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COMPARISON IN WOODY SPECIES COMPOSITION, DIVERSITY AND COMMUNITY STRUCTURE AS AFFECTED BY LIVESTOCK GRAZING AND HUMAN USES IN BEECH FORESTS OF NORTHERN IRAN

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Abstract

In the more forested areas of Iran, rural people are in close relationship with natural resources, especially forests. This close association endangers the dynamics and sustainability of forest ecosystems. Hence, we investigated the effects of grazing and human uses on woody plant diversity, composition and forest structure in beech forests of northern Iran. We thus compared a 50-ha area protected against livestock and human disturbances to a 50-ha unprotected area. In each area, we recorded tree species, diameter at breast height (DBH) of merchantable trees, and stem numbers of shrub species in 1000-m^2 plots established in a random-systematic sampling design. These data allowed us to compute diversity indices separately for tree and shrub layers. Results revealed that tree density, mean tree DBH and total basal area were significantly higher in the protected than in the unprotected area. However, in both the tree and the shrub layers, values of Shannon diversity, evenness index, richness, and shrub density were lower in the protected area than in the unprotected area. Because forest structure, composition and diversity are closely associated with human traditional activities, we recommend that conservation programs be implemented in collaboration with local people to help establish effective management aiming at providing services for local people while restoring these forests.

Key words: disturbance, floristic composition, forest structure, Iran, species diversity.

Introduction

Understanding the relationship between plant diversity and land use history can have important implications in forest management decisions, especially when these ecosystems were widely used by humans (Tálamo et al. 2012). Iran is an important source of plant diversity with 22 % out of 8000 species that are endemic. Hyrcanian forests are one of the main floristic regions in northern Iran. These forests are located on the northern slopes of the Alborz Mountains overlooking the Caspian Sea (Sagheb-Talebi et al. 2003). Among forest communities in northern Iran, Oriental beech (*Fagus orientalis* Lipsky.) dominated stands are highly valuable because of their major contribution to carbon sequestration, socio-economic activities, soil protection and recreation resources (Wardle 1984). These forests correspond to an area of 565,000 ha in the province of Guilan and are subjected to commercial harvests although a small proportion has been protected or conserved. Approximately one-third of these forests have been destroyed in the last 35 years (Marvi-Mohadjer 2007). Nearly 87 % of the Iranian forest degradation was caused by human activities (Jazirei 2001), such as irregular grazing and wood consumption, and only 13 % by natural factors (Heydarpour Tutkale et al. 2008). The composition and diversity of plant communities in many of these natural ecosystems were considerably affected, and the extent to which these changes were significant depended on the intensity and frequency of degradation sources and on the ability of plant species to adapt to these new conditions (Herath et al. 2009).

The effect of human activities is exacerbated by livestock grazing, which affects 25 % of the earth's forest ecosystems (Asner et al. 2004). In the more forested areas of Iran, rural people are in close relationship with natural resources, especially forests (Reyers 2004). This close association endangers the dynamics and sustainability of forest ecosystems. Human activities in these areas can lead to loss of ecological resilience with forest cover destruction over the short term and flooding and erosion over the medium to long term. Ultimately, life conditions will be jeopardized in such forest ecosystems (Heydarpour Tutkale et al. 2008). During the process, grazing can change competitive balance between species (Jones et al. 2011), composition and abundance of plants, species dominance establishment of plant species (Bouahim et al. 2010), ecosystem processes and biodiversity (Polasky et al. 2011). These changes can progressively lead to unbalanced ecosystems, which can hardly revert to their initial state (Emlen et al. 1998). Therefore, conservation of forest biodiversity and structure has been considered as a management objective (Jonathan and Nicole 2005) and in the last few decades, especially after the Rio conference, the loss of biodiversity associated with human activities became a major source of concern for forest ecologists (UNCCD 2004). The ecological effects of grazing on biodiversity, forest structure and species composition have recently been studied and discussed, and different responses such as increase or decrease in richness, evenness and ecosystem functions have been observed in ecosystems submitted to grazing and human activities (Agra and Neeman 2012, Bouahim et al. 2010, Clark and Covey 2012).

Studying and surveying effects of livestock grazing and human uses on vegetation composition, diversity and community structure and acquire knowledge about these beech forests would yield important information, which is necessary to forecast forest composition, succession and determine the intensity of forest disturbance. Such studies could help to suggest initiate methods to adequately manage and reconstruction. We hypothesized that livestock grazing and human uses affected forest structure, composition and diversity in oriental beech forests. The specific objectives focused on (1) livestock grazing and human uses effects on forest structure, (2) livestock grazing and human uses effects on density and species composition in the tree and shrub layer, (3) livestock grazing and human uses effects on species diversity (richness and evenness). The results of this study are highly relevant to forest managers involved in decision making in similar forested areas.

Material and Methods

Study area

The study was conducted in a 100-ha forested area located in the Masal of Guilan province in northern Iran (37°14'00" to 37°19'20" N and 48°55'19" to 49°02'00" E). This area is characterized by a range of elevation from 300 to 2000 m a.s.l largely dominated by eastern slopes. Common forest soils are acidic and were deposited on parent materials composed of shill, sand stone and calcareous. Mean annual precipitation and temperature are 990 mm and 16 °C, respectively (information from station of Hydrologyand Meteorology Shanderman). While there is no permanent residential area in this region, dairy farmers and local people use the territory for animal husbandry during 2–4 months in spring and summer of each year. Over the years, the primary structure of these forests was modified because of disturbances such as heavy grazing by livestock, tree girdling, and excessive cutting of trees and shrubs to supply fuel wood. The forest is uneven-aged and is composed of mixed deciduous broadleaved trees and sometimes of unmixed beech trees. A conservation program was initiated seven years ago by fencing about 50 ha of these forests to reduce the effect of grazing pressure and the entry of livestock and humans.

Data collection

Data collection was achieved in July 2012 in a protected area adjacent to an unprotected area, 50 hectares each, which were selected on both sides of a road. The protected and unprotected areas shared similar altitude, slope and aspect. In each area, we used a random-systematic sampling with a 100 × 200 m grid to locate 25 1000-m^2 circular plots (Zobeiry 2006). Then, in each plot, tree species were identified and diameter at breast height (DBH) was measured on trees larger than 7.5 cm in diameter whereas stems of each shrub species were counted (Adel et al. 2013). We also collected some variables that can affect woody species diversity (Arévalo et al. 2011) such as the litter depth at five locations (Adel et al. 2013), number of dead trees, percent cover of the tree canopy and the herbaceous layer (Deléglise et al. 2011).

Data analysis

Species richness, Shannon's diversity (Allred et al. 2012) and evenness (de Villalobos and Zalba 2010) indices were calculated for each layer using the Ecological Methodology software for Windows, version 6.0 (Krebs 1999). Pearson correlations were used to determine the degree of linear dependence between environmental factors and diversity indices for both protected and unprotected area (Chaturvedi et al. 2012). Kolmogorov–Smirnov test was used to verify the normality of data distribution and the Levene test was used to evaluate the homogeneity of variances. Non-paired *t*-tests were used for normally distributed data while a non-parametric equivalent (Mann-Whitney *U*-test) was used for non-normal data. These analyses were conducted with the SPSS 16.0 software.

Results

Floristic characteristics

Statistical analyses indicated that tree density (N·ha^{-1}) and the total basal area were significantly higher in the protected area than in the unprotected area. Conversely, the mean number of shrubs per hectare was statistically greater in the unprotected area than in the protected area (Table 1).

The same tree and shrub species were identified in both areas. Only three tree species were recorded in protected and unprotected areas: *Carpinus betulus* L., *Alnus glutinosa* (L.) Gaertn. and *Fagus orientalis*. In the protected area, *Fagus orientalis* was more abundant (highest tree density) whereas in the unprotected area, *Carpinus betulus* was the dominant tree species. Density of *Fagus orientalis* and *Alnus glutinosa* species were significantly different ($P \leq 0.05$) between the protected and unprotected areas (Table 2).

Density of all shrub species was higher in the unprotected area than in the protected area. The total number of *Mespilus germanica* L., *Prunus divaricata* Ledeb., *Crataegus microphylla* C.Koch, and *Crataegus ambigua* A.K.Becker was significantly different between the two areas, although no statistical differences were detected for *Ruscus hyrcanus* Woron. and *Ilex aquifolium* L. (Table 2).

Table 1. Characteristics of study areas (Mean ± Standard error).

Characteristics	Protected	Unprotected	*P*
Density of trees, N·ha^{-1}	13.8 ± 1.41	6.8 ± 0.88	0.000 **
Density of shrubs, N·ha^{-1}	10.96 ± 1.6	24.88 ± 2.88	0.000 **
Basal area, m^2·ha^{-1}	37.1 ± 0.31	17.1 ± 0.22	0.000 **

Note: ** indicates significant differences at the 99 % level.

The DBH and the basal area of *Fagus orientalis* were higher area in the protected area than in the unprotected area. Mean DBH of *Carpinus betulus* and basal area of *Fagus orientalis* and *Carpinus betulus* were significantly different between the protected and unprotected areas (Table 3).

The number of trees in all diameter classes was higher in the protected area, although these differences were mostly apparent in the 35 to 60 cm classes. In the protected area, greater tree densities were observed in diameter classes 35 to 60 cm, which were twice the number of trees compared to the unprotected area. In the unprotected area, larger tree densities were observed in intermediate diameter classes (25–45 cm) and then in lower classes (10–20 cm). Lower tree densities were observed in higher diameter classes (> 60 cm) in both areas (Figure 1).

Biotic and abiotic factors

Among the studied biotic and abiotic factors, the mean number of dead trees per hectare and the canopy cover percentage were significantly larger ($P \leq 0.01$) in the protected area than in the unprotected area. In the unprotected area, percent of herbaceous cover and bare soil were higher than in the protected area, but these differences were not statistically significant (Figure 2).

Table 2. Density (N·ha^{-1}) and Standard Error (SE) of woody species in protected and unprotected areas.

Species	Life form	Protected		Unprotected		
		Mean	SE	Mean	SE	*P*
Fagus orientalis	Tree	107.2	14.06	30	7.04	0.000**
Carpinus betulus	Tree	11.2	5	30.8	1.25	0.1^{ns}
Alnus subcordata C.A.Mey	Tree	14.4	4.47	3.2	6.82	0.04*
Mespilus germanica	Shrub	10.4	3.62	31.6	9.75	0.04*
Prunus divaricata	Shrub	30.8	6.7	80	14.8	0.004**
Ruscus hyrcanus	Shrub	10	4.7	20.4	6.1	0.1^{ns}
Ilex aquifolium	Shrub	56.8	15.9	77.6	18.5	0.4^{ns}
Crataegus microphylla	Shrub	0.4	0.4	19.2	5	0.001**
Crataegus ambigua	Shrub	0.8	0.5	18.88	7.75	0.02*

Note: Significant differences **P* < 0.05, ***P* < 0.01, and ns – no significant.

Variation in diversity, richness and evenness

In both the tree and the shrub layers, values of the Shannon diversity and evenness indices as well as richness were lower in the protected area than in the unprotected area. However, the only significant differences ($p < 0.01$) between the protected and the unprotected areas were calculated for the diversity and richness indices in the shrub layer (Table 4).

In the tree layer of the protected area, evenness index was negatively correlated with the percent canopy cover, whereas the number of dead trees was positively and significantly correlated with all indices of diversity. In the shrub layer, the richness index was significantly and negatively correlated with the canopy cover, while the evenness index

Table 3. Diameter at breast height (DBH > 7.5 cm) and Basal area in Protected and Unprotected areas.

Species	DBH, cm			Basal area, m^2·ha^{-1}		
	Protected	Unprotected	*p*	Protected	Unprotected	*p*
Fagus orientalis	59.92	44.80	0.08^{ns}	76.46	28.17	0.000**
Carpinus betulus	16.29	36.11	0.003**	5.67	10.76	0.004**
Alnus glutinosa	29.95	29.86	0.4^{ns}	10.75	3.84	0.08^{ns}
Total	35.38	34.52	0.8^{ns}	92.88	42.78	0.000**

Note: Significant differences ***P* < 0.01, and ns – no significant.

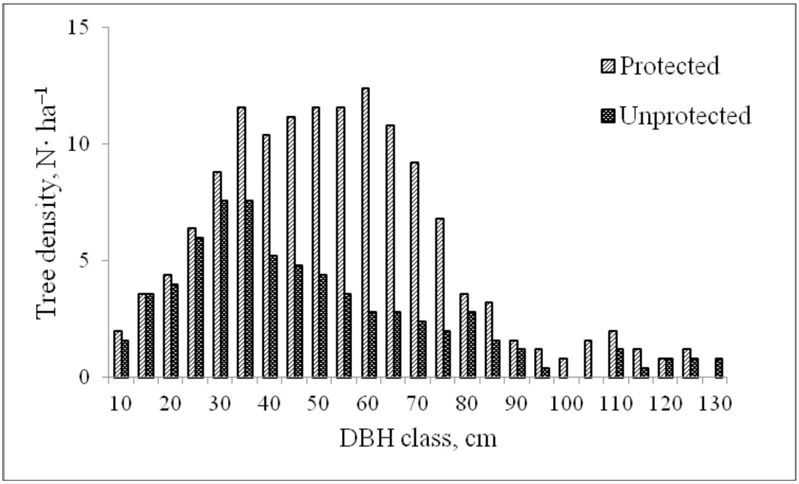

Fig. 1. Density-diameter distribution of trees in the two forest stands.

of the factors in the shrub layer. In the unprotected area, tree species richness was negatively and significantly correlated with the herbaceous cover, while the correlation between richness and evenness indices with the number of dead trees were positive and significant was not significant correlated with any

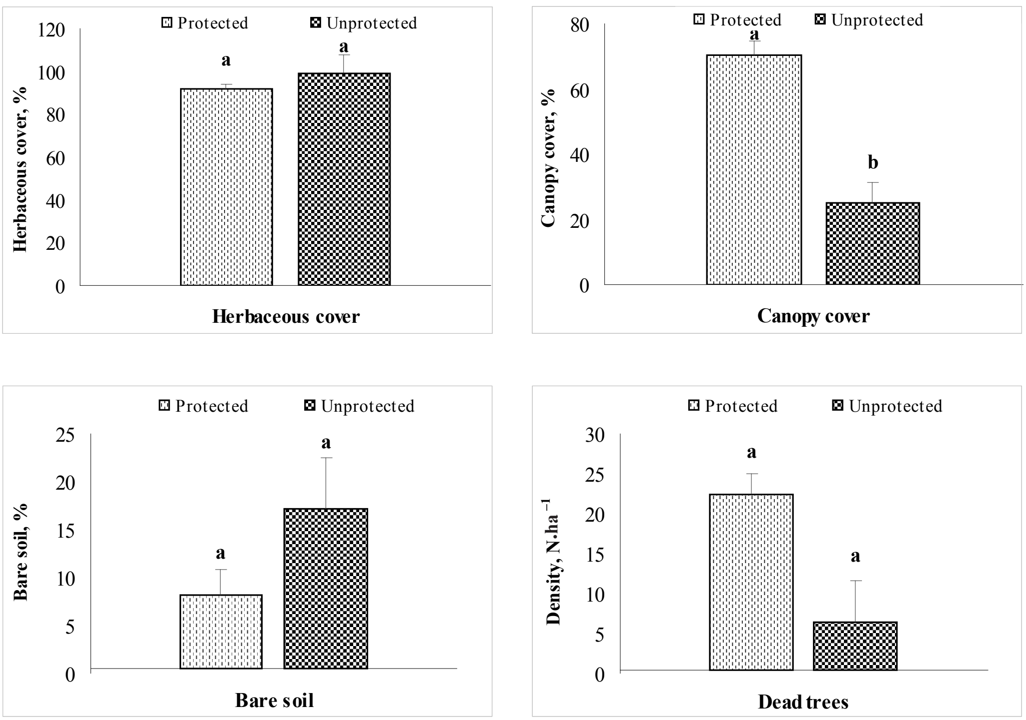

Fig. 2. Variability (Mean ± SE) in habitat variables between protected and unprotected areas.

Note: Different letters indicate significant differences at the 0.01 level.

Table 4. Statistical analysis (mean± standard errors) for diversity, richness evenness in tree and shrub layers in protected and unprotected areas.

Indices	Tree layer			Shrub layer		
	Protected	Unprotected	*p*	Protected	Unprotected	*p*
Diversity	0.67±0. 1	0.79±0.11	0.4	0.1 ±0.04	0.4 ±0.08	0.002**
Richness	1.72±0.15	1.84 ±0.16	0.5	2.4 ±0.17	3.5±0.32	0.003**
Evenness	0.77 ±0.114	0.9 ±0.119	0.2	0.77 ±0.09	0.80 ±0.11	0.8

Note: ** Indicate significant differences at the 99 % level between protected and unprotected areas.

Table 5. Pearson correlation coefficients between biotic and abiotic factors with diversity indices for woody species layers in protected and unprotected areas.

Factors	Protected				Unprotected			
	Tree		Shrub		Tree		Shrub	
	Richness	Evenness	Richness	Evenness	Richness	Evenness	Richness	Evenness
Canopy cover	0.54	–0.539*	–0.632*	–0.33	0.28	0.346	–0.570*	–0.63*
Dead trees	0.59**	0.642**	0.07	0.206	0.586*	0.804**	0.28	0.327
Herbaceous cover	0.212	0.225	0.347	0.40	–0.64**	–0.52	–0.277	–0.142

Note: * Indicates significant correlation at 0.05 level; ** indicates significant correlation at 0.01 level.

cant. In the shrub layer, large negative correlations were observed between canopy cover and both species richness and evenness, while correlations between the number of dead trees with richness and evenness was weakly positive (Table 5).

Discussion

Tree layer

Forest areas in northern Iran are commonly used for livestock grazing and by dairy farmers as forest pasture (Heydarpour Tutkale et al. 2008). In the unprotected area, people livelihood activities, such as grazing, lopping and felling of trees for fuel wood, girdling for fodder production and collection and dead trees reduced the density and frequency of tree species by creating micro-environmental heterogeneity (Kumar et al. 2004). However, tree species diversity, richness and evenness were higher in the unprotected area as already observed by Rutherford and Powrie (2010). These results can be explained by the establishment of light demanding species and to a more uniform distribution of individuals among species in the unprotected area. The heterogeneous species richness in the unprotected area has been caused in particular by the formation of a forest mosaic composed of patches with low and high tree diversity (Cadotte et al. 2002).

At the end of a natural succession process, the dominance of only one species is often reached, which also tends to be accompanied by few canopy openings, increasing stand density and thus poor tree diversity in response to the elimination or restriction of human interferences. In the protected area, *Fagus orientalis* was the dominant species and most plots were only composed of beech, this can explain the low diversity and richness index values in the protected area as it is the case when only one species constitutes more than 50–80 % of a forest canopy (Connell and Lowman 1989). In the unprotected area *Carpinus betulus* had the lowest density because of its poor ability to compete with *Fagus orientalis* and were thus gradually eliminated through competition. Unsuitable tree composition, low tree density and canopy openness caused by the removal and the natural mortality of dominant trees increase the availability of light and nutrients (Vockenhuber et al. 2011). However, grazing and other human disturbances can lead to changes in ecological conditions (Gorchov and Trisel 2003) which can modify the vegetation composition, particularly by promoting the establishment of invasive species (O'Brien et al. 2007, Vavra et al. 2007). However, in forests degraded by grazing and human uses, the establishment and development of *Fagus orientalis* was very difficult, which promoted the emergence of invasive species such as *Pteridium aquilinum* (L.) Kuhn, and *Sambucus ebulus* L. Therefore, evenness index in the unprotected area was higher due to reductions in dominance and in frequency of *Fagus orientalis* (Kupferschmid and Bugmann 2005), in competitive structure (Rutherford and Powrie 2010) and in canopy cover (Abanesi et al. 2005) as well as to the increasing dominance of *Carpinus betulus*. Destructive factors such as grazing and extensive tree removal promoted the establishment of this species because of its high seed production ability and its resistance to intense grazing (Akbarinia and Hukusima 1995).

The lower tree density observed in lower DBH classes as compared to intermediate DBH classes in the unprotected area can be explained by tree removal in lower DBH classes together with the increasing density of herbaceous species which reduce the establishment and the development of tree seedlings. Lower tree density in large diameter classes as compared to other DBH classes can be the result of tree senescence in the protected area (Lorimer et al. 2001) and by the removal of some of these trees by local people in the unprotected area (Schwartz and Caro 2003).

Shrub layer

The abundance of all shrub species, richness and evenness indices were higher in the unprotected area than in the protected area likely because of the ecosystem response to disturbances and to the establishment of shrub species resistant to grazing as observed by Onaindia et al. (2004) and Rodríguez-Soalleiro and Madrigal (2008), while de Villalobos and Zalba (2010) observed the contrary. Overall, the diversity of shrub species was higher than that of tree species (Kyde 1999) but shrub response to grazing was not identical among species (Archer 1989).

The high density of *Ilex aquifolium* in the protected area and *Prunus divaricata* in the unprotected area indicates that they were dominant species in their respective environment. The number of light demanding, deciduous species, such as

Mespilus germanica, Prunus divaricata, Crataegus microphylla and *Crataegus ambigua*, were higher in the unprotected area likely because they took advantage of the canopy openings related to dominant tree mortality (Rees and Juday 2002). Indeed, these conditions increase light availability to the forest floor which, in turn, positively influence nutrient cycling (Castedo-Dorado et al. 2012). However, disturbances such as livestock trampling can restrict the plant access to soil resources, facilitating the establishment of invasive woody species (Vavra et al. 2007).This can explain the negative correlation between tree canopy cover and shrub species richness in both areas (O'Brien et al. 2007). On the other hand, the changes in abundance of evergreen species such as *Ruscus hyrcanus* and *Ilex aquifolium* between protected and unprotected areas were less pronounced than those of deciduous species likely because of a lower browsing rate due to their high lignin content and the presence of thorns (Agra and Neeman 2012). In addition, these species are shade tolerant and can thus survive and develop under the extensive canopy cover of the protected area (Legare et al. 2002).

Conclusion

Forest ecosystems in northern Iran are used in various ways by local people. Furthermore, forest structure, composition and diversity are closely associated with grazing and other disturbances caused by human activities and these factors have created considerable negative effects on ecological processes. The overall results indicated that conservation affected the quality and quantity of the protected area, leading to a decreased diversity of tree and shrub layers, which demonstrates that forest protection and reaching to the climax stage are not necessarily associated with maximum biodiversity and species richness.

Protection of ecosystems against human-caused disturbances is important to identify their potential for effective management of biodiversity resources. Considering that, protected areas are in interaction with unprotected areas, it is recommend forest managers to avoid the complete separation of these areas and implemented conservation programs in collaboration with local people to help establish effective management and promote education and proper land utilization and thus help conserve natural resources and biodiversity. The results also suggest that grazing and human activities with low intensity along with controlled frequency of invasive species and judicious utilization of forest resource including selective felling can be considered as an interesting tool if the main objective of forest managers is to protection or even increase plant biodiversity.

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