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Impact of Forest Degradation on Breeding Birds of the Talysh Mountains in the Azerbaijan Republic

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Abstract

The Talysh Mountains in Azerbaijan are covered with deciduous broadleaf forests. Currently they are suffering ongoing forest degradation. The response of the local fauna to forest degradation is unknown. In this study breeding birds act as bioindicators and their response can reflect response of other taxonomic groups in this area. For the study I used the Line Transect method and surveyed 66.8 km of different forest degradation stages. I found 70 breeding bird species. Forest-dependent bird species showed a negative response to forest degradation, whereas open-land species were responding positively. The heavily degraded forests with a park-like or shrubby appearance show the highest number of bird species. The reason for this pattern is the horizontal vegetation structure in degraded forests, which are highly heterogeneous and thus forest-dependent and open-land species can breed here. Furthermore, I found the highest number of forest-dependent species in natural and slightly disturbed forests. Fourteen of them showed a significant negative response and are likely to become extinct with ongoing degradations.

1. Introduction

Deciduous broadleaf forests of the northern hemisphere are one of the most threatened ecosystems on the earth (Knapp 2005). They occur in three major disjunct regions (western Eurasia, eastern Asia and eastern North America). The increasing human population and their increasing demands for food and biofuels have caused a rapid decline and fragmentation of these forests due to agriculture, livestock farming, fuel wood and timber exploitations. Large areas of deciduous broadleaf forest have already been converted into coniferous woodlands or have been cleared for agriculture and pastures. Nowadays primeval deciduous broadleaf forests, which have never suffered a human impact, are rare and isolated. Once cut, a primeval forest is irreversibly extinct (Knapp 2005).

These forests have survived in western Eurasia only as small isolated remnants, mostly in inaccessible areas or within large forested areas, for example Białowieża Forest on the Polish/Belarusian border (Tomiałojć & Wesołowski 2004), Šúr National Nature Reserve in Slovakia (Korňan 2009), the Carpathians in Romania and the Ukraine and Colchic forests in Georgia. The largest remnants of primeval deciduous broadleaf forests on earth are to be found in northern Iran and the adjacent Azerbaijan and called the Caspian or Hyrcanian forest (Knapp 2005). This forest is regarded as tertiary relict forest with a remarkable biodiversity including 90 tree and 211 shrub species with a high proportion of endemic species (Prilipko 1954, Knapp 2005, Seifollahian 2005). 100,000 ha of pristine forest are to be found within the 1.8-million ha forest

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belt on the northern slopes of the Alborz Mountains in Iran (Knapp 2005). Globally, the Caspian forest is one of the most important deciduous broadleaf forests, due to its remarkably biodiversity, primeval conditions and large extension. In Iran there are 590,000 ha of Hyrcanian forest under the protection of one national park, five nature reserves and three natural monuments besides further forest reserves and wildlife refuges (Knapp 2005). Even outside the protected areas, the Hyrcanian forest in Iran appears natural due to its sustainable use supported by laws for a natural forestry, forestry planter-use, different aged deciduous forest, indigenous tree species, resettlement of the wood population out of the forest and reduction of silvopastures (Abdollahpour & Atui 2005, Mohadjer 2005, Saffari 2005).

Azerbaijan Republic holds a total of about 100,000 ha of the Hyrcanian forest (Michael Succow Stiftung 2009), but the current situation of the Hyrcanian forest in the country is different from that in Iran. After the breakdown of the Soviet Union in 1991, laws protecting the forest were not reintroduced and there followed an absence of regular forestry or management plans. Timber exploitation is for many inhabitants the only monetary income after Russian kolkhozes, as a major employer, disappeared. Thus, an ‘open access’ situation arose, which led to a rapid forest degradation caused by overusing the forest (Noack & Hidayatov 2007, Michael Succow Stiftung 2009). Further reasons for the degradation are silvopastures and tree lopping for livestock fodder and fuel wood (Scharnweber *et al.* 2007). Currently, only 17% of the Hyrcanian forest in Azerbaijan is treated as pristine forest, whereas 44% shows heavy degradation (Rietschel 2010).

Species responses to forest degradation, fragmentation and deforestation have attracted much recent interest throughout all continents and across most forest types (e.g. Edenius & Elmberg 1996, Poulsen 2002, Sekercioglu 2002, Echeverria *et al.* 2007, Murakami *et al.* 2008). It is evident that different species with different habitat requirements respond differently to a changing forest environment. No information is currently available about the impact of the ongoing degradation on the fauna of the Hyrcanian forest. Birds are useful bioindicators. Their ecological behaviour is widely known and they respond rapidly to a changing environment (Flade 1994). As a result, an understanding of birds’ responses to forest degradation can help to anticipate the reactions of the entire fauna of that ecosystem, and subsequently guide further nature conservation measures. Therefore the aim of this study was to find out which species are affected by forest degradation and to what extent.

2. Study Areas and Methods

2.1. Study areas

The Hyrcanian forest stretches in a large arc along the Alborz Mountains in northern Iran and reaches Azerbaijan in its southernmost part. It was here in the Talysh Mountains that the study was carried out covering the districts Yardimli, Masalli, Lenkoran, Lerik and Astara (Fig. 1).

The altitude ranges from –28 m asl at the Caspian coast in the East to 2,492 m asl in the Kiumiurkei Mountain at the Iranian border in the West. The forest belt stretches from sea level to 1,800 m asl, but due to logging and cultivation, the upper treeline nowadays is mostly below the natural limit (MENR 2004, Scharnweber *et al.* 2007) and the lowland is virtually completely deforested.

The number of tree species is high and includes many endemic or tertiary relict species like *Gleditsia caspica, Parrotia persica, Quercus castaneifolia, Albizzia julibrissin, Buxus hyrcana, Ruscus hyrcana* and *Acer hyrcanum* (MENR 2004, Hajiyev 2006). Established in 2004 and enlarged in April 2008 to 40,358 ha (MENR 2010), most of the area of the Hirkan National Park protects large tracts of primeval deciduous forest.

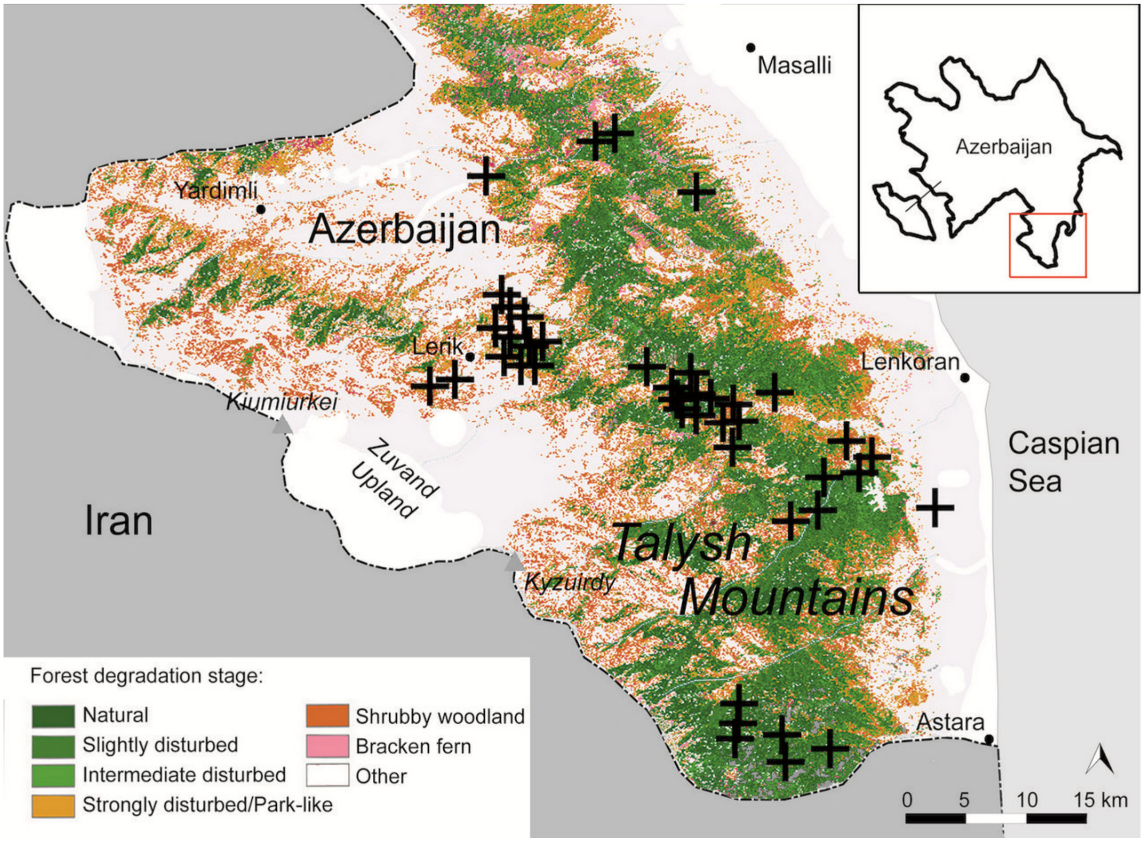

Fig. 1. Map of the study site and locations of transects (black crosses). Determinations of forest degradation stages are adapted from Rietschel (2010) who used LANDSAT satellite images.

2.2. Forest degradation stages

To investigate the impact of forest degradation on the breeding birds of the Hyrcanian forest, I used six forest degradation stages, which have been identified and described by Scharnweber *et al.* (2007). I identified these stages in the field by their typical vegetation structure and surveyed them adequately.

A) Natural forest stage: this stage shows no signs of human activities such as logging or silvopastures. It is generally restricted to higher altitudes above 500 m asl., but occurs also elsewhere along steep slopes or remote from human settlements and roads. The natural forest stage has primeval conditions and acted in this study as the reference state. I found this stage only within the Hirkan National Park.

B) Slightly disturbed forest stage: the slightly disturbed forest stage is similar to the natural forest stage. The human impact is low and often not obvious. Thus, this stage was in a few cases difficult to distinguish from the natural forest stage. Indications of a slightly disturbed forest stage are human paths, single snags, partly missing dead wood and evidence of grazing like excrement or traces of domestic animals or a reduced understorey. According to Scharnweber *et al.* (2007), there are no differences from the natural forest stage with respect to tree species composition and stand structure. Old-growth trees are still a common aspect.

C) Intermediate disturbed forest stage: logging, lopping and grazing are clearly visible in this stage. This stage can be found near villages often at distances of about 2–4 km or along roads. Loose grazing flocks of cattle or sheep can regularly be seen in this forest stage. The tree layer is still well developed, but with a less diverse stands structure and some gaps in the canopy. The intermediate disturbed forest is more suffused with light. This stage was common and widespread, especially along the main roads from Lenkoran to Lerik and from Masalli to Yardimli.

D) Park-like forest stage: this degradation stage is characterised by considerable logging and grazing activity, which leads to a park-like appearance. Trees are mostly cut down and only single old-growth trees are left, which mostly have a chopped appearance due to lopping. Snags are common. The foliage cover of the tree layer is light (ca. 5–10%). The herb layer is short due to intense grazing, and rejuvenation of trees is therefore rare. Denser forest fragments can occur. This stage can be found closer to villages (1–2 km), on ridge tops or in plains.

E) Shrubby woodland stage: the shrubby woodland stage is situated close to villages. It is the outcome of a frequently used former forest. Large trees are almost completely absent and shrubs dominate. Owing to lopping and pollarding, trees appear like small bushes, especially *Carpinus betulus* and *Quercus castaneifolia,* which rarely exceed heights of more than three metres. Grazing intensity is very high. This stage can also be found at higher altitudes along the upper tree line. Here, the occurrence is probably naturally triggered, as the growth of trees is inhibited by the rougher climate (lower precipitation, lower mean annual temperature or strong winds).

I disregarded the Treeless bracken fern stage described by Scharnweber *et al.* (2007) that is dominated by *Pteridium aquilinum*. It is limited to a few small locations only and could not be adequately sampled.

These degradation stages occurred throughout the forest belt and were thus sampled equally at all altitudes. There were no remarkable differences in tree species composition or forest structure caused by an altitudinal zonation or differences in slope exposition, which might affect the breeding bird communities.

2.3. Materials and Methods

Bird sampling

I surveyed birds from 3 April to 8 June 2008. This short period was selected to guarantee the highest levels of territorial activity of birds during the breeding season in spring. Outside this period territorial activity is be too sparse to provide reliable data; especially song activity considerably decreased in June when parents were occupied in caring for their nestlings. I chose the line transect method as the most suitable for this bird survey. This is a compromise between the point count and the mapping-census methods. The main advantage of the line transect method is a good ratio between time/effort and gained data (Flade 1994, Bibby *et al.* 1995, Südbeck *et al.* 2005). Südbeck *et al.* (2005) recommend surveying each transect four times during the breeding season. This was not possible in the present study, each transect being surveyed only once. This modification was necessary to achieve a broad overview of the large Talysh region. Furthermore, retracing an already visited transect in remote regions without paths or the reliable accuracy of a GPS device (Garmin GPS 60), is fraught with difficulties especially in dense forests over long distances.

Methodological problems of transects without repeated counts are discussed in Pëterhofs & Priednieks (1989) and Hilden & Järvinen (1989). The main concern according to Hilden & Järvinen (1989) was that only 50% of the breeding pairs are detectable during one count. This drawback was reduced as I walked transects slowly (ca. 1–1.5 km/hour) recommended in Südbeck *et al.* (2005). Too slow a pace could increase double counts of birds and was therefore avoided. Nevertheless, like most bird survey methods, this method is biased against quiet, secretive and nocturnal species (Bibby *et al.* 1995).

Surveying was done in the morning and occasionally in the evening when the diurnal bird activities peaked. No counts took place in poor weather conditions like on rainy or windy days (Flade 1994, Bibby *et al.* 1995, Südbeck *et al.* 2005).

Each study site and transect route was selected following the determination of forest degradation stages. The transect line was as straight as difficult topography, rivers or dense, thorny shrubs allowed. Along each transect line I recorded continuously all birds and their activities (e.g. singing, calling, feeding, flying).

Data analysis

The determination of ‘territories’ was reduced in precision, because every transect was visited only once. Väisänen (1989) categorised the breeding evidence for bird species, which I modified in this study. I treated the following observations as evidence of a territory: a single bird (male, female or juvenile), a pair, an occupied nest or a family. Flying individuals are treated as territories as long as they show territorial behaviour or at least an association with the habitat. Manifestly migrating or high flying birds, non-breeding flocks or birds remote from their typical nesting habitats or far from their breeding ranges are listed as without territories. Only birds within 200 metres of the transect line were included in the calculations to guarantee their association with the degradation stage. For each forest degradation stage, I calculated the relative abundance of each bird species using the formula: A=T/L, where A= relative abundance, T= number of territories, L= total transect length per degradation stage (km).

To ensure the comparability of the relative abundances of species in each degradation stage, the calculation was modified according to the different migratory behaviour of each bird species. Thus long-distance migrants are not included in the early transects of this study, as they arrive later in spring. Use of the total transect length per degradation stage would underestimate their relative abundance. Hence, for all bird species I used the date of its first observation to determine the number of kilometres per degradation stage (L). Therefore, the length (L) used for calculation of long-distance migrants is shorter than that of , non-migrants.

Statistical analysis

I used the Kendall rank correlation coefficient (Kendall's tau) to analyse the calculated relative abundance values of each bird species per forest degradation stage. I treated species with a Kendall's tau of –1 to –0.25 as responding negatively and 0.25 to 1 as responding positively. Species with a Kendall's tau of –0.25 to 0.25 were treated as showing no response.

Additionally, I calculated simple linear regression models for each species. These regressions show the strength of response on the basis of relative abundance values. Here, I used the natural forest stage as a reference state. A negative slope indicates a declining abundance with ongoing forest degradation, whereas a positive slope an increasing abundance. Species that did not occur in the natural forest stage were excluded from the linear regression analysis.

Nesting guilds

At the guild level, more coherence in the responses to forest degradation can be expected, because species belonging to the same guild have similar life history traits, dispersal ability, and spatial distribution and may show similar responses to disturbance (Pearman 2002). Hence, I analysed which guilds are affected by forest degradation and assigned them to four nesting guilds (ground nesters, shrub nesters, canopy nesters, cavity nesters) on the basis of a review of the literature (Glutz von Blotzheim & Bauer 1991, Glutz von Blotzheim & Bauer 1994, Flade 1994, Glutz von Blotzheim & Bauer 1998, Urquhart, & Bowley 2002, Alström & Mild 2003, Patrikeev 2004, Andretzke *et al.* 2005, Kirwan *et al.* 2008). If a bird species belonged to more than one guild, I used the most characteristic. The Common Cuckoo *Cuculus canorus* was excluded from this analysis because it was unclear which nesting guilds he parasitises most in the Talysh Mountains.

3. Results

I surveyed 66.8 km consisting of 42 transects (Fig. 1). Most of the surveyed transects were within the intermediate disturbed forest stage and the least surveyed within the natural forest stage (Table 1).

3.1. Species number

I expected a longer total transect length to produce a higher number of species. Therefore, I used species-area relationships (or rather 'species-sampling-effort relationships') to compare the relative species number of each degradation stage. For this purpose, I set a cut-level at the mean total transect length of 13,360 m cutting the different species-area-curves at the same length and allowed a comparison (Fig. 2). In total, 70 bird species have been identified to breed in the forest degradation stages (Table 1). The shrubby woodland stage was the most species-rich degradation stage. Natural forests, slightly disturbed and park-like forests had moderate relative species richness, whereas intermediate disturbed forests had rather small species diversity with a remarkably lower species-area-curve (Fig. 2).

3.2. Relative abundance

Figure 3 shows the relative abundances of the 15 most common species of birds within each forest degradation stage. The most abundant species in the natural, slightly and intermediate disturbed forest stages were Coal Tit *Periparus ater* and Chaffinch *Fringilla coelebs*. However, a comparison between bird species is theoretically not admissible because of the different detectability among bird species. This comparison is also biased towards eye-catching and loud-voiced birds.

A shift regarding species composition and relative abundance took place in the park-like forest stage (Fig. 3). The relative abundance of typical forest species declines with ongoing forest degradation (e.g. Coal Tit *Periparus ater,* Chaffinch *Fringilla coelebs,* Eurasian Wren *Troglodytes troglodytes,* Eurasian Robin *Erithacus rubecula*), whereas the relative abundance of open woodland species increased. Most of increasing species were associated with shrubs of open landscapes (e.g. Common Nightingale *Luscinia megarhynchos,* Common Whitethroat *Sylvia communis* and Red-backed Shrike *Lanius collurio*).

Table 1. Overview of surveyed transect length and breeding bird species per degradation stage. Note that bird species can occur in more than one stage.

Forest degradation stage	Transect length [km]	Species number
Natural forest stage	8.6	32
Slightly disturbed forest stage	12.1	40
Intermediate disturbed forest stage	18.9	39
Park-like forest stage	11.9	41
Shrubby woodland stage	15.3	56
Total	66.8	70

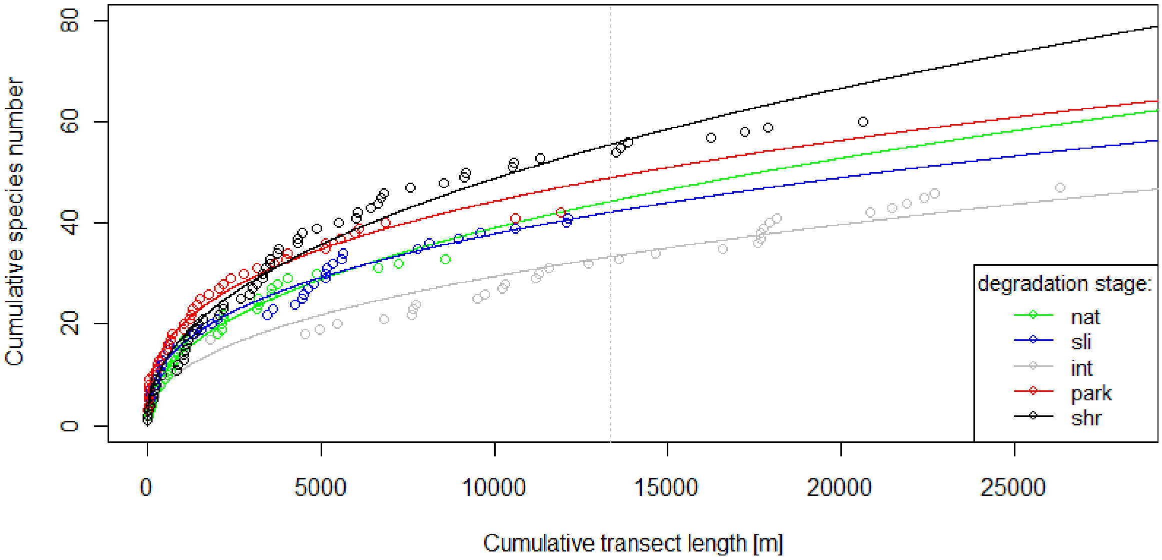

Fig. 2. Species-area curve of forest degradation stages (nat = natural forest stage, sli = slightly disturbed forest stage, int = intermediate disturbed forest stage, park = park-like forest stage, shr = shrubby woodland stage). Every new recorded species along a cumulative transect line per forest degradation stage is shown as a circle. To compare the species richness between the forest degradation stages a cutlevel was set at the mean total transect length of 13’360 m.

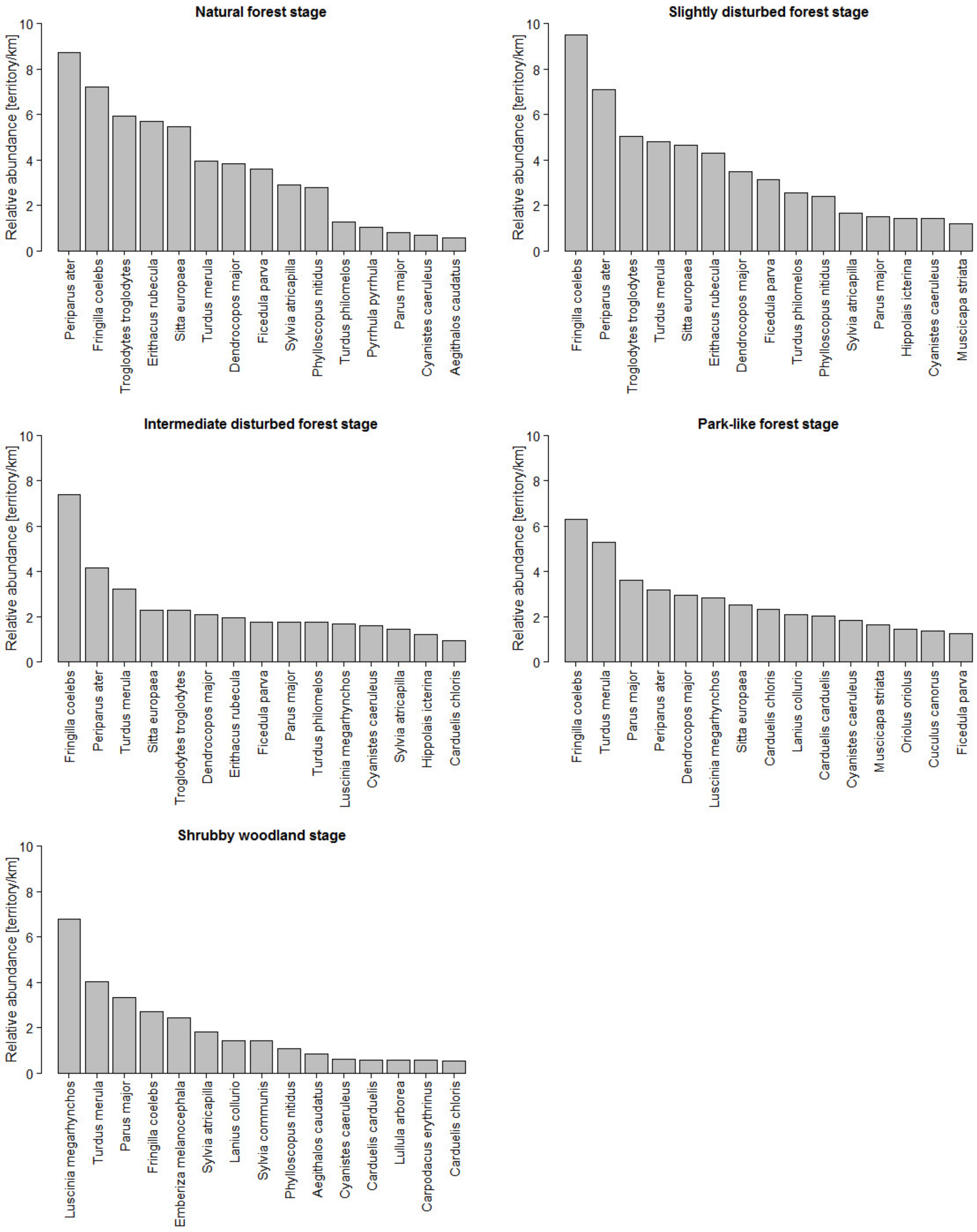

Fig. 3. Relative abundances of the 15 most common bird species per forest degradation stage.

Table 2. Response of the 47 most common breeding bird species (number of territories ≥ 5) and nesting guilds to forest degradation expressed as rank correlation coefficients (Kendall's tau) and linear regression models for birds breeding in natural forest stage. Species with a significant Kendall' tau are in bold.

	Rank correlation coefficient		Linear regression model					
Species	Kendall's tau	*p* value	slope±SE	slope t-value	intercept±SE	R^2	*F* Stat	number of territories
negative response:								
Ficedula semitorquata	-1.00	0.017	-0.27±0.03	-9.10	1.31±0.10	0.97	82.80	13
Ficedula parva	-1.00	0.017	-0.24±0.04	-5.75	1.35±0.14	0.92	33.04	130
Erithacus rubecula	-1.00	0.017	-0.25±0.04	-6.70	1.21±0.13	0.94	44.86	150
Troglodytes troglodytes	-1.00	0.017	-0.27±0.03	-9.35	1.29±0.09	0.97	87.48	177
Sitta europaea	-1.00	0.017	-0.23±0.03	-7.55	1.27±0.10	0.95	56.99	187
Periparus ater	-1.00	0.017	-0.23±0.01	-16.57	1.25±0.05	0.99	274.44	290
Dendrocopos major	-0.80	0.083	-0.18±0.06	-3.17	1.25±0.19	0.77	10.02	167
Picus viridis	-0.60	0.233	-0.11±0.04	-3.21	1.05±0.12	0.77	10.27	26
Phylloscopus nitidus	-0.60	0.233	-0.12±0.14	-0.86	0.94±0.46	0.20	0.74	72
Turdus philomelos	-0.60	0.233	-0.26±0.18	-1.46	1.84±0.59	0.42	2.13	91
Fringilla coelebs	-0.60	0.233	-0.15±0.08	-1.96	1.41±0.25	0.56	3.84	454
Buteo buteo	-0.40	0.483	-0.04±0.10	-0.43	0.83±0.32	0.06	0.19	10
Pyrrhula pyrrhula	-0.40	0.483	-0.19±0.11	-1.69	0.81±0.37	0.49	2.86	12
Carduelis spinus	-0.40	0.483	-0.15±0.09	-1.73	1.01±0.28	0.50	2.98	20
no response:								
Hippolais icterina	-0.20	0.817	0.17±0.43	0.40	2.31±1.43	0.05	0.16	50
Sylvia atricapilla	-0.20	0.817	-0.06±0.08	-0.75	0.85±0.25	0.16	0.56	129
Prunella modularis	-0.12	0.782	-0.03±0.19	-0.14	0.45±0.62	0.01	0.02	9
Motacilla cinerea	0.00	1.000	-0.15±0.39	-0.38	1.83±1.30	0.05	0.15	24
Aegithalos caudatus	0.00	1.000	0.01±0.22	0.06	0.96±0.74	0.00	0.00	39
Muscicapa striata	0.00	1.000	-0.06±0.68	-0.09	2.50±2.26	0.00	0.01	40
Alcedo atthis	0.11	0.801	0.00±0	NA	0.00±0	NA	NA	6
Dendrocopos minor	0.12	0.782	0.00±0	NA	0.00±0	NA	NA	6
Carpodacus erythrinus	0.20	0.817	1.19±0.74	1.61	-1.60±2.46	0.46	2.59	14
Columba oenas	0.20	0.817	0.03±0.15	0.21	1.00±0.48	0.01	0.04	16
Cuculus canorus	0.20	0.817	0.09±0.21	0.45	1.22±0.69	0.06	0.20	50
Turdus merula	0.20	0.817	0.01±0.07	0.19	1.04±0.24	0.01	0.04	277
positive response:								
Phoenicurus phoenicurus	0.32	0.448	-	-	-	-	-	11
Carduelis cannabina	0.36	0.405	-	-	-	-	-	9
Garrulus glandarius	0.40	0.483	0.09±0.16	0.55	0.40±0.55	0.09	0.30	15
Coccothraustes coccothraustes	0.40	0.483	1.07±1.21	0.89	2.21±4	0.21	0.78	45
Cyanistes caeruleus	0.40	0.483	0.11±0.27	0.41	1.57±0.9	0.05	0.17	92
Turdus viscivorus	0.53	0.207	-	-	-	-	-	9
Jynx torquilla	0.53	0.207	-	-	-	-	-	15
Oriolus oriolus	0.53	0.207	-	-	-	-	-	19
Carduelis chloris	0.60	0.233	2.39±2.25	1.06	1.09±7.47	0.27	1.13	66
Anthus trivialis	0.63	0.157	-	-	-	-	-	7
Sylvia communis	0.63	0.157	-	-	-	-	-	8
Emberiza calandra	0.63	0.157	-	-	-	-	-	9
Corvus cornix	0.74	0.077	-	-	-	-	-	22
Lanius collurio	0.80	0.083	-	-	-	-	-	33
Carduelis carduelis	0.80	0.083	-	-	-	-	-	47
Luscinia megarhynchos	0.80	0.083	7.71±1.23	6.25	-9.36±4.09	0.93	39.07	101
Upupa epops	0.84	0.052	-	-	-	-	-	7
Lullula arborea	0.84	0.052	-	-	-	-	-	14
Parus major	1.00	0.017	0.96±0.14	6.91	-0.01±0.46	0.94	47.78	162
nesting guild:								
Cavity	-0.8	0.083	-0.16±0.05	-3.24	1.25± 0.16	0.78	10.52	1205
Ground	-0.6	0.233	-0.09±0.07	-1.41	0.99± 0.22	0.40	1.98	539
Canopy	0	1.000	-0.03±0.09	-0.33	1.23± 0.29	0.03	0.11	857
Shrub	0.6	0.233	0.15±0.07	2.17	0.75± 0.22	0.61	4.69	543

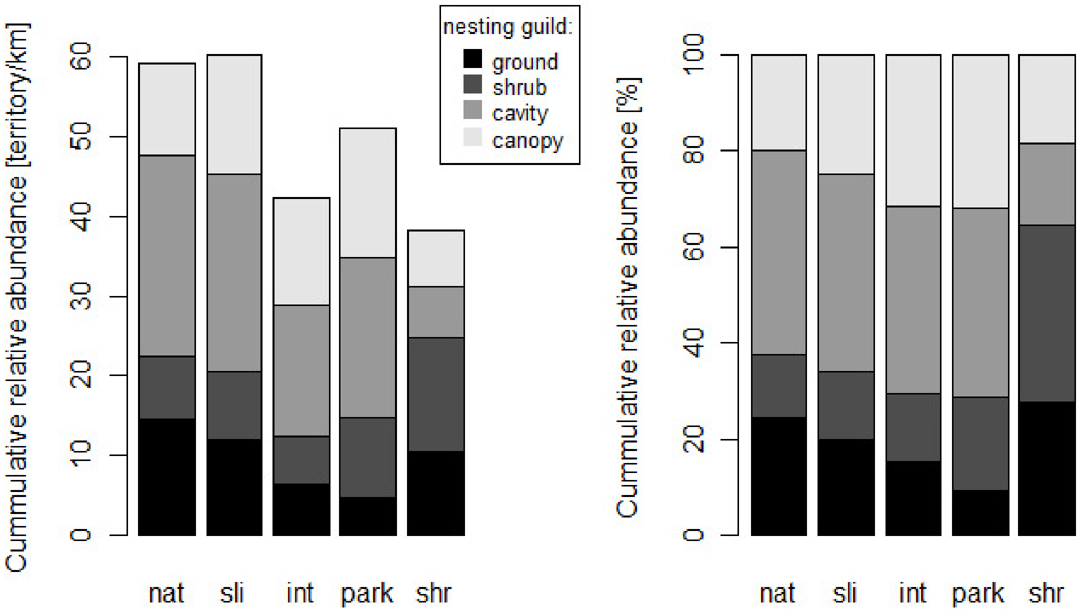

Fig. 4. Response of nesting guilds to forest degradation. (nat = natural forest stage, sli = slightly disturbed forest stage, int = intermediate disturbed forest stage, park = park-like forest stage, shr = shrubby woodland stage).

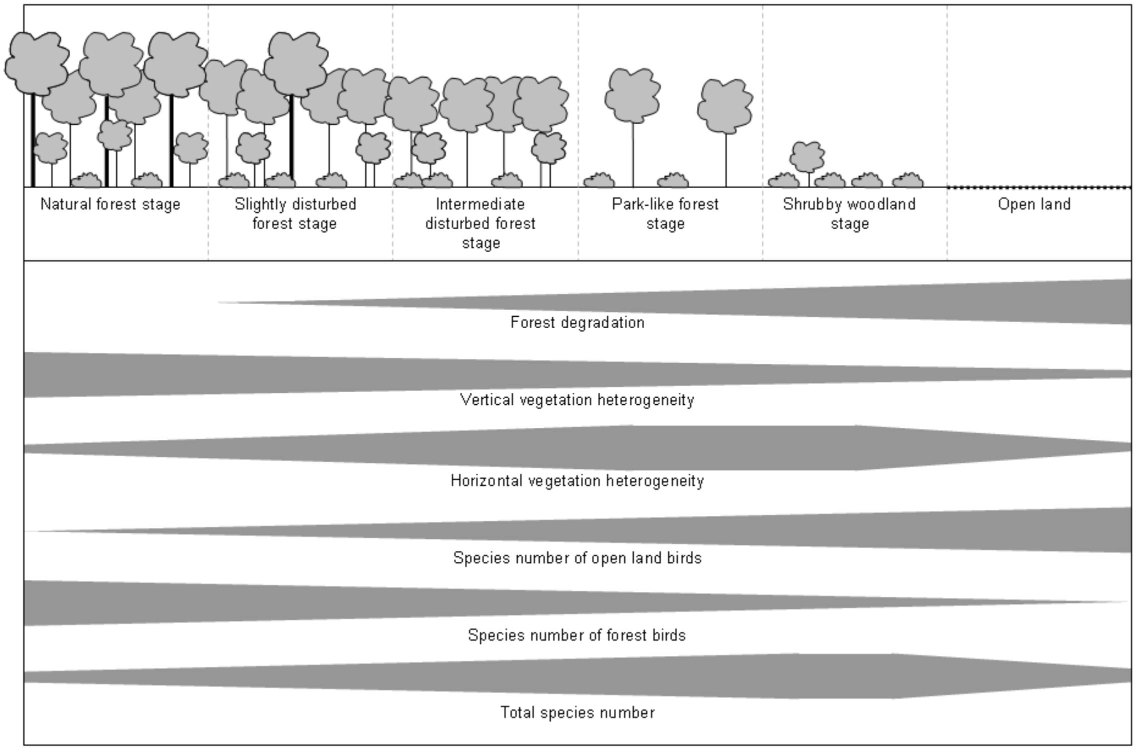

Fig. 5. Breeding bird response to forest degradation. Summarised schematic of the forest degradation stages.

3.3. Response to forest degradation at species level

The natural forest stage served as a gauge representing a pristine forest untouched by human activities. One response to increasing degradation is the formation of a different constellation of bird species. Fourteen bird species, of which six were significant, showed a negative response to forest degradation (Table 2). All of them were forest-dependent species and occurred in the natural forest stage. Here, higher abundances were visible in natural and slightly disturbed forest stage in comparison to heavier degraded stages (Fig. 3). Twelve species showed no response (Table 2). All of them have been recorded in the natural forest stage. Nineteen bird species that bred in the degradation stages show positive response to degradation, but only six of these species (Hawfinch *Coccothraustes coccothraustes*, European Greenfinch *Carduelis chloris*, Common Nightingale *Luscinia megarhynchos*, Great Tit *Parus major,* Blue Tit *Cyanistes caeruleus,* and Eurasian Jay *Garrulus glandarius*) are found in the natural forest stage (Table 2). Others are open-land or open-woodland species.

3.4. Response to forest degradation at guild level

In general, the highest relative bird territory abundances can be found in slightly disturbed and natural forest stages with 60.5 and 59.2 territory/km, respectively. The shrubby woodland stage holds the lowest bird abundance with 40.3 territory/km (Fig. 4).

The four analysed nesting guilds responded differently to each degradation stage. The dominating guild within all degradation stages, except the shrubby woodland stage, was cavity nesters (Fig. 4). This guild includes typical cavity breeders, such as Great Spotted Woodpecker *Dendrocopos major* and Blue Tit *Cyanistes caeruleus,* and semi-cavity breeders, such as Eurasian Treecreeper *Certhia familiaris*. Cavity nesters reached their highest relative abundances in natural and slightly disturbed forests with 25.2 and 24.9 territory/km, respectively. In contrast, only 7.7 territory/km occurred in the shrubby woodland stage. Canopy nesters were common in all degradation stages, except for the shrubby woodland stage. Shrub nesters dominated the shrubby woodland stage. Here the highest proportion and highest relative abundance can be found. Birds that breed on the ground showed a decline in relative abundance and proportion congruent with a degradation gradient from high values in natural forest stage to low values in park-like stage. Incongruently, the values of relative abundance and proportion rise again in the shrubby woodland stage (Fig. 4).

According to the rank correlations (Kendall's tau), cavity and ground nesters were negatively affected by forest degradation and shrub nesters positively. Canopy nesters showed no response (Table 2).

4. Discussion

4.1. Impact of forest degradation on nesting guilds

The heterogeneous vertical and horizontal vegetation structures of forests are important factors influencing the abundance and diversity of breeding bird communities. They provide a large number of ecological niches for a broad variety of bird species (MacArthur & MacArthur 1961, MacArthur 1968, Erdelen 1984, Tews *et al.* 2004, Kati & Şekercioglu 2006).

The vertical vegetation heterogeneity is great in natural and slightly disturbed forests and diminishes with ongoing degradation through the loss of tall and differently aged trees, the multi-storey structure and the soil enrichment imparted by freshly fallen and decaying trees and snags (Fig. 5). In natural and slightly disturbed forests the abundance of cavity breeders was greater than that in any of the other degradation stages (Fig. 4). This nesting guild was particularly affected by forest degradation, showing a decreasing abundance with ongoing degradation. The older and larger the trees are, the more cavities are available and the greater is the abundance of cavity breeders (Enoksson *et al.* 1995, Poulsen 2002). The high proportion of cavity breeders is typical of European old-growth forests (e.g. Wesołowski & Tomiałojć 1997, Saniga & Saniga 2004, Korňan 2009).

Furthermore, old and large trees with their voluminous crowns support a diverse vertical vegetation structure in natural forests and can therefore harbour a large number of canopy breeders (Fig. 4). Their abundance was lowest in the shrubby woodland stage owing to the less voluminous and less diverse canopy structure.

Ground breeders yielded high values in natural and slightly disturbed forests. A well developed, diverse and undisturbed herb and shrub layer enables several bird species to breed in high densities on the ground. With ongoing degradation frequent disturbances and a shortened herb layer due to the grazing of cattle and sheep reduces the breeding opportunities and success for ground breeders. The smallest abundance of ground breeders is to be found in the park-like forest stage (Fig. 4). However, with ongoing degradation the negative influence due to grazing is probably compensated for by an increasing number of thorny shrubs in the shrubby woodland stage that sheltered ground breeders, resulting in an increase of their abundance in this stage.

Wesołowski & Tomiałojć (1997), Wesołowski (2003) and Wesołowski (2007) found no evidence for interspecific competition caused by a shortage of nesting holes and food limitations in primeval forests. The presence of a diverse vertical vegetation structure in natural or slightly disturbed forests is the main reason why here abundances of forest birds reach their highest values (Figs. 4–5). Only here does the forest have a voluminous appearance with enough space to support high bird densities. With ongoing degradation, the volume of forests reduces and leading to a shortage of nesting and food resources and eventually bird densities will decrease. Furthermore, the edge effects of fragmented forests increase the risk of predation, resulting in smaller abundances within degraded forests.

4.2. Impact of forest degradation on species and species richness

As the calculation of diversity indices was invalid for methodological reasons, only the species number of each degradation stage was taken into account. The most species-rich stage was the shrubby woodland stage (Figs. 2 & 5). Here, the horizontal vegetation heterogeneity was high due to the patchy distribution of open and denser shrub formations, single old, chopped trees, small-sized forest remnants and often interspersed with open spaces such as pastures or meadows. This high degree of horizontal vegetation heterogeneity provided breeding opportunities for a large variety of forest-dependent and open-land species and is therefore an important factor in high species richness (Pino *et al.* 2000, Sekercioglu 2002, Kati & Sekercioglu 2006).

A high richness and diversity of species is a major concern for nature and bird conservation (e.g. Ramírez-Albores 2007). But this aim needs to be followed with caution in nature conservation planning, for within a large extended primeval forest, a diverse horizontal heterogeneity can only be achieved through fragmentation by grazing and logging. Not surprisingly, the most species-rich forest degradation stages were the shrubby woodland stage and the park-like forest stage (Fig. 5). Natural and slightly disturbed forests were relatively poor in species. Their horizontal structure was more uniform compared to degraded and fragmented forests with only a few natural forest clearings due to wind throws, fires or landslides. Open-land species were therefore rare and restricted to these locations or absent, which reduces the total number of species in these stages.

Despite the inferior total species richness of natural forests compared to the degradation stages, the diversity of forest-dependent species was greater. Some of them exist in the Talysh Mountains only in natural or slightly disturbed forests (e.g. Black Woodpecker *Dryocopus martius*, Eurasian Treecreeper *Certhia familiaris*). Furthermore, bird endemism is an important aspect to consider in reaching nature conservation decisions (Walther & Martin 2001). In the Hyrcanian forest bird endemism occurs mainly on subspecies level. Almost all of the subspecies are more or less forest-dependent birds, like *Phasianus colchicus talischensis, Dendrocopos minor quadrifasciatus, Garrulus glandarius hyrcanus, Periparus ater gaddi, Sitta europaea rubiginosa, Regulus regulus hyrcanus, Erithacus rubecula hyrcanus* (Agaeva 1979, Patrikeev 2004, Clements 2008). *Poecile hyrcana* was recently split from *Poecile lugubris*, but prefers degraded forests (Loskot 1978). Furthermore, Perktas & Quintero (2012) surveyed mitochondrial DNA variation of the great spotted woodpecker complex and found that *Dendrocopos (major) poelzami* should be treated as a separate species. Additional ‘new’ species are likely to emerge with ongoing research in this field.

Tomiałojć & Wesołowski (2004) stated that primeval forests are generally rich in species, which may be true of the Białowieża primeval forest in Poland, but the situation of the Hyrcanian forest is different. This forest is isolated, surrounded by deserts and treeless steppes. No connection with the boreal forest zone exists and therefore many boreal species, especially some resident families such as owls, tits, warblers, woodpeckers and grouses which help to make up the large number of species in Białowieża forest, are absent here, or occur in lower species numbers. A general high richness in species is therefore not a feature of primeval forests of the temperate zone, it is a feature of the transition zone of deciduous broadleaf forest to boreal forest.

Nevertheless, destruction or removal of forests would cause a species reshuffle, extirpating most forest-dependent bird species and encouraging colonisation by open-land species (Fig. 3), which is also observable in tropical rain forests after intensive logging or clear-cutting (e.g. Thiollay 1999, Patten *et al.* 2010). Any possible future recolonisation by forest species could never bring back the whole assemblage due to the extinction of some bird species. The British avifauna, for example, lacks several forest-dependent bird species, a deficiency for which no geographical or biological reason exist (e.g. Black Woodpecker *Dryocopus martius*), but which was probably caused by the widespread removal of forests centuries ago (Fuller *et al.* 2007, Wesołowski 2007).

4.3. Conclusion and conservation implications

The bird species richness and species abundance of the Hyrcanian forest are influenced by vertical and horizontal vegetation structures (Fig. 5). Parts of the forest with primeval conditions support high levels of bird abundance and high numbers of forest-depended bird species, which are dependent on those primeval conditions. The preservation of large-scale forested areas in the Talysh Mountains is therefore crucial to the whole avifauna. Birds, as a generally well-studied taxonomic group (Flade 1994), may stand for the broad variety of further taxonomic groups such as mammals, amphibians, reptiles and insects. The reaction of these groups to forest degradation in that region is completely unknown, but an anticipation of their response can be derived from the observed response of birds.

Drawing an analogy from the effect on the birds, I anticipate further local extinctions of individual species among these taxonomic groups with ongoing degradation and fragmentation. This loss of biodiversity can only be avoided or even reduced by sustainable forestry, which is in balance with ecological processes. The slightly or intermediate disturbed forests may serve as models whereby a large amount of the original avifauna can successfully coexist with forest utilisation.

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