), pointing to the need for law enforcement and further studies on green criminology (Ribeiro 2017). Therefore, this work aimed to evaluate the spatial patterns of environmental crimes in the FDB to possibly unveil their causes based on the most popular criminological theories. Such results may provide a broader view of the subject to local managers and policymakers.

The study was conducted in the Federal District of Brazil (FDB), which ranges through 5,802 km² in the central region of Brazil and within the Cerrado neotropical savanna, the largest bioma hotspot in the Western Hemisphere (Sawyer et al. 2017). The Cerrado harbors 3.3% of the world's plant species and 4.6% of the world's vertebrate species (Myers et al. 2000). It borders four biomes (Amazon, Caatinga, Atlantic Forest, and



Pantanal) out of Brazil's six biomes (plus Pampas and Cerrado). It plays a key role in protecting biodiversity and natural resources. Still, the headwaters of three of South America's major river basins are within the Cerrado biome (Amazon/ Tocantins Rivers, São Francisco River, and Plata River), which supply 40% of Brazil's freshwater (Sawyer et al. 2017; WWF - World Wide Fund for Nature 2020).

The FDB shelters parks, reserves, research stations, natural heritage, and some other categories that altogether are called Conservation Units - UCs (Brasil 2000; Distrito Federal 2010; IBRAM - Instituto do Meio Ambiente e dos Recursos Hídricos do Distrito Federal 2014). Ecosystems are kept free from human interference in UCs where natural heritage protection is the main goal. Visitors and human activities are allowed in some other UC categories to practice and encourage sustainable development (Brasil 2000; Corrêa and Abreu 2014). Conservation Units (UCs) cover 92% of FDB territory, and rules on their use are commonly more restrictive in UCs than elsewhere in FDB (IBRAM - Instituto do Meio Ambiente e dos Recursos Hídricos do Distrito Federal 2014). Due to the extension covered by UCs and their more restrictive rules of use, we hypothesized that crimes against nature preferentially cluster within Conservation Units.

The Federal District of Brazil (FDB) was divided into 31 counties composed of urban areas and respective countryside around towns until 2019. Environmental crimes are subject to investigation by local police, and data recorded between 2009 and 2016 were organized on tables and grouped into five categories according to Law Nr 9,605/1998 (Brasil 1998), namely: (1) crimes against fauna, (2) crimes against flora, (3) crimes against urban planning and cultural heritage, (4) pollution, and (5) crimes against Conservation Units – UCs, which are legally protected areas. All categories of crimes (e.g., fauna, flora, pollution) can occur in urbanized areas and within UCs.

To check the spatial randomness of environmental crimes, we run neighborhood proximity statistical analyses to check the presence of clusters and hotspots of criminal events. Most approaches that aim to test crime grouping depart from the null hypothesis that crimes are randomly spatially distributed (Eck et al. 2005). Spatial statistics were performed using the ArcGIS® software.

We identified clusters by using the Optimized Hotspot Analysis tool based on Getis-Ord G_i^* statistics, which adopt the average and median neighborhood proximity calculations to verify incident data aggregation and identify an appropriate scale of analysis according to the input features and aggregates points in fishnet polygons (Getis and Ord 1992; Ord and Getis 1995). The polygon grid is positioned over the points of crime locations, and points on each polygon cell are counted for the analysis. When a polygonal cell does not retain any incidence point, null cells are removed and the remaining cells are analyzed (ESRI 2011).¹

The findings: Are environmental crimes random?

The Federal District of Brazil (FDB) police recorded 4,787 environmental crimes between 2009 and 2016, from which 3,045 records were geo-referenced under SIRGAS 2000 coordinate system. The number of records on pollution events and crimes against flora was insufficient for applying the neighborhood proximity statistical analysis as it requires at least sixty observations (Table 1). Three categories of crimes presented enough records to be separately analyzed: crimes against Conservation Units (UC), crimes against fauna, and crimes against urban planning and cultural heritage (Table 1).

¹ For more details about Optimized Hot Spot Analysis, please access <https://pro.arcgis.com/en/pro-app/latest/tool-reference/spatial-statistics/optimized-hot-spot-analysis.htm>



The majority of these 3,045 records were randomly distributed in the Federal District of Brazil (FDB) territory between 2009 and 2016, and there were few significant clusters of environmental crimes as a result. Of the total geo-referenced records, 2,059 were randomly distributed across the territory without forming statistically significant clusters (Andresen 2011) (Table 2).

Table 1. Crime records with geographic coordinates available for cluster analysis, according to the year and criminal type defined in Law No. 9,605 /98.

Description	2009	2010	2011	2012	2013	2014	2015	2016	TOTAL
*UC	129	136	151	108	135	69	122	144	994
FAUNA	50	88	153	104	106	84	119	187	891
FLORA	6	10	6	4	7	4	4	8	49
POLLUTION	-	-	2	1	-	1	-	-	4
URBAN	223	142	167	150	97	78	101	149	1107
TOTAL	408	376	479	367	345	236	346	488	3045

* Conservation units

Source: Polícia Civil do Distrito Federal/ Departamento de Gestão da Informação/ Divisão de Apoio Técnico e Estratégico/ Seção de Estatística Criminal/ Prot. 352039/16-DGDOC/SPCD (2016). Note: data compiled by autor.:

Table 2. Results description of the cluster analysis for crimes of harm to Conservation Units (UCs), crimes against fauna and urban planning and cultural heritage. The G_i^* score reflects the density or dispersion in a grouping of records. A Score of Zero means that the results were not significant. Negative scores represent coldspot cells, and positive scores represent hotspot cells. "Cells count" refers to the number of cells generated by the fishnet polygon in the analysis of each type of crime and "Crimes sum" refers to the total number of crimes counted in cells of each classification.

G_i^*	Harm to Conservation Units				Crimes against fauna				Crimes against urban planning			
	Cells count		Crimes sum		Cells count		Crimes sum		Cells count		Crimes sum	
-3	25	7.9%	53	5.3%		-		-		-		-
-2	36	11.4%	75	7.5%		-		-		-		-
-1	21	6.6%	47	4.7%	15	5.2%	23	2.6%		-		-
0	165	52.2%	520	52.3%	223	76.9%	619	69.5%	277	93.6%	920	83.1%
1	13	4.1%	62	6.2%	11	3.8%	48	5.4%		-		-
2	26	8.2%	110	11.1%	11	3.8%	34	3.8%		-		-
3	30	9.5%	127	12.8%	30	10.3%	167	18.7%	19	6.4%	187	16.9%
Total	316		994		290		891		296		1107	

Source: ArcGIS® 10.3. Note: data compiled by autor.

Crimes according to year

When we analyzed the incidence of crimes according to the year, clusters appeared in 2009, 2011, 2012, and 2016 (Figure 1). According to the following analysis, 2009, 2011 and 2012 strongly contributed to forming crimes against urban planning and cultural heritage hotspots in Sobradinho and Sobradinho II counties in the central-northern Federal District of Brazil (FDB).

In 2009, each polygon grid cell appropriated to the scale of analysis calculated according to the adopted methodology had an area of 2.7km². Santa Maria and Gama counties on the southwestern border of FDB registered more crimes than the rest of the entire territory (Figure 1, 2009). Such a hotspot spread through



urban areas, rural areas, and UCs. Another hotspot appeared in the central-northern part of FDB, in the Sobradinho and Sobradinho II counties.

Data from 2011 formed unitary area polygon cells of 1.9 km². A hotspot was again formed over the same Sobradinho and Sobradinho II counties like in 2009 (Figure 1, 2011). Another hotspot was located downstream of Paranoá Lake. Hotspots in Sobradinho and Sobradinho II counties are located in urban zones, and the cluster next to Paranoá Lake is surrounded by three urban parks. According to Ribeiro (2017), 2011 was the year with the highest absolute number of records of environmental crimes in FDB for reasons that could not be identified.

Another hotspot was once more identified over Sobradinho/Sobradinho II counties in 2012, suggesting a sensitive area for the occurrence of environmental crimes (Figure 1, 2012). Each generated polygon cell has an area of 2.6 km². The configuration of this urban area seems to affect crime levels, corroborating Brantingham and Brantingham's (1993) work on Crime Pattern Theory, which suggests that offenders were more likely to target areas close to where they live.

In 2016, the polygon grid cells of 2.7 km² formed a large cluster contemplating Ceilândia, Taguatinga, and Samambaia counties close to two UCs on the southwestern FDB (Figure 1, 2016). We believe this cluster was influenced by crimes against UCs and crimes against fauna, in which 20.9% of records were concentrated in these three counties in 2016. The proximity of these counties to the UCs that share boundaries with them may be favoring the occurrence of environmental crimes. Offenders living in those counties may enter the UCs to commit crimes by hunting, poaching, and logging.

Analyzing the areas of disorder in Amsterdam, Steenbeek and Kreis (2015) have identified that levels of disorder were not restricted to the neighborhood boundaries but often transcend the administrative areas under analysis. Homogeneity among contiguous neighborhoods supports similar levels of disorder as observed in areas over southwest and central-north counties in BFD.

Still, studies of criminal location choice suggest that offender's behavior is based on the evaluation of 'rewards', 'risks' and 'efforts' associated with criminal opportunity and satisfaction of their needs employing minimal effort (Johnson and Bowers 2004; Cornish and Clarke 2008; Bernasco and Nieuwbeerta 2005), although 'greater rewards typically require corresponding levels of risk' (Townesley et al. 2016).

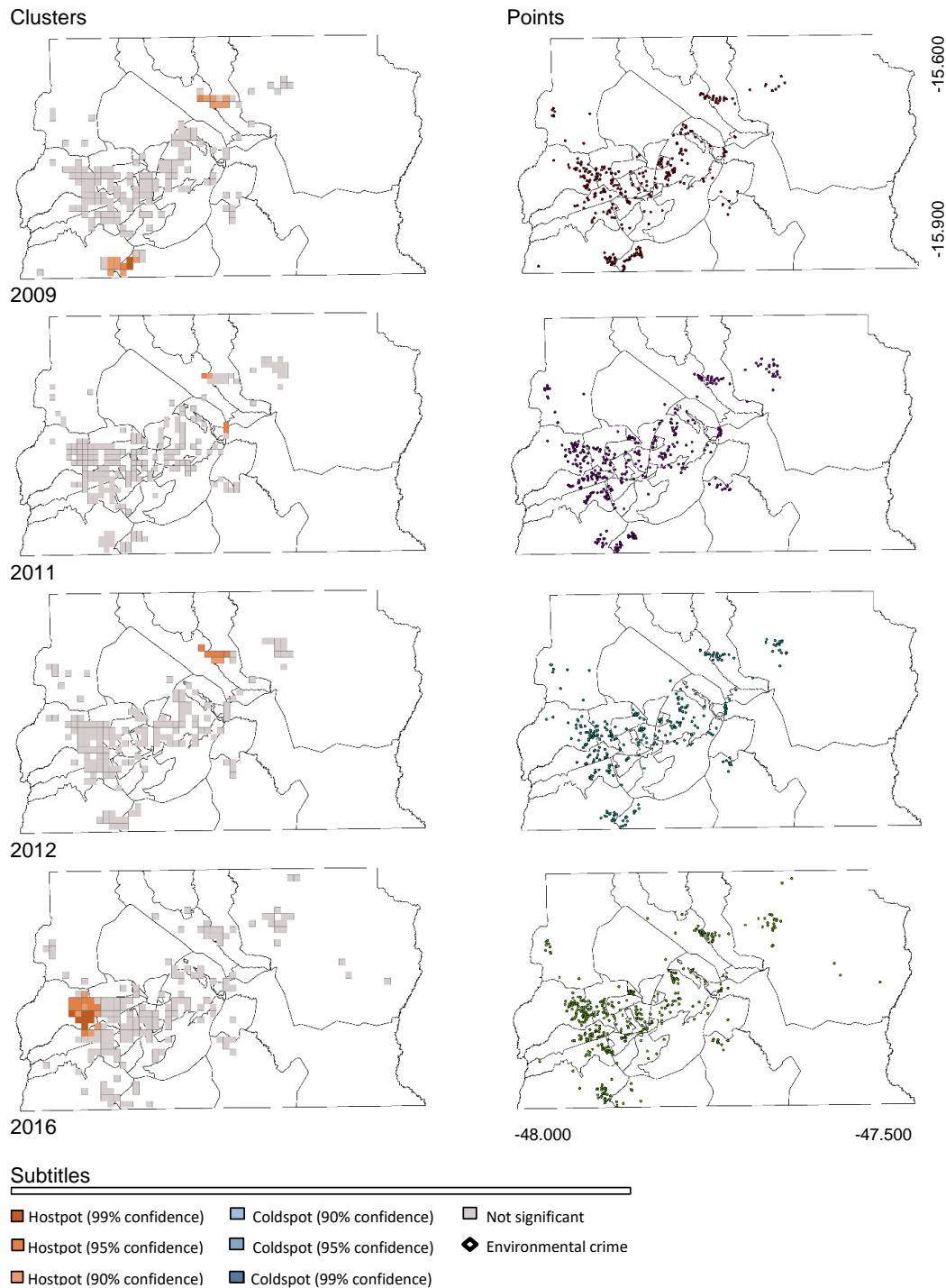


Figure 1: Significant clusters of environmental crimes detected from 2009 to 2016 over Federal District of Brazil territory are shown on the left column. Points with local crimes registered are shown on the right column. No significant clusters were detected in 2010, and from 2013 to 2015. It is possible to realize that crimes occur over similar areas, notoriously urban areas with higher concentration of inhabitants.² Source: ArcGIS® 10.3. Note: data compiled by autor.

² Cluster charts are built with friendly daltonian color palette.

Crime categories

The Federal District of Brazil (FDB) presents 92% of its territory protected within Conservation Units – UCs and the spatial analysis unveiled many clusters of crimes against UCs, being some of them hotspots and others coldspots (Figure 2). The unitary area of each polygon grid cell has 1.5 km². We could identify crime hotspots in a highly urbanized area in Taguatinga, Ceilândia, Samambaia, and Recanto das Emas counties on the southwestern FDB and crime coldspots in Brasília city and some neighbor counties.

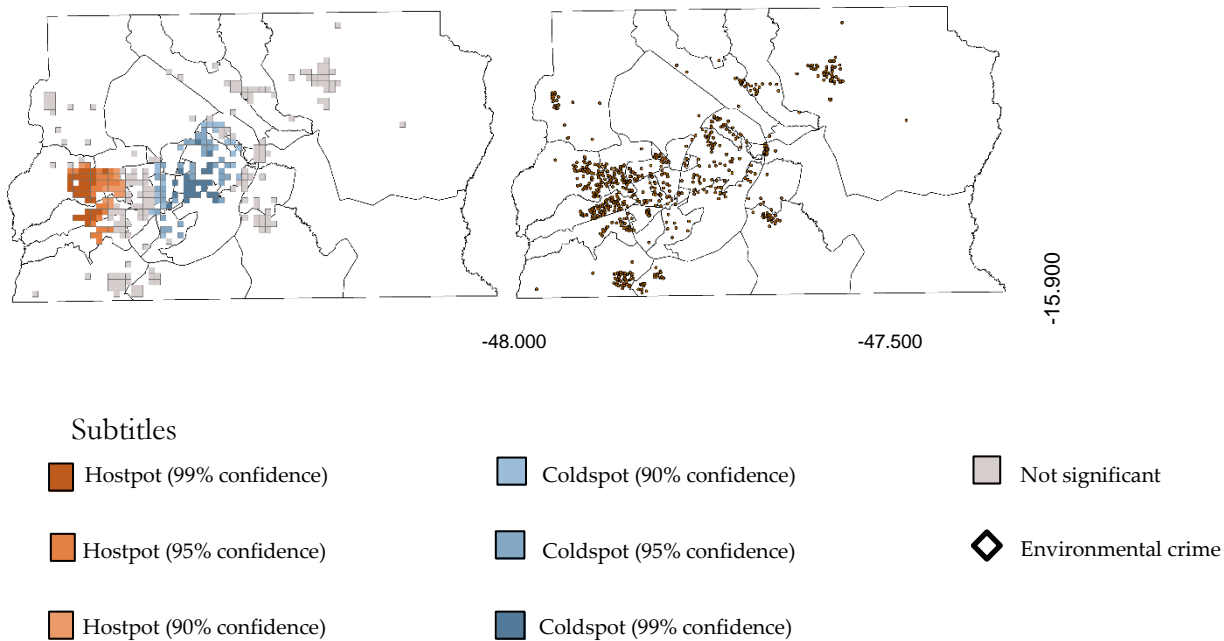


Figure 2. Significant clusters of crimes against Conservation Units over Federal District of Brazil territory are shown at the first map; points with local crimes registered are shown at the second one. No significant clusters were detected for crimes against flora and pollution. It is possible to realize that crimes occur over similar areas, notoriously urban areas with higher concentrations of inhabitants. Source: ArcGIS® 10.3. Note: data compiled by autor.

Some discontinuities between hotspots of crimes against UCs may be attributed to the existence of rural areas between Samambaia and Recanto das Emas counties and UCs between Taguatinga and Ceilândia counties, which are the most populated areas in the FDB (Figure 2). Since UCs are entrapped between these two densely populated areas, it is possible that the gaps in the hotspot zone were a result of sub-notification of crimes as it was identified in studies about homicide, crimes of sexual assault, and theft in Brazil (Soares 2008; Musumeci 2007). Sometimes, there is a difference between the actual number of crimes and the recorded number of crimes, called a dark figure of crime, which impacts on crime statistics and planning against it (Biderman and Reiss 1967; Skogan 1977).

Crimes against UCs registered in areas that aim to protect four major local river basins correspond to 41.8% of the total number of registers. Inhabitants and human activities are allowed in these UCs, and in UCs where they are not, only two crimes were registered over the same period. Once the visibility of social and physical disorder depends on the presence of an observer to denounce it, crimes that occur in areas of low population density may not be notified to local police (Steenbeek and Kreis 2015).

Another explanation for such a discontinuity may be caused by a phenomenon called permeability by Groff et al. (2014). It arises from land uses and urban network compositions, like streets, kinds of transportation, and



travel limits imposed by natural and manmade barriers that reduce permeability because high permeability favors movement from one to another locality (Groff et al. 2014).

There is conflicting evidence on how permeability links crimes and whether the degree of permeability should be considered criminogenic. Encounter theorists argued that highly permeable streets provide potential watchers, interveners, and informal social control, called natural policing (Hillier 2004). Enclosure theorists highlight that the design of buildings and communities can limit accessibility to legitimate users only (Newman 1996). Rural, urban, and suburban contexts may explain the divergences among results of studies and should be considered relevant in explanatory analysis (Cozens 2008). In the present study, low permeability caused by small rural areas and an UC established on a sloping terrain seemed to reduce crime records. It may show the influence of land use and natural topography on environmental crimes.

Crimes records against UCs in a group of counties over the central-southwestern axis of FDB, including Brasília, Guará, Lago Sul, Lago Norte, Park Way, Cruzeiro, Sudoeste, Candangolândia, and Núcleo Bandeirante counties were below the entire network average and they formed altogether a broad area of coldspot (Figure 2, Harm). This area has high-income and high-schooling populations (CODEPLAN - Companhia de Planejamento do Distrito Federal 2016). Income, age composition, marital status, and dwelling time were the most feasible predictors of crimes elsewhere on empirical analyses using routine activity theory (Cohen and Felson 1979; Kennedy and Forde 1990; Tseloni et al. 2002; Fisher 2003).

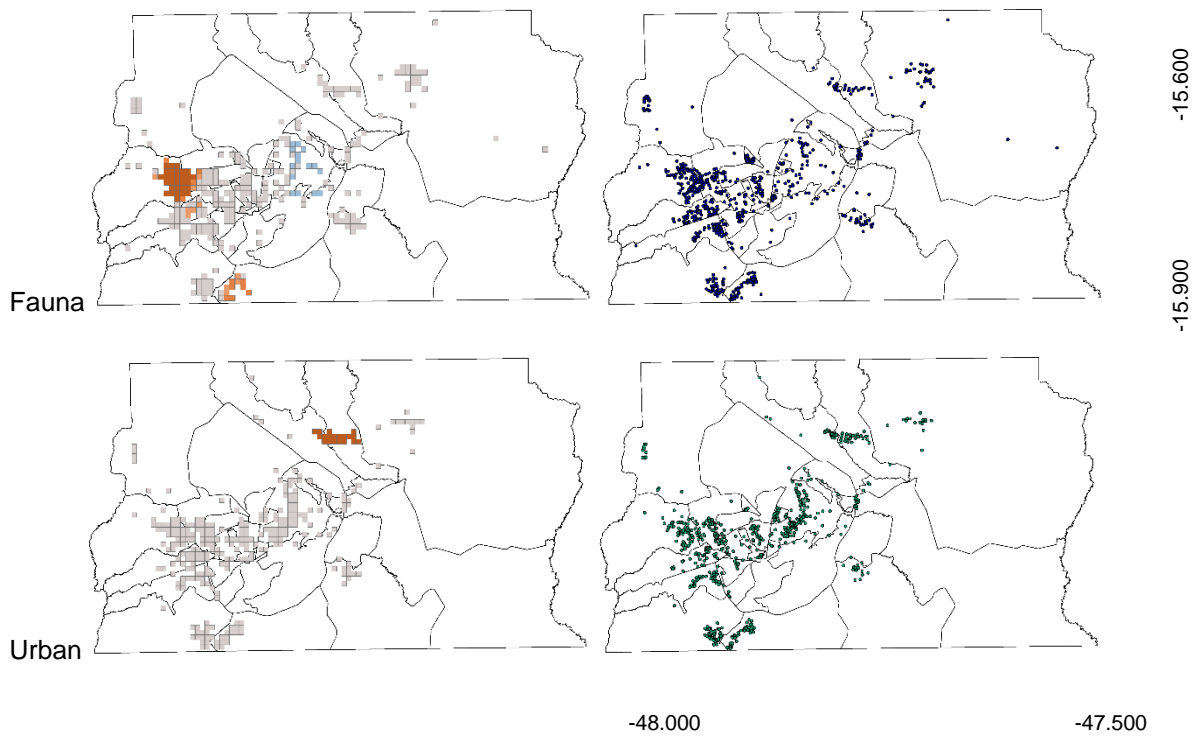
Economic and social predictors related to routine activity and social disorganization theory have influenced environmental crimes in the FDB (Ribeiro 2017; Ribeiro and Corrêa 2019). Average income, dwelling time, and age composition are predictors that reduce the number of crimes against UCs in the FDB (Ribeiro and Corrêa 2019). However, the same study has suggested that other predictors not evaluated in the same research may also influence the number of environmental crimes.

There are dense hotspots for crimes against fauna in two southwestern counties, namely Taguatinga and Ceilândia, in the vicinities of two major UCs, the Brasília National Forest and the Brasília National Park (Figure 3, Fauna). These polygon grid cells have 1.3 km² each one. Another hotspot of crimes against fauna was registered next to the Santa Maria county at the southwestern border of FDB, while it was observed a fauna coldspot in Brasília city and Lago Sul county both on the central part of FDB. This fauna coldspot occurred in urban areas.

Crimes against fauna described in Law Nr 9,605/1998 refer to the illegal trade of wildlife, animal mistreatment, and illegal fishing, but they were not categorized in our database (Brasil 1998). As a result, researchers dealing with wildlife trafficking face the lack of organized data that spoil studies on trafficking and its impacts on biota, making the prognosis even more complex (Hernandez and Carvalho 2006; Borges et al. 2006).

There is a dense hotspot of crimes against urban planning and cultural heritage over Sobradinho and Sobradinho II counties (Figure 3, Urban). These counties house the second-highest absolute number of this category of crimes in the BFD Ribeiro (2017), and 88.9% of records refer to graffiti. The polygon cells of this analysis have 1.1 km² each.

Crime patterns can be influenced by land use (Andresen 2011), since some types of land use have been identified as major attractors of certain kinds of crime when human activities are concentrated in time and space, offering opportunities for those crimes to happen (Kinney et al. 2008). In this case, the permeability phenomenon happens in a singular way (Groff et al. 2014). We have found a high permeability urban area predominantly compound of irregular residential agglomerations. The area is isolated by low permeability sloping terrains compound by rural areas and the most preserved Conservation Unit all along the north border of BDF. Such features have hampered access and confined the population to some specific sites.



Subtitles

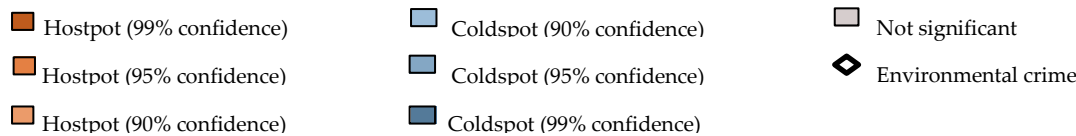


Figure 3. Significant clusters of crimes against fauna (above) and crimes against urban planning and cultural heritage (below) over Federal District of Brazil territory are shown on the left column. Points with local crimes registered are shown on the right column. It is possible to realize that crimes occur over similar areas, notoriously urban areas with higher concentration of inhabitants. Source: ArcGIS® 10.3. Note: data compiled by autor.

Conclusions

This study has identified twelve environmental crime clusters over the Federal District of Brazil (FDB) territory. These clusters were formed according to year and crime category.

The number of records on crimes against fauna, urban planning, cultural heritage, and Conservation Units areas were unevenly distributed through the territory as crime events were clustered in specific locations. There was also a temporal variation of environmental crime hotspots in the FDB. However, the number of records on crimes against flora and pollution was insufficient to allow their spatial analysis in the study area.

Clusters of different environmental crimes were frequently detected in the same area. Urbanized areas in the southwestern and central-northern have repeatedly registered hotspots, while the central area of FDB was a place of coldspots.

There were no clusters of crimes against UCs, although a couple of hotspots were detected nearby. In this sense, there has likely been a sub-notification of crimes against flora when they were committed in UCs.



Clusters have extrapolated county limits and were not faithful to local geographical boundaries. Land use homogeneity and crime opportunity context seems to have influenced the spatial distribution of environmental crimes recorded by the local police in FDB.

Most of the environmental crimes occurred in urban areas rather than in rural ones and UCs. Urban areas concentrate human activities and may have increased visibility of crimes and police control over densely inhabited locals compared to remote environments. The permeability phenomenon, tightly associated with land use, could provide solid answers to different environmental crime patterns analyzed in this study.

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