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Review Paper

ECOLOGY OF CRIME IN URBAN AND SUBURBAN AREA: SPATIAL PATTERNS OF CRIME IN THE CITY OF NIŠ (SERBIA)*

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Abstract. *The ecological theory of crime was first introduced into criminology by the Cartographic School of Criminology in the 19th century. Ecological theories of crime were further developed by the Chicago School of Criminology in the early 20th century. Contemporary ecological theories include routine activity theory, crime pattern theory, and rational choice theory. The impact of the ecological perspective in scientific research of crime is noticeable in today's studies too. Modern scientists, researchers, and practitioners study crime by using the geographic information system, statistical and geostatistical methods, and crime mapping. The empirical research on the spatial patterns and concentration of crime in the City of Nis, Republic of Serbia, was conducted on the research sample of property crimes and violent crimes committed in the years 2008, 2013 and 2018. All the cases were geocoded into spatial units which represent urban and suburban areas in the territory of the City of Niš. Descriptive statistics was used to identify the urban areas with the highest crime rate. Andersen's Spatial Point Pattern Test (SPPT) was used to check the research hypothesis that the spatial patterns of crime are stable over time. This hypothesis has not been confirmed as the findings show that criminal activity demonstrates a trend of moving away from the central city zones towards the urban (residential) areas and suburban settlements. The results of this empirical research are of scientific and practical value. This spatial analysis of crime is among the first analysis of this kind in Serbia and the Balkans, and it was the very first time in the region that such analysis involved the application of the Spatial Point Pattern Test (SPPT). The research results maybe useful when creating security strategies and crime prevention policies by the police, decision-makers, and other stakeholders.*

Key words: *crime concentration, property crime, violent crime, Spatial Point Pattern Test (SPPT), urban and suburban areas, Niš, Serbia*

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1. INTRODUCTION

Crime has been studied by scientists from the beginnings of modern criminology. The first criminological theories were developed by the *Classical School of Criminology* in the 18th century and then by *the Positivist School of Criminology* in the 19th century. Different criminological theories use biological, psychological or sociological concepts to explain the phenomenology and etiology of crime. *The ecological theories of crime* have a significant place among the criminological theories dealing with the nature and causes of crime, and the social reaction to the occurrence of crime. Their development dates back to the emergence of the *Cartographic School of Criminology* in the 19th century, when Adolphe Quetelet and Andre-Michel Guerry, the two founders of criminal statistics, laid down the factual grounds for the development of positivist learning.[1] They worked on the analysis of the first criminal statistics in France in the first half of the 19th century. They studied the impact of different natural, demographic and social factors on the commission of crime and, based on the attained results, developed the first crime maps in different regions and countries. These researches are considered to be the precursor of modern ecological theories of crime, and the insight into social causes of crime provided by the representatives of the Cartographic School paved the way for sociological theories of crime (Konstantinović-Vilić, Nikolić-Ristanović, Kostić, 2012:284-285).

The first socially-oriented theoretical study of criminology was embodied in the work of *the Chicago School of Criminology* in the early and mid-20th century. Clifford Shaw and Henry McKay studied the spatial distribution of antisocial behavior in Chicago. The authors search for explanation of crime and delinquency in the context of the changing urban environment and the ecological development of the city. Using the model developed by Ernest Burges, they identified city areas with high crime rates and observed several urban areas clearly divided into five concentric zones (spanning from the city center and the business zone to the residential zone) (Ignjatović, 2006: 185). Shaw developed the concept of social disorganization, which implies that the weakening of social control in the local community is caused by the weakening of traditional values and the mixing of cultures of different immigrant groups. Grounded in the ecological approach of the Chicago School, the geography of crime has long been based on social disorganization theory, which links the occurrence of crime to characteristics of residential communities and their residents (Vandeviver & Bernasco, 2017: 1).

On the other hand, modern studies are based on *theories of choice*. They underscore the spatial dimension of crime and reaction to crime, illustrating the role of social and physical environment in the occurrence of crime and the choice of suitable targets. These theories are based on rationality in choosing the place and people's understanding of the criminal and other possibilities, which further leads to developing police prevention in particular places. Modern ecological theories include routine activity theory, crime pattern theory, and rational choice theory. Cohen and Felson (1979) used the *routine activity theory* to elaborate on the social change and crime rates, including the situational and spatial factors of crime. *Crime pattern theory* combines elements from the rational choice perspective, routine activities theory and environmental psychology to explain variation in the spatio-temporal distribution of crime (Brantingham&Brantingham,1984, 2008; according to Vandeviver et al, 2017: 1). Crime pattern theory suggests that rational

[1] See more in: Ignjatović, 2006a.

offenders become aware of suitable targets in the absence of capable guardians while performing their daily activities and routines. Offenders may exploit these opportunities immediately or return to exploit them later. Crime, then, is the result of the interactions between motivated offenders and their physical and social environment (Vandeviver, et al., 2017: 1). *The rational choice theory* is based on the theoretical concept that each offender chooses between "benefits" and "costs" of crime. The rational choice perspective on crime and crime control (Cornish & Clarke, 2008, 1986; according to Vandeviver, et al., 2017: 1) focuses on the offender's decision-making. It argues that offending is purposive behavior through which offenders seek to benefit. In making the decision to offend as well as in choosing the place for the commission of crime, offenders balance the costs and benefits of their choices and select the option which is to bring the greatest benefit. This perspective highlights that crime does not occur at indiscriminate locations but that crime site selection is the result of a (semi-)conscious decision-making process. This perspective emphasizes that offenders' spatial decision-making process is informed by a range of attributes of the physical and social environment (Vandeviver, et al, 2017: 1).

These theories have been the starting points for many contemporary studies. Nowadays, the environmental approach to crime analysis uses the Geographical Information System (GIS) georeferencing, locating hotspots of crime, and analysis of the spatial distribution of crime. Since the late 1980s, "followers of this line of research have provided empirical evidence of place concentration using various measures of crime, focusing on different crime places and geographic units of analysis, and employing different time windows of the dataset"(Lee, Eck, SooHyun, Martinez, 2017: 1).

2. Spatial Analysis of Crime

"Crime is an inherently spatial phenomenon and crime mapping tends to be point-specific. While some crimes are more difficult to map (internet fraud, tax evasion and some motoring offenses such as driving without a license), the majority of criminal activity and day-to-day incidents that police are required to respond can be analyzed spatially"(Ratcliffe, 2004: 62). Vandeviver & Bernasco (2017) point out two important concepts reached by the geography of crime studies: crime concentration at micro-places, and smaller trips from the offenders' place of residence to the place of committing a crime, so-called "distance decay" (Vandeviver & Bernasco, 2017: 2). "Hotspots are aggregations of the raw crime data, designed to identify the sites of highest incident concentration"(Ratcliffe & McCullagh, 1999: 385). Sherman (1995) suggests that "most hot spots never have any shootings, let alone murders. But all hot spots, as defined here, are small places in which the occurrence of crime is so frequent that it is highly predictable, at least over a year. Within this definition, the phenomenon of hot spots appears to be widespread in the U.S. and elsewhere" (Sherman, 1995: 35). Sherman (1995) also noted that the triangle of crime contains more than motivated individuals prone to crime. For a crime to occur, a victim and an offender need to be in the same space and time, without any controllers. In the study of Minneapolis, for example, an analysis of 323,000 calls to the police in 1986 found that a small number of hot spots produced most of the crime in the city (Sherman, Gartin, Buerger, 1989). Sherman (1995) found that "only 3% of the places produced 50% of the calls to which the police were dispatched. This concentration was even greater for the predatory crimes of robbery, criminal sexual conduct, and auto theft: only 5% of the 115,000 street addresses and

intersections in the city produced 100% of the calls for those, usually stranger-perpetrated, offenses" (Sherman, 1995: 36). Weisburd and Green (2000) also found that approximately "20 percent of all disorder crimes and 14 percent of crimes against persons were concentrated in 56 drug crime hotspots in Jersey City, New Jersey, that comprised only 4.4 percent of street segments and intersections in the city", which is similar to Sherman's 3% finding. These results were confirmed by longitudinal studies of crime.

In the longitudinal research of juvenile arrests according to a place of arrest, Weisburd, Morris & Groff (2009) found that criminal incidents where juveniles are arrested and crime in general concentrate on hot spots and prove the important stability of that position over time. They confirmed the efficiency of routine activity theory for the understanding of the concentration of juvenile crime at places. They also found that "approximately 3–5% of the street segments are responsible for all incidents during any given year. Less than 1% of total street segments are responsible for 50% of the arrest incidents during any given year from 1989 to the 2002 year of study"(Weisburd, et al, 2009: 461). Lee, Eck, SooHyun& Martinez (2017) conducted a meta-analysis of crime concentration at place and found that only 5% of places account for about 55% of crime. They noted that, "if there is a "law" of concentration, it describes the general shape of the distribution—that a relatively small proportion places account for a relatively large proportion of crimes. Such a law would not guarantee, for example, that the most crime-ridden 5% of the places contain any specific percent of crime, except that these places would have a lot more than 5%" (Lee, et al., 2017: 11).

All these findings confirm the theory that crime is concentrated at places. But, what are the characteristics of these high crime places, and what is their inherent environment? In their research, Brantingham and Brantingham (1995) identified big bus stations, large shopping malls with many stores and restaurants, and the public library as some of the most common hot spots that generate crime (crime generators). They also analyzed the hot spots by the type of committed crime; thus, for example, robberies are most commonly committed in sports centers, youth centers, restaurants, and laundries (Brantingham & Brantingham, 1995: 15).

3. THEORETICAL FRAMEWORK AND HYPOTHESIS

Crime concentration has been confirmed in European studies as well. According to the results of longitudinal burglary research conducted by Vandeviver and Steenbeek (2017), although the rate of this type of crime was reduced by about 30 % in Antwerp (Belgium) in the period from 2005 to 2016, the concentration of crime remained stable in these 12 years. They found that burglary is strongly concentrated in particular Antwerp street segments. Under 10% of Antwerp street segments experienced burglary at least once during the study period, and fewer than 3% of all street segments produced most of burglaries (Vandeviver &Steenbeek, 2017:130).

Andresen (2009) developed the Spatial Point Pattern Test (SPPT) and started comparing similarities of spatial patterns of crime over time, alongside with the crime concentration in Vancouver (Canada). In the same research, he compares household burglaries with auto-thefts at the level of census tract. According to the results of this study, burglaries have stronger concentration than auto-thefts in the neighborhoods of Vancouver, although auto-thefts have a stronger concentration in commercial (business) areas. It particularly

refers to auto-thefts in central business areas and their surroundings, and in the largest shopping malls in the city center, outside the central business area. Correlating these results with the findings of routine activity theory, Andersen confirms the existence of suitable targets, especially in shopping malls (Andresen, 2009: 342). Considering violent crime, Andresen (2009) found the concentration of this crime in crowded areas, in the promenades located east of the central business area. Violent crime has a stronger concentration than burglaries in the commercial area of Vancouver, which includes "Vancouver's Skid Row", the urban ghetto area of cheap pubs and homeless people (Andresen, 2009: 342). Andresen and Malleson (2011) found that street segments containing more criminal acts of one type of crime have high rates of other types of crime as well. In terms of types of crime, robbery and sexual attack were not recorded in 95% of streets in Vancouver. Burglaries and vehicle thefts were recorded in 50% of places. Within the 6% of street segments where robberies were recorded, half of all robberies occurred in 15% of street segments (Andresen & Malleson, 2011: 66). In another research, Malleson and Andresen (2014) found that violent crime is clustered in the city center and the surrounding neighborhoods. These clusters are expected in the city center, particularly due to the underpopulation of the downtown area and a large number of criminal events among the low-income population residing there. The central zone is surrounded by industrial zones, which are also underpopulated or populated by low-income population. The most notable exceptions are violent crime clusters surrounding a large hospital in the north-east (St. James's University Hospital) and two small areas in the south-western neighborhoods. Yet, Malleson and Andresen note that the violent crime cluster in the vicinity of the university hospital may simply be a matter of location where violent criminal events were reported (Malleson & Andresen, 2014: 116-117).

After conducting a 14-year longitudinal study of crime trends and spatial patterns of crime in the City of Seattle, Weisburd, Bushway, Lum and Yang (2004) concluded that "crime is tightly clustered in specific places in urban areas, and that most places evidence little or no crime". Their results show that micro places in the majority of the street segments generally had stable concentration of crime over time. Moreover, the findings indicate that the trajectories (places) that evidenced decreasing or increasing trends also showed some stability throughout the observed period (Weisburd, et al., 2004: 310).

Depending on the applied method of analysis, the results may vary. If larger spatial units such as areas, settlements or entire streets are taken instead of smaller spatial units such as street segments, the concentration of crime may be weaker, because there is a higher chance for crimes to occur in each larger spatial unit than in a street segment. This has been confirmed by empirical research conducted by Andresen, Linning & Malleson (2017), Lee et al. (2017), and Steenbeek &Weisburd (2016). Lee et al. (2017) noted that "if we look at the most crime afflicted 5% of the places, when looking at household or address data, one finds about 55% of the crime being accounted for. The worst 5% of the street segments, in contrast, account for around 42% of the crimes. And the worst 5% of the neighborhoods account for only around 20% of the crimes" (Lee et al., 2017: 7). Their findings also show that crime concentration has not changed over time and remained relatively stable (Lee et al., 2017: 8). On the basis of their meta-analysis, they conclude that "there is no doubt that crime is concentrated in a small number of places", regardless of the applied measurement method, the geographic units of analysis, or the type of crime (Lee et al., 2017: 11).

Based on the foregoing studies and research findings, several working hypotheses can be suggested for further research. In this longitudinal empirical research on the ecology of crime in the urban and suburban area of the City of Niš (Serbia), covering the period from 2008 to 2018, the author will test the following hypotheses:

1. Crime is concentrated in central city areas, in large boulevards, streets, and squares;
2. Crime is concentrated in crowded areas which represent hot spots of crime and crime generators (e.g. shopping malls, bus stations, larger bus stops, open markets, casinos, pubs, cafes and other crowded places);
3. Crime rates in the central city areas are higher than crime rates in the urban and suburban areas;
4. Crime is stable in space and time; spatial patterns and distribution of crime remain stable over time.

4. Empirical Research Data and Methods

4.1. The subject matter and goal of empirical research

The subject matter of this empirical research is the ecology of crime and the analysis of the geospatial distribution of crime in the urban and suburban areas of the City of Niš (Serbia). Relying on the environmental theories of crime, this method of analysis was chosen in order to establish the spatial distribution of crime in the City of Niš and compare the findings with the former criminological research on the environmental study of crime, the crime scene, criminal environment, the concentration of crime, and the characteristics of hot spots as crime generators.

4.2. Research sample and methodology

The research data for the analysis of spatial patterns and distribution of crime, involving property-related crime and violent crime committed in the territory of the City of Niš (Serbia), were obtained from the Police Department in Niš, the Ministry of the Interior of the Republic of Serbia.[2] The requested statistical data were related to the criminal offences envisaged in the Criminal Code of the Republic of Serbia[3], including the following criminal offences against property: *Theft* (Article 203), *Aggravated Theft* (Article 204), *Grand Theft/Larceny* (Article 205), *Robbery* (Article 206), as well as the following violent crimes: *Serious Bodily Injury* (Article 121), *Minor Bodily Injury* (Article 122), *Brawling* (Article 123), *Threat or Endangerment by Dangerous Instruments in Brawl or Quarrel* (Article 124), and *Violent Conduct* (Article 344). The obtained data included all the aforesaid criminal offences committed in the City of Niš in the years 2008, 2013 and 2018. The 5-year time span was deemed to be an adequate time framework for comparing differences and similarities in the geospatial distribution and concentration of crime. Given that spatial distribution of crime is a macro phenomenon that is not subject to frequent change, the 5-year periods are considered relevant for this kind of analysis and have been used in similar studies of spatial patterns of crime (Andresen, Malleson, 2011).

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[2] It should be noted that the Police analytics department may provide only the data about crimes where criminal charges have been raised against the offender. This empirical research was based on such data.

[3] Krivični zakonik Republike Srbije (Criminal Code of the Republic of Serbia), *Službeni glasnik RS,* br. 85/2005, 88/2005 –ispr., 107/2005 – ispr., 72/2009, 111/2009, 121/2012, 104/2013, 108/2014 i 94/2016.

The City of Niš is the third largest city in Serbia with a population of approximately 255,518 citizens. It is one of the oldest cities in the Balkans and the largest city in central and southeastern Serbia, which covers about 596.71 square kilometers. It is the administrative center of the Nišava District and the legislative, business and university center of southeastern Serbia.[4]

4.3. Instruments and analytic strategy

The obtained data were processed by using the statistical software SPSS Statistics 24 and Microsoft Office 2016 Excel. Spatial units for analysis in this research are the city boroughs, residential areas and settlements in the urban and suburban areas of the City of Niš. These areas represent natural, geographical and societal units, in line with the current allocation of residential areas in the City of Niš. The analysis included a total of 41 spatial units[5]. Maps were created in the Geographic Information System ArcGIS Online. Geocoding was performed by localizing the crime via Internet searches, the free "Google Maps" application, and the "PlanPlus" application. Every street address in the obtained database was geocoded according to a particular spatial unit. The data were processed in SPSS, and the descriptive statistics (presented in tables and graphs) was used for describing the distribution of crime by type and the spatial distribution per unit. In the final phase of this empirical research, spatial patterns of crime were tested by using Andersen's (2009) nonparametric Spatial Point Pattern Test (SPPT) in order to determine the stability of the spatial distribution of crime in the City of Niš.

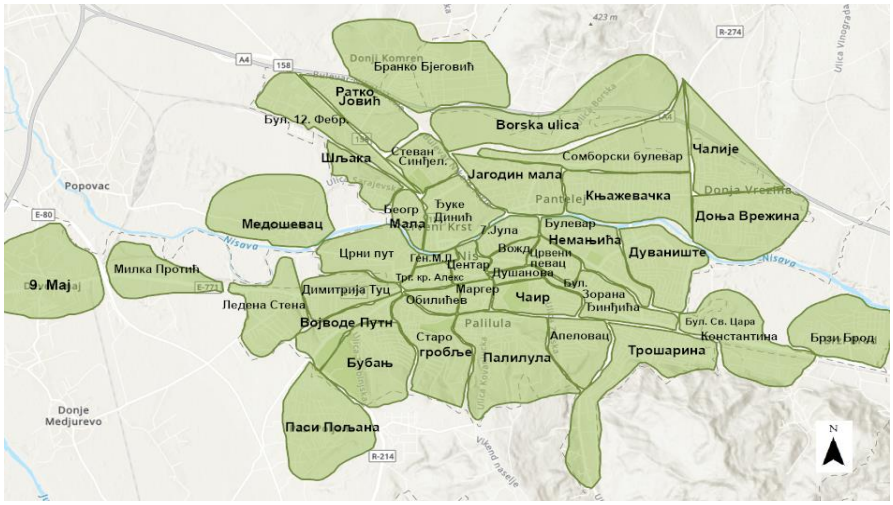

Fig. 1 Map of spatial units (residential areas, boroughs, settlements) in the City of Niš Selected for the spatial analysis of crime
Source: Map of spatial units in the City of Niš created in *ArcGIS Online* by D. Stanković, 2019

[4] Demographic datawere retrieved from the official website of the City of Nis (https://www.ni.rs/) on 05.04.2020.
[5] Spatial units (boroughs, residential areas, settlements) showed in Picture 1: Apelovac, Bulevar 12. Februar, Bulevar Zorana Djindjića, Bulevar Nemanjića, Bulevar Svetog Cara Konstantina, Čair, Cara Dušana, Centar (City center), Crveni pevac, Dimitrija Tucovića, Generala Milojka Lešjanina, Jagodin mala, Knjaževačka, Ledena stena, Marger, Medoševac, Milka Protić, Obilicev venac, Palilula, Ratko Jović, Naselje 7. jul, Šljaka, Somborski bulevar, Staro groblje, Stevan Sindjelić, Trg kralja Aleksandra, Vojvode Putnika, Vozda Karadjordja, Beograd mala, Borska, Branko Bjegovic, Brzi brod, Bubanj, Trosarina, Čalije, Crni put, Naselje 9. maj, Pasi Poljana.

4.4. Limitations of the study

It should be noted that geocoding and analysis were conducted in line with available resources and instruments. In some cases, it was impossible to determine the exact location of the criminal event because the obtained databases did not provide *x* and *y* coordinates. Many cases were recorded only by the street name (without a house number) where the crime was committed. The local community units (official city administrative-territorial units) could not be included in the analysis as spatial units because the same street turned out to be part of two local community units (depending on the part of the street where the house number is located). Thus, it was impossible to perform the analysis by street segments, as formerly done by some researchers in contemporary studies of environmental crime. Therefore, the spatial units were determined according to the geographic (natural) residential areas, which were used as referential points for geocoding cases into specific spatial units.

5. Research Results and Discussion

5.1. Descriptive statistics

The police database comprised 6.494 cases from the territory of the City of Niš. However, intending to ensure the minimum acceptable hit (or success) rate[6] needed for the spatial analysis to exclude biases in the study, we excluded some suburban settlements and villages because many streets in these settlements have the same street names (e.g. "Maršal Tito Street" can be found in the villages "DonjeMedjurovo", "Popovac", "Čokot", etc.), which made it impossible to determine which spatial unit the street actually belonged to. After geocoding the cases, the research sample included a total of 4,934 cases for analysis: 1,699 cases from the year 2008, 2,064 cases from the year 2013, and 1,171 cases from the year 2018 (Figure 1). Thus, we could use 76% of the total number of cases from the obtained databases.

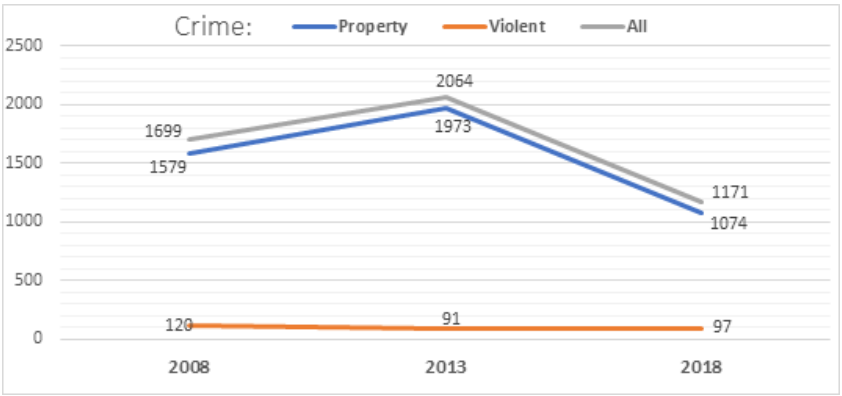

Fig. 1 Data on property crime, violent crime and total number of cases per year
Source: Graph created in *Microsoft Office 2016 Excel* by D.Stanković, 2019

[6]Rattclife considers it to be 85 % of the original database; for more, see Rattclife (2004) and Andresen (2009).

As shown in *Figure 1* and *Table 1*, the vast majority of cases are property-related crimes. In 2008, the database included about 93 % of property crimes (1,579 cases) and only7 % of violent crimes (120 cases). In 2013, the database comprised 95.6 % of property crimes (1,973 cases) and 4.4 % of violent criminal acts(91 cases). In 2018, there was a total of 91.8 % of property crimes (1,074 cases), and 8.2 % of violent crimes (97 cases).

In *Table 1*, we can see that the most common criminal act was *Aggravated Theft* (a total of 2,457 cases during all three years), followed by *Theft* with a total of 1,913 cases in the study period, while *Grand Larceny* was recorded in only 9 cases and *Threat by Dangerous Instruments in Brawl* occurred in only 7 cases in the years under observation. The most common violent crime was *Violent Behavior*, with a total of 121 recorded cases.

Table 1 Criminal offences by year under observation (2008, 2013, 2018)

Criminal act	2008	2013	2018	Total
Theft	623	871	419	1913
Aggravated Theft	832	1020	605	2457
Grand Larceny	4	4	1	9
Robbery	120	78	49	247
Serious Bodily Injury	19	22	25	66
Minor Bodily Injury	51	29	20	100
Brawling	5	4	5	14
Threat by Dangerous Instruments in Brawl	/	7	/	7
Violent Behavior	45	29	47	121

Source: Table created in *Microsoft Office 2016 Excel* by D. Stanković, 2019

If we analyze the data by the year, we can notice that some spatial units differ from others by a higher or lower number of cases. In line with the previous research (Andersen & Malleson, 2011; Brantingham & Brantingham, 1995; etc) and ecological theories, some spatial units stand out from others. These are commonly the central urban areas, with a great concentration of people in shopping malls, business centers, stores, open markets, cafes, and bus stations.

Table 2 shows that three spatial units stand out from others in the year 2008 in terms of recorded criminal acts: a) „Bulevar Nemanjića“ unit with 155 cases (9.1%); b)„City center“ with 54 cases (9.1%); and c) „Djuka Dinić“ unit with 128 cases (7.5% of all crime in 2008), which covers the Niš Fortress, green market, open market, the central bus station and other crime generators. They are followed by „Vožda Karadjordja Street“ unit with 93 cases (5.5 %). The lowest crime rates were recorded in the suburban settlements: „9. May“ with 6 cases (0.4%); „Donja Vrežina“ with only 3 cases (0.2%); and „Milka Protić“ with 5 cases (0.3%). This kind of spatial distribution of crime is consistent with the past studies (e.g. Wikstrom, Dolmen, 1990), proving that residential settlements in urban and suburban areas are less frequently recorded as places of crime when compared to the central city zone.

Table 2 Crime data by spatial units per year (2008, 2013, 2018)

Spatial unit (borough, residential area, settlement)	2008 count (%)	2013 count (%)	2018 count (%)
Donja Vrezina	3 (0.2)	35 (1.7)	17 (1.5)
Calije	8 (0.5)	9 (0.4)	10 (0.9)
Somborski bulevar	14 (0.8)	23 (1.1)	30 (2.6)
Borska	25 (1.5)	48 (2.3)	22 (1.9)
Knjazevacka	65 (3.8)	106 (5.1)	51 (4.4)
City Center	154 (9.1)	107 (5.2)	55 (4.7)
Vozda Karadjordja	93 (5.5)	64 (3.1)	25 (2.1)
Generala Milojka Lesjanina	42 (2.5)	50 (2.4)	12 (1)
Cara Dusana	55 (3.2)	36 (1.7)	16 (1.4)
Cair	78 (4.6)	68 (3.3)	23 (2)
Bulevar Nemanjica	155 (9.1)	176 (8.5)	97 (8.3)
Duvaniste	67 (3.9)	65 (3.1)	81 (6.9)
Obilicev Venac	41 (2.4)	40 (1.9)	29 (2.5)
Marger	8 (0.5)	20 (1)	10 (0.9)
Djuke Dinic	128 (7.5)	141 (6.8)	92 (7.9)
Bulevar 12. Februar	41 (2.4)	80 (3.9)	47 (4)
Ratko Jovic	13 (0.8)	33 (1.6)	40 (3.4)
Branko Bjegovic	32 (1.9)	38 (1.8)	25 (2.1)
Palilula	70 (4.1)	107 (5.2)	46 (3.9)
Staro groblje	62 (3.6)	70 (3.4)	28 (2.4)
Apelovac	16 (0.9)	16 (0.8)	8 (0.7)
Bubanj	15 (0.9)	23 (1.1)	5 (0.4)
Ledena Stena	12 (0.7)	31 (1.5)	12 (1)
Naselje 9. maj	6 (0.4)	23 (1.1)	8 (0.7)
Pasi Poljana	/	7 (0.3)	6 (0.5)
Crni put	65 (3.8)	117 (5.7)	94 (8)
Medosevac	6 (0.4)	5 (0.2)	5 (0.4)
Trosarina	38 (2.2)	64 (3.1)	45 (3.8)
Crveni Pevac	66 (3.9)	79 (3.8)	44 (3.8)
Dimitrija Tucovica	48 (2.8)	63 (3.1)	38 (3.2)
Bulevar dr Zorana Djindjica	75 (4.4)	42 (2)	22 (1.9)
Brzi brod	10 (0.6)	12 (0.6)	7 (0.6)
Milka Protic	5 (0.3)	9 (0.4)	4 (0.3)
Jagodin mala	29 (1.7)	32 (1.6)	13 (1.1)
Vojvode Putnika	27 (1.6)	49 (2.4)	11 (0.9)
Naselje 7. jul	28 (1.6)	31 (1.5)	12 (1)
Trg kralja Aleksandra	44 (2.6)	49 (2.4)	23 (2)
Bulevar Sv. Cara Konstantina	23 (1.4)	35 (1.7)	17 (1.5)
Beograd mala	10 (0.6)	26 (1.3)	21 (1.8)
Stevan Sindjelic	11 (0.6)	12 (0.6)	6 (0.5)
Sljaka	11 (0.6)	18 (0.9)	14 (1.2)
Sum	1,699 (100)	2,056 (100)	1,171 (100)

Source: Table generated in *SPSS Statistics* by D. Stanković, 2019

In the year 2013, we can observe a noticeable increase in crime, with a total number of 2,059 cases as compared to 1,699 cases in the year 2008 (Table 2). *Table 2* shows that criminal offences were most frequently committed in the spatial units „Bulevar Nemanjića“

with 176 cases (8.5%) and „Djuka Dinić“ with 141 cases (6.8%), which were followed by „City center“ and the urban borough „Palilula“, with 107 cases (5.2 %) each. A significant increase in crime was recorded in the spatial unit „Crni put“ (covering the open market, a Roma settlement, and abandoned factory „Machine Industry Nis“) with a total of 117 cases (5.7 %), and in „Knjaževački Bulevar“ unit with a total of 106 cases (5.1 %). On the other hand, the crime rate was reduced in some centrally-located spatial units. For example, in 2013, the spatial unit „Vožda Karadjordja Street“ had a total of 64 recorded cases (3.1 %) as opposed to 93 cases (5.5%) in the year 2008. Generally, in 2013, crime was concentrated in the most crowded city square and streets, in the central city area and the longest boulevards. The common feature in all these spatial units are open markets, shopping malls, bus stops, and business centers. Yet, according to the observed parameters, crime seems to be gradually moving away from the city center towards large city boulevards and suburban settlements. Thus, a significant increase in the number of offences was recorded in the suburban settlements: in 2008, the spatial unit „9. May“ had 6 cases (0.4%) as compared to 23 cases (1.1%) in 2013; similarly, „Donja Vrežina“ had only 3 cases (0.2%) in 2008 as opposed to 35 cases (1.7%) in 2013. The spatial units „Bubanj“, „Ledena Stena“ and „Branko Bjegović“ also recorded higher crime rates. In 2013, the lowest number of cases was recorded in the suburban settlements „Medoševac“ with 5 cases (0.2%) and „Pasi Poljana“ with 7 cases (0.3%).

The database for the year2018 included a total of 1,171 geocoded criminal acts (*Table 2*). The significant drop in the number of recorded crimes was evident in the spatial units' statistics. As we can see in *Table 2*, the spatial unit „Bulevar Nemanjića“ had 97 cases (8.3 %), followed by the suburban units „Crni put“ with 94 cases (8 %) and „Djuka Dinić“ with 92 cases (7.9%). In comparison to 2013, all these units had a slight decrease in the recorded number of crimes. In 2018, the „City Center“ had 55 recorded cases (4.7%) as compared to 154 cases (9.1 %) recorded in 2008, which shows a significant decrease of crime in the central city area. On the other hand, the crime rate kept growing in the urban settlements „Duvanište“, which had 81 recorded cases (6.9%) as compared to 3.1% in 2008 and 3.9% in 2013, and „Trošarina“, which had 45 recorded cases (3.8%) as compared to 2.2 % (38 cases) in 2008 and 3.1% (64 cases) in 2013. The lowest crime rate was recorded in the suburban settlement „Milka Protić“, with 4 cases (0.3 %), which is similar to 0.3% in 2008 and 0.4% in 2013. Although the spatial unit„Stevan Sindjelić“ is an urban settlement located in the vicinity of hot spots such as the Niš Fortress and open markets in „Djuka Dinić“ unit, it had only 6 recorded cases (0.5%) in 2018 and can be considered as a small oasis of safety. On the whole, the 2018 statistical data confirmed the trend previously observed when comparing the 2008 and 2013 data. According to the observed parameters, it may be concluded that criminality keeps moving away from the city center and centrally located boroughs towards urban and suburban settlements.

5.2. The application of the Spatial Point Pattern Test (SPPT)

The SPPT was applied to measure the stability of global spatial patterns of crime in the City of Niš. As defined in the first step of the SPPT (Andersen, 2009), geocoded data from 2008 was designated as a base data set, while 2013 and 2018 were tested data sets. The area-based base map of spatial units was obtained in ArcGIS Online (*Picture 1*). Spatial references to each point in each data set were assigned and the number of points was counted inside each of the spatial units for the base data set. An 85 percent random sample of the points was extracted from the test data set in the software SPSS and then

aggregated by the spatial reference (steps 4 and 5 in Andersen, 2009). These steps were repeated 20 times as we did not have the computational capacity and enough time for the 200 times analysis (applied by Andersen in his study), but earlier studies in spatial distribution confirmed that 20 iterations were enough for analysis and that a lower number of repetitions is sufficient for processing spatial tests (Davis, Keller, 1997; Hope, 1968). Then, tables were created for the "spatial unit" variables so that each table included 20 different results obtained from random sampling. These results were ordered from the highest to the lowest values and the nonparametric 95% confidence interval was calculated for each spatial unit by deleting 2.5% from the bottom and the top of the table (leaving 18 results in each table). Finally, for each spatial unit, it was determined whether the value from the base data set fell within the 95% confidence interval; thereupon, the S-Index match was calculated to provide a measure of similarity between the spatial point patterns. The test generates a similarity index. The S-Index is a global parameter that shows the percentage of spatial units with homogeneity for both point maps in the same scale, ranging from zero (perfect heterogeneity) to one (perfect homogeneity) (Melo, Matias & Andresen, 2015: 320). In this analysis, regardless of the type of crime, criminal offences were aggregated per spatial units, as this kind of SPPT analysis was used in some former research (Andresen &Malleson, 2014).

Table 2 Results of the Spatial Point Pattern Test

Base data set – Test data set	S-Index
2008 – 2013	0.35
2008 – 2018	0.25

Source: Table generated in *SPSS Statistics 24* by D. Stanković, 2019

Table 2 shows the results of the Spatial Point Pattern Test. In the analysis of the year 2008 as the base data set and the year 2013 as the test data set, we got an S-Index value of 0.35, which demonstrates that the spatial distribution of crime has preserved its pattern over time at the level of 35%. This shows that 35% of spatial units preserved a similar spatial pattern of crime during the 5-year period. As noted by the authors of the SPPT, there is no exact limit in the S-Index value for determining the similarity of spatial patterns; but, to confirm similarity, it should be at the level from 0.80 to 0.90. For this analysis, we will take a limit of 0.80, which was used in some former applications of the SPPT (Andresen &Malleson, 2014). The S-Indeks of 0.35 falls below the limit of 0.80; therefore, we can conclude that the tested data set from the year 2013 did not preserve the same spatial pattern of crime as the base data set from the year 2008. As shown in *Table 2*,the S-Index for the analysis of years 2008 and 2018 is even lower, at the level of 0.25, which means that only 25% of spatial units held the same spatial pattern of crime. The S-index of 0.25 also falls bellow the 0.80 limit; therefore, we can conclude that the spatial pattern of crime in the year 2018 is dissimilar to the one in the year 2008. The difference in the spatial patterns of crime in the period of 10 years (2008-2018) is even more prominent than it was after a five-year period (2008-2013). The analysis has shown that crime is gradually decreasing in the central city zone and exponentially increasing in the urban and suburban settlements. If this trend continues, we can expect more ongoing changes in the spatial distribution of violent and property crime in the urban and suburban areas of the City of Niš.

According to the results of Andresen and Malleson (2011: 66), a very low percent of streets in Vancouver account for 50% of different criminal offenses, with huge variations in the type of crime (ranging from 1% in terms of robbery to 8% in terms of burglary). In the empirical research of the City of Niš, the analysis shows even more substantial variations in the type of committed crime. Aggravated larceny, which can be considered as an equivalent to burglary in the Anglo-American criminal codification, accounts for 50% of committed criminal offences, while robbery accounts for 4 to 7 %, depending on the year under observation. While Andersen and Malleson (2011: 65) noted that the percentage of streets segments that account for 50 % of crime was quite stable over time (1991, 1996, and 2001), the results of the empirical research in the City of Niš suggest that the spatial pattern of crime is not stable and that crime is gradually being dislocated from the inner city zones to the outer urban and suburban areas.

5.3. Evaluation of the working hypothesis

The use of descriptive statistics and the Spatial Point Pattern Test (SPPT) in the presented analysis provided an efficient tool for checking of the working hypothesis of this research. The first hypothesis was that crime is concentrated in central city areas, large streets, boulevards and squares. This hypothesis has been confirmed based on the results that the most crime falls within the spatial units such as „Bulevar Nemanjića“, „Djuka Dinić“ and „City Center“. The research results have concurrently confirmed the second hypothesis, suggesting that crime is concentrated in crowded areas (such as shopping malls, bus stations, larger bus stops, open markets, casinos, pubs, cafes and other crowded places) which represent hot spots of crime and crime generators. For example, the spatial unit „Djuka Dinić“ includes the central bus station, green market, open markets, and Niš Fortress park, while the spatial unit „City center“ covers the central city square, many stores, shopping malls, central promenade, restaurants, cafes and other crowded places. The third hypothesis, positing that crime rates in the central city areas are higher than crime rates in the urban and suburban areas, has also been confirmed. The percentage of crime committed in each spatial unit clearly demonstrates the huge differences between these areas. For example, in the year 2008, only 3 cases (0.2%) were recorded in the suburban settlement „Donja Vrežina“ as compared to 155 cases (9.1%) recorded in the urban residential area „Bulevar Nemanjica“. These differences are equally demonstrated in the analysis of the 2013 and 2018 databases. Although the findings show a decrease of crime in the central city zones (e.g.“City Center”, “Cara Dusana”, “Palilula”, “Cair”) particularly in 2018, and despite the apparent change in the spatial distribution of crime which was recorded to be moving from the city center towards the urban city areas and suburban settlements, the central city zones still feature higher crime rates (on the whole). The last hypothesis was that spatial patterns of crime remain stable over time. As demonstrated by the application of the SPPT, similarity indexes in the observed periods (0.35 in the 2008-2013 analysis and 0.25 in the 2008-2018 analysis) are way below the stipulated limit (0.80).Therefore, we can conclude that the fourth hypothesis has not been confirmed as the research show that the spatial patterns and distribution of crime in Niš have been changing.

6. CONCLUSION

The urban and suburban environments are human products. Brantingham and Brantingham (1995) call them by-products, created to meet our daily needs (residential neighbourhoods, houses, shops, offices, factories, warehouses, government buildings, parks, sports and recreational grounds, transportation systems, bus stops, roadways, parking garages, etc.). Yet, all these places can be hot spots or generators of crime. The way we design, devise and develop these large building blocks of our daily activities may have a major impact on our security, fear of crime, and occurrence of crime, including the actual type, scope or timing of crime that we may experience in the urban environment (Brantingham & Brantingham, 1995: 5).

Relying on the relevant criminological theory and ecological approach to crime, the empirical research on the spatial patterns and distribution of crime in the City of Niš was conducted by using the databases obtained from the Police Department in Niš on property crimes and violent crimes committed in the territory of the City of Niš in the years 2008, 2013 and 2018. The research results show that crime is concentrated in the central city areas, in crowded places such as shopping malls, business centers, open markets, bus stops, parks, stores, casinos, etc. Generally, crime rates in the central city areas are higher than crime rates in the urban and suburban areas. The results of the Spatial Point Pattern Test (SPPT) indicate that spatial patterns and distribution of crime change over time. The concentration of crime diffuses from the central city zones to urban and suburban areas, where crime is on the rise.

The results of this empirical research are of both scientific and practical value. The author hopes that this study will encourage future scientific research and analysis in the field of environmental criminology in the territory of the City of Niš and in other cities in the Republic of Serbia. The scientific value of this study is that it is a rare empirical research in Serbia and the Balkans conducted by using this kind of methodology in criminological research on spatial patterns and distribution of crime. More importantly, it was the first time that scientific research in criminology was conducted by using the Spatial Point Pattern Test (SPPT). The practical value of this empirical research on spatial patterns and distribution of crime is that the findings may be useful to a number of stakeholders: the police authorities in the City of Niš and in other cities in Serbia as a practical tool for developing criminal policy, the police officials and managers involved in developing crime prevention strategies, as well as the city government and local community authorities as a source of information for instituting relevant programs and measures which may contribute to crime prevention, public security and citizen safety.

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EKOLOGIJA KRIMINALITETA U GRADSKOM I PRIGRADSKOM PODRUČJU – PROSTORNI OBRASCI KRIMINALITETA U NIŠU, SRBIJA

Ekološka perspektiva je u kriminologiji nastala još sa pojavom kartografske škole, a čikašku ekološku školu prate teorija rutinskih aktivnosti, teorija kriminalnog obrasca i teorija racionalnog izbora. Uticaj ekološke teorije značajan je i danas. Naučnici, istraživači i praktičari proučavaju kriminalitet koristeći geografski informacioni sistem, mapiranje kriminala i geostatističke metode. Sa ciljem proučavanja prostornih obrazaca kriminaliteta u Nišu, tokom kalendarske 2008, 2013, i 2018. godine sprovedeno je empirijsko istraživanje krivičnih dela sa elementima nasilja i koristoljublja na teritoriji Grada Niša. Krivična dela su geokodirana u prostornim jedinicama koje predstavljaju gradska i prigradska naselja u Nišu. Deskriptivna statistika je korišćena za identifikaciju područja najopterećenijih kriminalom, dok je Andersenov Spatial Point Pattern Test (SPPT) korišćen za utvrđivanje stabilnosti u prostornim obrascima. Rezultati govore da je kriminalitet koncentrisan u centralnim gradskim područjima, ali da se njegovi prostorni obrasci menjaju, i da se prostorna distribucija pomera ka gradskim i prigradskim naseljima. Istraživanje je od naučnog i praktičnog značaja. Retka su istraživanja prostorne distribucije kriminaliteta u Srbiji, a primena Andersenovog testa je prva u regionu. Rezultati mogu biti od koristi za kreiranje bezbednosnih strategija i prevenciju kriminala od strane policije, pravosudnih organa, gradskih službi i građana.

Ključne reči: *koncentracija kriminaliteta, nasilnički i imovinski kriminal, Test sličnosti prostornih obrazaca, gradsko i prigradsko područje, Niš, Srbija*