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The effects of habitat fragmentation on bird communities in Hyrcanian forests (Case study: Gorgan Township)

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Abstract

Habitat destruction is one of the main factors threatening species so that until 1980 about 30 percent of species became endangered because of degradation and destruction of wildlife habitat. Birds were surveyed in four different patch sizes (<1 ha, 1-10 ha, 10-25 ha and >300 ha). Environmental variables, including forest cover type, characteristics of the structure and complexity of vegetation and those of landscape as well as the number of birds were recorded within a 25-m radius of each of 74 sampling points. Results showed that habitat variables including vegetation type, number of snags, number of logs, number of trees with dbh 0- 20, 20-50, 50-100, 100-300 cm and basal area were the most important variables affecting the presence of birds in the study area. The results of this study highlighted the importance of forest patches and their attributes in conservation and enhancement of bird's habitat as well as in conservation of biodiversity of forest ecosystems.

Keywords: Birds, Forest patches, Conservation, Gorgan

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1. Introduction

Forest fragmentation is a process of landscape alteration in which natural areas are subdivided into smaller patches (Lindenmayer and Burgman, 2005). Forest fragments are a form of habitat fragmentation, occurring when forests are cut down in a manner that leaves relatively small, isolated patches of forest known as forest fragments or forest remnants. The matrix that separates the remaining forest patches can be natural open areas, farmland, or developed areas. Island forest is an isolated piece of forest in the middle of surrounded matrix that is too small to support major components of the forest ecology. According to Laurence and Bierregaard (1997) fragmented forests are becoming one of the most pervasive physiognomies in the countries around the world. Owing to the effects of human disturbances in the tropical region, the forest patches and fragments are decreasing in size as forest edges move away (Gascon *et al.*, 2000). Fragmentation of habitats is one of the main causes which lead to biodiversity degradation (Vitousek *et al.*, 1997), destruction of wildlife habitat and increasing amount and magnitude of the edge effects. The main characteristics of the fragmented forests are: (1) greater habitat discontinuity, (2) greater edge influences, (3) reduced and degraded forest cover, (4) shrink core area, and (5) increased isolation of patches as compared to contiguous forests (Howell et al., 2000). Although fragmentation declines the total number of species, there is also a big concern over the fact that the species lost from the habitat fragments may be the ones of high conservation value, such as the low density or forest-specialist species (Estrada *et al.*, 1993) or the species with small geographical ranges (Willson *et al.*, 1994). The forests are being deteriorated rapidly through deforestation and habitat fragmentation, which are major causes of biodiversity loss (Wilcox and Murphy, 1985; Turner, 1996). Thus, the relative effects of forest fragmentation and degradation have become important issues for conservation biology and protected area management. Deforestation and habitat fragmentation have a profound effect on species distribution and abundance in many parts of the world (Laurance, 1999). Deforestation and human-induced habitat fragmentation are occurring primarily because of logging, burning for pasture, and slash-and-burn agriculture practices (Debinski and Holt, 2000; Jolly and Jolly, 1984). In this study we assessed the effects of deforestation and fragmentation on Hyrcanian forest birds' communities. Hyrcanian's forests are rich in endemic taxa and considered to be seriously threatened by deforestation and habitat fragmentation. However, very little is known about how these processes affect biodiversity. Herein, we examine how forest birds' communities and function groups have been affected by fragmentation at patch scales, by determining relationships between species richness and individual species abundance and patch metrics. Bird response to tropical-forest fragmentation has been studied in Central America, South America and Asia, but we found no study (Kull, 2002) of this kind in Iran. We analyzed the distribution of birds in a large number of Hyrcanian forests of Iran to determine whether the abundance and species composition of birds are affected by the area and fragmentation of forest.

2. Material and methods

2.1. Study area

The study was conducted in forest remnants located to the East and West of Gorgan township in Golestan, Iran (36 13 N- 36 59 N, 53 13 E- 54 45 E) during autumn 2011 and 2012. The climate of this region is humid; with average monthly temperatures ranging from 3.7°C in February to 33.1°C in July and annual precipitation of 655 mm. we selected deciduous forests for study sites because forest fragmentation was a serious problem in the area. We chose 26 patches in 3 regions including Shastkalateh, Nomal and Ghorogh for our assessments (Figs. 1 and 2).

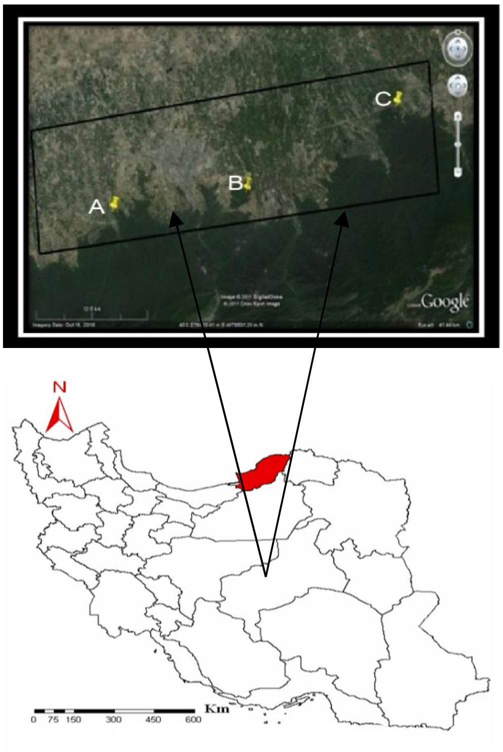

Figure 1. The location of Golestan Province and study area

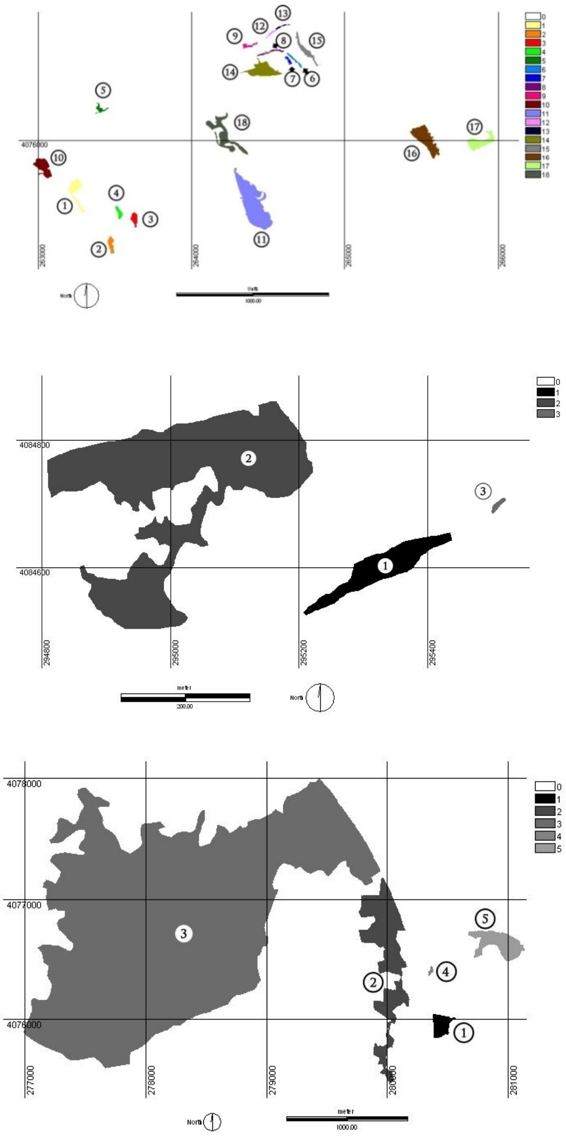

Figure 2. The location of fragmented forests (a: Shastkalateh, b: Nomal, c: Ghorogh)

2.2. Bird Surveys

Species richness and density of birds were determined using the point- count method (Newmark, 1991; Bibby *et al.,* 1992). A total of 74 point count stations were placed in 26 forest remnants.

2.3. Habitat Surveys

The number of point count stations varied depending on area of the remnant: 18 stations in remnants <1 ha; 6 stations in remnants 1-10 ha; 1 station in remnants 10-25 ha and 1 station in remnants >300 ha in size. Each station had a fixed radius of 25 m and stations were located at least 100 m apart to minimize the risk of counting the same individual bird twice. Circles of 25 m radius were selected because this was the farthest point an observer could detect and see birds in these forests. Ten minutes were spent at each station (Watson, 2004). Bird surveys were carried out by author during autumn 2011 and 2012. Each station was visited twice. The author wore drab clothing to avoid detection biases induced by bright colors (Gutzwiller and Marcum, 1993). Only the species sighted within the point count area were recorded as present, calls were used to locate birds and to aid identification. Surveys were confined to hours 06:00- 10:00 in the morning and on days without rain or strong wind. The data captured in point count stations provided a good representation of the species richness in each remnant (O'Dea, 2004). We estimated habitat parameters including vegetation type, number of snags, number of fallen dead trees, number of trees with height more than 20 m, number of trees with dbh 0-20, 20- 50, 50- 100 and 100-300 cm.

2.4. Statistical Analyses

Relationships between relative bird species abundances and the landscape structural variables were investigated using Canonical Correspondence Analysis (CCA) in CANOCO 4.5 (Ter Braak, 1986; 2002). We used CCA as it has been proven to be useful in determining relationship between environmental variables and bird species abundance in other studies (Calme and Desrochers, 2000; Shochat *et al.*, 2001). This is because CCA is a direct gradient analysis in which the ordination axes extracted are selected by multiple regression using linear combinations of the environmental variables (Ter Braak, 1986). Relative abundance per point count at each remnant was used as the biological data and landscape metrics were used as the environmental data. The significance of the first three canonical axes was tested using Monte Carlo test with 10000 permutations. All regression analyses were calculated using the statistical package SPSS (Porter *et al.*, 2005). Patch size were determined from a supervised classified Landsat TM satellite image using ArcView GIS software. Also, biodiversity, density and composition indices were calculated for each site using Ecological Methodology, Distance and CAP4 Software, respectively.

3. Results

The total number of birds was calculated as the number of birds seen. In autumn 14 species from 12 families were identified and the total number of birds was calculated as 378 (Table 1).

Table 1. The birds recorded in four different patch sizes in autumn

Species	Scientific name
Chaffinch	*Fringilla coelebs*
Great Spotted Woodpecker	*Dendrocopos major*
Great Tit	*Parus major*
Blackbird	*Turdus merula*
Wren	*Troglodytes troglodytes*
Long-tailed Tit	*Aegithalos caudadus*
Nuthatch	*Sitta europea*
Red-breasted Flycatcher	*Ficedula parva*
Robin	*Erithacus rubecula*
Coal Tit	*Parus ater*
Blue Tit	*P. caeruleus*
Lesser Spotted Woodpecker	*Dendrocops syriacus*
Warbler	*Hyppolais caligata*

The biodiversity indices (Simpson, Shannon, Kamargo, Nee and N2) were calculated for each site using Ecological Methodology Software (Table 2).

Table 2. The biodiversity index in four different patch sizes in autumn

Biodiversity	(ha) <1	(ha) 1-10	(ha) 10-25	(ha) >300
Simpson	0.73	0.77	0.70	0.8
Shannon	2.03	2.5	2.01	2.68
Kamargo	0.54	0.43	0.45	0.49
Nee	0.34	0.14	0.23	0.15
N2	3.51	4.19	3.31	4.87

a: patch size with <1 hectare

The biodiversity indices Simpson, Shannon and N2 indices were maximum in patch sizes more than 300 hectares. Kamargo and Nee indices were maximum in patch sizes at least 1 hectare in size. The density index was calculated for each site using Distance Software (Table 3).

Table 3. Birds' density in four different patch sizes in autumn ± **s**tandard deviation

Type of species	patch sizes at least 1(ha)	patch sizes 1-10 (ha)	patch sizes 10-25 (ha)	patch size more than 300(ha)	model
Blackbird *Turdus merula*	0	21.23±0.35	8.33±0.04	13.28±0.35	Uniform/ Cosine
Long-tailed Tit *Aegithalos caudadus*	37.34±0	14.93±0	0	11.95±0	Hazard rate/ Cosine
Great Tit *Parus major*	2.55±0.42	2.03±0.25	16.55±5.87	10.79±0.85	Uniform/ Cosine
Wren *Troglodytes troglodytes*	0	0	0	1.48±0.05	Uniform/ Cosine
Robin *Erithacus rubecula*	8.87±3.9	9.93±3.49	16.56±5.79	7.38±2.9	Uniform/ Cosine
Red-breasted Flycatcher *Ficedula parva*	52.94±9.86	28.93±5.79	63.7±11.58	23.97±4.52	Uniform/ Hermite

Birds had a different pattern of density in four different patch sizes in autumn. According to Table 3, Red-breasted Flycatcher had maximum density in all patch sizes. Robin had minimum density in patch size 300 ha. Long-tailed Tit and Wren had minimum density in patch sizes10-25 ha. Wren had minimum density in patch sizes 1-10 ha. Blackbird had minimum density in patch sizes <1 ha. Also, we used Anosim and Simper Analysis for calculating birds' combination for each patch size and season separately through CAP4 software (Table 4).

Table 4. Analysis of paired "ANOSIM" for similarities between the harvests in various treatments in autumn

Type1	Type2	Peremutation	p_value
patch sizes at least 1(ha)	patch sizes1-10 (ha)	1000	0.001
patch sizes at least 1(ha)	patch sizes10-25(ha)	1000	0.02
patch sizes at least 1(ha)	patch size more than 300(ha)	1000	0.001
patch sizes1-10 (ha)	patch sizes10-25(ha)	1000	0.001
patch sizes1-10 (ha)	patch size more than 300(ha)	1000	0.001
patch sizes10-25 (ha)	patch size more than 300(ha)	1000	0.001

According to the Table 4, in autumn all treatments in the four different patch sizes (<1 ha, 1-10 ha, 10-25 ha and >300 ha) showed a significant relationship (P<0.05). According to Table 5, in autumn in patches sizes at least 1 ha, 1-10 ha and 10-25 ha, more than %91, %76, %69 of bird's combination contained Red-breasted Flycatcher respectively.

Table 5. Forest bird species composition in different treatments (analysis of similarity SIMPER) in autumn

Species type in different treatment	Average frequency	Average similarity	Contribution percentage of each species	Cumulative percentage
patch sizes1-10 (ha)				
Red-breasted Flycatcher	2.26	36.82	91.57	91.57
patch sizes1-10 (ha)				
Red-breasted Flycatcher	1.79	21.61	76.91	76.91
Robin	0.84	3.104	11.04	87.95
Great Tit	0.68	1.68	5.98	93.93
patch sizes10-25 (ha)				
Red-breasted Flycatcher	3.08	35.53	69.73	69.73
Great Tit	2.5	10.15	19.19	89.64
Robin	1.17	5.17	10.16	99.79
patch size more than 300(ha)				
Great Tit	2.12	10.66	60.53	60.53
Red-breasted Flycatcher	0.96	3.89	22.12	82.66
Wren	0.68	1.36	7.74	90.39

In patch sizes more than 300 ha %60 of bird's combination contained Great Tit. According to Table 6, environmental variables had strong relationship with the birds' community.

Table 6. Canonical Ordination Analysis table of bird species in forest patches in autumn

Term	axes				Total
	4	3	2	1	
Eigenvalues	0.17	0.18	0.24	0.41	3.495
Relationships between bird species and environmental variables	0.68	0.75	0.68	0.85	
Cumulative percentage variance of species	28.7	23.8	18.7	11.9	
Cumulative percentage variance between species and environmental variables	67.9	56.1	44.1	28.1	
Of all the eigenvalues of a conventional					3.495
F (Monte Carlo test)					1.478
P (Monte Carlo test)					0.002

4. Discussion

Great Tit and Wren were among the most abundant species in patch sizes more than 300 ha. Also, Great Spotted Woodpecker was among the most abundant species in this patch size. We also found a positive relationship between this bird and litter depth and number of trees with DBH 0-20, 20-50. The Great Spotted Woodpecker And Long-tailed Tit had strong relationship with the number of trees with dbh 100-300 (Figure 3).

Nuthatch is usually associated with dead trees and the trees with dbh 100-300 for nesting and cavity creation (Porter *et al.*, 2005). Nuthatches are natural forest specialists, which could be considered as naturalness indicator for forests. Vulnerability of cavity-nesting birds was higher with regards to habitat changes (Gorgani *et al.*, 2012).

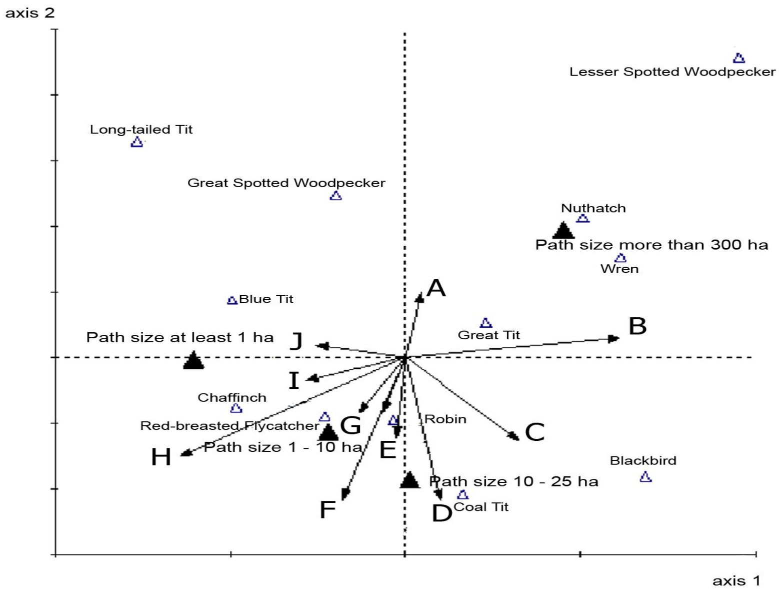

Figure 3. Canonical Analysis Ordination diagram in autumn showing the relationship between species, environmental variables and treatments. Arrows show the environmental variables. A: litter depth, B: number of trees with dbh 20- 50 cm, C: canopy cover trees, D: humidity, E:litter cover, F: number of trees with dbh 50-100cm, G: rock cover, H:temperature, I: vegetation cover, J: number of trees with dbh 100-300 cm. Small triangles show bird species and big triangles show treatments.

There was a lot of the number of trees with DBH 100-300 cm in patch more than 300 ha. And this patch was a good habitat for Nuthatch. Woodpecker had a very important ecological role for forest bird community. This species is placed in ' primary Cavity-nesting birds. By calculating biodiversity, Simpson, Shannon and N2 were maximum in patch more than 300 ha. Camargo and Nee were maximum in patch <1 ha. Woodpeckers were feeding under the bark of trees (Doyon *et al.,* 2005). And when they were searching for food, they removed skin of trees and the lower layer of dead trees and old trees were exposed for feeding on other species of forest birds (Mahon *et al.,* 2008). Therefore all the woodpeckers Avifauna were associated the dead trees exclusively. There were a lot of dead treed in patch more than 300 ha therefore there was a good habitat for Woodpecker. Doyon (2005) studies showed the trees with rough bark like oak, with high age and high density can be especially important for birds such as woodpeckers.

Also, trees with cavities were a key indicator of habitat selection for birds of this group (Mahon *et al.,* 2008; Pasinelli, 2003). For this reason, the Great Spotted Woodpecker was in patch sizes more than 300 (Setayeshi *et al.,* 2012).

Accordingly, woodpeckers have very important ecological role for the birds living in the forest. These species are placed in 'Primary Cavity-nesting birds' group. Primary Cavity-nesting birds drill holes in trees for building their nests. These holes are subsequently used by other forest species (Martin *et al.,* 1999). When woodpeckers are gleaning the tree bark to find food, the trees are exposed to feed other species of the birds (Mahon *et al.,* 2008). Woodpeckers are included in the nutritional field: hunters under the bark of trees (Doyon *et al.,* 2005) and for this reason all woodpeckers were associated with snags and logs", and these birds were more in patch size 300 ha.

Wren usually preferred areas with large trees as habitat and made the nest in holes in old trees or under trees (Porter *et al.,* 2005). Wren is placed in the "Secondary Cavity-nesting bird species" group, meaning they occupy cavities produced by species of primary cavity nesting birds. The number of nests was built by Cavity-nesting bird species was almost too much, in this patches. "Long-tailed Tit" preferred open forests with lush vegetation, and a bush covered edge (Porter *et al.,* 2005) in the patch sizes more than 300 ha.

5. Conclusion

Results showed that diversity indices including Simpson and Shannon heterogeneity and N_2 had the highest values in forest patches with more than 300 ha in area. However, Kamargo and Nee diversity indices had higher values in forest patches <1 ha. One reason is that patches with more than 300 ha in area due to the large area, can retain more species than their original (Vahabzadeh, 2003).

Forest structure variables have been cited as the most important factors in determining the characteristics of birds' habitat, and species richness. The number of trees with suitable dbh in height, was important sources of niche, food, and shelter, and was directly related to the presence of birds (Amini Tehrani et al., 2011). In this study, like other studies, the diversity and density of birds were maximum in patches more than 300 ha in size. Patches <1 ha had a large number of species of birds, that showed the important role of these patches. By including these patches, we did not lose sight of their important role in the richness and diversity of birds' community. Hence, the patches at least 1 hectare in size was also important (Setayeshi *et al.,* 2011).

The results of this study highlighted the importance of forest patches for conservation and enhancement of birds' habitat and conservation of biodiversity of forest ecosystems.

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