The relationships between environmental and disturbance factors in temperate deciduous forest ecosystem (Amasya/Turkey)

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Abstract: Deciduous forests face many disturbance factors. Grazing and cutting are the leading factors in this disturbance. The study area's vegetation was analyzed using numerical methods to identify plant communities and determine the relationship between environmental gradients and disturbance factors. The species diversity was calculated using alpha and beta diversity indexes. As a result, four different communities were identified in the study area. One of the communities was under grazing pressure while the other community was under cutting pressure. No disturbance factors were found in the remaining two communities. Elevation and soil moisture were found to be important in the distribution of plant communities. pH, soil moisture, soil % N content and canopy factors were found to be important. The highest Shannon-Wiener diversity index values were found in non-cutting and non-grazing forest communities. The lowest Shannon-Wiener diversity index values were found in grazing and cutting forest communities. Unlike the Shannon-Wiener diversity index, the highest beta index values were found in grazing and cutting forest communities. The lowest beta index values were found in non-cutting and non-grazing forest communities.

Key words: Plant ecology, plant diversity, numerical method

Özet: Yaprak döken ormanlar birçok tahribat faktörüyle karşı karşıyadır. Özellikle oltatma ve ağaç kesimi bu faktörlerin başında gelmektedir. Çalışma Alanının vejetasyonu, bitki komünitelerinin tespiti ve çevresel faktörler ile tahribat faktörleri arasındaki ilişkiyi belirlemek için nümerik metotlar kullanılarak analiz edilmiştir. Türk çiçekçiliği alfa ve beta çiçekçiliği indeksleri kullanılarak hesaplanmıştır. Sonuç olarak, çalışma alanında 4 farklı komünite tespit edilmiştir. Bu komünitelerden biri oltatma baskısı altındağın diğer komünite başa kesimi baskısı altında. Diğer komünitelerde ise tahribat faktörleri bulunmaktadır. Rakım ve toprak neminin bitki komünitelerinin doğalgınlımda önemi olduğu bulunmuştur. pH, toprak nemi, toprak N içeriği ve kanopi faktörleri önemi bulunmuştur. En yüksek Shannon-Wiener indeks değerleri ağaç kesimi ve oltatma olmayan orman komünitelerinde bulunmuştur. En düşük Shannon-Wiener çiçekçiliği değerleri ise oltatma ve ağaç kesimi olan orman komünitelerinde bulunmuştur. Shannon-Wiener çiçekçiliği indekslerinin aksine, en yüksek beta çiçekçiliği indeks değerleri oltatma ve ağaç kesimi olan orman komünitelerinde bulunmuştur.

Anahtar Kelimeler: Bitki ekolojisi, bitki çiçekçiliği, nümerik metod

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1. Introduction

There are significant relationships between plant species and environmental factors in terrestrial ecosystems. Topography, soil characteristics and climatic conditions are determinants factors affecting plant diversity (Davies et al., 2007; Korkmaz et al., 2016). For example, soil pH (Borchsenius et al., 2004; Hofmeister et al., 2009), nutrient availability (Small and McCarthy, 2005; van Calster et al., 2008), soil moisture (Qian et al., 1997, Lenière and Houle, 2006), the mass of litter layer (Gazol and Ibáñez, 2009; Kooijman, 2010), light availability (Härdtle et al., 2003; Tinya et al., 2009) and distance to forest edge (Harper et al., 2005; Gonzalez et al., 2010) are among the most critical environmental factors (Vockenhuber et al., 2011).

In temperate deciduous forests, approximately the 90% of vegetation consists of vascular plant diversity (Whigham, 2004; Gilliam, 2007). The composition and diversity of the ground flora in temperate deciduous forests are affected by the composition of the canopy species and soil and climate characteristics (Hunter, 1999; Augusto et al., 2003; Gilliam, 2007; Barbier et al., 2008). While underground vegetation contributes significantly to total biodiversity in temperate forests, it contributes less to total forest biomass (Gilliam, 2007).

There are many disturbance factors in temperate forests. Among these, grazing and tree cutting are among the most important. Grazing and tree cutting cause complexity and instability in species interactions (Fakhireh et al., 2012; Huseynova et al., 2013; Xu et al., 2016; Kılıç et al., 2018). The intensity of disturbance allows some species to establish, grow, and reproduce (Pierce et al., 2007; Duru et al., 2010; Frenette-Dussault et al., 2012; Kılıç et al., 2018).

In this study, we examined relationships among disturbance (grazing and tree cutting), environment factors (soil pH, soil nitrogen, soil moisture and light availability) and biodiversity in the temperate deciduous forest.

2. Materials and Method

The study area is located in the Yeşilirmak basin in the central region of Turkey. The study area is located...
between 400 m and 1100 m in altitude (Fig. 1). The study area has between oceanic and continental climates. The mean annual temperature and the mean annual precipitation are 13.9°C and 397.5 mm, respectively. The maximum mean temperature is 31.7 °C (August), while the lowest mean temperature is −0.6 °C (January). The vegetation consists of Irano-Turanian and Mediterranean species. Natural flora has been affected by grazing and tree cutting.

Taxonomic nomenclature followed was that of Davis (1965-1985) and Davis et al. (1988), Tutin and Heywood (1964-1980), Güner et al. (2000) and Güner et al. (2012). Four plots were selected from floristically and structurally homogeneous places according to the goal of study. Ten relevés was established for each plot, and the size of plots was determined according to the minimal area method (Westhoff and van Der Maarel, 1978). A cover-abundance value for each species in each relevés was determined using the Braun-Blanquet (1964) scale. Soil samples for each relevés were taken at a depth of 35 cm. Soil pH values were measured using deionized water (1:1) by pH meter (Kacar, 2012). Soil nitrogen was determined by the way of micro-Kjeldahl method (Bradstreet, 1954). Water content was determined by the gravimetric method (Bayrakli, 1987, Kutbay and Ok, 2003). Light availability was determined using a Lutron Light Meter LX-1102 (Schuster and Diekmann, 2005).

Plant communities according to disturbance factors were separated by using TWINSPLAN procedure. To determine what environmental factors were significant, we also treated our data with Detrended Correspondence Analysis (DCA) and Principal Component Analysis (PCA). Numerical methods were performed by using the “Community Analysis Package 4 version” software (Seaby and Henderson, 2007).

Statistical analysis was performed by using a SPSS (25.0 version) software. The differences among plant communities were investigated by one-way ANOVA. The biodiversity parameters were assessed by Tukey’s significant difference (HSD) test to rank the means.

3. Results

TWINSPLAN analysis revealed four plant communities. They are grazing, non-grazing, cutting and non-cutting plant communities. Diagnostic species of the grazed area are Acantholimon acerosum (Willd.) Boiss. var. acerosum, Achillea setacea Waldst. et Kit, Carduus pycnocephalus L. subsp. albidas (Bieb.) Kazmi, Globularia trichosantha Fisch, and Juniperus foetidissima Wild., while the ungrazed areas are characterized by Avena sterilis L., Calepina irregularis (Asso) Thell., Capsella bursa-pastoris (L.) Medik., Hordeum vulgare L., Taraxacum officinale (L.) Weber ex F.H.Wigg., and Urtica dioica L.
diagnostic species. Diagnostic species of tree cutting areas are *Cerasus mahaleb* (L.) Miller var. *mahaleb* (L.) Miller, *Cistus creticus* L., *Colutea arborescens* L., *Cruciata taurica* (Pallas ex Wild.) Ehrend, *Jasminum fruticans* L., *Pistacia terebinthus* L. subsp. *palaestina* (Boiss.) Engler, *Polygala pruinosa* Boiss. subsp. *pruinosa* Boiss., and *Vicia narbonensis* L., while uncutted areas are characterized by *Amelanchier rotundifolia* (Lam). Dum.-Courset, *Arbutus andrachne* L., *Globularia trichosantha* Fisch, *Juniperus oxycedrus* L. subsp. *oxycedrus*, *Phillyrea latifolia* L., *Quercus hartwissiana* Steven, and *Q. petraea* (Mattuschka) Liebl. diagnostic species (Fig. 2).

![Diagram showing plant communities considering disturbance factors in the study area resulting from the TWINSPAN analysis.](image)

Figure 2. Plant communities considering disturbance factors in the study area resulting from the TWINSPAN analysis.

Detrended correspondence analysis (DCA) diagram showed the existence of the gradient considering the first axis (Eigenvalue of axis 1 is 0.96). It is an elevation gradient. Plant communities have spread depending on the elevation. Plant communities in non-grazing and non-cutting areas grouped at the left of ordination plot, whereas plant communities in cutting and grazing areas grouped at the right of the ordination plot (Fig. 3).

![DCA ordination plot](image)

Figure 3. Result of the detrended correspondence analysis (DCA) with the ordination diagram showing plant communities’ position.

The first two axes explained 81.79 % total variance of the Principal Component Analysis (PCA). PCA revealed that pH, soil nitrogen content (%), soil water content were found to be significant in axis 1, while light availability was found to be significant in axis 2. Soil nitrogen (%) and soil water content were negative in axis 1, while soil pH and light availability were positive in axis 1 and 2, respectively (Table 1).

Light availability was positively correlated with plant communities in cutting areas, While soil nitrogen content and water content were negatively correlated plant communities in grazing areas. pH was positively correlated with plant communities in non-grazing areas (Fig. 4).
Species diversity indices (H and J) were high in non-cutting and non-grazing plant communities compared to the other areas. Beta diversity was high in cutting and grazing plant communities as compared to the other areas. Statistically significant differences were found among the beta diversities with respect to plant communities (Table 2).

4. Discussions

The effects of environmental and disturbance factors on plant communities in terrestrial ecosystems are significant (Davies et al., 2007; Pausas and Austin, 2001). These factors affect the establishment, growth and reproduction of species (Pierce et al., 2007; Duru et al., 2010; Frenette-Dussault et al., 2012). According to TWINSPAN and DCA analysis, we found the main four plant communities: grazing, cutting, non-cutting and non-grazing. These communities are distributed according to altitude. Because topographic factors (altitude, geographical aspect, and slope) are primary factors of vegetation distribution (Mark et al., 2000) and affecting plant diversity (Vujnovic et al., 2002).

Overgrazing in meadows and pastures damages the ground flora and prevents the regeneration of dominant species (Malik et al., 2016). However, Petit et al. (1995) stated that overgrazing increases the proportion of unrelated species.

When evaluated results obtained, Shannon–Wienner diversity indexes of grazing vegetation were lower than the other vegetation types (Zhao et al., 2007; García et al., 2016; Tardella et al., 2016; Kılıç et al., 2018). It has been shown that overgrazing has a significant effect on species richness and diversity and that the number of species and diversity indexes are lower in these areas (Lu et al., 2017; Tälle et al., 2016). Besides, it has been shown that overgrazing negatively affects bush and tree species and thus decreases species richness (Roder et al., 2002; Kumar and Shahabuddin, 2005).

In cutting vegetation, light availability is the main factor (Tardella et al., 2016). Cutting causes permanent grazing gaps, and grassland species are recolonized (Dzwonko and Loster, 1998). These areas are called wood-pastures. If regeneration fails, wood-pastures become permanent. (Bergmeier et al., 2010). In non-cutting vegetation, canopy species have an excellent availability to take light as compared to subcanopy species. Besides, soil pH and nitrogen content affect ground flora formations (Augusto et al., 2003; Chai et al., 2016).

Species diversity indices (H and J) were high in non-cutting vegetation compared to the cutting vegetation. The ground flora diversity and composition is influenced by the species composition of the canopy species (Barbier et al., 2008; Gilliam, 2007; Hunter, 1999). Beta diversity was higher in cutting and grazing plant communities than the other plant communities.

Overgrazing harms the ground flora in meadows and pastures, preventing the regeneration of dominant species (Malik et al., 2016). Also, the disappearance of shrub and tree species causes the species richness to decrease.

Table 1. Eigenvalues for studied environmental factors (Significant values were marked in bold).

|                  | Axis 1  | Axis 2  |
|------------------|---------|---------|
| Soil pH          | 0.508   | -0.266  |
| Soil nitrogen content (%) | -0.568  | -0.450  |
| Soil moisture    | -0.646  | 0.229   |
| Light availability | 0.033  | 0.820   |

Figure 4. PCA analysis of the among environmental factors and plant communities.

Table 2. Diversity indices of plant communities (Different lowercase letters indicate significant differences).

|                  | Grazing | Non cutting | Non grazing | Cutting | Sig. |
|------------------|---------|-------------|-------------|---------|------|
| Shannon–Wienner H indice | 0.882±0.024a | 0.973±0.012a | 0.921±0.008a | 0.890±0.011a | 0.352ns |
| Shannon J indice   | 1.016±0.031a | 1.062±0.027a | 1.229±0.019a | 1.235±0.009a | 0.244ns |
| β indice           | 3.481±0.240e | 0.367±0.004a | 0.215±0.003a | 1.137±0.021b | 0.022* |
gradually (Roder et al., 2002; Kumar and Shahabuddin, 2005). Considering the results obtained, it was consistent with previous studies (Faria et al., 2018). Tree cutting and forestry studies increase habitat heterogeneity (Bergmeier et al., 2010).

Paying attention to the protection of biological diversity in forestry activities should be the main goal of sustainable forest management. In this study, we revealed that disturbance and environmental factors affect vegetation types and species composition.

Conflicts of Interest
Authors have declared no conflict of interest.

Authors’ Contributions
The authors contributed equally.

References
Augusto L, Dupouey JL, Ranger J (2003). Effects of tree species on understory vegetation and environmental conditions in temperate forests. Annals of Forest Science 60: 823-831.

Barbier S, Gosselin F, Balandier P (2008). Influence of tree species on understory vegetation diversity and mechanisms involved – a critical review for temperate and boreal forests. Forest Ecology and Management 254: 1-15.

Bayraklı F (1987). Plant and soil analysis. Samsun: OMU Faculty of Agriculture.

Bergmeier E, Petermann J, Schroder E(2010). Geobotanical survey of wood-pasture habitats in Europe: Diversity, threats and conservation. Biodiversity and Conservation 19: 2995-3014.

Borchsenius F, Nielsen PK, Lawesson JE (2004). Vegetation structure and diversity of an ancient temperate deciduous forest in SW Denmark. Plant Ecology 175: 121-135.

Bradstreet RB (1954). Kjeldahl method for organic nitrogen. Analytical Chemistry 26(1): 185-187.

Braun-Blanquet J (1964). Pflanzensoziologie-Grundzüge der vegetationskunde. Springer Verlag, Wien and New York.

Chai Y, Yue M, Wang M, Xu J, Liu X, Zhang R, Wan P (2016) Plant functional traits suggest a change in novel ecological strategies for dominant species in the stages of forest succession. Oecologia 80:771-783.

Davies KW, Bates JD, Miller RF (2007). Environmental and vegetation relationships of the Artemisia tridentata spp. wyomingensis alliance. Journal of Arid Environments 70: 478-494.

Davies PH (1965-1985). Flora of Turkey and the East Aegean Islands, Vol. 1-9. Edinburgh: Edinburgh Univ. Press.

Davies PH, Mill RR, Tan K (1988). Flora of Turkey and the East Aegean Islands, Vol. 10 (Suppl.). Edinburgh: Edinburgh Univ. Press.

Duru M, Ansquer P, Jouany C, Theau JP, Cruz P (2010). Comparison of methods for assessing the impact of different disturbances and nutrient conditions upon functional characteristics of grassland communities. Annals of Botany 106:823-831.

Dzwonko Z, Loster S (1998). Dynamics of species richness and composition in a limestone grassland restored after tree cutted. Journal of Vegetation Science 9:387-394.

Fakhireh A, Ajorlo M, Shahryari A (2012). The autecological characteristics of Desmostachya bipin nata in hyper-arid regions. Turkish Journal of Botany 36:690-696.

Faria N, Peco B, Carmona CP (2018). Effects of haying on vegetation communities, taxonomic diversity and sward properties in mediterranean dry grasslands: A preliminary assessment. Agriculture, Ecosystems & Environment 251: 48-58.

Frenette-Dussault C, Shipley B, Léger JF, Meziane D, Hingrat Y (2012). Functional structure of an arid steppe plant community reveals similarities with Grime’s C-S-R theory. Journal of Vegetation Science 23:208-222.

Garcia RR, Jáuregui BM, García U, Osoro K, Celaya R (2009). Effects of livestock breed and grazing pressure on ground-dwelling arthropods in Cantabrian heathlands. Ecological Entomology 34(4): 466-475.

Gazol A, Ibáñez R (2009). Different response to environmental factors and spatial variables of two attributes (cover and diversity) of the understorey layers. Forest Ecology and Management 258: 1267-1274.

Gillias FS (2007). The ecological significance of the herbaceous layer in temperate forest ecosystems. Bioscience 57: 845-858.

Gonzalez M, Ladet S, Deconchat M, Cabanettes A, Alard B, Balent G (2010). Relative contribution of edge and interior zones to patch size effect on species richness: an example for woody plants. Forest Ecology and Management 259: 266-274.

Guner A, Aslan S, Ekim T, Vural M, Babaç MT (2012). Tree cutting and disturbance and environmental factors affect vegetation types and species composition.

Harper KA, Macdonald SE, Burton PJ, Chen JQ, Brosofske KD, Saunders SC, Euskirchen ES, Roberts D, Jaiteh MS, Esseen PA (2005). Edge influence on forest structure and composition in fragmented landscapes. Conservation Biology 19: 768-782.
Hofmeister J. Hosek J. Modry M. Rolecek J (2009). The influence of light and nutrient availability on herb layer species richness in oak-dominated forests in central Bohemia. Plant Ecology 205: 57-75.

Hunter ML. (1999). Maintaining biodiversity in forest ecosystems. Cambridge: Cambridge University Press.

Hüseyinova R, Kilinc M, Kútchy HG, Kilic DD, Bilgin A (2013) The comparison of Grime’s strategies of plant taxa in Hacı Osman Forest and Bafra Fish Lakes in the central Black Sea region of Turkey. Turkish Journal of Botany 37:725-734.

Kacar B (2012). Toprak analizleri, 3rd ed. Ankara: Nobel Ltd.

Kılıç DD, Kútchy HG, Sürmen B, Hüseyinoğlu R (2018). The classification of some plants subjected to disturbance factors (grazing and cutting) based on ecological strategies in Turkey. Rendiconti Lincei. Scienze Fisiche e Naturali 29(1): 87-102.

Kooijman A (2010). Litter quality effects of beech and hornbeam on undergrowth species diversity in Luxembourg forests on limestone and decalcified marl. Journal of Vegetation Science 21: 248-261.

Korkmaz H, Yalcin E, Kútchy HG, Yildirim C (2016). The influence of environmental factors on the distribution and composition of plant communities in Kızılirmak Valley-Black Sea region, Turkey. Revue d'écologie 71(1): 21-34.

Kumar R, Shahabuddin G (2005). Effects of biomass extraction on vegetation structure, diversity and composition of forests in Sariska Tiger Reserve, India. Environmental Conservation 32(3): 248-259.

Kútchy HG, Ok T (2003). Foliar N and P resorption and nutrient levels along an elevational gradient in Juniperus oxycedrus L. subsp. macrocarpa (Sibth. & Sm.) Ball. Annals of Forest Science 60:449-454.

Leniere A, Houle G (2006). Response of herbaceous plant diversity to reduced structural diversity in maple-dominated (Acer saccharum Marsh.) forests managed for sap extraction. Forest Ecology and Management 231: 94-104.

Lu X. Kelsey KC, Yan Y, Sun J, Wang X, Cheng G, Neff JC (2017). Effects of grazing on ecosystem structure and function of alpine grasslands in Qinghai-Tibetan Plateau: a synthesis. Ecosphere 8(1): e01656.

Magurran AE (2004). Measuring biological diversity. Oxford: Wiley-Blackwell Publishing.

Malik ZA, Pandey R, Bhatt AB (2016). Anthropogenic disturbances and their impact on vegetation in Western Himalaya, India. Journal of Mountain Science 13(1): 69-82.

Mark AF, Dickinson KJ, Hofstde RG (2000). Alpine vegetation, plant distribution, life form, and environments a humid New Zealand region. Arctic, Antarctic, and Alpine Research 32:240-254.

Pausas JG, Austin M (2001). Patterns of plant species richness in relation to different environments: An appraisal. Journal of Vegetation Science 12: 153-166.

Pettit NE, Froend RH, Ladd PG (1995). Grazing in remnant woodland vegetation: changes in species composition and life form groups. Journal of Vegetation Science 6(1): 121-130.

Pierce S, Luzzaro A, Caccianiga M, Ceriani RM, Cerabolini B (2007). Disturbance is the principal α-scale filter determining niche differentiation, coexistence and biodiversity in an alpine community. Journal of Ecology 95:698-706.

Qian H, Klinka K, Sivak B (1997). Diversity of the understory vascular vegetation in 40 year-old and old-growth forest stands on Vancouver Island, British Columbia. Journal of Vegetation Science 8: 773-780.

Roder W, Gratzer G, Wangdi K (2002). Cattle grazing in the conifer forests of Bhutan. Mountain Research and Development 22(4): 1-7.

Schuster B, Diekmann M (2005). Species richness and environmental correlates in deciduous forests of Northwest Germany. Forest Ecology and Management 206:197–205.

Seaby RM, Henderson PA (2007). Community analysis package (4.1.3). Lymington: Pisces Conservation Ltd.

Small CJ, McCarthy BC (2005). Relationship of understory diversity to soil nitrogen, topographic variation, and stand age in an eastern oak forest, USA. Forest Ecology and Management 217: 229-243.

Tällé M, Deák B, Poschlod P, Valkó O, Westerberg L, Milberg P (2016). Grazing vs. mowing: A meta-analysis of biodiversity benefits for grassland management. Agriculture, Ecosystems & Environment 222: 200-212.

Tardella FM, Piermarteri K, Malatesta L, Catorci A (2016). Environmental gradients and grassland trait variation: insight into the effects of climate change. Acta Oecologica 76:47-60.

Tinya F, Marialigeti S, Király I, Nemeth B, Odor P (2009). The effect of light conditions on herbs, bryophytes and seedlings of temperate mixed forests in Örıseg, Western Hungary. Plant Ecology 204: 69-81.

Tüton TG, Heywood VH (1964-1980). Flora Europaea, Vol. 1-5. Cambridge: Cambridge Univ. Press.

van Calster H, Baeten L, Verheyen K, De Keersmaeker L, Dekeyser S, Rogister JE, Herny M (2008). Diversifying effects of overstorey conversion scenarios on the understorey vegetation in a former coppice-with-standards forest. Forest Ecology and Management 256: 519-528.

Vockenhuber EA, Scherber C, Langenbruch, C, Meißner M, Seidel D, Tscharnkte T (2011). Tree diversity and environmental context predict herb species richness and cover in Germany’s largest connected deciduous forest. Perspectives in Plant Ecology, Evolution and Systematics 13(2): 111-119.

Vujnovic K, Wein RW, Dale MRT (2002). Predicting plant species diversity in response to disturbance magnitude in grassland remnants of central Alberta. Canadian Journal of Botany 80: 504-511.

Westhoff V, Van Der Maarel E (1978). The Braun-Blanquet approach. In Classification of plant communities (pp. 287-399). Dordrecht: Springer.
Whigham DE (2004). Ecology of woodland herbs in temperate deciduous forests. Annual Review of Ecology, Evolution, and Systematics 35: 583-621.

Whittaker RH (1960). Vegetation of the Siskiyou Mountains, Oregon and California. Ecological Monographs 30:279-338.

Xu F, Li M, Zhou D, Liu X, Wang R, Guo W (2016). The response of wetland plant communities to disturbance: alleviation through symmetric disturbance and facilitation. Polish Journal of Ecology 64:327-338.

Zhao WY, Li JL, Qi JG (2007). Changes in vegetation diversity and structure in response to heavy grazing pressure in the northern Tianshan Mountains, China. Journal of Arid Environments 68(3): 465-479.