



## RESEARCH PAPER

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## Using satellite images to measure ecological metrics of landscape of the conserved area of North Iran

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### Abstract

Landscape ecology is a new view which concerns the interactions between spatial pattern and ecological processes. Important principles of landscape include: landscape composition, structure, operation and change. To quantify the landscape features and to assess and study the habitat at landscape scale, landscape metrics are used. By quantifying these features, managerial decisions for conservation can be made more rapidly and cost-efficiently. Efforts are made here for using these metrics to make decisions concerning conservation in the limits of a conserved area and to facilitate doing studies in this field to be able to use the data obtained from the landscape ecological metrics together with other environmental and ecological factors for making decision and for managing the area under management. To this aim, Bojagh national park was chosen as the study area. Bojagh national park in Guilan province, measuring 3266.83 ha, is the first national park in Iran. Initially, by using satellite images of Bojagh national park area, obtained from IRS satellite, classification by ENVI 4.8 software was done based on surface covers, and then habitat patches were separated by using Arc GIS 9.3 software. After that, ecological metrics were measured by Patch analyst software. Totally 12 metrics out of the 15 ones were calculated per patch. Through interpreting the results, desirable information is provided about the area, folding and the extent of patches contact with the surrounding environment. The greatest area and total edge are those of the open water body and the highest extent of folding is related to the western sandy lands of beach margin.

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## Introduction

According to the definition offered by International Union for Conservation of Nature (IUCN) on Caracas Congress in 1992, national parks are protected areas which are mainly managed for ecosystem conservation and for recreation. In fact national parks are national offshore or onshore areas which are managed to maintain the utility of one or more ecosystems for the present or the future generations and provide the required domain for environmentally compatible intellectual, scientific, educational and recreational usages. To this aim, any detrimental exploitation and domicile which threaten the existence of the area, must be removed and prohibited (Henric, 2004).

Among these, the new landscape ecology approach, a sub-field of ecology science, via presenting new methods, offers a new view for determining the conservational values of regions. This view by using landscape metrics allows quantifying the special arrangement and ecosystem structures to reach valuable results in the field of habitat management and to save time and money (Kevin, 2001). In landscape studies, the area under study can be selected at different levels.

Landscape is composed of three main components which include patches, corridors, and a matrix. Through understanding these elements, more accurate managerial decisions can be made regarding landscape. The matrix is the part that encompasses all elements, inside which patches and corridors can be seen. A group of patches form the mosaic and a group of corridors form the network. Within patches and corridors, edges can be observed which have a strong relationship with the matrix and nearby patches (Richard, 1986).

There is a wide set of landscape metrics which is used to quantify the spatial patterns in the limits of heterogeneous landscapes. Developers and users of these metrics aim to objectively describe the landscapes that humans assess subjectively as

clumpy, dispersed, random and fragmented for example. (Kevin & André *et al.*, 2006)

The number of existing metrics to calculate spatial arrangement and patterns of landscape is expressed differently in different resources. The maximum number stated for these metrics is 54 (Kevin & Samuel, 2008). Other resources have mentioned the number of 40 (B. Zaragozí *et al.*, 2012). Any way, what is important is that many of these metrics provide the researcher with similar features and amounts such as the metrics of patch density and mean patch size which both form one feature of landscape in the format of two distinct metrics. In fact, selecting the type and number of metrics can be done based on the type of the study area and decision made by the researchers (Kevin & Samuel, 2008). Different software have been designed to calculate these metrics, of which Fragstate designed by McGarigal and Marks in 1994, Patch analyst, SPAN designed by Turner in 1990 (William, 2001), PA4 and r.le can be named. All of them have applications in quantifying the landscape structure.

Patch analyst software used in this research, was designed by Ramplet *et al.* in 2003. This software works in Arc GIS and calculates the metrics at class or landscape level (Jean-Pierre, 2007). Since the early 1980s, attention was paid to quantify landscape patterns and several landscape metrics which had wide applications, were derived from percolation theory, fractal geometry and information theory (a branch of mathematics concerning the development of species diversity). Increase of spatial data availability, especially over the last two decades, has provided numerous opportunities to develop, test and apply landscape metrics. (Sarah & Monica, 2002) Landscape metrics have, so far, been used in different fields of environmental studies on the level of natural resources.

Among these studies, that of Amanda and Roodwald (2008) can be mentioned. In their paper, they stated that using landscape metrics in conservation

program can have a rapid and economic operation. Zaragozi and *et al.* concluded from their studies that landscape metrics can be used in a wide range of landscape studies, among which, studies related to soil erosion, environmental management and programming etc. can be mentioned (B. Zaragozi *et al.*, 2012). Faith, Kearns *et al.* in their studies indicated that using factors in the scale of landscape can facilitate managing freshwater especially within urban areas and doing research in this domain (Faith & Vincent, 2005). Zebardast, used landscape metrics to investigate the decay caused by passing a road through Golestan national park (Lobat & Majid, 2011). Khazaei and Azari Dehkordi used landscape metrics to evaluate the extent of decay suffered by Shafarood basin in Guilan province and identified the conservable, damaged and other areas (Nooshin & Forood, 2009). Rashidi used landscape ecological metrics to prioritize the conservational patches of

Golestan. (Parinaz & Abdurassool, 2010)

It must be mentioned that the range of using data derived from landscape metrics can be very wide and diverse and based on the goal of the research, the type of metrics and numerous software packages have been designed to calculate these metrics, of which the Patch analyst is used in this investigation.

*The area under study*

Bojagh national park, measuring 3266.63 ha., is located in the city of Astanehashrafieh, Guilan province. Geographically, it is located between longitude of 42 51 49 to 50 00 03 E and latitude of 37 24 58 to 37 28 59 N. With respect to the habitats, the park has the habitat types of wetland, grassland, river and beach. The most important role of this park is related to hibernation of migratory birds and it is a place for fish fertility. Habitat diversity has attracted a diverse set of birds to this area. Up to this time, the number of bird species observed in this park has been estimated as 234. Caspian seals, otters, hogs and jungle cats can be found in this area. 248 plant species from 164

different genera and 62 different families have been identified there. (Mohammad, 2010)

**Materials and methods**

In this research, at first, using the satellite images of the area, then classifying the satellite images and separating the habitat patches and at last calculating the landscape ecological metrics have been done to obtain numerical data of the structure and shape of patches of habitat.

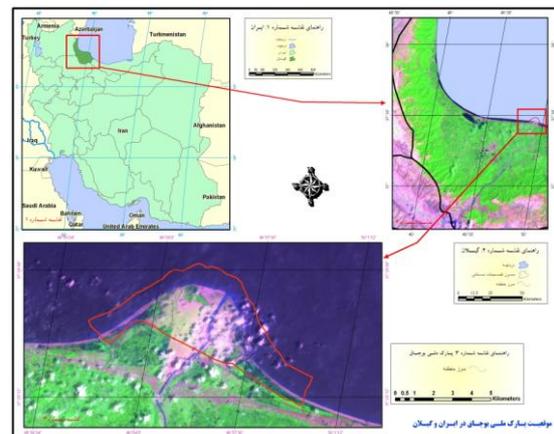


Fig. 1. The area under study.

However, limitation of the number of metrics comparable by patch analyst software is one of the weaknesses of this software which has caused much more limitation in using this software for research studies. Although patch analyst can be easily installed on Arc GIS task bar and can be easily used, but it calculates a limited number of metrics. This, based on investigational goal, may present some limitations to the researcher.

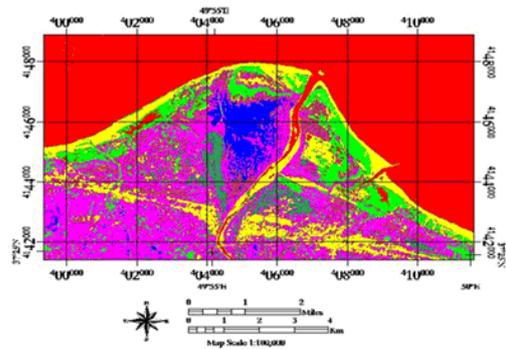


Fig. 2. Image obtained from classification.

*Using satellite images for classification:* IRS 2007 satellite images were used in this research and the satellite image was prepared in three color ranges. The existing bands included: blue band, red band, green band and panchromatic band. At first, the satellite image was geometrically corrected so as to be prepared for performance of the next stages in ENVI software. Then land uses and covers were separated.

*Preparing training samples to complement the classification task in ENVI software*

At this stage, the satellite images must be classified. Classification is the process of fragmenting the space of an image to meaningful homogenous areas without overlapping. The success of a processing system depends on the classification quality. Image classification can be done via supervised or unsupervised method. In supervised method, specifying a series of samples for image classification operation. In classification of satellite images to extract land use maps, after determining the land use classes, training samples are collected.

In this investigation, first the satellite image was geometrically corrected and the supervised method was used for classification. To this aim, training samples should be prepared. After going to the area and being informed from different zones of Bojagh national park, training samples obtained from each one of the land covers were prepared. To prepare training samples per each surface cover (including grassland, surface cover, reedy, open water body, Tamarix plants, sandy land and rice field) navigation in the area of 1 ha was done. In a somehow square shaped area, spot's harvest was performed by using GPS. To reduce classification errors, harvest in the area of 1 ha was done for larger surface covers such as grasslands and sandy lands. In general, natural community covers are used for patch separation in this research. Using natural communities is one of the essential methods for classification and for preparation of landscape maps in the form of distinct and understandable units (Bakhtiar & Mahmoud, 2008). In which plant communities are used for

separation and classification of patches more than others.

Then with respect to the training and cognitive samples obtained from the area, it became possible to identify the color ranges related to each land color by ENVI 4.8 software. Then the data of the prepared training samples were entered into the software in such a way that the number of the classes of interest was defined for the computer and then the software put the phenomena in specific and defined classes according to their range properties.

*Specifying the habitat patches by GIS software*

In this way and after determining the image's color, the output obtained from the software was entered into Arc GIS 9.3 medium and there different patches were separated from each other and each one of the classes were identified.

In fact, after classifying satellite images by ENVI software, the raster file was run in Arc GIS and then the raster file was converted to vector file. To do this 3 D Analyst function of "convert raster to features" item was used. It was because of analyzing and processing data in GIS software that the format of performing these files in vector. At last 11 classes were identified in the map, including 22 patches in total. In this way, the vector map was achieved. Each class is identified by a different color.

*Measuring landscape ecological metrics by patch analyst software*

Then by using patch analyst 4.2, the perimeter and area amount of patches was added to the 'attribute table'.

*By using this software, landscape ecological metrics were calculated*

The procedure of calculating metrics by using this software is that any type of patches, for example the sandy lands existing in the area, is identified as a layer in the

*Patch analyst*

and each patch of sandy lands, specified by a number, is included in a separate column. Then it must be specified in the software that whether the metrics must be calculated in class level or in the landscape one. Furthermore, the metrics to be calculated, should be determined, then the software is run. The calculated data in Excel format were provided for the researcher per each patch of the target layer. This software measures about 15 metrics in the domain of patch shape, shape complexities, patch density and also patch edges. The calculated metrics were investigated; a number of them didn't provide any data on class level, like patch surface standard deviation (PSSD) metric or Patch Size Coefficient of Variation (PSCoV), whose data was

zero per each patch. Metrics were measured separately and on the level of class. The most important calculated metrics included: Class Area (CA), Mean Perimeter- Area Ration (MPAR), Total Edge (TE), and Mean Shape Index (MSI). These metrics were calculated separately per patch (Sarah & Monica, 2002 ).

**Results**

*Results obtained from above-said stages are as follows:*

After doing Geometric Correction of the satellite image and classification of the image in ENVI software, the color ranges existing in the image bands were classified by using Maximum Likelihood Algorithm while considering the training samples.

**Table 1.** The data obtained from metrics calculation.

	CA	TLA	MedPS	MPS	MPE	ED	TE	AWMPFD	MPFD	MPAR	MSI	AWMSI
Classes	Area	Total Land Area	Medium Patch Size	Mean Patch Size	Mean Patch Edge	Edge Density	Total Edge	Area-weighted Mean Patch Fractal Dimension	Mean Patch Fractal Dimension	Mean Perimeter to Area Ratio	Mean Shape Index	Area Weigh Mean Shape Index
Grassland	273.68	273.68	273.68	273.68	13180.91	48.16	13180.91	1.28	1.28	48.19	2.24	2.24
Forest	60.75	60.75	60.75	60.75	7847.83	129.16	7847.83	1.34	1.34	129.2	2.84	2.84
Tamarix Plants	74.65	74.65	74.65	74.65	6841.19	91.64	6841.19	1.3	1.3	91.59	2.23	2.23
Reedy 0	153.43	592.6	153.43	153.43	13671.81	23.07	13671.81	1.33	1.33	89.09	3.11	3.11
Reedy 1	122.17	592.6	122.17	122.17	14152.24	23.88	14152.24	1.36	1.36	115.8	3.61	3.61
Reedy 2	230.35	592.6	230.35	230.35	13787.94	23.26	13787.94	1.3	1.3	59.89	2.56	2.56
Reedy 3	21.94	592.6	21.94	21.94	4545.64	7.67	4545.64	1.36	1.36	207.2	2.73	2.73
Reedy 4	65.69	592.6	64.69	64.69	8634.09	14.56	8634.09	1.35	1.35	133.5	3.02	3.02
Waterfront	17.94	73.92	17.94	17.94	4443.24	60.1	4443.24	1.38	1.38	247.6	2.95	2.95
Sefidrood River	55.97	73.92	55.97	55.97	7952.99	107.58	7952.99	1.35	1.35	142.1	2.99	2.99
Juncos acutus 0	88.15	469.36	88.15	88.15	9684.3	20.63	9684.3	1.34	1.34	109.9	2.9	2.9
Juncos acutus 1	381.2	469.36	381.2	381.2	31026.25	60.1	31026.25	1.36	1.36	81.39	4.48	4.48
Open Water Body	1211.73	1211.73	1112.73	1112.73	35583.3	29.36	35583.3	1.28	1.28	29.39	2.88	2.88
Rice Field	15.35	15.35	15.35	15.35	1658.76	108.03	1658.76	1.24	1.24	108	1.19	1.19
Sandy Land 0	83.81	367.94	83.81	83.81	10242.38	27.83	10242.38	1.35	1.35	122.2	3.15	3.15
Sandy Land 1	8.75	367.94	8.75	8.75	3718.55	10.1	3718.55	1.44	1.44	424.8	3.54	3.54
Sandy Land 2	21.7	367.94	21.7	21.7	3452.9	9.38	3452.9	1.32	1.32	159.1	2.09	2.09
Sandy Land 3	63.25	367.94	63.25	63.25	10940.01	29.73	10940.01	1.39	1.39	173	3.88	3.88
Sandy Land 4	190.41	367.94	190.41	190.41	23092.82	62.76	23092.82	1.38	1.38	121.3	4.72	4.72
Building	94.54	94.54	94.54	94.54	4748.86	50.22	4748.86	1.23	1.23	50.2	1.37	1.37
Wetland 0	10	32.21	10	10	1727.03	53.61	1727.03	1.29	1.29	172.5	1.53	1.53
Wetland 1	22.2	32.21	22.2	22.2	3910.68	121.39	3910.68	1.34	1.34	176.1	2.34	2.34

Then the resulted image was entered into Arc GIS and habitat patches were separated from each other. In Image No.3, these habitat patches are observable in 11 classes and 22 patches. The data obtained from metrics calculation are presented in Table 1 for each one of the patches separately. Considering the obtained data, the largest area is that of the open water body which has also the highest Total Edge (TE) with grassland patch being placed next to it. Besides, the highest amount of MSI is for sandy land patch No.4 and lowest amount of which is related to rice field patch. Many metrics have provided similar data on class level.

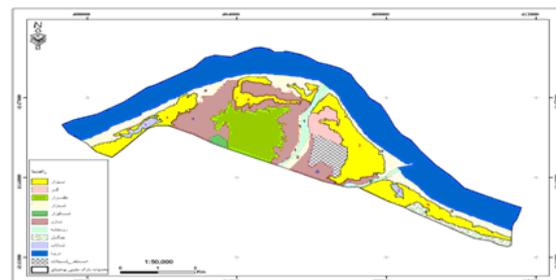
### Discussion

As expressed above, because of novelty of this view, the number of researches executed in this domain is limited. On the other hand, most of investigations executed in the domain of metrics measurement have been done via fragsatatesoftware and usage of patch analyst software in the executed studies is limited. In Iran, measuring landscape metrics on the level of a conserved area or a national park has been done for the first time in this investigation. Previously, Rashidi *et al* performed prioritization of patches for conservation in Guilan province, which was the first work of this type performed in Iran (Parinaz&Abdulrasool, 2010). For prioritization of patches for conservation in Golestan province, satellite images were used like what was done in the present study and for calculation of metrics, Fragstate software was used that the multiplicity of the metrics calculable in this software, allows taking advantage of a larger diversity of the metrics. In their research, they measured 8 metrics for the aimed patches. Beside data obtained from the metrics, they paid attention to the vegetation density and to the distance between patches and roads or residential areas.

Fragstate software has been used in other studies too. Khazaee and Dehkordi used a Landscape Degradation (LD) metric to assess the degradation model in Shafarood basin (Nooshin&Foorod, 2009). Zebardast used the metric of efficient size of the network ( $m_{eff}$ ) to analyze the fragmentation of

the forest vegetation caused by road construction in the limits of Golestan national park (Lobat&Mjided *al.*, 2011).

In using these metrics for conservation processes, attention must be paid to the shapes of patches and their complexities. Metrics like MPS, TE, MSI etc. can be used to this aim. The more MSI is close to one, the more circular is the shape of the patch. It means that the patch has less contact with the surrounding environment; hence, edge effect has less impact on the interior habitat of the patch and this, surely, shall increase the conservational value of the patch. Mean Perimeter to Area Ratio (MPAR) metric indicates the folding of the patch edge. The higher the number shown by this metric, the more will be the folding of the patch edge. This folding will increase the contact with the surrounding environment, so the conservational value of the area shall decrease in this way.



**Fig. 3.** Habitat patches, separated on GI.

Patch area metric which measures the area factor, indicates that a wider area can encompass more species and the habitat shall have a higher biological diversity value. These are significant points which must be considered in making conservational decisions and also during the process of conservation.

Using landscape metrics beside other ecological factors enables the researcher to consider the structure and spatial shape of the habitat patch and its location. Data obtained from the metrics can be used in different time intervals to determine the change amounts of a landscape over time, in this way it can be shown that how much the structure and

arrangement of a landscape has changed. On the other hand, these data together with other environmental and ecological features of the area or the habitat can be very effective in choosing a landscape for conservation. Also, the numerical and quantifiable data obtained from these metrics can provide a better understanding of the landscape structure in the research works and studies related to that area.

What is clear is that using these data with landscape ecological approach in wider levels can guide environmental managers and authorities in making more accurate and precise decisions and can highlight paying attention to habitat structures and shapes which none or less attention is paid to them in other approaches.

Landscape metrics can be used in other areas under organizational management, even on macro scales and in the level of cities and provinces. By involving ecological parameters and using more landscape ecological metrics in conversational processes, a more successful management of protected areas and national parks can be achieved. Metrics used and calculated in this research are of types which illustrate patch structure. For reaching better results in the conservation processes, studies can be done in total landscape level and according to the patches spatial arrangement and their relations with each other.

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