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Monitoring landscape changes in Caucasian black grouse (*Tetrao mlokosiewiczi*) habitat in Iran during the last two decades

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Abstract Caucasian black grouse (*Tetrao mlokosiewiczi*) is on the 'red' list of species of high conservation concern as nearest threatened (NT) and also in level (I) of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The black grouse distribution range in Iran is restricted to the Arasbaran region, Northwest of Iran, and the populations and range of this specialist bird species have been declining over the last decades. Management of forest and grassland structures is important for black grouse population survival. The main goals of this study were to monitor and quantify the landscape pattern changes in Caucasian black grouse habitat in the Arasbaran biosphere reserve in two periods of 14 years (1987–2001) and 10 years (2001–2011). For quantifying landscape pattern changes, various landscape metrics were derived by spatial analysis software FRAGS TATS 3.3, including NP (number of habitat patches), LPI (largest patch index) and TE (total edge). The results indicated that the proportion of forest decreased from 39.95 to 31.95 % and the proportion of grassland decreased from 44.45 to 38.44 % in the 24-year span. NP of forests increased in the first period and decreased in the second period of study. TE of dense forest at altitude above 1800 m decreased. Reduction of forest edge is an indicator of reduction in habitat availability for Caucasian black grouse which use the forest edge for living, lekking and hatching in upland. Our results provided quantitative data on habitat loss and fragmentation in the Arasbaran biosphere reserve and indicated negative impacts of the landscape structure changes on Black grouse habitat.

Keyword Landscape metrics · Land use/cover changes · Habitat loss · Caucasian black grouse · Arasbaran biosphere reserve

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Introduction

Many of the endangered species are threatened by multiple factors, but habitat loss and fragmentation brought on by anthropogenic pressures are generally regarded as the largest single cause of biodiversity crises and losses worldwide (Falcucci et al. 2007; Sekercioglu et al. 2011). Land use/cover change is a major factor for global change because of its interactions with climate, ecosystem processes, biogeochemical cycles, biodiversity and, even more important, human activities (Wu et al. 2006; Xiao et al. 2006; Zhang et al. 2011). Environmental perturbations are frequent and intense in modern, human-dominated landscapes (Malavasi et al. 2013). For example, anthropogenically induced changes of landscape elements often create islands of natural habitat embedded in an unsuitable matrix (Hanski 1999; Cook et al. 2002). Such alterations of landscape structures lead to fragmentation, i.e. to a decrease in habitat patch size and often to a concomitant increase of inter-patch habitat distances (Goodwin & Fahrig

2002), which both decrease interaction distances in landscapes.

The distribution, abundance and diversity of most species in an area are affected by the structural characteristics of a landscape such as habitat type, patch size, edge density, configuration and disturbance structures (Said and Servanty 2005). Landscape pattern changes may alter the number and type of patches (Bodart et al. 2011; Li et al. 2013; Salvati et al. 2013; Liu et al. 2014). These landscape pattern changes can have deleterious effects on natural habitats and population of many wildlife species (Fauth et al. 2000; Bolliger et al. 2011; Salvati et al. 2013; Buchmann et al. 2013; Makki et al. 2013). Land use/cover change via altering habitat area and spatial distribution of habitat patches affect the structure and spatial heterogeneity of a landscape (Broadbent et al. 2012). Landscape changes and habitat fragmentation in protected areas and ecologically sensitive regions can have negative impacts on wildlife populations (Lian et al. 2011; Torres et al. 2014).

Some species are more vulnerable than others to reduced area, respectively, to reduced population size and to increased isolation and edge effects that accompany the fragmentation process (Lienert et al. 2002). Habitat specialists are often more affected by habitat loss and isolation than generalists that also may survive in the matrix habitat (Cook et al. 2002; Joshi et al. 2006).

Specialists are likely to experience a higher mortality while dispersing through the matrix (Tischendorf et al. 2003). In addition, species also differ in the rapidity of response, and often, severe effects of habitat fragmentation on biodiversity may only be visible in the long term (Kareiva & Wennergren 1995; Debinski & Holt 2000).

Caucasian black grouse (*Tetrao mlokosiewiczi*) is a specialist bird species that in Iran is restricted to Arasbaran region (Masoud 2004b; Habibzadeh et al. 2010; Birdlife International 2012), north-western Iran. The population and range of this specialist bird species have been declining over the last decades (Baskaya 2003; Masoud 2004a; Birdlife International 2012; Birdlife International 2014). This species is one of the least known of all grouse in the world, and it was formerly classified as data deficient (DD) by the IUCN, and it is consequently listed as a nearest-threatened (NT) species in the IUCN red list in 2008 (Birdlife International 2012; Birdlife International 2014). Caucasian black grouse (*T. mlokosiewiczi*) is also on the list of the level (I) of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in Iran. In the 1970s, the presence of Caucasian black grouse was recorded in Iran (Majnoonian et al. 1983; Masoud 1993 and 1995). The Caucasian black grouse population is distributed within the mountainous northern region of east Azerbaijan province in the Arasbaran region (Behboody 1995; Masoud 2004b). It is located between 38′0.43″ to 38′0.53″ longitude and 46′0.32″ to 46′0.48″ latitude, in an area of approximately 10,000 ha within the Arasbaran biosphere reserve and 20,000 ha in the western open area (Habibzadeh et al. 2010).

Even though Arasbaran is designated as a biosphere reserve and is legally protected since 1976, the abundance of this species in Iran has further decreased within the last decades due to environmental changes. In Iran, land use/cover change in ecologically sensitive species habitats such as Caucasian black grouse habitat has been increased during the past decades, and ecological impacts have become highly visible (Shahbazi et al. 2009; Ebrahimi et al. 2014; Torahi & Rai 2013). For instance, habitat fragmentation by road construction, forest loss by cutting down trees and grassland destruction by overgrazing have deleterious effects on natural habitats containing species of conservation concern. In most cases, the ecological value of existing natural habitat has been considered of secondary importance in the face of compelling economic and social arguments for development. Notwithstanding these negative ecological impacts of habitat fragmentation and habitat loss, there are lacks of studies on the importance of landscape pattern changes on Caucasian black grouse habitat. In Arasbaran, micro-habitat characteristics of breeding display sites (Leks) of Caucasian black grouse has been studied from October 2006 to June 2008 for comparing micro-habitat characteristics among these sites (Habibzadeh et al. 2010). However, to our knowledge, there are no studies of Caucasian black grouse habitat at a landscape scale.

The main goal of this study was monitoring the habitat change of this specialist species in Arasbaran region at landscape level. Here, we provided quantitative data on spatial characteristic of black grouse habitat. In addition, we investigated the dynamics of the landscape properties during the last two decades, and showed how landscape metrics such as LPI (largest patch index), NP (number of habitat patches), and TE (total edge) have been changed during the last decades in the study area.

Material and methods

Study area

The study was carried out in the north-west of Iran in Arasbaran region at the border to Armenia and Azerbaijan which belongs to the Caucasus Iranian Highlands. The study area is in between the Caspian, Caucasus and Mediterranean regions. The area covers mountains, high alpine meadows, semi-arid steppes, rangelands and forests, rivers and springs. Since 1976, UNESCO has registered 72,460 ha of the region, confined to 38°40′ to 39°08′N and 46°39′ to 47°02′E, as a biosphere reserve (Fig. 1). The ecology of the Arasbaran region is unique within Iran (Rasuly et al. 2010; Alijanpour 2013). Arasbaran is habitat of more than 200 species of birds, notably Caucasian black grouse, grey partridge, black francolin and common pheasant, 29 species of reptiles, 48 species of mammals, notably wild goat, wild boar, brown bear, wolf, lynx and leopard and 17 species of fish. Arasbaran is the territory of several nomads who are mainly living in the buffer and transition zones. Economic activities in the biosphere reserve are mainly agriculture, animal husbandry, horticulture, apiculture, handicrafts and tourism, but business activities can also be found in urbanized areas. Caucasian black grouse (*T. mlokosiewiczi*) in Iran is restricted to the Arasbaran region (Habibzadeh et al. 2010). A part of the area is within the Arasbaran biosphere reserve and another part of that is in the western open area (Masoud 1995; Habibzadeh et al. 2010). Minimum and maximum altitudes in the study area are 720 and 2600 m asl, respectively. Caucasian black grouse lives in upland above 1800 m in altitude and mostly in the southern slopes (Masoud 2004a, b) and prefer edge of forests (Habibzadeh et al. 2010).

Image processing

In the present study, Landsat 5 Thematic Mapper image (TM) acquired on July 1987 and July 2011 and Landsat 7 Enhanced Thematic Mapper Plus (ETM+) satellite imagery acquired in 2001 were used for mapping land use/cover within black grouse habitat in the Arasbaran biosphere reserve to detect changes over a period of 24 years. The satellite images were geometrically corrected and atmospheric normalization (Tan et al. 2013; Burns & Nolin 2014; Pons et al. 2014). The geometric corrections can be applied in the first stages of the pre-processing of the data usually by the ground station receiving the raw data from the satellite (Bodart et al. 2011; Hansen and Loveland 2012; Burns & Nolin 2014). All the images had been geo-referenced by the nearest neighbour option (Burns & Nolin 2014) and were corrected and geocoded to the Universal Transverse Mercator (UTM) coordinate system using 20 ground control points (GCPs) (Herzfeld et al. 1999). The images were registered to the WGS_1984 UTM Zone39 datum projection system to match them with available digital topographic map at a scale of 1:25,000. To identify the training areas, we used Crosta method for false colour composite (FCC) creation (Tangestani & Moore 2000). Correct training areas selection is very important to accurate image classification (Tangestani & Moore 2000). In this study, the maximum likelihood algorithm was used for the classification. Maximum likelihood is a supervised classifier, i.e. the analyst supervises the classification by identifying representative areas, called training areas (Rasuly 2009; Bodart et al. 2011).

Accuracy assessment

Accuracy assessment of land use/cover mapping is an important step in the process of analysis of remote sensing data (Bodart et al. 2011; Tan et al. 2013; Vanonckelen et al. 2013). In this study, we used a stopography map at a scale of 1:25,000 prepared by NGO (National Geographical Organization), data collected during the field visits and information obtained from interview with native people and different references data to classification accuracy, and overall classification accuracy algorithm, that it's the ratio number of correct classifications to total number of samples evaluated (Vanonckelen et al. 2013). The overall accuracy constitutes the percentages of correctly classified classes lying along the diagonal and is determined as in Eq. 1:

$$\text{overall accuracy} = \frac{\sum(\text{correctly classified classes along diagonal})}{\sum(\text{row total or column total})} \tag{1}$$

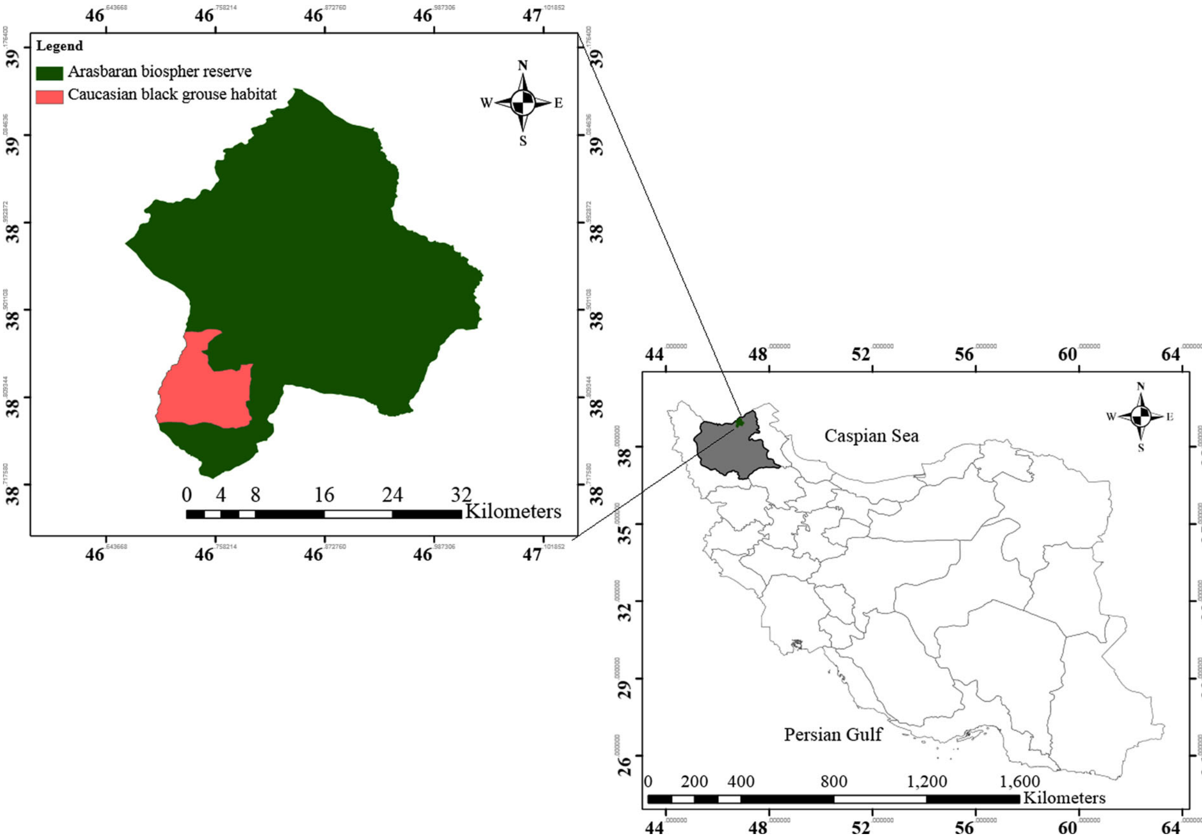


Fig. 1 Study area: Caucasian black grouse habitat in Arasbaran biosphere reserve (Northwest of Iran)

Land use/cover change

The most common opinion about change detection is bi-temporal analysis, the direct comparison of two images or characterizations (Hansen and Loveland 2012). Another approach is multi-temporal change detection that uses more imagery to enhance the feature space beyond a time 1 to time 2 construct. In this study, we classified the maps of 1987, 2001 and 2011 and five land use/cover classes including: dense forests, sparse forests, shrub land, grassland and farmland were identified (Table 1). After identifying land use/cover classes on the images, we used change detection algorithm (post-classification) to identify land use/cover changes. In this case, to image processing and land use/cover mapping, Arc GIS 10, IDRISI Taiga and ENVI 4.8 software were used. Change detection indicated in two different periods and for comparing the changes intensity in the two study periods, the mean changes per year were calculated and the mean were compared between the two study periods.

Table 1 Land use/cover characteristics in the Caucasian black grouse habitat in Arasbaran Biosphere Reserve (Northwest of Iran)

Land use/cover types	Description
1. Dense forest	Lands were dominated by broad-leaved, canopy cover is over 50 %
2. Sparse forest	Lands were dominated by coniferous and broad-leaved, canopy cover is under 50 %
3. Grassland	Lands with herbaceous types
4. Shrub land	Lands with *Astragalus* sp. and *Festuca* sp
5. Farmland	Lands covered temporary crops followed by harvest and a bare soil period

Quantifying landscape pattern changes

Landscape structure can be acting as indicators of ecological changes (Ramezani and Grafstrom 2014). Landscape pattern should be quantified (Lechner et al. 2013; Ramezani and Grafstrom 2014), and for this purpose, too many landscape metrics have been developed (Plexida et al. 2014). These metrics are defined based on measurable attributes such as area, edge and number of patches (Wu et al. 2002; Ramezani and Grafstrom 2014). Landscape metrics are plenty applied in landscape ecology to quantify landscape spatial structure and habitat patches (Hargis et al. 1998; McAlpine and Eyre 2002; McGarigal 2004; Cushman et al. 2008).

We applied spatial pattern analysis software FRAG STATS 3.3 (McGarigal 2004), to calculate landscape metrics of each class type and total landscape. FRAG STATS computes several simple statistics representing area at the patch, class and landscape levels (McGarigal 2004). We chose several metrics including: percentage of landscape (PLAND), number of patches (NP) and largest patch index (LPI), landscape shape index (LSI), patch density (PD), edge density (ED) and also total edge (TE) to quantify the landscape pattern dynamics of the study area (Table 2) to indicate habitat changes.

We used area metrics such as LPI and PLAND to quantify landscape composition. At the class level, FRAGSTATS computes the percent of landscape (PLAND) occupied by each class type (McGarigal 2004). The percent of landscape (PLAND) changes specially percent of forest change can impress black grouse population with change in refuge, breeding and hatchery sites. By calculating the change in the LPI of forest land, we can show how largest habitat patches of black grouse changed during the study period. It could be important because hiding is one the most important attitude of black grouse for living and durability, and therefore, integrity and size of forest patches can cover spoken necessities.

Table 2 List of 10 class-level landscape structure metrics calculated for the analysis (Cushman et al. 2008)

Metric number	Acronym	Name
1	PLAND	Percent of landscape
2	NP	Number of patch
3	TE	Total edge
4	PD	Patch density
5	LPI	Largest patch index
6	ED	Edge density
7	LSI	Landscape shape index

There are several simple statistics representing the number or density of patches at the class and landscape levels. These metrics usually are best considered as representing landscape configuration (McGarigal 2004). NP of a particular habitat type such as forest patches for black grouse may affect a variety of ecological processes. For example, the number of patches may determine the number of subpopulations in a spatially dispersed population for species exclusively associated with that habitat type. NP was used in this study to indicate fragmentation that can affect black grouse population survival. There is evidence of negative effects of large-scale habitat fragmentation on black grouse populations, such as in the extensive forests of Finland or the lowland heaths in northwest continental Europe (Kurki et al. 2000; Ludwig et al. 2009). Patch density (PD) has the same basic utility as number of patches as an index, except that it expresses number of patches on a per unit area basis that facilitates comparisons among landscapes of varying size and identical size in the different times.

Edge metrics usually are best considered as representing landscape configuration. Total amount of edge in a landscape is important to many ecological phenomena. In particular, a great deal of attention has been given to wildlife-edge relationships (McGarigal 2004). In landscape ecological investigations, much of the presumed importance of spatial pattern is related to edge effects. Black grouse lives on the edge of forests in normalized form, and TE index of forest can indicate black grouse habitat in the Arasbaran region, and change on the forest edge shows habitat changes in the study habitat. Black grouse prefers living above 1800 m altitude in Arasbaran region (Masoud 2004a, b); TE metric in dense forest above 1800 m altitude was calculated. For calculation, the TE metric in high altitudes, the digital elevation model (DEM) was used.

LSI was also calculated. This index measures the perimeter to area ratio for the landscape as a whole. This index is identical to the habitat diversity index (McGarigal 2004).

Results

Land use/cover changes

The land use/cover maps in 1987, 2001 and 2011 are presented in Fig. 2. The results of the classification and comparison of maps showed that 8 % of the dense forest cover has been lost between 1987 and 2011 and from 39.95 % in the 1987 has been decreased to 31.75 % in 2011 (Fig. 3) (Table 3). Sparse forest in study periods was increased by 2.10 %, while grassland has decreased by 6.01 % in 24 years of study period (Fig. 3) (Table 3). Shrub land was increased by 12.35 % in two study periods (1987 to 2011). Farmland in black grouse (*T. mlokosiewiczi*) habitat showed 0.44 % declined (Fig. 3) (Table 3).

The changes in the percentage of land use/cover are demonstrated in the diagram (Fig. 3), which revealed the loss of dense forest, grassland and farmland, as well as expansion of the sparse forest and shrub land in the 24-year span.

The results of this study revealed that rate of land use/cover changes varied in two different periods (1987–2001) and (2001–2011) (Fig. 4). The negative and positive signs on the graph, below and above of the horizontal axis, demonstrate decreasing and increasing of the land cover class in the study area, respectively (Fig. 4).

Comparison of the changes between the two observational time periods, reduction of dense forest in the second period (2001–2011) was considerably higher than during the first period of study (1987–2001). In the first period (1987–2001), the mean rate of dense forest reduction per year was 5.4 ha per year, which shows considerable increase of deforestation in the second period (2001–2011) by mean reduction of 44.2 ha per year (Fig. 4).

Expansion of the shrub land in the last decade has been 53.2 ha per year which is much higher than the first period of study (19 ha expansion per year). For the other classes of land use/cover, the change in the last decade (second period of study) was less than the first period (Fig. 4).

Table 4 shows the percentage of land use/cover changes to other land use/covers in the study area. Dense forest in the black grouse habitat mostly has converted to the sparse forest and grassland, and sparse forest has converted to the grassland (Table 4). The grassland has converted to shrub land by 11.80 % that was the highest conversion rate. Abandoned farmlands in the study area have mostly changed to Shrub land (Table 4).

Quantifying landscape metrics changes

The landscape-scale impacts of land use/cover changes on Caucasian black grouse habitat were assessed by landscape metrics changes in the two study periods. Landscape metrics values in 1987, 2001 and 2011 are given in Table 5. Total Edge (TE) of both forest classes

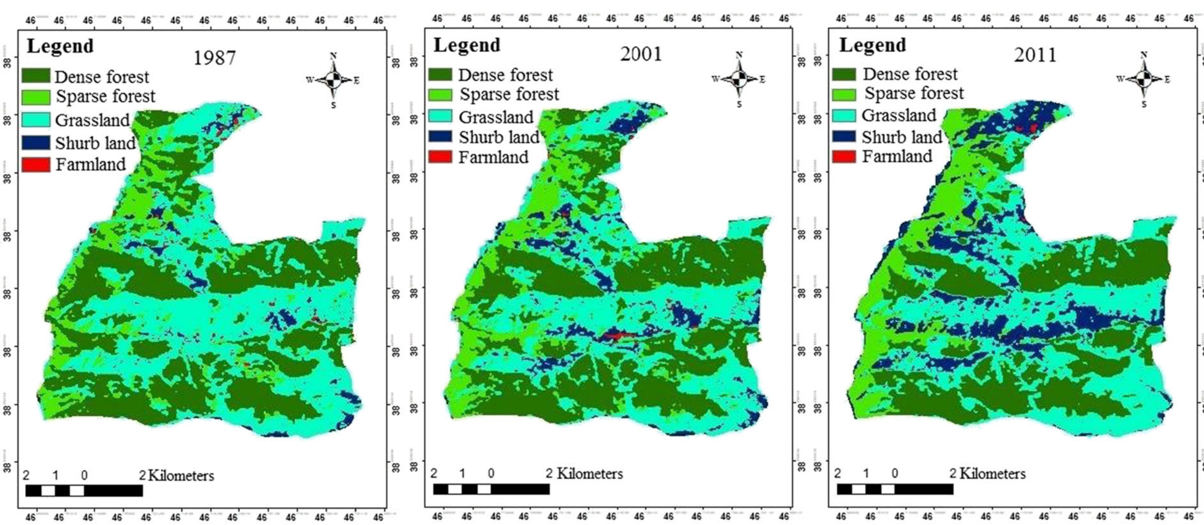


Fig. 2 Land use/cover map of Caucasian black grouse habitat in Arasbaran biosphere reserve in 1987, 2001 and 2011

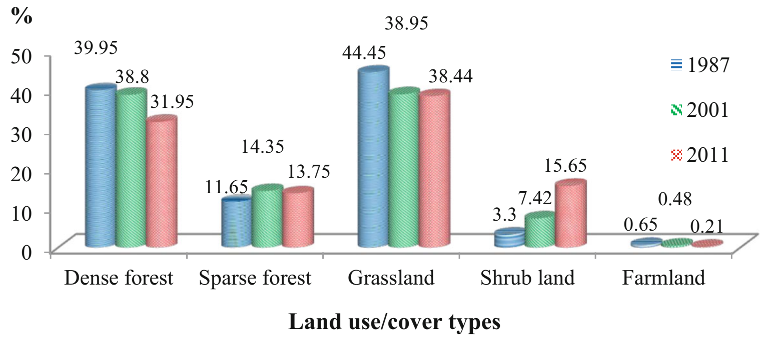


Fig. 3 Percentage of Land use/cover types in the Caucasian black grouse habitat in 1987, 2001 and 2011

declined in whole the study periods (Table 5). While in Shrub land and grassland classes increased (Table 5). The TE metric of dense forest showed considerable reduction about 67.6 Km (from 271.5 km, come to 203.9 Km). The results showed that although from 1987 to 2001, TE of dense forest above 1800 m altitude has increased from 101,100 to 104,800 m (3700 m increased), however, from 2001 to 2011, total edge of dense forest decreased from 104,800 to 93,100 m (11,700 m decreased). It means 8 km of black grouse habitat has been lost in the forest margin in the study area in last decades.

NPmetric is frequently used for examining the changes in land use/cover by habitat fragmentation. Change in NP of the study area is shown in Fig. 5. According to this chart, The NP of all the land cover classes, except farmland, increased in the first period (1987–2001). In despite during 2001 to 2011, NP has been decreased from 140 units to 96 for dense forest and from 337 units to 154 for sparse forest (Fig. 5) (Table 5).

ED decreased from 42.04 m/ha (in 1987) to 41.16 m/ha (in 2001) and to 31.58 (In 2011) for dense forest and it increased from 33.80 m/ha to 37.82 in the first period for sparse forest. In the second period, it decreased to 22.80 m/ha (Table 5).

Dense forest patch characteristics are shown in Fig. 6. According to the figure, the number of large patches is much lower than smaller patches. The figure also shows that in 2001, the number of small patches with less than 1 ha area is higher in 1987. However, in 2011, in comparison with 2001, the number of small patches with less than 1 ha area has significantly decreased. Patch density (PD) of dense forest increased from 1.83 to 2.16 patches/ha in the first period (1987–2001), while during 2001 to 2011, PD has been decreased from 2.16 patches on per hectare to 1.48 patches, and decreased from 4.77 patches to 2.38 for sparse forest in the whole periods (Table 5). Considerable point about PD metric is increasing number of patches on the shrub land from 2.57 patches on per hectare to 4.02 patches (Table 5, Fig. 2).

The result of quantifying landscape shape index (LSI) metric revealed that landscape shape index in the dense forest decreased from 13.93 to 11.22 and increased from 14.60 to 19.27 in the shrub land (Table 5). Largest patch index (LPI) of dense forest increased from 8.50 to 14.70 % in the first period (1987 to 2001) and decreased from 14.70 to 11.47 % in the second period (Table 5).

Table 3 Land use/cover changes in the Caucasian black grouse habitat in Arasbaran biosphere reserve

Land use/cover	1987		2001		2011		Changes (1987–2011)	
	ha	%	ha	%	ha	%	ha	%
1. Dense forest	2580.40	39.95	2504.95	38.80	2063.05	31.95	−517.35	−8.00
2. Sparse forest	751.67	11.65	925.30	14.35	887.75	13.75	136.08	2.10
3. Grassland	2870.10	44.45	2517.00	38.95	2481.20	38.44	−388.90	−6.01
4. Shrub land	213.48	11.65	479.00	7.42	1010.60	15.65	797.12	12.35
5. Farmland	41.75	0.65	31.23	0.48	14.05	0.21	−27.70	−0.44

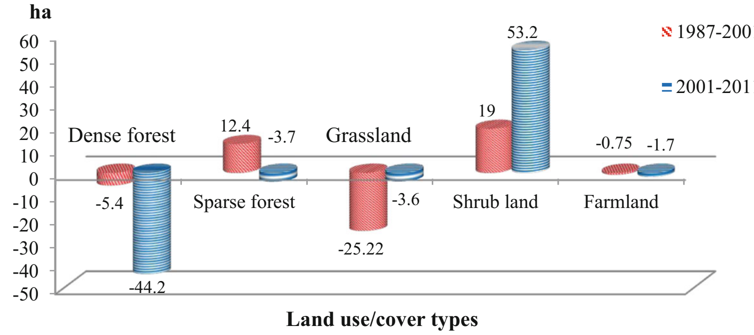


Fig. 4 Land use/cover changes intensity (mean changes per year) during the two study periods (1987-2001) and (2001-2011)

Discussion

We estimated land use/cover changes and landscape metrics change in the Caucasian black grouse (*T. mlokosiewiczi*) habitat in the Arasbaran biosphere reserve, and prevision the impact of land use/cover changes, according to habitat selection of Caucasian black grouse. In addition, the impact of land use cover changes during the last two decades on habitat loss and fragmentation in the study area was investigated in this study. Dense forest and grassland have been decreased by 8 and 6.01 %, respectively (Table 3). The reasons of

Table 4 The percent of land use/cover change to other land use/cover in the Caucasian black grouse habitat in Arasbaran biosphere reserve

Change from	Change to	Changes (%)		
		1987–2001	2001–2011	1987–2011
Dense forest				
	Sparse forest	3.75	2.63	5.36
	Grassland	1.27	6.00	5.30
	Shrub land	0	0.16	0.35
	Farmland	0	0	0
Sparse forest				
	Dense forest	1.10	1.00	0.87
	Grassland	1.73	2.75	2.50
	Shrub land	0.26	0.65	0.73
	Farmland	0	0	0
Grassland				
	Dense forest	2.77	1.05	2.20
	Sparse forest	2.03	0.89	0.75
	Shrub land	4.32	8.99	11.80
	Farmland	0.32	0.04	0.09
Shrub land				
	Dense forest	0	0	0
	Sparse forest	0.02	0.26	0.07
	Grassland	0.76	1.58	0.92
	Farmland	0.03	0.13	0.06
Farmland				
	Dense forest	0	0	0
	Sparse forest	0	0	0
	Grassland	0.25	0.07	0.19
	Shrub land	0.28	0.36	0.39

Table 5 Landscape metrics changes during the study periods in different land cover types in the Caucasian black grouse habitat

Landscape	Dense forest			Sparse forest			Grassland			Shrub land			Farmland		
Metrics	1987	2001	2011	1987	2001	2011	1987	2001	2011	1987	2001	2011	1987	2001	2011
NP	118	140	96	308	337	154	176	198	207	166	198	260	81	45	32
TE ($*10^4$)	27.15	26.58	20.39	21.82	24.42	14.72	36.58	40.49	41.26	8.15	14.85	24.49	2.57	1.65	0.85
PD	1.83	2.16	1.48	4.77	5.22	2.38	2.72	3.06	3.20	2.57	3.06	4.02	1.25	0.69	0.49
LPI	8.50	14.70	11.47	2.60	3.68	4.99	34.28	30.39	32.79	0.33	0.82	2.60	0.05	0.15	0.06
ED	42.04	41.16	31.58	33.80	37.82	22.80	56.65	62.71	63.90	12.62	23.00	37.93	3.98	2.55	1.31
LSI	13.93	13.86	11.22	20.29	20.53	12.33	18.41	21.42	20.66	14.60	17.82	19.27	10.09	7.45	5.64

dense forest loss is cutting down trees for fuel consumption by native people (Alijanpour 2013; Tan et al. 2013), overgrazing in pastures around forest margin (Ebrahimi et al. 2014), clear cutting of forest for preparing grazing area and also impacts of copper mining in the southern of study area (Masoud 2004b). Dense forest mostly has been converted to sparse forest and grassland which was mainly caused by cutting down trees (Sobanski & Marques 2014). Reduction of dense forest especially above the 1800-m altitude in Arasbaran should be considered as a threat for Caucasian black grouse population.

The results of the study also revealed the dramatic conversion of grassland to shrub land by 11.8 % (Table 4) that happened due to overgrazing in pastures (Ebrahimi et al. 2014) and also by climate change which could provide more suitable condition for rising shrub land than grassland in the study area (Shahbazi et al. 2009). Grassland and forest constitutes Caucasian black grouse habitat (Birdlife International 2012), and decrease in these land covers will cause confining habitat availability for the black grouse population (Masoud 2004b; Habibzadeh et al. 2010; Birdlife International 2012; Zohmann et al. 2014; Nixon et al. 2014).

In the other hand, in some of the villages in the study area such as Mazgar, the forest restoration has been recorded (Masoud 1993).

The annual rate of land cover change in the study area showed that dense forest in first period (1987–2001) has been declined by 5.4 ha on a per year, while in the second period (2001–2011), the change rate significantly increased to 44.2 ha on a per year (Fig. 4). This habitat loss in the last decade happened by human interferences in the region by road construction which may also facilitate access to hunters, poachers and uncontrolled tourism. In addition, new roads commonly promote economic development which may compromise conservation goals (Broadbent et al. 2012; Makki et al. 2013; Zhang et al. 2014). In addition, raising the price of dairy and fuel in recent years in Iran contributed to overgrazing in the pastures and deforestation for creating grazing space, and also willingness of native people for using woods for fuel consumption, which both caused the land cover changes in Arasbaran biosphere reserve.

In this study, we used some landscape metrics as indices of habitat availability or suitability for Caucasian black grouse population in Arasbaran region. For instance, using the TE is because Caucasian black grouse prefer edge of forest for living and lekking (Masoud 1993). Therefore, edge of forest almost is explanatory of black grouse habitat. The other landscape metrics which were used in this study, including PLAND (percent of landscape), NP (number of patch), LPI (largest patch index) and ED (edge density) are also useful for demonstrating effects of spatial pattern change at landscape scale on the species habitat (Samuel et al. 2008; Plexida et al. 2014).

Caucasian black grouse lives in the edge of forest. Assessing the changes of TE (total edge) metric of forest shows forest margin change. Changes of TE metric of forest above 1800-m altitude shows from 2001 to 2011 the TE of the dense forest decreased (11.7 km). Reduction of dense forest edge is an indicator of reduction in habitat availability for Caucasian black grouse population which uses the forest edge for living, lekking and hatching (Masoud 1993). Land use/cover changes make habitat destruction in the natural regions and decline forest, and grassland that are beneficial for black grouse for refuge and feeding (Masoud 1993; Masoud 2004a, b; Wegge & Kastdalen 2008; Sekercioglu et al. 2011; Wegge and Rolstad 2011).

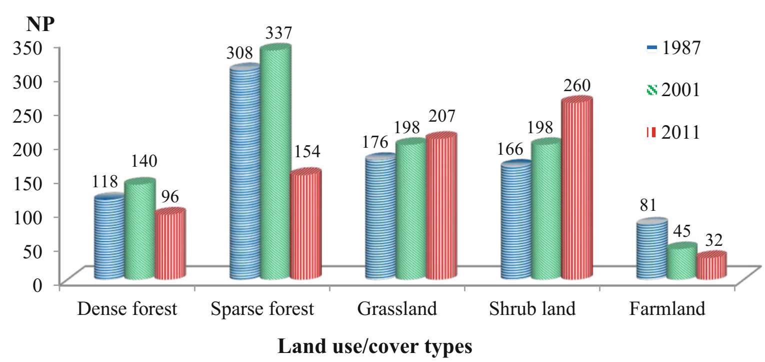
The comparison of NP of forest revealed that number of forest patch increased from 1987 to 2001 that shows fragmentation in the forest cover in the black grouse habitat (Makki et al. 2013). In contrast, in the second period, NP declined due to the loss of the smaller fragments (Fig. 5). The first effect of forest fragmentation would be increasing grazing area and accordingly overgrazing around of the forest cores. Livestock verge to the forest margin tensions black grouse hatchery and feeding site on the edge of forest. Some more effects of forest fragmentation are decreasing blizzard and hunter refuges. According to Fig. 6, number of patches with less than 5 ha area in the dense forest has increased; however, the number of larger patches with more than 100 ha has been decreased due to fragmentation in the study area (Hargis et al. 1998; Habel & Zachos 2012).

Edge density (ED) standardizes edge to a per hectare that we can comparisons among landscape of varying size or identical size in the different times. According to this study, reduction of ED in the forest lands indicates habitat loss. Reduction of dense forest edge especially over 1800-m altitude should be considered as a threat for Caucasian black grouse population. However, ED metric changes explain edge of land use/cover changes in the study area. Some land cover edges are important for Caucasian black grouse life and changes of margins are impressive. Decreasing of dense forest edge about 11 m in a per hectare (Table 5) as for ED metric results cannot be helpful for black grouse. Naturally decreasing of forest edge will be habitat desolater for our bird.

Patch density (PD) on forest covers decreased that shows some of forest patches has been lost in the study area. Losing of forest patches means black grouse habitat and refuge loss. Some of villages due to minimization of pastures in the village range revival the forest. Large patch index (LPI) of forest cover increased that shows proceedings of some villages were useful. However, losing of forest patches will be disastrous for black grouse population (Masoud 2004).

Decreasing of landscape shape index (LSI) is helpful for habitat patches and for species protection because of edge effects mitigations (McGarigal 2004). But about black grouse habitat will be contradiction. LSI measures the perimeter to area ratio for the landscape as a whole and because of black grouse chooses edge of forest and decreasing of LSI on the forest cover cannot be advantage. Increasing of LSI in the forest cover shows increasing edge than patch area that shows habitat

Fig. 5 Number of patches of different land cover types in the Caucasian black grouse habitat in 1987, 2001 and 2011



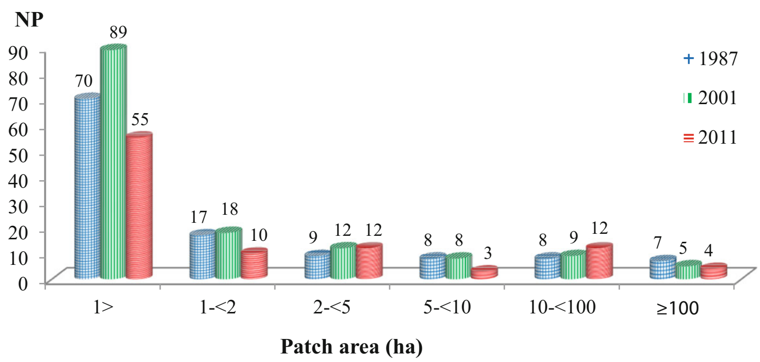


Fig. 6 Patch size distribution of dense forests in the Caucasian black grouse habitat in 1987, 2001 and 2011

development in the forest patches. But according to Table 5, we found out LSI decreasing on the forest cover.

Due to the importance of forest edge in the black grouse habitat (Thomas et al. 2007; Masoud 1995), reduction of forest edge especially in upland is an indicator of reduction in habitat availability for Caucasian black grouse population in Arasbaran which use the forest edge for living, lekking and hatching in altitude above 1800 m. Our results provided quantitative data and evidence of habitat loss and landscape fragmentation in the Arasbaran biosphere reserve and indicated negative impacts of the landscape structure changes on black grouse habitat.

Conclusions

We conclude that conservation strategies should consider not only the micro-habitats characteristics, but also the surrounding landscape context that influences populations of Caucasian black grouse (*T. mlokosiewiczi*) in habitat patches. Spatial pattern of the habitat patches as well as the interactive effects of landscape metrics are important concerns in conservation of black grouse.

This study also revealed that conservation planning should take into account the landscape dynamics and lag effects of habitat fragmentation because some fragmentation will only be apparent and pronounced after decades.

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