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Detecting Forest Fragmentation with Morphological Image Processing in Golestan National Park in northeast of Iran

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ABSTRACT: Fragmentation, or breaking apart of habitats, is one of the major causes of decline in biological diversity. Mature ecosystems, especially dense forests are very sensitive to this phenomenon and roads are one of the major causes of fragmentation in forest landscapes. Present investigation aims to trace landscape fragmentation in dense forests of Golestan national park in northeast of Iran between 1987 and 2008 by use of Landscape fragmentation tool, considering the hypothesis that presence of road in this national park is a major cause of forest fragmentation. The results of this research indicate considerable increase in deforestation, edge amount besides decrease in dense forest areas and conversion of large core areas to small and isolated patches, which can be interpreted as increase in fragmentation and less connectivity. This phenomenon can be easily traced near the existing road in Golestan national park, where edges have evolved from simple and curve lines to more complex shapes having elongated boundaries which is a sign of being influenced by anthropogenic factors.

Key words: Forest fragmentation,Golestan national park,Deforestation,Edge amount

INTRODUCTION

Landscapes are being altered at unprecedented rates (Forman and Alexander 1998; Gardner, *et al.*, 2007), resulting in fragmentation or breaking apart of habitats (Fahrig and Nuttle, 2006; Bissonette, 2007; Koffi, 2007; Collinge, 2009) which affects the spatial arrangement, shape and relative proportions of different habitat patches (Green *et al.*, 2006; Lloyd, *et al.*, 2006) and has a profound influence on ecological processes that are sensitive to alteration of the composition of environments (Lloyd, *et al.*, 2006). The results of habitat fragmentation are habitat loss and habitat insularization, both of which contributed to the decline of biodiversity (Naveh, 1998; Sanderson and Harris, 2000; Forman, *et al.*, 2003; Pichancourt, *et al.*, 2006; Girvetz, *et al.*, 2008), because larger habitats shelters more species (Burel and Baudry, 2003). In such situation, specialist and interior species become vulnerable to extinction due to limited viable habitat availability (Farina, 1998; Pichancourt *et al.*, 2006). Ecosystems provide several goods and services (Jing and Zhiyuan, 2011). Mature ecosystems, specially dense forests are very sensitive to fragmentation. A forest can be reduced by fragmentation to small portions of isolated trees and fall in the early successional stage (Farina, 2010). Roads are one of the major causes of fragmentation (Geneletti, 2006; Coffin, 2007), specially in forest landscapes (Laurance *et al.*, 2002). Construction and improvement of roads in forest areas, have different direct and indirect impacts on landscapes, such as increasing the accessibility of remote areas (Forman and Deblinger, 2000), allowing logging and deforestation for new agricultural and pasture fields (Nagendra *et al.*, 2003; Freitas, *et al.*, 2010), which mainly lead to increase the amount of edge and decrease the interior habitat size (Crow, 2006; Liu, *et al.*, 2008). Landscapes bisected by roads would be expected to have more and smaller habitat patches with less connectivity and higher proportions of edge (Saunders, *et al.*, 2002; Selman, 2006).

Landscape ecologists consider the identification of relationships between landscape structure and ecological processes (Turner, 2005; Girvetz, *et al.*, 2008). Because the ecological consequences of landscape change are difficult to measure, specially at broad spatial and temporal scales, the quantification of landscape pattern has often been used as an indicator of potential ecological effects (Gardner, *et al.*, 2007). As ecosystems are dynamic, application of

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remote sensing data and progress in landscape analysis techniques and tools provide the capability of tracking this dynamism and changes (Nagendra, *et al.*, 2004).

Although many researches have focused on fragmentation (i.e.: Lugo and Gucinski, 2000; Southworth, *et al.*, 2004; Delgado, *et al.*, 2007; Laurance, 2008; Giulio, *et al.*, 2009; Freitas, *et al.*, 2010), temporal dynamics have not been widely addressed explicitly in fragmentation may be because the concept of fragmentation has most often been conceived in a very limited spatial sense (Bissonette, 2007). This analysis aims to trace the trends of landscape fragmentation in a temporal scale of 21 years. Landscape fragmentation tool is used to quantify and locate forest fragmentation in Golestan national park in northeast of Iran between 1987 and 2008 by use of satellite imagery of the area considering the hypothesis that the existing road in this national park which is being reconstructed recently has a major role in causing fragmentation in dense forest land covers.

MATERIALS & METHODS

Golestan national park is the first national park in Iran, which is located in north east of the country between Golestan, Khorasan and Semnan provinces (Majnoonian, *et al.*, 1999). It ranges from 37° 16' 43''N to 37° 31' 35''N and 55° 43' 25''E to 56° 17' 48''E, with the area of more than 91000 hectares and perimeter of 147 kilometers. Golestan national park is a mountainous area with the average altitude of 1378 meter above the sea. The variety in landform and microclimate are major factors causing high biodiversity and suitable habitat for different types of plants and animals species, making this area worth protecting as a national park. Dense forests that cover the western part of Golestan national park are precious relique Hyrcanian deciduous forests which prepare habitat for many species, some of which are considered endangered (such as *Panthera pardus saxicolor* (EN), *Rhinolophus hipposideros* (VuA2c), *Capra aegarus aegagrus* (VuA2cde), *Ovis orientalis arkal* (VuA2cde)).

Unfortunately, operation and reparation of an existing road in the area, which has been destroyed by flash floods, are major threats to the biodiversity of this national park. Location of the study area is illustrated in Fig. 1.Landscape fragmentation tool is used to map the types of fragmentation present in a land cover type of interest (i.e. dense forest). Fragmentation type is determined by proximity to fragmenting features such as road. The Landscape Fragmentation Tool v2 is based on a study by Vogt et al. (2007). This tool works on ArcGIS 9.3 and requires raster land cover data that should be reclassified to forest and non- forest covers (Parent, 2009).

The result of applying this tool is defining different parameters of fragmentation as core, patch, perforated

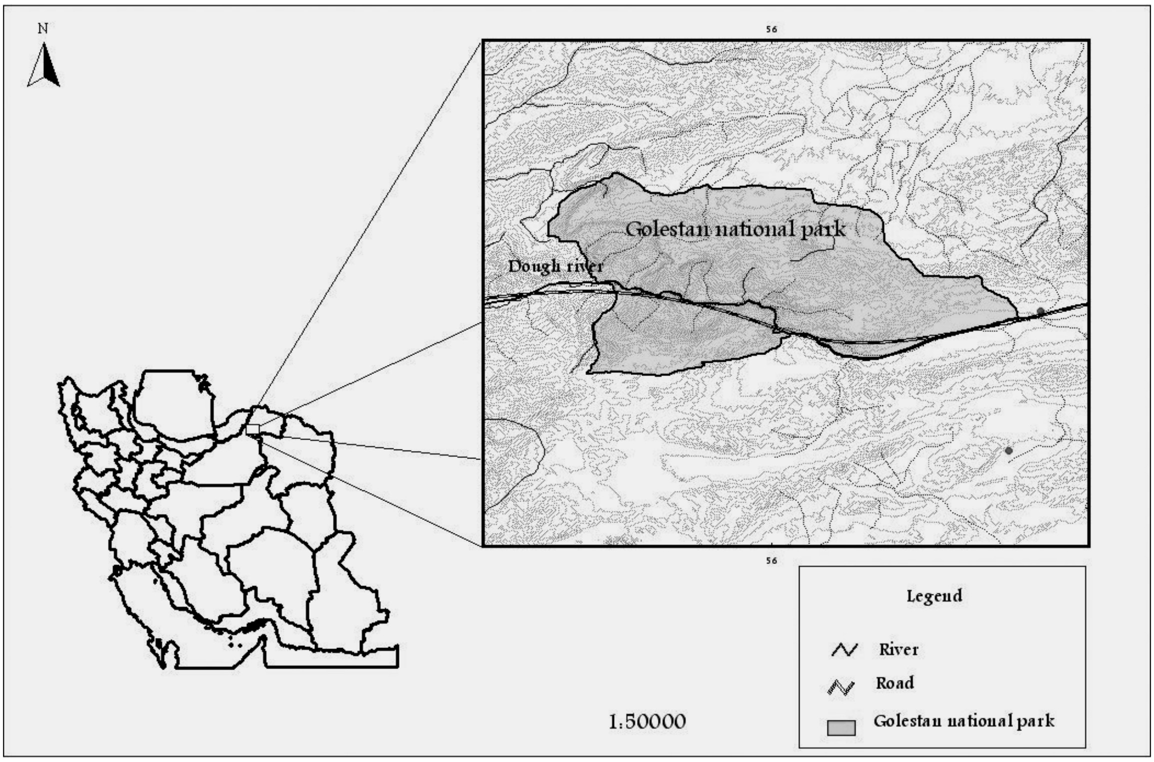

Fig. 1. Location of the study area

and edge areas. As far as fragmentation is associated with increase in edge and perforated areas, along with decrease in core areas (Zeng and Wu, 2005), comparing this parameters for different time series, can provide insight about fragmentation progress in a given area. Four classes of forest pattern can be distinguished in this method. 'Core forest' is relatively far from the forest–non-forest boundary and 'patch forest' comprises coherent forest regions that are too small to contain core forest. 'Perforated forest' defines the boundaries between core forest and relatively small perforations, and 'edge forest' includes interior boundaries with relatively large perforations as well as the exterior boundaries of core forest regions (Vogt, *et al.*, 2007).

In order to prepare necessary data for fragmentation analysis, land cover maps for Golestan national park were developed based on TM and IRS images acquired in 1987 and 2008. Because the resolutions of the images were different, the IRS image pixel size was resampled to that of TM image (30 meters). The images were rectified and georeferenced using the road map of the area. False color composition of RGB= 4, 3, 2 was used for on-screen digitizing of the images. Distinguished land cover types were dense forests, range woodlands, ranges, destroyed forest shrub lands, farms, built areas, river and road. Two land cover maps were reclassified to forest and non-forest covers. The four classes of forest pattern were derived by landscape fragmentation tool and the changes of these spatial patterns were compared in the two time series maps.

RESULTS & DISCUSSION

Changes in different classes of forest pattern of the study area in 1987 and 2008 are illustrated in Fig. 2 and 3, and their subsequent areas are compared in Table 1. As it is illustrated in this table, total area of dens forests declines -9.56 percent in period of investigation. The area of core forests which are intact forests that can form an interior habitat shows -12.23 percent decrease, whereas core forests with area less than 250 acres increase by rate of 8.29 percent. Also patches (forest covers with the area less than 250 acres) appear in the landscape. Perforated forest or the boundaries between core forest and relatively small perforations decreases over 55 percent, while edge forest which is interior boundaries with relatively large perforations as well as the exterior boundaries of core forest regions shows 17.55 percent increase. Cores between 250 and 500 acres could not be found in land cover maps of the two time series of investigation.

The results of this analysis show growth in fragmentation indications in the study area which can be summarized as increase in deforestation, edge amount and decrease in large forest areas. The result of this trend has changed large core forests to small and isolated patches, which means less connectivity in this national park, which makes flows of matter, energy and organisms difficult. As a result of this trend, meta-populations of vulnerable species have less chance to move between and colonize interior habitat patches and efficiently relate to one and other.

As it is shown in Fig. 3, one main axis of deforestation and increase in edge amount is along the road, so it can be concluded that the existing road in Golestan national park, is one of the factors causing fragmentation in its dense forest covers. Also edges have evolved from simple and curve lines to more complex elongated boundaries which, according to Forman (1995), is a sign of being shaped by anthropogenic factors. This change can be seen in Fig. 4 which illustrates the same segment of road crossing dense forests of Golestan national park in 1987 and 2007. It can be seen that in addition to conversion of forest area to non- forest areas, the amount and complexity of edges have increase in time of investigation. Also some of the perforated areas have joint and made a bigger fragmentation, which is the reason why perforated areas have decreased during the period of investigation.

Table 1. Changes in different classes of forest pattern of the study area in 1987 and 2008

Classes of forest pattern	Amount in 1987	Amount in 2008	change	Percent of change
Total Area (acres)	104169	94208	-9961	-9.56
Patch	-	3177	3177	-
Edge	71146	83633	12487	17.55
Perforated	15008	6659	-8349	-55.63
Core< 250 acres	639	692	53	8.29
250<Core< 500 acres	0	0	0	-
Core > 500 acres	381547	334900	-46647	-12.23

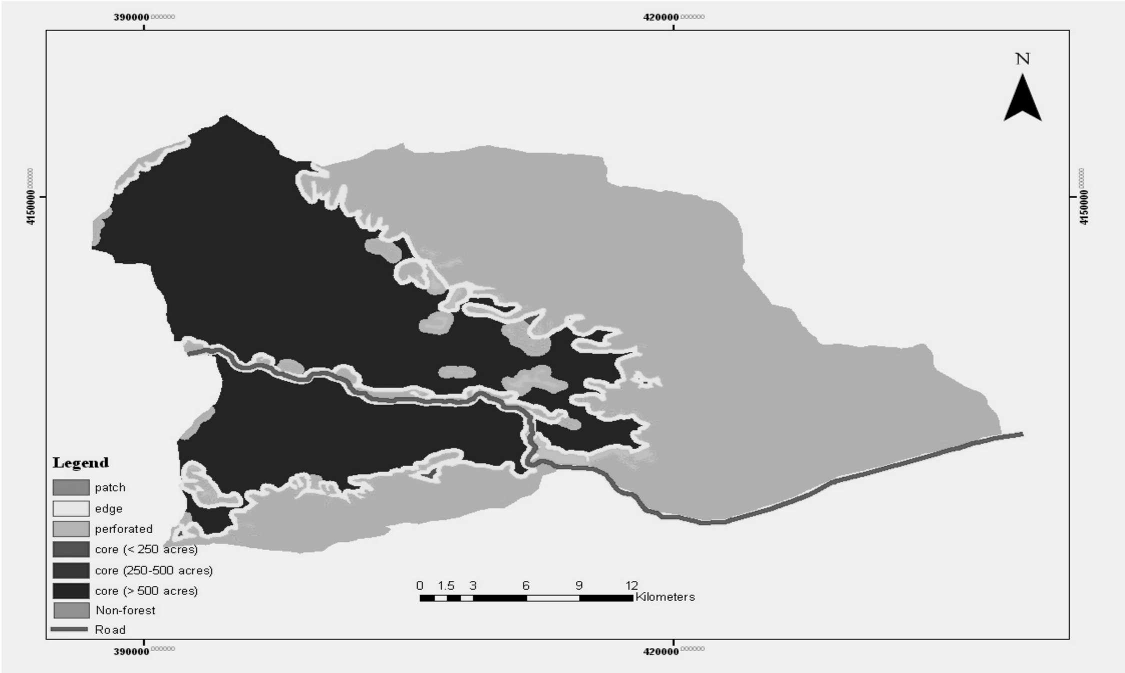

Fig. 2. Forest spatial pattern classes in 1987

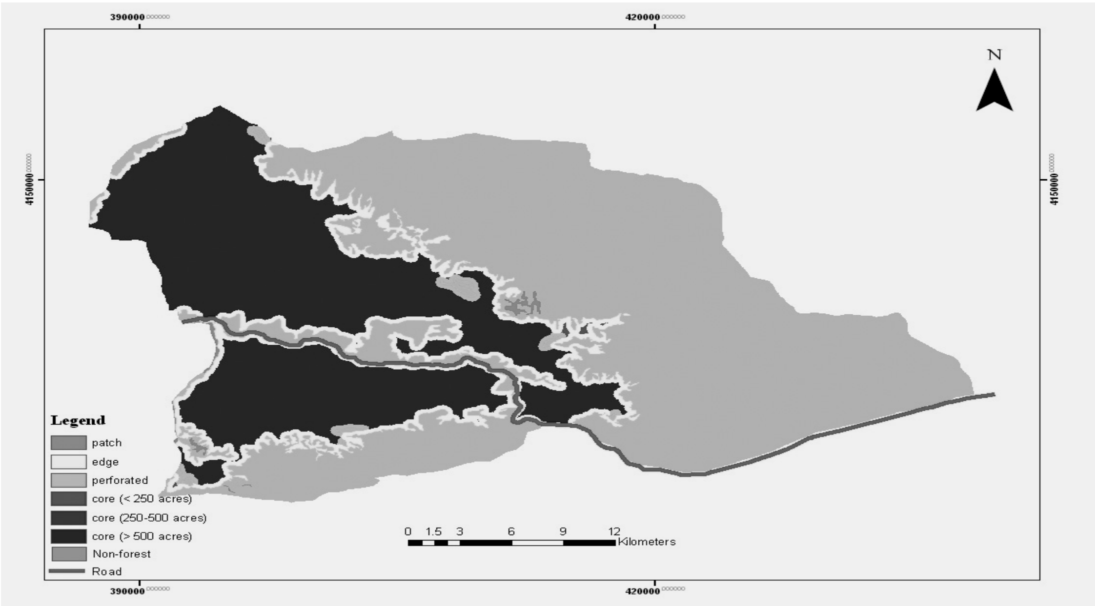

Fig. 3. Forest spatial pattern classes in 2008

CONCLUSION

Assessing trends of landscape fragmentation can be very helpful in monitoring systems of sustainable landscape management, (Jaeger, *et al.*, 2008) especially in protected areas. Landscape fragmentation tool is a powerful approach that can both quantify and locate fragmented areas in landscapes, specially in forests. When a landscape becomes more fragmented, amount of edge and number of smaller patches increase, whereas core area of lager patches decreases. All these indications are traceable in Golestan national park in the period of investigation, in an alarming rate. This information can help managers of the park to prepare a mitigation plan to preserve dense forests and lowering the rate of further destruction.

Fragmentation plays an essential role in the survival of populations (Burel and Baudry, 2003) by changing physical and biotic flows through and along patch boundaries (Lavers and Haines-Young, 1993) and it has been identified as one of the possible causes of the regime shift in the ecosystems (Jiang and Shi, 2010). Therefore maintaining large patches in protected landscapes are important for biodiversity conservation (Weins, *et al.*, 2004). Also maintaining connectivity between fragments is very important for preserving meta-populations, by keeping a rate of migration or

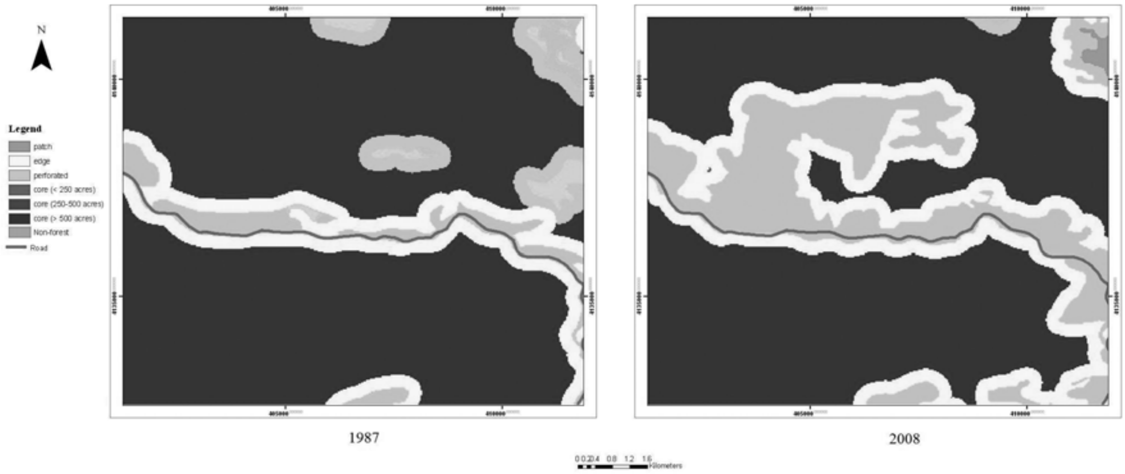

Fig. 4. increasing fragmentation in a segment of road crossing dense forests of Golestan national park

gene flow to or from a local population or a habitat patch in the patch network (Hanski, 2010). Therefore, habitat patches must be both large enough to support viable populations and connected enough to allow a sufficient movement of individuals, thus preventing genetic and demographic erosion (Collinge, 2009). Another important matter that should be included in Golestan national park's management plan is preserving existing dense forest patches and connecting them by proper passages for animal dispersal specially by making the existing road permeable in certain places. Also it is important to note that habitat loss and fragmentation can interact synergistically with other (unknown) factors to produce harmful effects on species and ecosystems (Collinge, 2009). The effects of road construction and maintenance on forest fragmentation cannot be separated from other natural and anthropogenic disturbances in the area such as fire, flash flood and illegal wood harvest. Therefore it can be summarized that the overall anthropogenic and natural disturbances in Golestan national park, has lead to a considerable structural changes in dense forest, which is more noticeable in the roadside area.

Dense forest is a mature ecosystem on its climax. In this stage of succession, ecosystem is more stable, but once it breaks, it would be almost impossible to go back to the previous successional stage. Therefore the present trend of fragmentation in Golestan national park is definitely a sign of instability in ecosystem.

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