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INVESTIGATION OF HERBACEOUS SPECIES DIVERSITY IN FOREST, ECOTONE AND PASTURE AREAS OF UPLAND IN THE NORTH OF IRAN

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Abstract

Biodiversity of ecosystems is determined to a considerable extent by the diversity of herbaceous species. The aim of this study was to examine and compare diversity of herbaceous species in the forest, ecotone, and pasture located in upland areas in Shirud, Mazandaran Province, Iran. In each area, eight 100 m^2 circular sampling plots were established along a transect using random-systematic method, and coverage of herbaceous species was recorded in each plot. There were significant differences in diversity, evenness and richness among the forest, ecotone and pasture areas. The results of ANOVA and Duncan's tests indicated that the forest and pasture sites had higher diversity compared to ecotone. Jaccard and Sørensen's similarity coefficients also confirmed the better growing conditions for herbaceous species in the forest and pasture sites in comparison to the ecotone. This paper presents evidence that species diversity is closely linked to grazing intensity.

Key words: herbaceous diversity, grazing, forest, ecotone, pasture, Mazandaran.

Introduction

Plant diversity plays an ecological key role in forest ecosystems, including in succession and nutrient cycles (Gilliam 2007, Hart and Chen 2008, Nilsson and Wardle 2005). Thus, vegetation studies are important to assess the current state of forest ecosystems and to project it in the near future (Oxbrough et al. 2014). In the last few decades, especially after the Rio Conference, loss of biodiversity associated with human activities became a main source of concern for forest ecologists (UNCED 1992). Maintaining biological diversity is a key aim of global forest policy, which promotes ecosystem health in the face of changing land use and climate. Sustainable management of forest ecosystems is essential to the society and economic by services that forests provide. It is an important component of the environmental policies at national level and is a specific focus of the Conventional on Biological Diversity (Oxbrough et al. 2014). Therefore, it is essential to estimate the plant diversity of forest ecosystems. Such estimation can assist the for-

est managers to identify endangered species and to reveal the population trends. Moreover, quantifying plant diversity allows comparison of different sites and regions (Gotelliand and Colwell 2001).

Natural heterogeneity in a geographical area reflects habitat diversity. Ecotones are one of the major factors that cause such diversity. Pioneer American plant ecologist, Frederic Clements (1905) defined an ecotone as a "junction zone between two communities, where the processes of exchange or competition between neighboring formations might be readily observed". The main features of these areas are vegetation transition (Schumann et al. 2003, Suzuki et al. 2006) and species diversity (Junyan et al. 2014). Flora and fauna diversity in ecotones are often richer than in the neighboring ecosystems; however, overexploitation could pose a serious threat to their ecological diversity (Sharma et al. 2014).

Pasture is a natural ecosystem that contains vast genetic resources, plant and animal diversity. The biological diversity of pastures is determined mostly by their plant diversity that ensures stability of the ecosystems against changing environmental factors (McCann 2000). Protection of pasture ecosystems entails management and conservation of their ecological complexity and this can only be achieved by studying and measuring species diversity. With the advance of science related to natural resources and necessity for maintaining biodiversity and managing valuable natural resources, there is a growing interest in examining ecological diversity through different diversity indices (Ghazoul and Sheil 2010, Newton 2007).

Measurement of biodiversity in an ecosystem is essential for biological control and conservation of genetic resources (Ninan 2012). Species composition, dominance, evenness, and the number of species are important parameters used in evaluating the ecological conditions of ecosystems (Orwin et al. 2014). These parameters show the diversity, richness, and status of these resources and help adopting an appropriate management plan. The present study examines the herbaceous species diversity of the forest, ecotone, and pasture located in upland areas in Shirud of Mazandaran Province, and provides insights into the way that will help to restore and manage these ecosystems.

Materials and Methods

Study area

Shirud area is located in southern Tonekabon city in Mazandaran province from 36°41′05″ to 36°45′40″N and from 50°46′0″ to 50°50′10″ E. It is bordered by private farmlands from the north, by Chalakrud watershed basin from the west, and by Tiromrud watershed basin from the east and south. Minimum and maximum altitudes are 100 and 3520 m a.s.l., respectively. The total area of Tiromrud basin is 20287 ha. The average annual temperature of the region is 16 °C, the average annual rainfall is 1100 mm, and the maximum and minimum monthly rainfalls are 269.6 mm and 38 mm, respectively (Ramsar Synoptic Weather Station 2012). The forest soils are acidic with a pH varying between 5.5 and 6.5. The present study was carried out in the forest with slope of 50 %, ecotone with slope of 25 % and pasture with slope of 40 %. According to the general overview of study area and local experts` view, the forests, grassland and ecotone are affected by grazing intensity. For this reason, we considered the average grazing intensity of the forest and the pasture, and high in-

tensity grazing in the ecotone site. Criterion for selecting ecotone was low slope since grazing intensity (especially sheep) was high there. The forest type is beech community (*Fagetum-oreintalea*) and the predominant tree species in the forest are *Fagus orientalis* following by *Carpinus betulus*, *Alnus subcordata*, *Parrotia persica*, *Acer velutinum*, *Quercus castaneifolia* and *Fraxinus excelsior.*

Data collection

First, the sampling range was selected in the forest with tree, shrub and herbaceous species, the ecotone with shrub and herbaceous species, and the pasture sites with herbaceous species at altitude of 1754 to 2275 m a.s.l. using a map of the area. Systematic sampling was done along a transect at 50, 100 and 150 m intervals across the forest, ecotone and pasture sites with different grazing intensity. We selected two areas in which grazing intensity were medium (i.e., forest) and high (i.e., ecotone) in order to assess the grazing effect. To determine the grazing intensity of Shirud area, we used restrictions on water resources, slope, distance from the village and the camp livestock. Nested plot method was used to sample herbaceous species and the minimal area curve was plotted (100 m^2 was obtained in this study) (Houeto et al. 2013). Overall, eight plots were established in each area, where the coverage of herbaceous species was estimated.

Data analysis

The diversity indices were calculated using Ecological Methodology software, and the results were further analyzed by SPSS 16. Kolmogorov-Smirnov test was used to examine the normality of data. Given the normal distribution of data, one-way ANOVA was used to compare the three sites, and Duncan's test was applied for multiple comparisons of means.

The diversity, evenness, and richness of each area were calculated using the software mentioned above (McArt et al. 2012, Robbins et al. 2006, Oldeland et al. 2010):

- Shannon-Wiener index (Hamilton 2005): This index has higher sensitivity to rare species. It is a suitable method for comparing diversity in different areas (Pena et al. 2010, Jongsma et al. 2014).
- Simpson index: Simpson index is the probability that two individuals taken at random belong to the same species (Leps et al. 2006).
- Smith and Wilson's evenness index: This index is based on the variance in abundance of species. According to Smith et al. (2008) this is the best evenness, because it is independent of species richness and is sensitive to both rare and abundant species in a sample or a community (Garibaldi et al. 2013, Han et al. 2014).
- Richness index: The simplest and most common measurement of species richness is the number of species (Garibaldi et al. 2013).

Similarity among the three studied sites was examined by Jaccard and Sørensen coefficients (Table 1).

Table 1. Jaccard and Sørensen's similarity coefficients.

Similarity index	Description
Jaccard $S_J = \frac{a}{a+b+c}$	*a* = number of species in common for both sites.
Sørensen $S_S = \frac{2a}{2a+b+c}$	*b* = number of species in the first sample or community.
	c = number of species in the second sample or community.

Results

The list of herbaceous species in the forest, the ecotone and the pasture sites are shown in Table 2. Totally 71 species belonging to 39 families were identified (33 species and 23 families in the forest, 26 species and 21 families in the ecotone,

Table 2. List of the herbaceous species in studied areas.

Species	Family	Mean percent cover			Relative frequency		
		Forest	Ecotone	Pasture	Forest	Ecotone	Pasture
Achillealanulosa Nutt.	Asteraceae	-	-	5	-	-	0.13
Agrostis stolonifera L.	Poaceae	7	-	7	0.13	-	0.5
Alchemilla vulgaris L.	Rosaceae	-	5.38	5.5	-	1	0.5
Allium sativum L.	Alliaceae	6	-	-	0.13	-	-
Alyssum iranicum Hausskn ex Baumg.	Brassicaceae	-	-	3.38	-	-	0.25
Alyssum maritimum (L.) Lam.	Brassicaceae	4.8	-	-	0.63	-	-
Arctium lappa L.	Asteraceae	6	-	-	0.13	-	-
Artemisia annua L.	Asteraceae	6.5	-	-	0.75	-	-
Asperula odorata L.	Rubiaceae	20.29	-	-	0.88	-	-
Atriplex tatarica L.	Chenopodiaceae	-	-	4	-	-	0.25
Capsella bursa-pastoris L.	Brassicaceae	-	-	3.5	-	-	0.25
Carex hirta L.	Cyperaceae	7.5	-	6	0.25	-	0.5
Carex sylvatica L.	Cyperaceae	8.5	-	-	0.5	-	-
Centaurea iberica Trevir. &Spreng.	Asteraceae	-	-	5	-	-	0.13
Centaurium pulchellum (SW.) Druce	Gentianaceae	-	-	1	-	-	0.13
Chelidonium majus L.	Papaveraceae	-	-	2	-	-	0.25
Cichorium intybus L.	Asteraceae	-	4.88	5	-	1	0.5
Cirsium spectabilis DC.	Asteraceae	2.5	19.25	6	0.13	1	1
Colchicum kotschyi Boiss.	Liliaceae	-	2	-	-	0.13	-
Conyza bonariensis L.	Asteraceae	-	-	2	-	-	0.25

Crocus caspius Fisch. &C.A.Mey. ex Hohen	Iridaceae	4.5	15.38	5.83	0.25	1	0.75
Cuscuta campestris L.	Cuscutaceae	-	-	5	-	-	0.13
Cynoglossum creticum Mill.	Boraginaceae	-	3	-	-	0.13	-
Digitalis purpurea L.	Scrophulariaceae	6.67	4	-	0.38	0.13	-
Eryngium caucasicum Trautv.	Apiaceae	-	-	4	-	-	0.25
Euphorbia amygdaloides L.	Euphorbiaceae	6.25	-	-	0.5	-	-
Filago vulgaris Lam.	Asteraceae	-	-	5	-	-	0.13
Fragaria vesca L.	Rosaceae	5.6	-	-	0.63	-	-
Galium ghilanicum Stapf	Rubiaceae	-	-	6.5	-	-	0.25
Geranium maculatum L.	Geraniaceae	6.2	-	5.75	0.63	-	1
Geranium molle L.	Geraniaceae	-	-	5	-	-	0.25
Geum urbanum L.	Rosaceae	-	-	3	-	-	0.25
Heracleum persicum Desf. exFisch.	Apiaceae	4	5	-	0.13	0.13	-
Hypericum androsaemum L.	Hypericaceae	5.75	-	-	0.5	-	-
Juncus fontanesii J.Gay	Juncaceae	-	5	-	-	0.13	-
Lamium album L.	Lamiaceae	5.4	-	4.67	0.63	-	0.38
Malva parviflora L.	Malvaceae	-	2	-	-	0.13	-
Medicago sativa L.	Papilionaceae	-	5	4	-	1	0.5
Mentha pulegium L.	Lamiaceae	-	8	-	-	0.25	-
Mercurialis perennis L.	Euphorbiaceae	5	-	-	0.25	-	-
Nasturtium officinale W.T. Aiton	Brassicaceae	-	3.25	-	-	0.13	-
Phlomis bruguieri Desf.	Lamiaceae	7	2	4	0.13	0.25	0.37
Phyllitis scolopendrium L.	Aspleniaceae	6.5	-	-	0.25	-	-
Plantago major L.	Plantaginaceae	-	-	3	-	-	0.13

Plantago ciliata Desf.	Plantaginaceae	-	5.88	8.25	-	1	0.5
Polygonatum orientale Desf.	Asparagaceae	7	2	-	0.25	0.13	-
Polygonum convolvulus L.	Polygonaceae	-	-	2	-	-	0.13
Primula heterochroma Stapf.	Primulaceae	7	-	4.2	0.5	-	0.63
Pteridium aquilinum (L.) Kuhn	Hypolepidaceae	6	5	19	0.25	0.25	0.4
Ranunculus arvensis L.	Ranunculaceae	-	4.25	6.4	-	1	0.63
Rosa canina L.	Rosaceae	8	-	-	0.13	-	-
Rubus fruticosus L.	Rosaceae	16	15	-	0.25	1	-
Rumex sp.	Polygonaceae	-	21.63	8	-	1	0.5
Salvia officinalis L.	Lamiaceae	7	-	-	0.38	-	-
Sambucus ebulus L.	Caprifoliaceae	7	6	-	0.38	0.13	-
Sedum hispanicum L.	Crassulaceae	-	-	2	-	-	0.13
Senecio vernalis Waldst. & Kit.	Asteraceae	-	2	-	-	0.13	-
Silene conica L.	Caryophyllaceae	-	-	4.75	-	-	0.25
Silene gallica L.	Caryophyllaceae	-	-	5.75	-	-	0.25
Solanum melongena L.	Solanaceae	7.75	-	-	0.5	-	-
Taraxacum sp.	Asteraceae	-	-	4	-	-	0.13
Teucrium hyrcanicum L.	Lamiaceae	-	-	3	-	-	0.13
Thymus carnosus Boiss.	Lamiaceae	-	-	3	-	-	0.13
Trifolium resupinatum L.	Papilionaceae	6	-	9.29	0.38	-	0.88
Urtica dioica L.	Urticaceae	11.88	15	5.67	0.5	0.13	0.38
Veronica persica Poiret.	Scrophulariaceae	-	-	5	-	-	0.13
Viola sylvestris Lam.	Violaceae	5.2	2.88	4.25	0.63	1	0.5

and 40 species with 27 families in the pasture).

In the ecotone, the highest cover percentage belonged to *Cirsium spectabile* (19.25 %), followed by *Crocus caspius* (15.38 %), *Rumex* sp. (21.63 %), *Urtica dioica* (15 %), in the forest, *Rubus fruticosus* (15 %), *Asperula odorata* (20.29 %) and in the pasture, *Pteridium aquilinum* (19 %) had the maximum percent cover (Table 2).

As shown in Figures 1 and 2 (Jaccard and Sørensen similarity coefficients), the highest similarity was found between the forest and pasture sites and the lowest one – between the ecotone and pasture sites.

A comparison of the studied sites in terms of evenness, richness and diversity (using one-way ANOVA and Duncan's multiple range tests) are given in Table 3.

Duncan's test revealed that there was a significant difference between the forest and the ecotone sites, and between the ecotone and the pasture sites in Simpson and Shannon-Wiener indices (α = 1 %). However, no significant difference was found between the forest and pasture sites. There was also significant difference between the forest and pasture sites in the Smith-Wilson index (α = 5 %), and between the studied sites in species richness, which was higher in the forest and pasture in comparison to the ecotone (Table 3).

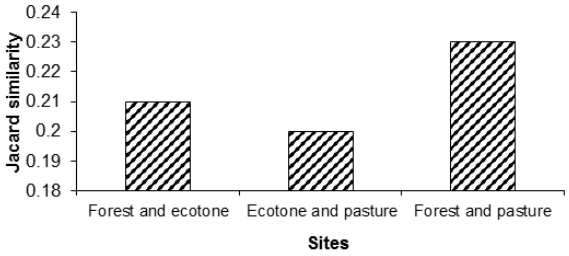

Fig. 1. The values of Jaccard's similarity coefficient in the studied sites.

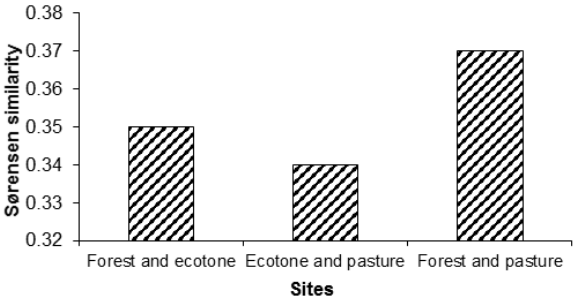

Fig. 2. The values of Sørensen's similarity coefficients in the studied sites.

Table 3. The values of diversity indices in studied sites.

Index	Site	Mean±*SD*	*P*-value
Simpson	Forest	0.04±0.72	0.001**
	Ecotone	0.17±0.68	
	Pasture	0.04±0.90	
Shannon-Wiener	Forest	0.56±3.39	0.001**
	Ecotone	1.07±2.12	
	Pasture	0.45±3.59	
Smith and Wilson	Forest	0.06±0.84	0.009**
	Ecotone	0.14±0.63	
	Pasture	0.16±0.79	
Richness	Forest	12.5±4.69	0.00*
	Ecotone	0.14±0.63	
	Pasture	3.92±16.13	

Note: *SD* – standard deviation; *P* – level of significance; * indicate significant difference at the 0.05 level; ** indicate significant difference at the 0.01 level.

Discussion

Understanding the effect of biological stress on an ecosystem is an impor-

tant issue because each stress tends to cause area destruction and reduced diversity. This study revealed that the grazing has decreased the diversity, evenness and richness of species in the studied sites. The results indicated that there is a significant difference among the ecotone, forest and pasture sites in species abundance and diversity. Jaccard and Sørensen's similarity coefficients showed high similarity between the forest and pasture, and low similarity between the ecotone and pasture sites. This states that herbaceous species in the forest and the pasture sites have been less exploited. In contrast, they have experienced severe biological stress caused by anthropogenic pressure by people and livestock and this has led to decrease of species diversity and richness. Grazing causes changes in the pattern of species dominance (Aikens et al. 2007, Rasingamet al. 2009). *Cirsium spectabilis*, *Crocus caspius*, *Rumex* sp., *Urtica dioica, Rubus fruticosus, Asperula odorata*, *Pteridium aquilinum* were dominant and indicator species in the forest, ecotone and pasture areas, respectively (McEvayetet al. 2006, Ebrahimi et al. 2014).

In addition, the results indicate that diversity of herbaceous species is higher in the forest and pasture than in the ecotone. There was higher species richness in the forest and the pasture in compared to the ecotone, and clearly grazing is one factor that reduces the richness and abundance of species. This subject is supported by the results of Bouahim et al. (2011). Reduced species richness due to cattle grazing has been reported in various studies (Altesor et al. 2006, Loydi et al. 2012, Pykälä 2005, Roberts and Zhu 2002, Schumann et al. 2003). In the studied sites cattle grazing affected more the evenness of herbaceous species than the richness. Evenness plays more significant role in maintaining diversity than richness. This is consistent with the results of Anderson and Hoffman (2007), Arévalo et al. (2007), Casado et al. (2004), and Fernández-Lugo et al. (2009). It is associated with abundance, and maximum values are obtained when all species are equally represented (Hayek and Buzas 2013). Species evenness was higher in the forest and pasture sites than in the ecotone, where grazing pressure has decreased the coverage of species, thus reducing evenness and diversity (Ebrahimi et al. 2014). Overgrazing reduces species evenness and can disturb an ecosystem (Navarro et al. 2006), but moderate grazing has a positive effect on plant stability (Klimek et al. 2007, Van der Walt et al. 2014, Sun et al. 2008).

Comparison of species diversity indicated that diversity indices were significantly higher in sites subjected to moderate grazing compare to the sites with overgrazing (α = 1 %). Our results support the Mligo's study (2006), which showed that grass cover was negatively correlated with grazing intensity, and moderate grazing ensures annual regeneration of species. Like Hendricks et al. (2005), we found that diversity is lowest in areas around cattle pens where grazing pressure was the highest. This is consistent with the results of Austrheim and Eriksson (2001), McIntyre and Lavorel (2001), Pykälä (2005), Weiss et al. (2014), Zhao et al. (2007), Mligo (2006), Guo et al. (2010), Tárrega et al. (2006) and Barger et al. (2004).

Our results support the reports that high intensity grazing leads to decreased species diversity. Significantly lower diversity and evenness in a high-intensity grazing site indicates that the community faces difficult conditions and destruction of the area causes loss of certain critical plant spe-

cies. On the other hand, moderate grazing increases species diversity and has a positive effect on the grass cover of the region. Our findings showed that the level and quality of biodiversity in the region is closely linked to destructive grazing and conservation of herbaceous species that can play an effective role in maintaining and increasing plant diversity. The forest and the pasture are in more favorable conditions than the ecotone, although the forest had lower diversity in comparison with the pasture site. This can be attributed to tree canopy cover in the forest that leads to lower replacement of grass cover. The results of this research are consistent with the findings of Parr et al. (2012).

Conclusions

Species diversity is closely linked to grazing intensity. Therefore, the planning should be based on local participation and should promote proper exploitation methods that help the conservation of natural resources and biodiversity. Based on the present findings, we recommend that exploitation of plants by local people should be limited when cattle is herded to unprotected areas. It is necessary to evaluate species diversity in these ecosystems continually in order to restore them to their initial phase.

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