

## ***Application of Effective Mesh Size Metric for the Analysis of Forest Habitat Fragmentation inside the Defined Road Effect Zone of Golestan National Park***

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### **Introduction**

Landscape ecology, as a problem oriented science can play a substantial role in the investigation of structural and functional changes of landscapes. Fragmentation is one of the major processes causing changes in landscapes. It is considered as one of the main threats to biodiversity, causing land covers or habitats to break to smaller and less connected pieces and thus reducing their connectivity.

Landscape ecological metrics which are quantitative tools to measure landscape changes have experienced lots of evolutions. Recently, landscape metrics have varied and evolved from merely describing structural changes to tools for quantification of ecological processes. One of these metrics is Effective Mesh Size ( $m_{eff}$ ) which indicates the probability of connection between two points in landscape and not being separated by barriers like roads. This metric can be used to explain ecological processes like animal dispersion and habitat viability. Therefore, it is useful to investigate structural changes in sensitive areas (such as national parks). Jaeger (2002) compared effective mesh size with 21 other metrics, with regard to their reliability for quantifying landscape fragmentation considering criteria including: intuitive interpretation, mathematical simplicity, modest data requirements, low sensitivity to small patches, monotonous reaction to different fragmentation phases detection of structural differences, mathematical homogeneity, and additively. Effective mesh size ranked the highest according to these criteria. Therefore, this metric has been chosen to quantify landscape changes in the present research.

Roads are one of the major factors causing fragmentation in habitats and natural land covers such as forests. Variety of impacts and large zone of influence together with long operating times of these linear infrastructures, make them serious threats to biological diversity throughout the world. The significance of roads' impacts on landscape is so high that a new branch has emerged in ecology named road ecology. In road ecology, there is a concept called "Road Effect Zone" which is defined as the areas in both sides of a road that major ecological impacts of the road are traceable up to there. The maximum width of this buffer is estimated to 1000 meters from each side of the road. The presence of roads in sensitive and natural areas, specially protected areas, leads to a reduction in values and effective functions of them. Besides, direct impacts resulting from construction and operation of roads and increased access to natural areas leads to indirect consequences such as land cover change, illegal prey, human caused fire, etc. One major example of this problem in Iran is the road crossing Golestan national park. Although this road has been damaged in several flash floods because of wrong site selection (in riverside), it is being simultaneously under construction and operation in the same location.

### Materials and Methods

Golestan national park is the first national park in Iran, which is located in north east part of the country between Golestan, Khorasan and Semnan provinces. It is located between 37° 16' 43"N and 37° 31' 35"N, and 55° 43' 25"E and 56° 17' 48"E, with an area of more than 91000 hectares and a perimeter of 147 kilometers.

Golestan national park is a mountainous area with an average altitude of 1378 meters above the sea. Variety in landform and microclimate are major factors causing high biodiversity and suitable habitats for different types of plants and animals species, which make it worth protecting as a national park. Unfortunately, the operation of a road in the area, which is also being under reparation is a major threat, not only because of disturbances caused by the road itself, but also because of the certain influences of the road on the hydrological regime of the adjacent river.

This research aims to use landscape ecological approach to quantify structural changes in this road's effect zone. Effective mesh size landscape metric ( $m_{eff}$ ) is used to achieve this aim. This metric expresses the likelihood that any two randomly chosen points in the region under observation may or may not be connected. The more the presence of barriers (e.g., roads, railroads, urban areas) in the landscape, the less is the chance of two points to be connected. The probability is converted into the size of an area called the effective mesh size. The effective mesh size calculation for a given planning unit  $j$  is calculated using the following formula:

$$m_{eff}(j) = \frac{1}{A_{ij}} \sum_{i=1}^n A_{ij}^2$$

Where  $n$  is the number of defragmented patches in planning unit  $j$ ,  $A_{ij}$  is the size of patch  $i$  within planning unit  $j$ , and  $A_{ij}$  is the total area of planning unit  $j$ .

In order to use this metric, planning unit, barriers and defragmented patches should be identified and scored with proper codes. In order for this to be carried out, land cover maps of the study area for 1987 and 2008 were derived from Landsat and IRS satellite images respectively. The resolutions of images were resampled to the same size of 30 meters. Road effect zone maps were derived from overlaying road, changing dense forest to other land cover types and considering a theoretical width of 1000 meters.

### Results

Maps of fragmentation geometries show the spatial distribution of patch sizes bounded to fragmenting elements in the study area (Figure 1). Using these maps, effective mesh size metric ( $m_{eff}$ ) and its changes in the period of investigation were calculated (Table 1). This metric shows a decrease of 47.40% in the period of investigation.

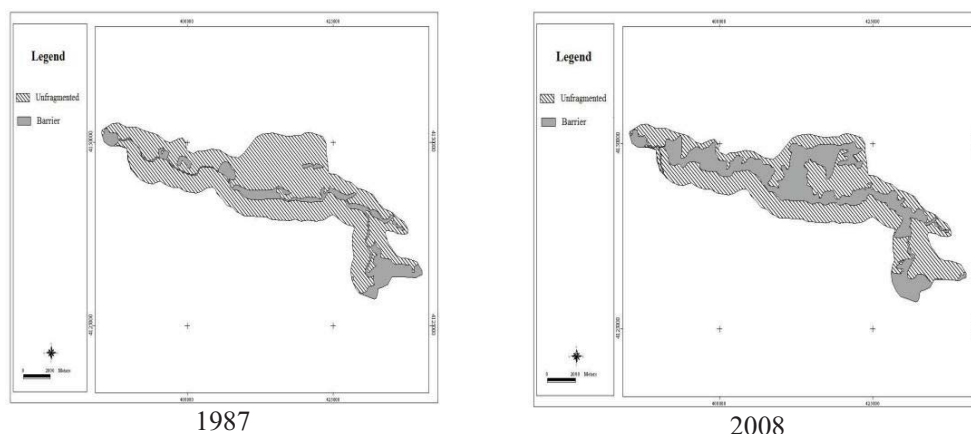


Fig. 1: Fragmentation geometry in Golestan national park's road effect zone in 1987 and 2008

**Table 1: Effective mesh size ( $m_{eff}$ ) amount and its changes in the period of investigation**

Year of investigation	Effective mesh size metric ( $m_{eff}$ )	Change
1987	2758.27	-47.40
2008	1450.79	

**Discussion**

The results show significant structural changes in the road effect zone landscape and increase in fragmentation in dense forest area. Remarkable decrease in effective mesh size metric ( $m_{eff}$ ) indicates lower connectivity and viability of forest habitats in the road effect zone in the period of investigation.

Regarding high ecological sensitivity in dense forest landscapes in the road area, it is necessary to consider monitor these landscapes changes in Golestan National Park management program. Considering the complexity of ecosystems and many inseparable factors affecting the structural changes in the road effect zone (including flash floods, fire, recreational activities, pollution, climate change, etc.), it is important to also monitor these factors. Using landscape structural change as a result of all affecting factors can be helpful to more precise investigations and adopting mitigation measures to restore forests in the road effect zone.

**Key Words**

Golestan national park, Fragmentation, Effective mesh size metric, Road effect zone