Peyzaj Parçalanmasının Siirt'in Endemik Bitki Türleri Üzerine Etkileri

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Öz

Bu çalışmanın amacı, 2000-2012 yılları arasında Siirt peyzajında meydana gelen parçalanmanın, endemik bitkiler üzerindeki etkisini araştırmaktır. Yöntemsel olarak, 2000-2012 yıllarına ait CORINE arazi örtüsü/arazi kullanımı verisi kullanılarak leke sınıfları üretilmiştir. Bu leke sınıfları için Patch Analyst programında yer alan ve FRAGSTATS arayüzüyle çalışan PatchGrid eklentisi kullanılarak peyzaj metrikleri hesaplanmıştır. Siirt peyzajında yer alan endemik bitkilere ait bilgiler derlenerek sayısal ortama aktarılmıştır. Ek olarak, Siirt peyzajında yer alan endemik bitki türlerinin IUCN kırmızı liste sınıfları da değerlendirilmiştir. Araştırma bulgularına göre, belirtilen yıllar arasında Siirt peyzajındaki en parçalı leke sınıfları 2012 yılında kıyı peyzajı ve üzüm bağları olmuştur. Her iki leke sınıfı için MPS, NumP ve CA değerleri 100% düşüş göstermiştir. Diğer yandan aynı yıllar arasında meyve bahçeleri, seyrek bitki alanları, sulanmayan ekilebilir alan ve doğal çayırlıklar daha büyük lekelere dönüşmüştür. Endemik türler ile leke sınıfları arasındaki ilişkiye bakıldığında, türlerin bulunduğu leke sınıflarının 48%'i değişime uğramıştır.

Anahtar Kelimeler: Peyzaj parçalanması, endemik türler, CORINE, arazi kullanımı, arazi örtüsü, PatchGrid, Siirt

Effects of Landscape Fragmentation on Endemic Plant Species of Siirt

Abstract

In this study we aim to investigate the effect of fragmentation on the endemic plant species in the Siirt landscape between 2000 and 2012. Patch classes were systematically generated using CORINE land cover/land use data from 2000 to 2012. Landscape metrics were calculated using the PatchGrid plug-in that is included in the Patch Analyst programme, which works on FRAGSTATS interface. Furthermore, IUCN red list classes of endemic plant species in this landscape were evaluated. Thus, the most fragmented patch classes were coastal landscape and vineyards in 2012. MPS, NumP, and CA values for both these patch classes showed a 100% decrease. On the other hand, fruit trees and berry plantations, sparsely vegetated areas, non-irrigated arable land and natural grasslands turned into larger patches during the same period. When the relationship between endemic species and patch classes was investigated, 48% of the patch classes in which these species were found changed.

Keywords: Landscape fragmentation, endemic species, CORINE, land use, land cover, PatchGrid, Siirt.

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1. Introduction

Landscape fragmentation reduces the amount of available space for species, changes the flow of matter and often disrupts the species interaction. There are various studies (Damschen & Brudvig, 2012); (Ibáñez, Katz, Wolf, & Barrie, 2014); (Irl, et al., 2015) that have measured the effects of landscape fragmentation on plant species. In a fragmented landscape, the extent and abundance of any plant population is determined by patch size (Kiviniemi, 2008); (Collins, Holt, & Foster, 2009); (Tomimatsu & Ohara, 2010). Decreasing patch size is an important consequence of landscape fragmentation. However, the isolation of fragmented patches varies depending on the landscape and land uses (Saunders, Hobbs, & Margules, 1991); (Ricketts, 2001). Therefore, changes in land use caused by humans are considered to be the greatest threat for species, and the changes deeply affect the interconnected ecological systems (Vié, et al., 2008); (Dewan, Yamaguchi, & Rahman, 2012). Particularly in developing countries, the changes in land cover/land use are affected in parallel with socio-economic developments, resulting in landscape fragmentation (Grimm, et al., 2008). Urbanisation, which occurs on a large and rapid scale in rural areas influences the energy and material flow in the landscape, adversely affects local/regional biodiversity, and causes changes in climatic parameters (Green & Baker, 2003). Furthermore, urbanisation leads to a significant reduction in arable land, habitat destruction, extinction of species, and deterioration of landscape structure with patch fragmentation (Alphan, 2003); (McKinney, 2006); (Xian, Crane, & Su, 2007); (Grimm, et al., 2008); (Eroğlu, et al., 2018); Çorbacı & Dönmez, 2019). Various landscape metrics have been developed and used to measure spatial changes in the landscape structure (McGarigal & Marks, 1995; O'Neill, Riitters, Wickham, & Jones, 1999). Recent studies (Hargis, Bissonette, & Turner, 1999; O'Neill, Riitters, Wickham, & Jones, 1999; Dramstad, et al., 2001; Herold, Scepan, & Clarke, 2002; Leitão & Ahern, 2002; Luck & Wu, 2002; Kamusoko & Aniya, 2006) have shown that the pattern or structure of a landscape can be quantified using land cover/land use data in combination with a wide range of landscape metrics or indices. Landscape fragmentation analysis allows the recognition of impacts on biophysical factors such as biodiversity and socio-economic outcomes (Nagendra, Munroe, & Southworth, 2004; Antrop, 2005). Performing metric measurements for each land cover/land use data is mandatory to identify landscape fragmentation and to determine its impact on species. The resulting information guides landscape architects, urban planners, ecologists, and resource managers to support sustainable development in rapidly changing regions (Herold, Scepan, & Clarke, 2002). The Siirt Province has become the centre of beliefs and cultures because it is located at an important transition point between Mesopotamia, Transcaucasia, and Anatolia (Kılınç, 2019). The topographic and climatic characteristics of the South-eastern Anatolia region, wherein Siirt located, manifest a remarkable biodiversity. However, this region known as Upper Mesopotamia has recently been under anthropogenic pressure due to the construction of dam and roads and other activities, resulting in changes in the landscape structure and thus negatively affecting biodiversity (Öztürk, Altay, Gücel, & Altundağ, 2017).

Herein, we investigated the effect of fragmentation on the endemic plants in the Siirt landscape between 2000 and 2012. Thus, we investigated the following: (1) degree of fragmentation in the Siirt landscape during specific years and (2) extent to which the endemic plants present in the patch classes in this region were affected as a result of landscape fragmentation.

2. Material and Methodology

2.1. Material

Siirt is located in Turkey, South-eastern Anatolia, at 37.9293° in the northern latitude and at 41.9413° in the eastern longitude (Figure 1). It is a small city established in the fold zone of the Southern Taurus Mountains, which form a natural border between Mesopotamia and Anatolian civilisations. The roads connecting the eastern and western cultures pass through Siirt and provide a rich heritage and landscape diversity for Siirt. However, the increasing human-nature interaction in the recent years have led to the fragmentation of the landscape in Siirt. According to Davis (1965), Siirt is located in the squares B8-B9-C8-C9. As a phytogeographic region, it is located in the Iran-Turanian region. Although there are 27 endemic species in the Siirt province, these species are registered in the classes *Liliopsida* and *Magnoliopsida*.
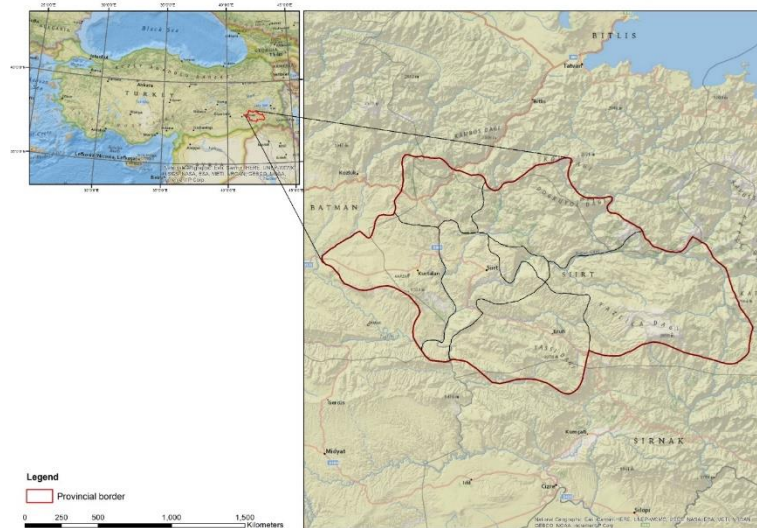
Figure 1. Geo-location of Siirt.

2.2. Methodology

2.2.1 Classification of land use types as patch classes and landscape metrics

CORINE 2000 -2012 land cover/land use vector data were used to determine the patch classes (EEA, 2019); (Ministry of Agriculture and Forestry, 2019) (Figure 2). The descriptions of CORINE codes were added to the ArcGIS attribute table. The patch classes were then defined based on these explanation with reference to the method proposed by Uzun (2003) (Table 1). A total of 18 and 17 patch classes were generated for CORINE 2000 and 2012 land cover/land use data, respectively. To calculate the temporal and spatial changes in the study area, vector data of patch classes were converted to raster format and then landscape metrics were calculated using Patch Analyst 4.0 (PatchGrid FRAGSTATS interface) (Rempel, 2015) developed for the ArcGIS 10x programme interface. Working with FRAGSTATS interface, PatchGrid measures landscape through landscape metrics developed by McGarigal & Marks (1995).
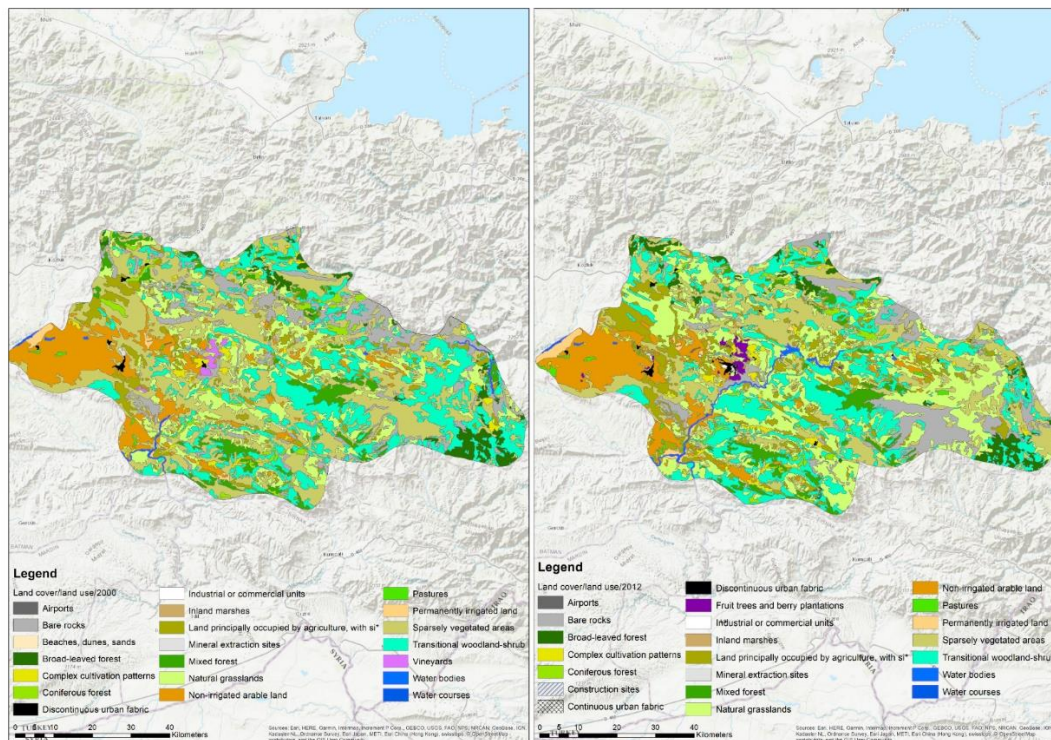

Figure 2. Land cover/land use categories between 2000-2012 of Siirt.

Table 1 Land cover/land use types classified as patch classes.

CORINE Land Cover/Land Use	Patch Class	CORINE Land Cover/Land Use	Patch Class
2000	2000	2012	2012
Airports	Urban, rural, industrial and commercial landscape	Airports	Urban, rural, industrial and commercial landscape
Bare rocks	Bare land	Bare rocks	Bare land
Beaches, dunes, sands	Coastal landscape	Broad-leaved forest	Broad-leaved forest
Broad-leaved forest	Broad-leaved forest	Complex cultivation patterns	Complex cultivation patterns
Complex cultivation patterns	Complex cultivation patterns	Coniferous forest	Coniferous forest
Coniferous forest	Coniferous forest	Construction sites	Urban, rural, industrial and commercial landscape
Discontinuous urban fabric	Urban, rural, industrial and commercial landscape	Continuous urban fabric	Urban, rural, industrial and commercial landscape
Industrial or commercial units	Urban, rural, industrial and commercial landscape	Discontinuous urban fabric	Urban, rural, industrial and commercial landscape
Inland marshes	Inland marshes	Fruit trees and berry plantations	Fruit trees and berry plantations
Land principally occupied by agriculture, with significant areas of natural vegetation	Land principally occupied by agriculture, with significant areas of natural vegetation	Industrial or commercial units	Urban, rural, industrial and commercial landscape
Mineral extraction sites	Mineral landscape	Inland marshes	Inland marshes
Mixed forest	Mixed forest	Land principally occupied by agriculture, with significant areas of natural vegetation	Land principally occupied by agriculture, with significant areas of natural vegetation
Natural grasslands	Natural grasslands	Mineral extraction sites	Mineral landscape
Non-irrigated arable land	Non-irrigated arable land	Mixed forest	Mixed forest
Pastures	Pastures	Natural grasslands	Natural grasslands
Permanently irrigated land	Permanently irrigated land	Non-irrigated arable land	Non-irrigated arable land
Sparsely vegetated areas	Sparsely vegetated areas	Pastures	Pastures
Transitional woodland-shrub	Transitional woodland-shrub	Permanently irrigated land	Permanently irrigated land
Vineyards	Vineyards	Sparsely vegetated areas	Sparsely vegetated areas
Water bodies	Water landscape	Transitional woodland-shrub	Transitional woodland-shrub
Watercourses	Water landscape	Water bodies	Water landscape
		Watercourses	Water landscape

According to Gustafson (1998), landscape metrics are categorised in two as spatial and non-spatial. Non-spatial metrics define landscape composition and measure patch class numbers or proportions of the total area, whereas spatial metrics define patch characteristics and provide information on fragmentation status (Table 2). Thus, extensive measurements were made using the metrics by statistically calculating the raster input and a .dbf output file was generated by PatchGrid (FRAGSTATS interface). Seven metrics (CA, NumP, MPS, AWMSI, ED, IJI, and MPI; Table 3) were used to measure landscape fragmentation in the Siirt province. AWMSI and ED are spatial metrics, whereas CA, NumP, IJI, MPI, and MPS are non-spatial metrics. CA is the spatial definition of each patch class. NumP is the number of patches in the class. CA and NumP are used to demonstrate landscape change. MPS is the average patch size and the most important indicator of diversity within the landscape. AWMSI weights patches according to their size. Particularly, large patches are weighted more than small ones in calculating the average patch shape in the landscape or class. In addition, AWMSI is used to measure the patch sensitivity in fragmentation.

Table 2. Non-spatial and spatial metrics (Li and Reynolds, 1995; Gustafson, 1998).

Name	Description	Quantification
Non-spatial metrics	Composition	Number of categories Proportions Diversity (richness, evenness)
Spatial	Configuration	Patch-based metrics Size Shape Patch density Connectivity Fractal dimension Pixel-based metrics Contagion Lacunarity

Table 3. Landscape metrics used in this study.

Patch size and density metrics	Shape metrics	Edge metrics	Diversity metrics
Mean patch size (MPS)	Average weighted mean shape index (AWMSI)	Edge density (ED)	Interspersion juxtaposition index (IJI)
Number of patches (NumP)			Mean proximity index (MPI)
Class area (CA)			

ED is the density of patch edges in the landscape and, was chosen to understand the interrelated ecological effects. IJI measures the degree of affinity of the patches to each other. IJI value approaches 0, when the distribution of contiguity of the unique patches is uneven and the value approaches 100, when all the patch types are equally contiguous to each other. MPI measures the degree of fragmentation and isolation of a patch. The nearest-neighbour statistics is used for this measurement. To study the landscape fragmentation in the study area between 2000 and 2012, CORINE 2000-2012 vector data were converted to raster data and landscape metrics were calculated at the class level using PatchGrid (FRAGSTATS interface; Figure 3). A database file (.dbf) was created by the programme showing the selected and calculated metrics. The FRAGSTATS interface has the following five types of statistics for measuring landscape: (1) patch size and density metrics, reveal landscape fragmentation and configuration; (2) shape metrics, measure the geometric complexity of the landscape, (3) edge metrics, specify the distribution, length, and amount of edges between patch types; (4) diversity metrics, measure the isolation of patches in the landscape; and (5) core area metrics, measure the size of a patch independently of the outer periphery (McGarigal & Marks, 1995; Rempel, 2015). We used three patch sizes and density metrics, one shape metric, one edge metric, and two diversity metrics to measure the fragmentation.

2.2.2 Establishing the database of endemic species in Siirt

The list of endemic species was created according to Davis (1965-1967-1970-1972-1975-1978-1982- 1984-1985). New species not included in this list were updated according to checklist created by Dönmez (2006); Özgökçe & Ünal (2007); Özhatay, Kültür, & Aslan (2009); Özhatay, Kültür, & Gürdal (2011-2015-2017); Karabacak, Yıldırım, & Martin (2014); Celep, Karabacak, Malekmohammadi, Fidan, & Doğan, (2016); and Şenkul & Kaya (2017). In addition, the endemic status of each species and the squares and cities in Turkey where they are located, were confirmed using the Turkish Plants Data Service (TUBIVES, 2004). The location, direction, distance, and elevation details were obtained from the above mentioned sources and recorded in an excel file according to the family, taxon, grid number, and location information. Furthermore, elevation values were determined using the Google Earth programme and assigned to ArcGIS as point data. The point data was associated with the spatial parameters and integrated with the PatchGrid data to determine, to which extent the endemic species were affected by landscape fragmentation.
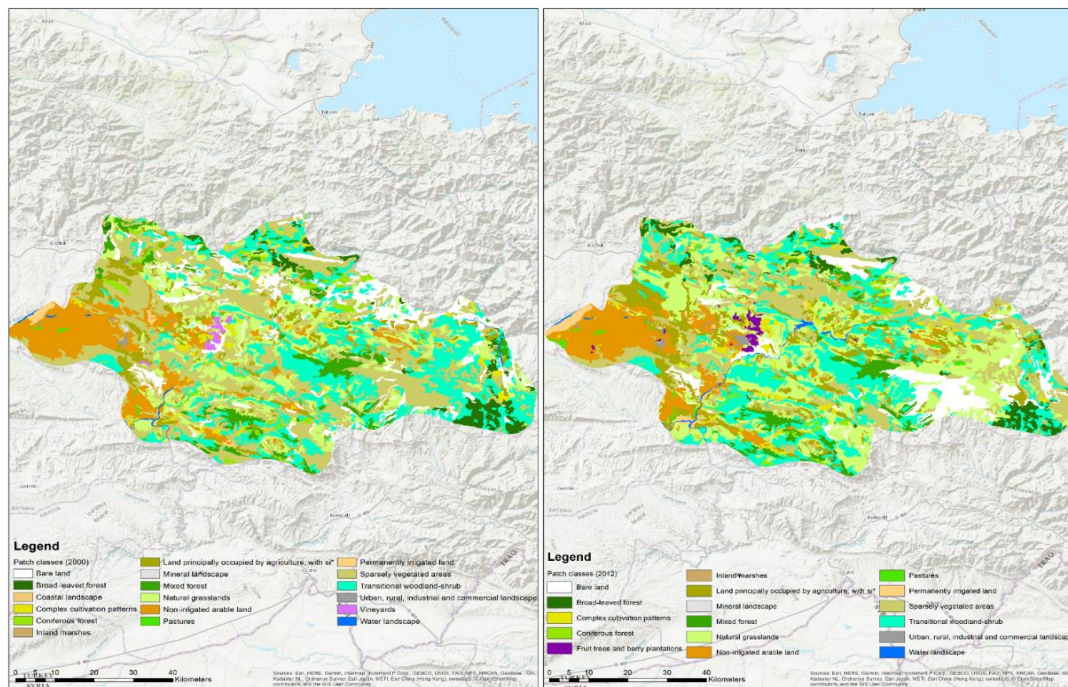
Figure 1. Patch classes in 2000-2012.

Global conservation status of the endemic species was determined using the Van Herbarium (Van Herbarium, 2019) database and the Global Biodiversity Information Facility (GBIF, 2019) database in addition to the red list prepared by the International Union for Nature Conservation (IUCN Red List, 2019).

3. Results and Discussion

3.1. Patch level changes in the Siirt landscape

The most significant changes in patch classes were observed during the selected years. The patch classes of coastal landscape, vineyards, and fruit trees and berry plantations that existed in 2000 were not found in 2012. In addition, changes in the patch classes were observed in area sizes (Table 4). The reason for this change is the transformation of the coastal landscape and some of the vineyard patches into the sparsely vegetated areas. Similarly, non-irrigated arable land, sparsely vegetated areas, mineral landscape, natural grasslands, bare land, vineyards and land principally occupied by agriculture with significant areas of natural vegetation turned into the fruit trees and berry plantations during this period. According to the statistical results of the metrics showing landscape fragmentation at the patch level, MPS and CA values of fruit trees berry plantations were the highest during this period. This means that the corresponding patch class had become the largest patch in the landscape with 1400% increase from 2000 to 2012. The most fragmented patch classes were the coastal landscape and the vineyards in 2012. MPS, NumP, and CA values for both these patch classes showed a 100% decrease. Thus, the reduction in patch size led to fragmentation in the landscape. Patch shape is one of the most important ecological indicators showing landscape fragmentation because it affects the material flow and movements (Forman, 1995; Uzun, 2003). The high AWMSI value indicates that the patch shapes are becoming more irregular (Paudel & Yuan, 2012). In other words, a high AWMSI value means a high degree of fragmentation and non-circular patch shape. In the present study, all AWMSI values were >1; therefore, the patch shapes were not circular. Considering fragmentation during this period, water landscape and natural grasslands were more fragmented in 2012 compared to the other patches. Forman (1995) states that circular patches have better ecological advantage under optimum conditions. On comparing the ED values, the edge density of natural grasslands was higher and more fragmented with a value of 8.36. Furthermore, IJI index measures the extent to which patch types are dispersed. Landscapes where patch types are well dispersed (equally adjacent), have high values, whereas those where patch types are poorly dispersed have low values (McGarigal & Marks, 1995). Mineral landscape and pastures showed a weak distribution along with the fruit trees and berry plantations. Coastal landscape and vineyards showed a very good distribution in 2000 (21.13% and 22.86%, respectively; Table 5).

Table 4. Areal changes in path classes. [Increase in areal changes in percent column is indicated with (+) and decrease with (−)].

Patch classes	Hectares (ha)		Percent (%)
	2000	**2012**	
Bare land	79502	64564	+%18
Broad-leaved forest	29624	27047	−%86
Coastal landscape	74		−%100
Complex cultivation patterns	9943	12508	+%25
Coniferous forest	10244	7234	−%29
Fruit trees and berry plantations		3088	+%100
Inland marshes	274	204	−%25
Land principally occupied by agriculture	32401	61394	+%89
Mineral landscape	241	202	−%16
Mixed forest	28332	23915	−%15
Natural grasslands	125878	145711	+%15
Non-irrigated arable land	56988	49966	−%12
Pastures	791	2636	+%233
Permanently irrigated land	4877	6753	+%38
Sparsely vegetated areas	258558	321142	+%24
Transitional woodland-shrub	146005	169644	+%16
Urban, rural, industrial and commercial landscape	1125	2402	+%113
Vineyards	2330		−%100
Water landscape	17048	13323	−%21

However, in 2012, the same patches showed a better distribution along with the fruit trees and berry plantations. Coastal landscape and vineyards showed a very good distribution in 2000, whereas they showed irregular distribution in 2012. That is why, vineyards and coastal landscape did not exist in 2012 and fruit trees and berry plantations emerged in 2012. MPI measures the isolation and fragmentation status of a patch (Gustafson & Parker, 1992). If all other conditions are equal, a patch that is larger than another patch and located in an environment defined by the scanning radius has a larger index value. Similarly, if all other conditions are equal, a patch found in an environment in which the corresponding patch type is distributed with larger, more adjacent, and/or closer patches than another patch has a larger index value. In other words, the patch classes in 2000 showed a larger and more contiguous distribution than those in 2012. During the same year, vineyards patch class was the weakest and the most isolated patch class. Fragmentation manifests on the landscape via the following three effects: 1) increase in number of patches, 2) decrease in patch size, and 3) increase in patch isolation (Fahrig, 2003). When all the landscape metrics selected in the Siirt landscape were evaluated in terms of fragmentation, coastal landscape and vineyards had 100% fragmentation rate. In contrast to these two patches, fruit trees and berry plantations, sparsely vegetated areas, non-irrigated arable land, and natural grasslands turned into larger patches.

3.2. Endemic plant species in Siirt and their classification

According to the list created based in the selected references, 27 endemic plant species were present in the Siirt province (Davis, 1965-1967-1970-1972-1975-1978-1982- 1984-1985; Dönmez, 2006; Özgökçe & Ünal, 2007; Özhatay, Kültür, & Aslan, 2009; Özhatay, Kültür, & Gürdal, 2011-2015-2017; Karabacak, Yıldırım, & Martin, 2014; Celep, Karabacak, Malekmohammadi, Fidan, & Doğan, 2016; and Şenkul & Kaya, 2017). Table 6 that represents the distribution of the classes according to families, shows that 70% and 30% species belong to *Magnoliopsida* and *Liliopsida*, respectively.

3.3. Endemic plant species and landscape fragmentation

Changes in land cover/land use affect landscape and diversity as much as ecological factors (Aksoy & Uzun, 2011). A total of 27 endemic species were documented in the Siirt landscape during the years between 1965 and 2017 by Davis, (1965-1967-1970-1972-1975-1978-1982- 1984-1985); Dönmez, (2006); Özgökçe & Ünal, (2007); Özhatay, Kültür, & Aslan, (2009); Özhatay, Kültür, & Gürdal, (2011-2015-2017); Karabacak, Yıldırım, & Martin, (2014); Celep, Karabacak, Malekmohammadi, Fidan, & Doğan, (2016); and Şenkul & Kaya, (2017).

Table 5. Results of landscape metrics

Patch classes	MPS		NUMP		CA		AWMSI		ED		IJI		MPI	
	2000	2012	2000	2012	2000	2012	2000	2012	2000	2012	2000	2012	2000	2012
Bare land	441.22	693.47	121	69	53387.25	47849.75	3.89	4.08	3.94	2.63	61	64.56	448.18	400.77
Broad-leaved forest	437.57	348.43	34	45	14877.25	15679.5	2.88	3.41	0.93	1.21	51.36	49.65	281.81	269.45
Coastal landscape	72.25		1		72.25		1.91		0.01		55.89		0	
Complex cultivation patterns	166.81	159.68	57	77	9508	12295	2.05	2.35	0.94	1.32	67.36	72.54	8.21	20.72
Coniferous forest	254.17	192.2	35	32	8896	6150.5	2.11	2.1	0.72	0.58	61.46	53.13	34.95	73.54
Fruit trees and berry plantations		206.03		15		3090.5		2.26		0.24		67.82		181.5
Inland marshes	91.83	102.12	3	2	275.5	204.25	1.45	1.43	0.03	0.02	44.9	54.48	0.53	0.39
Land principally occupied by agriculture	204.76	212.42	151	252	30919	53529.25	2.47	2.7	2.56	4.67	62.91	67.02	21.8	126.16
Mineral landscape	241.5	40.25	1	5	241.5	201.25	1.48	1.62	0.02	0.04	21.13	54.85	0	0.02
Mixed forest	414.2	423.12	59	47	24437.75	19886.5	3.02	3.13	1.72	1.39	57.16	55.8	88.35	89.76
Natural grasslands	373.56	535.53	205	239	76579.5	127991.25	2.96	5.03	5.83	8.36	63.15	69.78	320.2	1436.13
Non-irrigated arable land	942.22	815.17	57	59	53706.75	48095	3.25	3.65	1.97	1.86	63.65	74.75	426.93	2719.81
Pastures	132.29	150.8	6	15	793.75	2262	1.87	2	0.09	0.23	22.86	48.53	0.19	4.87
Permanently irrigated land	267.52	321.7	13	16	3477.75	5147.25	1.89	1.94	0.22	0.28	56.71	60.69	8.5	113.83
Sparsely vegetated areas	752.59	523.91	231	205	173847.5	107401.5	5.21	4.99	10.01	7.07	69.52	69.35	1545.94	1927.23
Transitional woodland-shrub	540.27	464.08	202	238	109135.25	110450.25	4.26	3.8	6.83	7.24	61.9	67.58	839.76	518.95
Urban, rural, industrial and commercial landscape	139.91	114.23	821	21	1119.25	2398.75	1.91	2.42	0.12	0.27	59.13	68.34	0.07	107.13
Vineyards	467.05		5		2335.25		1.94		0.14		65.04		242.48	
Water landscape	164.73	262.42	10	10	1647.25	2624.25	5.13	7.67	0.31	0.5	73.17	73.72	160.43	223.83

Table 6. Distribution of endemic plant species by class, number of species and family

Class	Number of species	Family
Magnoliopsida	2	*Boraginaceae*
	1	*Brassicaceae*
	1	*Campanulaceae*
	1	*Caryophyllaceae*
	1	*Dipsacaceae*
	4	*Fabaceae*
	5	*Lamiaceae*
	1	*Papaveraceae*
	1	*Plumbaninaceae*
	2	*Scrophulariaceae*
Liliopsida	5	*Liliaceae*
	3	*Orchidaceae*

Figure 4 represents the endemic species and their patch classes of Siirt. All endemic species were grouped in 12 families, and the patch classes containing these species were transformed during the study period. Patches representing complex cultivation patterns, bare land, and non-irrigated arable land, and transitional woodland shrub transformed into broad-leaved forests, land principally occupied by agriculture with significant areas of natural vegetation, natural grasslands, water landscapes, bare lands, and sparsely vegetated areas in 2012 (Table 7). Patches that transformed during this period are indicated in *italic* in the table. This transformation is parallel to the results of landscape metrics, that is why the relevant patches are larger or absent, indicating the change in land cover/land use in 2012. The distribution of the 12 families in the Siirt landscape according to the red list, was also examined (Table 8). Out of the 27 endemic species, one showed distributed in EN, two in CR, two in VU, seven in LC, two in LR/cd, and 13 in NE categories. There are 13 species that have not been evaluated (NE) or included in any red list category (Figure 5) yet. The common feature of the species in this category is that they are located among limestone, steppe, bevelled areas and *Quercus sp*. forest openings. During the study period, the patch classes including nine of these 13 species were changed in the Siirt landscape. The patch class of five species turned into natural grasslands, that of one species turned into bare lands, that of one species turned into broad-leaved forests, and that of two species turned into land principally occupied by agriculture with significant areas of natural vegetation. In addition, the habitat of two endemic species in the VU category was determined as saline areas and mountainous areas by Davis, (1965-1967-1970-1972-1975-1978-1982-1984-1985). The patches containing these species did not undergo any change during the study period. The Patch class of one species in the EN category remained the same as bare land. Although there were seven species in the LC category, there was a change in the patch classes in two of these species. The patch class of one species turned into bare lands and that of one species turned into transitional woodland shrub. The patch class of one of the two species in the LR/cd category changed from sparsely vegetated areas to natural grasslands. The patch class including one of the two species in the CR category turned from non-irrigated arable land into water landscape due to the dams built in the region. The reason for this transformation can be explained as enlargements in the water holding areas due to the merger og Ilisu Dam located in the southwest of the province with the Alkumru and Sirvan Dams located in the north. Thus, the patch classes of 13 endemic species located in different patch classes changed. These changes in the patch classes are thought to affect the red list categories as well. On the other hand, the red list classification by IUCN is conducted at a global scale. When the assessment scale is reduced to the country, region and province scale, the endangered status of the species also changes. Although there are no previous studies conducted in the Siirt province, Şenkul & Kaya (2017) evaluated the digital data of the endemic plant species in Turkey. In the present study, we evaluated the endemic plants in the Siirt province and related them to landscape fragmentation. In addition, the IUCN red list classification was used to evaluate endemism in detail. Although the quadrature system was used as a reference in both studies (Davis, 1965-1967-1970-1972-1975-1978-1982- 1984-1985), the scale differences between the two studies affected the details in the study. In the study which was conducted by Şenkul & Kaya (2017), the distribution of endemic taxa was made according to the provinces, and it was stated that there are 36 endemic taxa in the Siirt province. In the present study, 27 endemic taxa were found in the Siirt province, and 13 (48%) of these have still not been classified by the IUCN. On the other hand, Aksoy & Uzun (2011) investigated the relationship between land use types and endemism at the provincial scale and examined the IUCN red list classification of endemic plant species in the Duzce province. They concluded that endemic plant species in the forest land use were in danger due to road and dam constructions. In the present study, one endangered endemic species was identified, that was affected by Ilisu, Alkumru, and Sirvan dams, which are large-scale dam projects in the South-eastern Anatolia region.
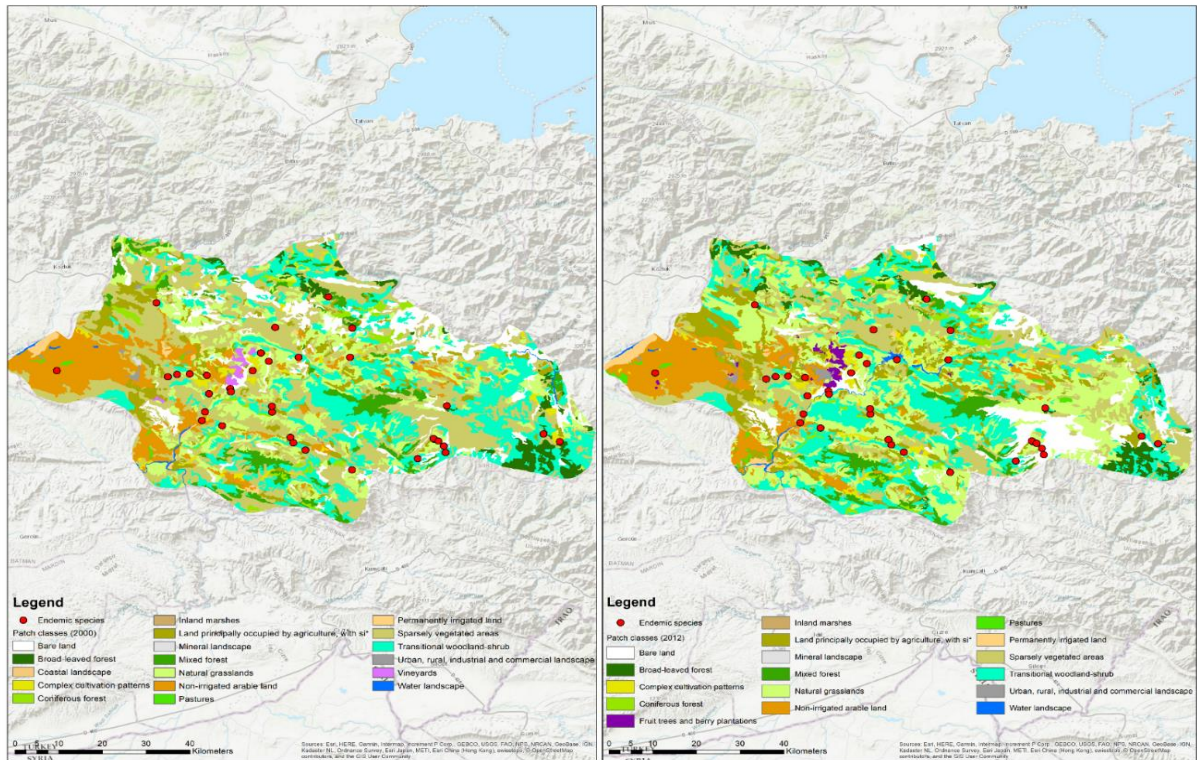
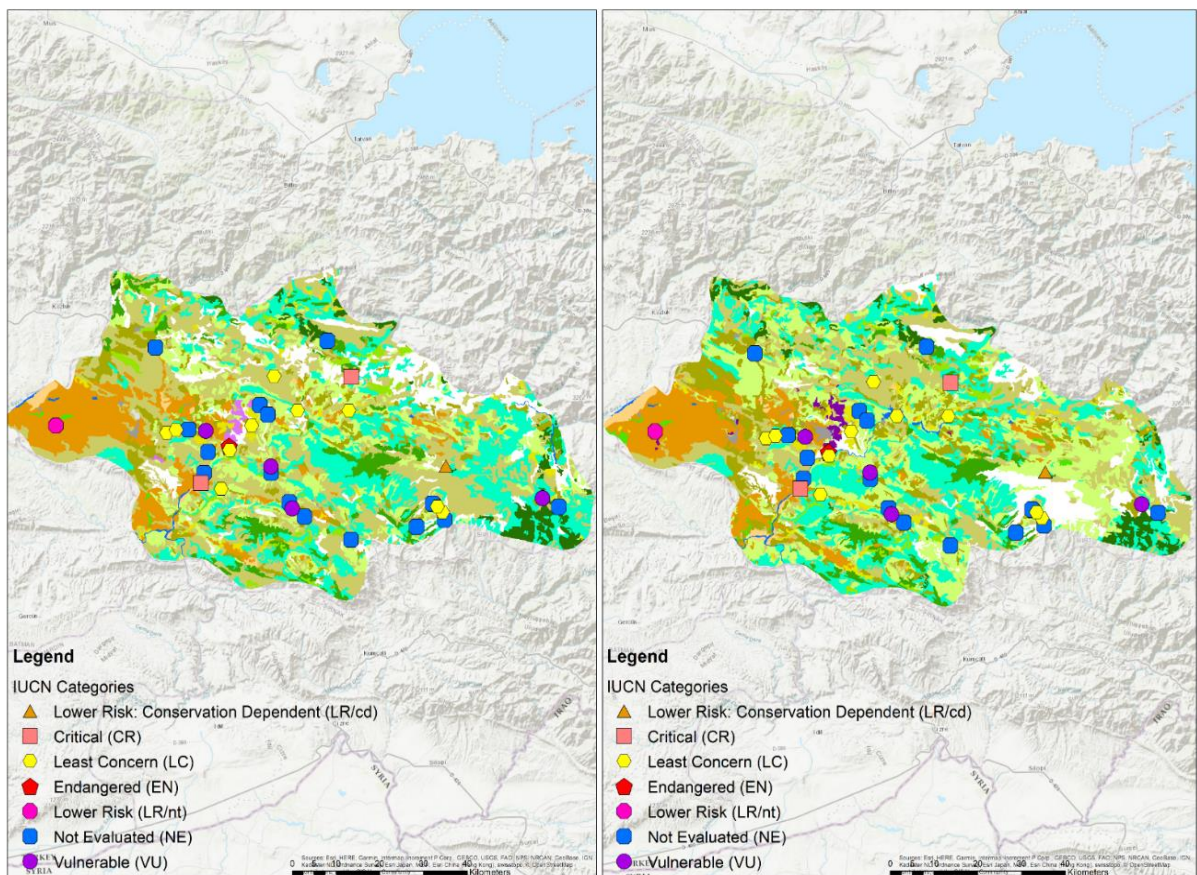Figure 4. Endemic species and their patch classes of Siirt.

Figure 5. Distribution of endemic species by IUCN red list categories of Siirt landscape between 2000-2012; respectively.

Table 7. Distribution of endemic species by patch classes and different families between 2000-2012 (Patches that transformed during this period are indicated in *italic* in the table).

Family	Patch00	Patch12
Boraginaceae	*Sparsely vegetated areas*	*Bare land*
Boraginaceae	Non-irrigated arable land	Non-irrigated arable land
Brassicaceae	Transitional woodland-shrub	Transitional woodland-shrub
Campanulaceae	Sparsely vegetated areas	Sparsely vegetated areas
Campanulaceae	Sparsely vegetated areas	Sparsely vegetated areas
Caryophyllaceae	Natural grasslands	Natural grasslands
Caryophyllaceae	*Complex cultivation patterns*	*Broad-leaved forest*
Dipsacaceae	*Sparsely vegetated areas*	*Natural grasslands*
Fabaceae	*Bare land*	*Natural grasslands*
Fabaceae	*Bare land*	*Natural grasslands*
Fabaceae	Transitional woodland-shrub	Transitional woodland-shrub
Fabaceae	Non-irrigated arable land	Non-irrigated arable land
Lamiaceae	Bareland	Bare land
Lamiaceae	*Sparsely vegetated areas*	*Natural grasslands*
Lamiaceae	Complex cultivation patterns	Complex cultivation patterns
Lamiaceae	Mixed forest	Mixed forest
Scutellaria	Transitional woodland-shrub	Transitional woodland-shrub
Liliaceae	Natural grasslands	Natural grasslands
Liliaceae	Transitional woodland-shrub	Transitional woodland-shrub
Liliaceae	*Sparsely vegetated areas*	*Land principally occupied by agriculture with significant areas*
Liliaceae	Natural grasslands	Natural grasslands
Liliaceae	*Non-irrigated arable land*	*Water landscape*
Orchidaceae	*Sparsely vegetated areas*	*Water landscape*
Orchidaceae	Land principally occupied by agriculture with significant areas	Land principally occupied by agriculture with significant areas
Orchidaceae	Sparsely vegetated areas	Sparsely vegetated areas
Orchidaceae	Natural grasslands	Natural grasslands
Orchidaceae	Sparsely vegetated areas	Sparsely vegetated areas
Orchidaceae	Transitional woodland-shrub	Transitional woodland-shrub
Orchidaceae	Transitional woodland-shrub	Transitional woodland-shrub
Papaveraceae	*Bare land*	*Sparsely vegetated areas*
Plumbaninaceae	Land principally occupied by agriculture with significant areas	Land principally occupied by agriculture with significant areas
Plumbaninaceae	Transitional woodland-shrub	Transitional woodland-shrub
Plumbaninaceae	Sparsely vegetated areas	Sparsely vegetated areas
Scrophulariaceae	*Transitional woodland-shrub*	*Bare land*
Scrophulariaceae	Bare land	Bare land

Table 8. Classification of endemic species by IUCN red list categories in Siirt

IUCN categories	Endangered (EN)	Critic (CR)	Vulnerable (VU)	Least Concern (LC)	Lower Risk (LR/cd)	Not Evaluated (NE)
Number of Taxa	1	2	2	7	2	13

Paudel & Yuan (2012) investigated landscape change using GIS modelling and the Patch Analyst plugin. In their study, landscape metrics were calculated for 1975, 1986, 1998, and 2006, and the change in landscape was examined. In addition, a model was established for the future deforestation and urbanisation within the framework of the regional land use plan for 2030. In the present study, in addition to the landscape metrics in the aforementioned study, IJI and MPI metrics and the PatchGrid (FRAGSTATS interface) plugin were used. Fahrig (2003) and McGarigal & Cushman (2003) highlighted that, in calculations with metrics, rather than other factors that fragmentation is associated with, the individual assessment of patches comes into question, leading to difficulty in interpreting the results. On the other hand, Delin & Andrén (1999) stated that a study conducted on the patch scale could not be a resource for evaluations at the landscape scale. It is not possible to make an inference on the landscape scale from a value of >1 on the patch scale. However, most of the work on fragmentation is performed on individual patches and does not represent the entire landscape.

4. Conclusions

Thus, landscape fragmentation is a dynamic process that affects both biota and abiota and has manifested on the endemic plant species in the Siirt landscape between 2000 and 2012. Some patches responded to this process by shrinking, decreasing in number, or disappearing, whereas other patches increased in size and continued to exist by adapting to the diversity. Conservation strategies should be developed on a provincial basis because the patches that increased in size during the study period supported the existence of more species. For shrinking patches, recommendations should be made to maintain the current situation. Understanding these changes and processes in the landscape structure will be a driving force for the fulfilment of planning, management, and protection responsibilities for the landscapes in accordance with the European Landscape Convention. This will lead to effective landscape planning and management.

References

1. Aksoy, N., & Uzun, O. (2011, April 18). Distribution and conservation significance of endemic plants in Duzce province. *International Journal of the Physical Sciences, 6*(8), 2143-2151. Retrieved from http://www.academicjournals.org/IJPS
2. Alphan, H. (2003, September 2). Land-use change and urbanization of Adana, Turkey. *Land Degradation and Development, 14*(6), 575-586. doi:10.1002/ldr.581
3. Antrop, M. (2005, January 15). Why landscapes of the past are important for the future. Landscape and Urban Planning, 70(1-2), 21-34. doi:10.1016/j.landurbplan.2003.10.002
4. Celep, F., Karabacak, O., Malekmohammadi, M., Fidan, M., & Doğan, M. (2016). First record of Psylliostachys spicata (Plumbaginaceae), confirmation of Salvia pratensis (Lamiaceae) from Turkey, and taxonomic status of Salvia ertekinii. Turkish Journal of Botany, 40(2), 226-230. doi:10.3906/bot-1503-48
5. Collins , C. D., Holt, R. D., & Foster, B. L. (2009, September). Patch size effects on plant species decline in an experimentally fragmented landscape. Ecology, 90(9), 2577-2588. doi:https://doi.org/10.1890/08-1405.1
6. Çorbacı, Ö. L., & Dönmez, Y. (2019). Peyzaj yapısının (Peyzaj Karakter Tiplerinin) tanımlanması ve haritalanması: Bartın İli Amasra İlçesi Örneği [Determining and mapping of the landscape structure (Landscape Character Types): Case of Amasra district of Bartin province. In G. Akademi, & L. G. Kaya (Ed.), Mimarlık, Planlama ve Tasarım Alanında Yeni Ufuklar (pp. 329-366). Ankara: Gece Akademi.
7. Damschen, E. I., & Brudvig, L. A. (2012, April). Landscape connectivity strengthens local—regional richness relationships in successionalplant communities. Ecology, 93(4), 704-710. Retrieved 01 09, 2020, from https://www.jstor.org/stable/23213718
8. Davis, P. H. (1965). Flora of Turkey (Vol. 1). Edinburg, Edinburg, Great Britain: Edinburg University Press.
9. Davis, P. H. (1967). Flora of Turkey (Vol. 2). Edinburg, Edinburg, Great Britain: Edinburg University Press.
10. Davis, P. H. (1970). Flora of Turkey (Vol. 3). Edinburg, Edinburg, Great Britain: Edinburg University Press.
11. Davis, P. H. (1972). Flora of Turkey (Vol. 4). Edinburg, Edinburg, Great Britain: Edinburg University Press.
12. Davis, P. H. (1975). Flora of Turkey (Vol. 5). Edinburg, Edinburg, Great Britain: Edinburg University Press.
13. Davis, P. H. (1978). Flora of Turkey (Vol. 6). Edinburg, Edinburg, Great Britain: Edinburg University Press.
14. Davis, P. H. (1982). Flora of Turkey (Vol. 7). Edinburg, Edinburg, Great Britain: Edinburg University Press.
15. Davis, P. H. (1984). Flora of Turkey (Vol. 8). Edinburg, Edinburg, Great Britain: Edinburg University Press.
16. Davis, P. H. (1985). Flora of Turkey (Vol. 9). Edinburg, Edinburg, Great Britain: Edinburg University Press.
17. Delin, A. E., & Andrén, H. (1999, February). Effects of habitat fragmentation on Eurasian red squirrel (Sciurus vulgaris) in a forest landscape. Landscape Ecology, 14(1), 67-72. doi:https://doi.org/10.1023/A:100804000
18. Dewan, A. M., Yamaguchi, Y., & Rahman, M. Z. (2012, December 14). Dynamics of land use/cover changes and the analysis of landscape fragmentation in Dhaka Metropolitan, Bangladesh. Geojournal, 77(3), 315-330. doi:10.1007/s 10708-010-9399-x

19. Dönmez, A. A. (2006, April 3). Teucrium chasmophyticum Rech. f. (Lamiaceae): A new record for the flora of Turkey. Turkish Journal of Botany, 30(4), 317-320. Retrieved from http://journals.tubitak.gov.tr/botany/issue.htm?id=659

20. Dramstad, W. E., Fry, G., Fjellstad, W. J., Skar, B., Helliksen, W., Sollund, M. L., . . . Framstad, E. (2001, December). Integrating landscape-based values—Norwegian monitoring of agricultural landscapes. Landscape and Urban Planning, 57(3-4), 257-268. doi:10.1016/S0169-2046(01)00208-0

21. EEA. (2019, June 06). EEA Europa Data and Maps. Retrieved July 2, 2019, from CORINE land cover 2000-2012 seamless vector data: https://www.eea.europa.eu/data-and-maps

22. Eroğlu, E., Kaya, S., Doğan, T. G., Meral, A., Demirci, S., Başaran, N., Çorbacı, Ö. L. 2018. Determination of the visual preferences of different habitat types. Fresenius Environmental Bulletin, 27, 4889-4899.

23. Fahrig, L. (2003, November). Effects of habitat fragmentation on biodiversity. Annual Review of Ecology, Evolution, and Systematics, 34(1), 487-515. doi:10.1146/annurev.ecolsys.34.011802.132419

24. Forman, R. T. (1995). Land mosaics: the ecology of landscapes and regions. Cambridge: Cambridge University Press.

25. GBIF. (2019, October 2). Retrieved June 10, 2019, from Global Biodiversity Information Facility: https://www.gbif.org/

26. Green, D., & Baker, M. G. (2003, May 15). Urbanization impacts on habitat and bird communities in a sonoran desert ecosystem. Landscape and Urban Planning, 63(4), 225-239. doi:10.1016/S0169-2046(02)00195-0

27. Grimm, N. B., Foster, D., Groffman, P., Grove, J. M., Hopkinson, C. S., Nadelhoffer, K. J., . . . Peters, D. P. (2008, June). The changing landscape: ecosystem responses to urbanization and pollution across climatic and societal gradients. Frontiers in Ecology and the Environment, 6(5), 264-272. doi:10.1890/070147

28. Gustafson, E. J. (1998, March). Quantifying landscape spatial pattern: What is the state of the art? Ecosystems, 1(2), 143-156. doi:10.1007/s100219900011

29. Gustafson, E. J., & Parker, G. R. (1992, June). Relationships between landcover proportion and indices of landscape spatial pattern. Landscape Ecology, 7(2), 101-110. doi:10.1007/BF02418941

30. Hargis, C. D., Bissonette, J. A., & Turner, D. L. (1999, February). The influence of forest fragmentation and landscape pattern on American martens. Journal of Applied Ecology, 36(1), 157-172. doi:10.1046/j.1365-2664.1999.00377.x

31. Herold, M., Scepan, J., & Clarke, K. C. (2002, August). The Use of remote sensing and landscape metrics to describe structures and changes in urban land uses. Environment and Planning A: Economy and Space, 34(8), 1443-1458. doi:10.1068/a3496

32. Ibáñez, I., Katz, D. S., Wolf, S. M., & Barrie, B. T. (2014, July 23). Assessing the integrated effects of landscape fragmentation on plants and plant communities: the challenge of multiprocess-multiresponse dynamics. Journal of Ecology, 102(4), 882-895. doi:https://doi.org/10.1111/1365-2745.12223

33. Irl, S. D., Harter, D. E., Steinbauer, M. J., Puyol, D. G., Fernández-Palacios, J. M., Jentsch, A., & Beierkuhnlein, C. (2015, November). Climate vs. topography – spatial patterns of plant species diversity and endemism on a high-elevation island. Journal of Ecology, 103(6), 1621-1633. doi:https://doi.org/10.1111/1365-2745.12463

34. IUCN Red List. (2019, March 1). Retrieved July 1, 2019, from IUCN Red List of Threatened Species: https://www.iucnredlist.org/

35. Kamusoko, C., & Aniya, M. (2006, August 8). Land use/cover change and landscape fragmentation analysis in the Bindura District, Zimbabwe. Land Degradation and Development, 18(2), 221-233. doi:10.1002/ldr.761

36. Karabacak, O., Yıldırım, H., & Martin, E. (2014). Bellevalia pseudolongipides sp. nova (Asparagaceae): New species from South Eastern Anatolia, Turkey. Phytotaxa, 188(4), 209-217. doi:10.11646/phytotaxa.188.4.3

37. Kılınç, N. (2019, January 21). Siirt ve çevresinin turizm coğrafyası [Tourism geography of Siirt and its environs]. Doctoral dissertation. Istanbul, Istanbul, Turkey: Istanbul University Institute of Social Sciences. Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp

38. Kiviniemi, K. (2008, January-February). Effects of fragment size and isolation on the occurrence of four short-lived plants in semi-natural grasslands. Acta Oecologica, 33(1), 56-65. doi:https://doi.org/10.1016/j.actao.2007.09.005

39. Leitão, A. B., & Ahern, J. (2002, April 15). Applying landscape ecological concepts and metrics in sustainable landscape planning. Landscape and Urban Planning, 59(2), 65-93. doi:10.1016/S0169-2046(02)00005-1

40. Li, H., & Reynolds, J. F. (1995, June). On definition and quantification of heterogeneity. Oikos, 73(2), 280-284. doi:10.2307/3545921

41. Luck, M., & Wu, J. (2002, December). A gradient analysis of urban landscape pattern: a case study from the Phoenix metropolitan region, Arizona, USA. Landscape Ecology, 17(4), 327-339. doi:10.1023/A:1020512723753

42. McGarigal, K., & Cushman, S. A. (2003). The gradient concept of landscape structure: Or, why are there so many patches? (pp. 1-44). Amherst: University of Massachusetts Amherst. Retrieved from http://www.umass.edu/landeco/pubs/Gradients_short.pdf

43. McGarigal, K., & Marks, B. J. (1995). Fragstats: spatial pattern analysis program for quantifying landscape structure. United States: U.S. Department of Agriculture Pacific Northwest Research Station.

44. McKinney, M. L. (2006, January). Urbanization as a major cause of biotic homogenization. Biological Conservation, 127(3), 247-260. doi:10.1016/j.biocon.2005.09.005

45. Ministry of Agriculture and Forestry, R. o. (2019, June 19). Ulusal Arazi Örtüsü CORINE 2000-2012. Retrieved January 05, 2019, from Tarım Orman Açık Veri Portalı: http://veri.tarimorman.gov.tr/

46. Nagendra, H., Munroe, D. K., & Southworth, J. (2004, February). From pattern to process: landscape fragmentation and the analysis of land use/land cover change. Agriculture, Ecosystems & Environment, 101(2-3), 111-115. doi:10.1016/j.agee.2003.09.003

47. O'Neill, R. V., Riitters, K. H., Wickham, J. D., & Jones, K. B. (1999, December 24). Landscape pattern metrics and regional assessment. Ecosystem Health, 5(4), 225-233. doi:10.1046/j.1526-0992.1999.09942.x

48. Özgökçe, F., & Ünal, M. (2007, May 5). A new record for Turkey: Malcolmia exacoides (DC.) Spreng. (Brassicaceae). Turkish Journal of Botany, 31(4), 345-347. Retrieved from http://journals.tubitak.gov.tr/botany/issue.htm?id=721

49. Özhatay, N., Kültür, Ş., & Aslan, S. (2009, April 29). Check-list of additional taxa to the supplement Flora of Turkey IV. Turkish Journal of Botany, 33(3), 191-226. doi:10.3906/bot-0805-12

50. Özhatay, N., Kültür, Ş., & Gürdal , B. (2015). Check-list of additional taxa to the supplement Flora of Turkey VII. Istanbul Journal of Pharmacy, 45(1), 61-86. Retrieved from https://dergipark.org.tr/en/pub/iujfp/issue/25584

51. Özhatay, N., Kültür, Ş., & Gürdal, B. (2017). Check-list of additional taxa to the supplement Flora of Turkey VIII. Istanbul Journal of Pharmacy, 47(1), 31-46. doi:10.5152/IstanbulJPharm.2017.006

52. Özhatay, N., Kültür, Ş., & Gürdal, M. B. (2011, May 8). Check-list of additional taxa to the supplement Flora of Turkey V. Turkish Journal of Botany, 35(5), 589-624. doi:10.3906/bot-1101-20

53. Öztürk, M., Altay, V., Gücel, S., & Altundağ, E. (2017). Plant diversity of the drylands in Southeastern Anatolia-Turkey: Role in human health and food security. In A. A. Ansari, S. S. Gill, Z. K. Abbas, & M. Naeem (Eds.), Plant biodiversity-Monitoring, Assessment and Conservation (pp. 83-124). Boston, United States of America: CABI.

54. Paudel, S., & Yuan, F. (2012, January 4). Assessing landscape changes and dynamics using patch analysis and GIS modelling. International Journal of Applied Earth Observation and Geoinformation, 16, 66-76. doi:10.1016/j.jag.2011.12.003

55. Rempel, R. (2015, December 10). Spatial Ecology Program-Analysis Tools/Patch Analyst. Ontario, Ontario, United States of America: Queens Press, Ontario Ministry of Natural Resources and Forestry. Retrieved from http://www.cnfer.on.ca/SEP/

56. Ricketts, T. H. (2001, July). The Matrix Matters: Effective isolation in fragmented landscapes. The American Naturalist, 158(1), 87-99. doi:https://doi.org/10.1086/320863

57. Saunders, D. A., Hobbs, R. J., & Margules, C. R. (1991, March). Biological Consequences of Ecosystem Fragmentation: A Review. Conservation Biology, 5(1), 18-32. Retrieved from http://www.jstor.org/stable/2386335

58. Şenkul, Ç., & Kaya, S. (2017, December 6). Türkiye endemik bitkilerinin coğrafi dağılışı [Geographical distribution of endemic species of Turkey]. Türk Coğrafya Dergisi, 69, 109-120. doi:10.17211/tcd.322515

59. Tomimatsu, H., & Ohara, M. (2010, April). Demographic response of plant populations to habitat fragmentation and temporal environmental variability. Oecologia, 162(4), 903-911. doi:10.1007/S00442-009- 1505-8

60. TUBIVES. (2004). Retrieved March 3, 2019, from Turkish Plants Data Service : http://tubives.com/

61. Uzun, O. (2003, December). Düzce Asarsuyu Havzası peyzaj değerlendirmesi ve yönetim modelinin geliştirilmesi [Landscape assessment and development of management model for Duzce, Asarsuyu Watershed]. Doctoral dissertation. Ankara, Ankara, Turkey: Ankara University Graduate School of Natural and Applied Sciences. Retrieved from https://tez.yok.gov.tr/UlusalTezMerkezi/tezSorguSonucYeni.jsp

62. Van Herbarium. (2019, February 1). Retrieved July 5, 2019, from The Virtual Herbarium of Lake Van Basin: http://vanherbaryum.yyu.edu.tr/ingindex.htm

63. Vié, J. C., Hilton-Taylor, C., Pollock, C., Ragle, J., Smart, J., Stuart, S. N., & Tong, R. (2008). The IUCN Red list: a key conservation tool. (J. C. Vié, C. Hilton-Taylor, & S. N. Stuart, Eds.) Gland, Switzerland: IUCN. Retrieved from https://www.iucn.org/sites/dev/files/import/downloads/the_iucn_red_list_a_key_conservation_tool_1.pdf

64. Xian, G., Crane, M., & Su, J. (2007, December). An analysis of urban development and its environmental impact on the Tampa Bay watershed. Journal of Environmental Management, 85(4), 965-976. doi:10.1016/j.jenvman.2006.11.012