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Determination of Field Use Changes by Using Landscape Metrics: "Erzurum City Example"

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ABSTRACT: The human increases environmental pressures and consumes resources. Therefore; Landscapes are also changed by natural events or human beings over time. Landscape ecology examines these changing relationships and takes landscape as a level and system within the concept of hierarchical order. Landscape structure analysis is an important method used in ecological planning studies, which analyzes the landscapes in the matrix-patch-corridor model by dividing them into units and provides analytical data with the help of landscape metrics and interprets the landscape structure. In this context, ecological-based planning should be made in cities, corridors are created. Aquatic and Terrestrial ecological corridors are ecosystems that connect two different landscape matrices. They combine with different landscape matrices and patches to form an integrated landscape mosaic. This approach, which also forms the basis of green infrastructure systems, emphasizes centers, connections. The green infrastructure is designed with a systematic approach that ensures the sustainability of ecological networks, protects and improves natural and cultural living environments, within the scope of the landscape system integrity, on a city scale. In this context, Erzurum city green areas, centers and their connections are handled ecologically. In order to protect the existence of urban flora and fauna, to ensure the integrity and to maintain continuity, it is desired to fulfill green infrastructure requirements. Using the Patch Analyst 4.2 software, the interactions, fragmentation states, habitat qualities, sizes, differences of the patches that make up the matrix of the research area were evaluated on the basis of landscape ecology.

Keywords: Landscape metrics, Urban open-green area, Erzurum, Landscape structure, Landscape planning, Landscape measurements

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Makale 30 Haziran – 7 Temmuz 2019 tarihlerinde Budapeşte / MACARİSTAN' da düzenlenen "1st WORLD CONFERENCE ON SUSTAINABLE LIFE SCIENCES WOCOLS 2019 Sempozyumu'nda " sözlü bildiri olarak sunulmuştur. Sempozyum kitapçığı genişletilmiş özet olarak yayınlanmıştır.

INTRODUCTION

Depending on the increase in population, the growth of cities, increasing human needs create different land use functions in cities such as settlements, industry, agriculture, and destroy natural areas in this formation. Preventing habitat disintegration and ensuring ecosystem integrity is important in ensuring human quality of life in and around cities (Gordon et al., 2009; Balaban and Tamer 2016; Eroğlu 2018).

In 1938, Carl Troll stated that the natural sciences included landscape sciences and the concept of landscape ecology emerged. According to Troll, landscape ecology is the science that examines the relationship between environmental conditions and living things in the landscape (Odum and Berrett, 2008). The formation of landscape mosaic with this branch of science, its function, development, how it can be understood (Bastian, 2001).

Natural events, social, economic, political events can cause changes in the landscape. When landscape ecology examines this change, it also identifies events among the components of the ecosystem. These data contribute to the fields of landscape architecture, regional planning and landscape planning (Odum and Berrett, 2008; Demir and Demirel, 2018).

Urban landscapes such as river landscapes, forest landscapes, lake landscapes differ in terms of spatial relationships. According to McGarigal, (2006), landscape structure explains the connections and differences between these ecosystems. These areas, which differ from each other, constitute the spatial structure. Size, shape and number of ecosystems are important in understanding spatial relationships (Forman, 1995). These concepts are the use of land use forms created by people and landscape design of natural areas and this pattern changes over time (Forman, 2000; Kor, 2011).

In landscape ecology studies, the function, structure and change characteristics of landscape areas are considered as superior to the ecology (McGarigal and Marks, 1995). In the same study, the relationship between spatial elements is defined as function and the relationship between different ecosystems is structure. The temporal difference in landscape mosaics is change.

Şahin et al. (2011) stated that the number of stains, the shape of the composition and the landscape pattern formed by the size are important in understanding the structure of the landscape. Dramstad et al. (1996), in order to understand and interpret the landscape structure, it is necessary to divide the spatial pattern of the landscape into sections such as patch, corridor, matrix. These sections come together heterogeneously to form the landscape mosaic. The landscape matrix which forms the basis of the landscape mosaic is the whole of ecosystems that are close to each other in terms of function and origin. The healthy functioning of the ecosystem is provided by the balance of the patch-corridor-matrix system (Odum and Berrett, 2008).

In urban areas, stain- corridor-matrix model land-use planning is important in making ecological planning decisions. The numerical expression of how urban patterns change over time is used to understand the relationship between ecological and environmental processes (O'neil et. al., 1988; Lin et. al., 2020).

The use of landscape metrics in the analysis of landscape structure is important in understanding the ecological process of landscape. Landscape structure analysis and matrix-patch-corridor units that make up the landscape are the methods that help to understand the landscape structure through landscape metrics. Matrix-corridor and patch metrics in urban areas can be classified according to Table 1 (Ahern, 2007).

Table 1. Patch-corridor and matrix types in urban areas

Urban patches	Urban corridors	Urban matrix
Parks	Streams	Urban settlement
Sports fields	Canals	Industrial areas
Wetlands	Drainage paths	Garbage storage area
Urban agricultural fields	Waterways	Commercial areas
Cemeteries	Roads	Mixed areas of use
Campuses	Power transmission lines	
Open and green spaces		

Different metrics are used to interpret and understand the units that make up the landscape and to express them numerically (Turner et al., 2001). These metrics are the numerical expression of land-use types or landscape patterns (Hepcan, 2013). At the same time, landscape structure metrics understand the structure, functioning and change of the ecosystem that makes up the landscape and play an important role in the decision-making process of the planning stage for the future (Tağıl, 2006; Benliay, 2009). Also, metrics give the components, distribution and proportions of the pattern that make up the landscape (Leitao and Ahern, 2002). The results are important in the expression of landscape ecology mathematically (Forman, 2008) or quantitative landscape (Turner et al., 2001). In order to understand the relationship between the ecosystem components that make up the landscape structure, the landscape metrics mentioned in Table 2 are generally used (Tagil 2016; McGarigal and Marks, 1995; Leitao and Ahern, 2002).

Table 2. Landscape metrics used in landscape structure analysis

Symbol	Name	Description
CA	Blot size	It refers to the total area (hectare) of the stain class in the landscape.
NUMP	Number of stains	The refers to the total number of stains in a landscape or all stains contained in the landscape.
MPS	Mean stain size	Refers to the average size (hectares) of a stain class or all stains contained in a landscape.
ED	Edge density	It refers to the ratio of the total edge length of the spots of a class to the total area in the landscape.
MPE	Mean stain edge	It refers to the average edge length (m) of the class of stains in the landscape or of all stains.
MSI	Mean shape index	Expresses the complexity of stains in landscaping.
TLA	Total landscape area	Expresses the total landscape area subjected to landscape structure analysis.

At this stage of the study, landscape structure was analyzed by using landscape metrics in order to improve the ecological, socio-economic and socio-cultural values of Erzurum city center. As a result of the analysis, the relationships, size and differences of the patches forming the study area were evaluated.

MATERIALS AND METHODS

Materials

Erzurum is located between 39 ° 57 ′ 23 ″ North 41 ° 10 ′ 12 ″ East longitudes. Erzurum has an area of 25.000 km² in the Eastern Anatolia Region (Figure 1). The average temperature of the province with a continental climate is 19.6 °C, the cold average is -8.6 °C, the lowest temperature is -35 °C, the highest temperature is 35 °C (Anonim, 2019).

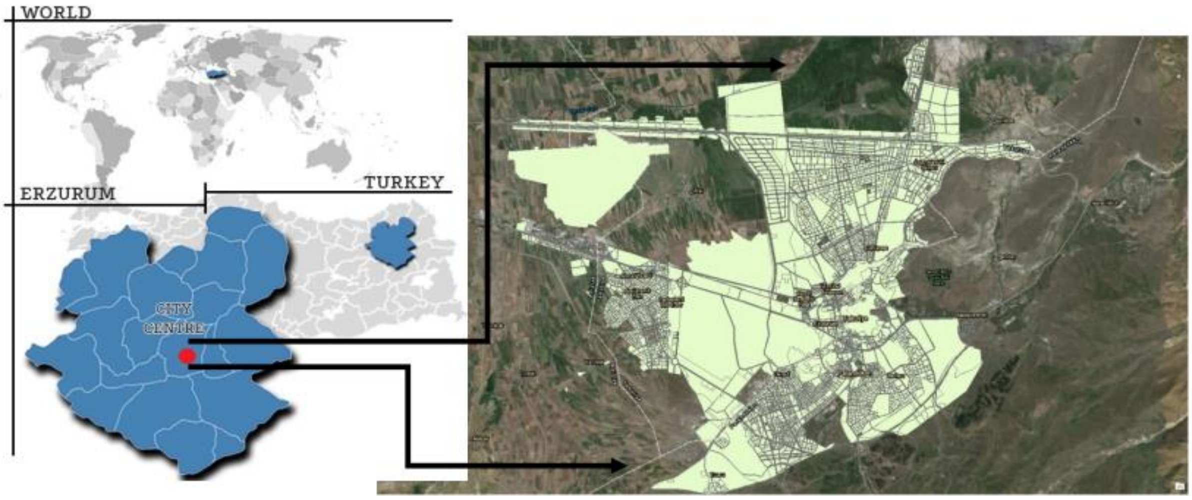

Figure 1. Working area (Erzurum)

Method

Land use status of the study area was obtained from LANDSAT 8 OLI (2017) satellite images and zoning plans obtained from Erzurum Municipality. Satellite images dated 13/02/2019, where the cloudiness rate is less than 15%, are used to obtain clearer satellite images and more accurate analysis results. The landscape structure was analyzed with the help of the landscape metrics indicated in Table 2 in order to understand the relations of the ecosystem functions in the research area with each other and their relations with their environment, and to interpret the existing and possible pressures on the areas of natural importance. Numerical data obtained using Patch Analyst 4.2 software (Figure 2) were interpreted by performing class level analyzes. This software has been used because it gives fast and accurate results in the analysis of landscape structure. The interactions of patches that constitute the matrix covering the research area with each other and their environment, fragmentation status, habitat quality, shape size and differences were evaluated on the basis of landscape ecology.

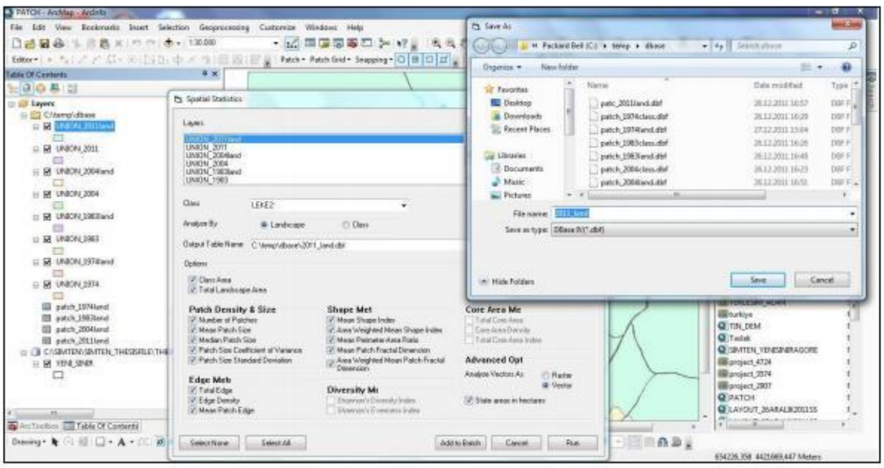

Figure 2. Data set and calculated metrics prepared by Patch Analyst program CA (stain size)

CA (stain size), NUMP (Stain number), MPS (Average Stain size), ED (Edge density), MPE (Average stain edge), MSI (Average Shape index), MPAR (Average Shape) for landscape structure analysis of the study area landscape metrics such as MPFD (Average Environmental Area Ratio) TLA (Total landscape area) were used.

RESULTS AND DISCUSSION

Land use in the city center according to the zoning plan has an area of 95.9 km^2 (Figure 3). The data obtained from the zoning plan were regrouped and formed at the upper scale. Table 3 shows the distribution of land uses in percent. In terms of usage of land use functions, the biggest usage form is Urban Social Infrastructure Areas (24.2%) which includes health, education, public institutions and mosque areas. Landscape pattern blot analysis results according to zoning plan are given in Table 4.

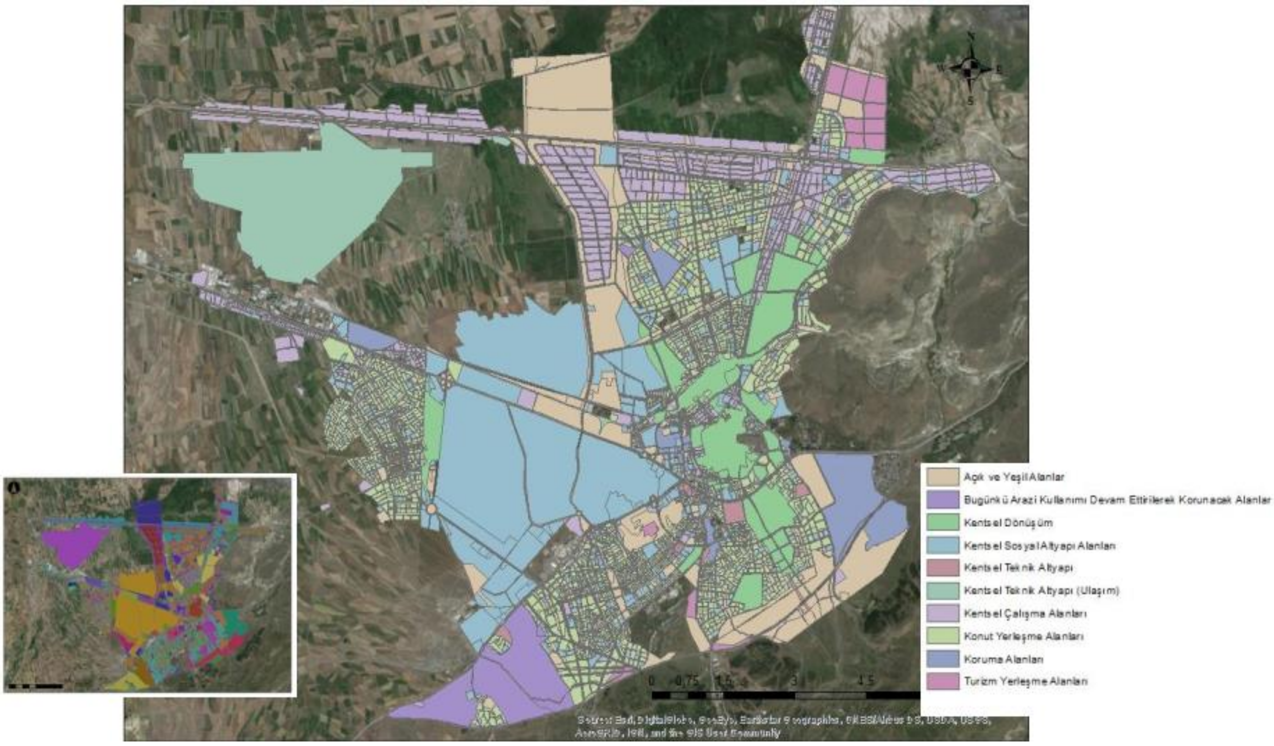

Figure.3. Workspace area usage functions

Table 3. Area usage function sizes of the work area

Area Usage Functions	Area (ha)	Percent (%)
Residential Settlement Areas	1544.79	16.1
Open - Green Areas	1937.96	20.2
Urban Technical Infrastructure	66.4529	0.7
Urban Social Infrastructure Areas	2323.2	24.2
Urban Work Areas	1080.04	11.3
Protected Areas	336.89	3.5
Urban Technical Infrastructure (Transportation)	899.655	9.4
Tourism Settlement Areas	157.059	1.6
Today's Land Use Areas	377.174	3.9
Urban transformation	869.469	9.1

Table 4. Landscape pattern stain analysis results for area usage functions according to zoning plan

Class	MSI	MPAR	MPFD	ED	MPE	MPS	NumP	TLA	CA
Residential Settlement Areas	1.28058	986,044	1,36138	80,3788	328,946	0,659041	2344	9592,69	1544.79
Open and Green Areas	2.52066	3495.29	1.57944	120.531	475.612	0.797187	2431	9592.69	1937.96
Urban Technical Infrastructure	1.43351	2508.96	1.50618	3.76678	314.205	0.577852	115	9592.69	66.4529
Urban Social Infrastructure Areas	1.18788	770.363	1.33752	30.4433	459.895	3.65858	635	9592.69	2323.2
Urban Work Areas	1.45295	1046.07	1.39709	40.1318	434.997	1.22038	885	9592.69	1080.04
Protected Areas	1.37339	2013.66	1.40115	2.91633	1075.98	12.9573	26	9592.69	336.89
Urban Technical Infrastructure (Transportation)	3.31213	1009.27	1.48262	4.53608	2900.88	59.977	15	9592.69	899.655
Tourism Settlement Areas	1.37637	301.576	1.29727	2.25548	1202.01	8.72551	18	9592.69	157.059
Today's Land Use Continuation	1.66753	193.534	1.29222	2.43333	3334.59	53.8819	7	9592.69	377.174
Urban transformation	1.41052	1983.32	1.3252	10.3715	1130.57	9.88033	88	9592.69	869.469

The areas to be forested, which are expressed as light green areas, are regrouped within themselves, such as parks, squares, refuges, protected areas, forest areas, cemeteries evaluated (Figure 4), the largest area was identified as parking areas with 33% (Table 5). Also, the landscape pattern stain analysis for Erzurum city is for the light-green area includes in Table 6.

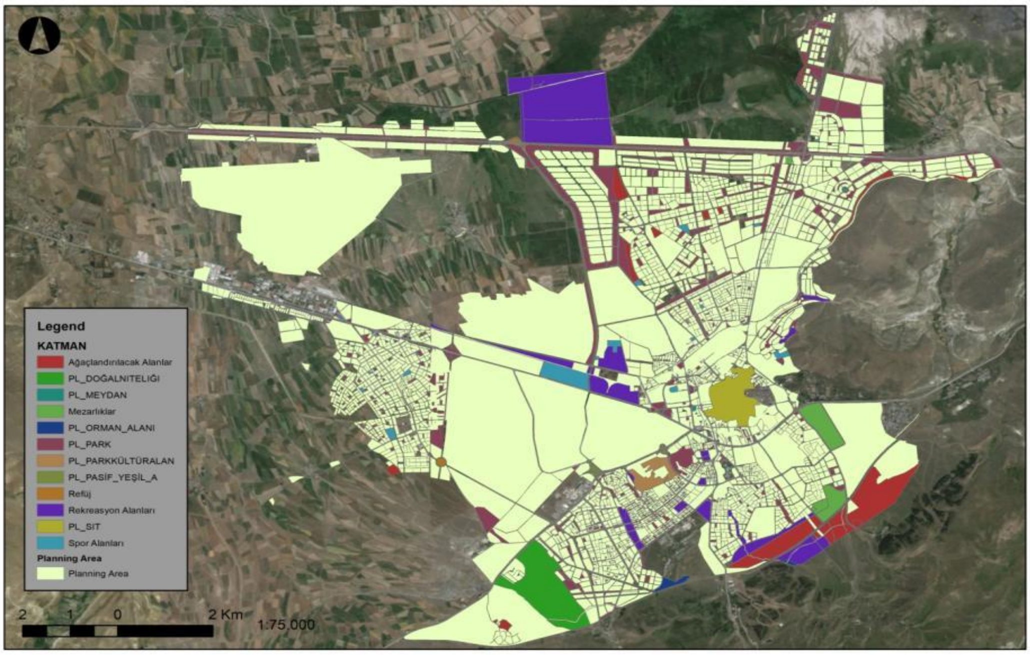

Figure 4. According to the zoning plan, open green areas of Erzurum city center

Table 5. Open-green area sizes of Erzurum city center

Area Usage Functions	Area (ha)	Percent (%)
Park	672.906	32.8
Sports Area	61.549	3
Areas to be afforested	250.581	12.2
Child Garden	172.958	8.43
Areas to Preserve Natural Quality	499.974	24.3
Recreation Areas	12.0341	0.58
Forest Area	81.1491	3.95
Cemetery	36.4782	1.77
Park Cultural Area	61.3944	2.99
Passive Green Areas	2.01948	0.09
Square	101.017	4.92
Refuge	98.0816	4.78

Table 6. Landscape pattern stain analysis results for open-green area functions according to zoning plan

Class	MSI	MPAR	MPFD	ED	MPE	MPS	NumP	TLA	CA
Park	1.76271	6275.46	1.50761	214.505	331.075	0.49993	1346	2077.46	672.906
Sports Area	3.63457	110112	1.34937	5.10509	530.281	3.07745	20	2077.46	61.549
Areas to be afforested	1.81567	226749	1.29788	19.774	1521.47	9.28078	27	2077.46	250.581
Child Garden	1.25203	1399.6	1.38859	10.4529	221.586	0.27878	98	2077.46	27.3205
Areas to Preserve Natural Quality	1.47227	151.785	1.27425	4.65994	3226.95	57.6527	3	2077.46	172.958
Recreation Areas	2.32734	149608	1.31832	27.3769	1354.16	11.9041	42	2077.46	499.974
Forest Area	1.78117	1576.37	1.47038	1.79062	619.99	2.00569	6	2077.46	12.0341
Cemetery	1.2532	220.562	1.2722	3.71354	1542.95	16.2298	5	2077.46	81.1491
Park Cultural Area	2.66262	156.278	1.35056	2.74408	5700.73	36.4782	1	2077.46	36.4782
Passive Green Areas	3.55126	4746.68	1.72799	86.202	572.145	0.196148	313	2077.46	61.3944
Square	1.28486	1144.54	1.39931	0.673906	233.336	0.33658	6	2077.46	2.01948
Refuge	4.15056	36989.2	1.74053	176.965	649.539	0.178475	566	2077.46	101.017
Protected area	1.76225	63.0783	1.2656	2.97807	6186.82	98.0816	1	2077.46	98.0816

As a result of the evaluation of the existing parking spaces received from the municipality and updated via satellite imagery (Figure 5), 119 existing parking spaces are in total 120 ha was determined. Landscape blot analysis was performed on the park areas (Table 7).

Figure 5. Available parking spaces in Erzurum city center

Table 7. Landscape pattern stain analysis results for the existing parking areas in the city center

Class	CA	NumP	MPS	ED	MPE	MSI	TLA	MPAR	MPFD
Park Areas	120.243	119	1.01045	368.824	372.678	1.33263	120.243	954.114	1.38491

CONCLUSION

Nowadays, changes in land use due to urban sprawl reduce the quality of human life. Understanding the temporal change of field use changes The interpretation and evaluation of ecological impacts is important in establishing field use policies.

In order to understand the relations between the parts of the ecosystem that make up the structure of the landscape and to interpret the pressures that may occur, the landscape of Erzurum city center study area was analyzed with landscape metrics. Numerical data obtained with Patch Analyst 4.2 software were interpreted in the analysis of landscape structure. The shape size and differences of the patches constituting the matrix of the study area were evaluated within the scope of landscape ecology.

Increasing stain size and stain number in the landscape structure is important in terms of decreasing the fragility of habitats (Uzun, 2003; Boongaling, C.G.K. et al., 2018; Lin et al., 2020; Liu et. al., 2020). But small scale stain The increase in the number is undesirable. Because the increase in the number of stains means more fragmentation of natural areas. Evaluating the stain number and stain size together would be a more accurate approach.

When the number of stains (NumP) produced by the landscape analysis of the land use functions according to the zoning plan is evaluated, we see 2431, 2344 and 885 stains in light green, residential and urban working areas. Areas of these classes (CA) are seen as 1937.9 ha, 1544.79 ha and 1080 ha, respectively. This is difficult to say with this information which stain class is more fragmented by looking at the stain numbers (NumP). Therefore, when the average stain size (MPS) is examined, urban study,1.22, 0.79 and 0.65 hectares are found for the light-green and residential area groups, respectively. In this case, when urban development plan is evaluated, urban work areas of the stain size was found to be more. When the fragility of the land use functions evaluated in the evelopment plan is evaluated, it is found that the high value fragility is in the residential settlement areas.

According to Forman (1995), not only stain numbers but also stain shapes are important. As Uzun (2003) states, the stain with a long form is less effective than the round-form stain. Long and curved stains contain less habitat than round shaped stains.

When the Table 4 of the area usage functions of the study area is evaluated, the stain shape According to the MSI (Average Figure Index) calculated for urban areas, urban technical infrastructure (transportation) is 3.31, open and green areas are 2.52 and urban working areas are 1.45. values. When MPAR (Average Peripheral Area Ratio) and MPFD (Average Stain Fractal Size) are examined, the general rule is that MPAR is small and MPFD is close to 1 The fact that the stains in that class have a more compact structure. In the area, MPAR values of today's land form areas to be protected, tourism areas and urban social infrastructure areas are 193.534, 301.576, 770.363, respectively. MPFD values are again respectively 1.29222, 1.29727, 1.33752. Circle shape is preferred for analysis with vector data, as stated in theoretical foundations. In this case, stains with more compact and circular shapes, as shown by the researches, more than the internal species more conformity. In this case, the form of land in the area will be protected areas and tourism areas and urban social infrastructure areas can be said that the stain shapes show deviations from the circle and the spots are in the form of more complex or long blots. In interpreting this information in terms of landscape fragility, it can be interpreted as follows, since habitat diversity may take place in more compact and circular spots. in the field While the urban social infrastructure areas exhibit high fragility, tourism areas are of medium value and the areas whose land shape is to be preserved show low fragility.

As Uzun (2003) states in his study, the edge of the stain that forms the landscape pattern differs from the stain. The edge structure of the stain affects food, energy and water flow. Ecological zones between the edges are important for planning. Stain edges TE, ED, MPE values are used in the evaluation of landscape metrics. But evaluation of ED from these indices is important.

Wei et al. (2020) determined basic metrics using a series of horizontal metrics to define agricultural fragmentation in the study of associating the landscape model, ecosystem service and land use management in urbanization of China, and also developed an integrated fragmentation index. Using this model, the spatial dynamics of agricultural fragmentation between Chinese cities between 2010 and 2017 were addressed.

When the matrix in the study area is examined, the ED values of Open and Green Areas, Residential Settlement Areas and Urban Study Areas are found as 120.531, 80.3788, 40.1318, respectively. When the results of these measurements are examined, high value fragility is observed in the Open and Green Areas group, while medium value fragility is observed in the Residential Settlement Areas and low value fragility is observed in the Urban Working Areas group.

According to the zoning plan the light-green area functions is obtained as a result of landscape analysis the number of stains (NumP) when evaluated, we look at the number of park, refuge and passive green area blot classes, we see 1346. 566 and 313 blots respectively. The areas (CA) of these classes are 672.9 ha, 101 ha and 61.3 ha, respectively. Stain sizes (MPS), for the median and passive green area parking area group respectively. Areas of 0.17, 0.19 and 0.49 ha are encountered. When the fragility of the land use functions evaluated in the zoning plan was evaluated, it was found that the high value fragility was in the parking areas.

When Table 6 evaluating the light-green area functions of the study area, the MSI (Mean Figure Index) calculated for the stain shape is evaluated, Refuge, Sport Areas Passive Green Areas have values of 4.15056, 3.63457 and 3.55126, respectively. When MPAR (Average Peripheral Area Ratio) and MPFD (Mean Stain Fractal Size) are examined, the general rule of thumb is that MPAR is small and MPFD is close to 1, indicating that the stains in that class have a more compact structure. In the area, Protected Areas, Areas to Preserve Natural Nature, Cemetery MPAR values are 63.0783, 151.785, 220.562 respectively. MPFD values are again 1.2656, 1.27425, 1.2722 respectively. In this case, the Protected Area, Naturally Protected Areas and Cemetery blot patterns show deviations from the circle and the blots are more complex or long blots. While the areas whose urban natural characteristics will be preserved in the area show high value fragility, the cemetery areas show moderate value and the protected areas show low value fragility.

When the light-green area blot edges matrix in the study area was examined, ED values of Refuge, Park and Recreation Areas were found to be 176.965, 214.505, 27.3769, respectively. When the results of these measurements are examined, Refuge group shows high value fragility, Park Areas medium value fragility and Recreation Areas group low value fragility.

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