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The Role of Slope As An Environmental Variable In Plant Biodiversity Change In Aegean Rangelands by SHE Analysis: The Case of Çakmar Rangeland

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Abstract: Rangelands, which have rich plant and animal biodiversity, are very important as a source of roughage for livestock. Rangeland vegetation patterns vary considerably under the influence of environmental factors. Indicator factors need to be identified and analyzed in order to manage conservation and utilization objectives. In rangelands of the Aegean region, the slope factor can greatly affect the rangeland plant biodiversity in areas close to the base rangeland. In order to investigate the spatial distribution and species variation in plant biodiversity caused by slope, 6 rangeland sites with different slopes were sampled in Koçarlı region (Aydın / Türkiye). Sampling was carried out using the transect method in the spring 2017 based on field observations. Following sampling, indicator species and species distribution and abundance were determined. Alpha biodiversity indices were used to determine the change in species biodiversity by SHE analysis. SHE analysis tests the relationship between S (species richness), H (Shannon-Wiener diversity index) and E (equality). This method aims to examine the contribution of the number of species and the concept of equity in the context of diversity. According to the information obtained as a result of the analysis, it was seen that the increase in slope may cause a decrease in species biodiversity. More species diversity was found in rangelands with low base and slope. Factors such as erosion and water transport affect the canopy and species abundance in high slope rangelands. However, other factors such as grazing intensity can reverse this situation. For this purpose, it has been determined that slope is an important environmental variable when preparing management plans based on grazing capacity and grazing animal species in vegetation studies.

Keywords: alpha biodiversity, rangeland vegetation, Shannon-Wiener index, rangeland ecology.

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1. INTRODUCTION

Rangelands play a crucial role in Türkiye's ecosystem and economy. Mismanagement practices have led to a significant loss of original vegetation in Turkish rangelands (Sürmen & Kara, 2022). Suitable range management changes are recommended to conserve natural resources in highland rangelands (Koç et al., 2020).. Rangelands, covering 22.9 million hectares in Türkiye, historically support livestock production through seasonal grazing (Yetişgin & Aydemir, 2019). These rangelands are vital for animal husbandry in the eastern Anatolia region due to the challenging topography and short growing season (Koç et al., 2021). Additionally, the use of commercial feeds for animal farming is common throughout Türkiye, impacting the utilization of rangelands (Mohammadi et al., 2021).Environmental variables are also under the influence of this situation. One of the most important of these environmental variables is slope. The relationship between slope and rangeland dynamics is a critical aspect of understanding the ecological and environmental processes in these ecosystems. Research by Koç et al. (2020) highlights the impact of elevation, slope aspect, and the degree of slope on the vegetation structure, composition, and productivity of rangelands in the Palandöken Mountains, Erzurum, Türkiye. This study emphasizes the influence of topographic factors, including slope, on rangeland deterioration due to heavy grazing, providing valuable insights into the specific mechanisms driving rangeland changes in this region.

The negative effect of slope on animal distribution disrupts homogeneous grazing in rangeland sites. Overgrazing in certain areas is exacerbated by environmental factors such as slope (Han et. al., 2008; Zeng et. al. 2014). This situation leads to a decrease in the canopy ratio in plant cover, decreased heterogeneity in botanical species composition and negative effects in terms of abundance. The Aegean Region is very important for the livestock sector with its 802,882 ha rangeland area (Demiroğlu and Özkan, 2017). Although these rangelands are generally subject to overgrazing, slope as an environmental variable affects the type and density of livestocks. In addition to the vegetation effect of the slope, erosion may cause the removal of useful soil cover. In order to prevent erosion and to maintain the active growth of vegetation, a certain amount of biomass must be left. The amount of biomass required to maintain active growth in short rangelands should be approximately 400 kg ha $^{-1}$(Molinar et. al., 2001).

Biodiversity; species diversity, structural diversity and functional diversity is defined in three different ways while in studies on forest ecosystems focusing mainly on plant species diversity (Negiz et. al., 2017). The current status of rangeland biodiversity is significantly changed by the reduction in habitat, land-use changes, loss of species, unplanned fire, overgrazing, climate change and the invasion of non-native species (Gemechu and Dalle, 2023).
The relationship between species richness and evenness is a much-unresolved issue in ecology (Tuomisto, 2012). Some researchers have argued that there is a strong relationship between species richness and evenness, while others have argued they are completely independent. The species richness- evenness relationship seems to be quite contradictory between theoretical and empirical perspectives (Su, 2018).

Shannon (H) and Simpson (E) indices are widely used in rangelands to measure species/type richness. In addition to these indices, diversity indices such as Margalef (D), Berger-Parker Dominance, Mclntosh D, Brillouin D, Fisher α and Q Statistic are also used. Apart from these, taxonomic species diversity indices have also been developed to assess taxonomic species diversity. This is preferred because it determines structural and functional diversity. (Özkan, 2012; Yazgı and Yılmaz, 2017).

It has been reported that the calculation of Alpha and Beta diversity formulas can be used as a tool to evaluate rangeland plant biodiversity and that changes that may occur over time can be controlled by identifying areas that need to be protected in intensively grazed areas (Gülsoy and Özkan, 2008).

Within the scope of this study, changes in rangeland sites with different slopes were examined together with this information by using this analysis method.

2. MATERIAL AND METHOD

The experiment was conducted in the spring season of 2017 in Çakmar / Koçarlı rangelands located in Büyük Menderes Basin. In the experiment, rangeland sites with 6 different slopes in approximately 55 ha rangeland area were determined as environmental variables. The Modified Wheel Point method with loop was used in vegetation measurements (Koç and Çakal, 2004). The measurements were carried out during the flowering period of indicator species in the rangeland, in five different part wtih 100 m line of the slopes.

The slope of the rangeland were classified as almost flat (0-1%), slightly sloping (2-5%), moderately sloping (6-11%), steep sloping (12-19%), very steep sloping (20-29%) and problematic (>30%). (İspirli et. al., 2016). Among these, summer asphodel (*Asphodelus aestivus*) (Figure 1.). was the most abundant species in every site. *Bromus tectorum* was the most abundant species only in the lowest slope area (.).. The average soil coverage rates of the slopes are 73%, 73%, 70%, 65%, 63% and 48% respectively. Along with the measurements, species richness and abundance were determined with the help of alpha species diversity analysis.

The analysis of biodiversity in rangeland studies often involves the assessment of various factors such as species richness, ecosystem services, and livestock production. emphasized the importance of landscape-scale features and practices, such as hedgerows, in enhancing biodiversity and ecosystem services in agroforestry systems (Torralba et al., 2016). Similarly, utilized a model to assess the impact of livestock production on rangeland biodiversity, highlighting the significance of understanding the effects of food demand and livestock production on future biodiversity (Alkemade et al., 2012).

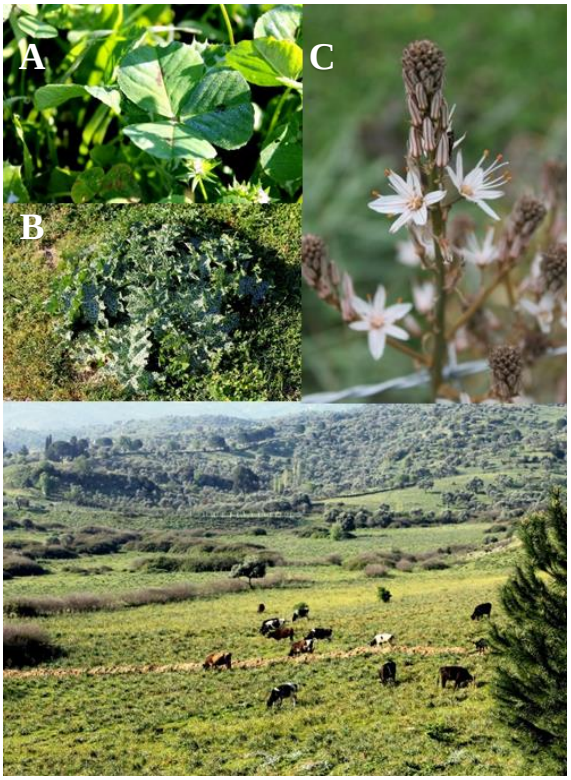


Figure 1. Çakmar rangelands (A: *Medicago arabica*; B: *Silybum marianum*; C: *Asphodelus* sp.)

Traditional alpha diversity indices include species richness, species diversity and equality. It is stated that SHE analysis is performed to see all of these expressions together. SHE analysis (S=Species Richness, H=Shannon-Wiener index,

E=equity, balance) is the graphical expression of H, E, ln(E) and ln(E)/ln(S). Formulas related to the terms used in SHE analysis are given below (Özkan, 2016).

$$S = \sum_{i}^{s} S_i$$

$$P_i = x_i / \sum_i^s x_i$$

$$H = -\sum p_i \ln p_i$$

$$E = e^H / S$$

In this formula, S is the number of species; Pi is the ratio of the percent cover value of species i to the sum of the percent cover values of all species; ln is the natural logarithm. It is calculated for each species in H's formula and is obtained by dividing the abundance value of a species in the sample area by the total abundance value of the species (N). Evenness takes a value between 0 and 1, with 1 representing full evenness. The higher the Shannon-Weiner value, the closer the number of individuals of species in this region is to each other than in other communities. (Kılınç et. al., 2006; Sürmen et. al., 2020).

3. RESULTS

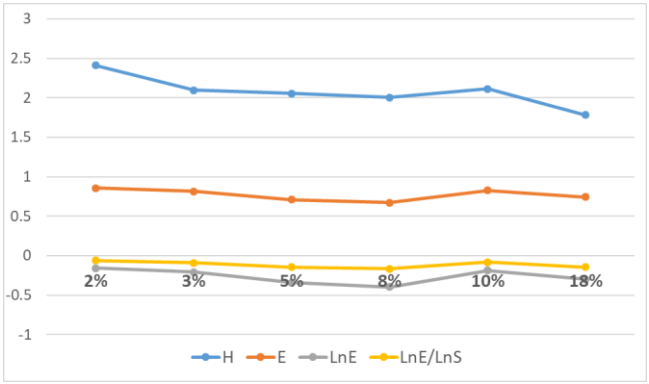
Following the vegetation measurements, negative findings were obtained in species diversity and abundance due to heavy grazing in rangeland areas. Intensive grazing continues almost all months of the year, especially in the rangeland area. In the rangeland area where the research was conducted, it was observed that species diversity and soil coverage rate were high in the slope, which is the determinant environmental factor, especially in the sites with a lower percentage of slope. In the rangeland site with a slope of 2%, the highest species diversity was detected with 13 species, while the species diversity decreased to 8 when the slope reached 18%. (Table 1;2.).

When the SHE analysis results were evaluated, the lowest H value among the 6 slopes was obtained from 18% slope. In addition, the lowest E value was observed at 8% slope, while the highest values in terms of LnE/LnS were determined at 2%, 3% and 10% slopes. According to these results, the rangeland area with 2% slope showed this result due to its higher species diversity, while 3% and 10% slopes showed more advantageous results due to their regular distribution although species richness was less than 3% and 5%. (Table 1;2.).

Table 1. Calculation results for SHE analysis terms of Çakmar rangeland sites

Slopes	S	H	E	LnE	LnE/LnS
%2	13	2,40972	0,85622	-0,15522	-0,06051
%3	10	2,09592	0,81329	-0,20665	-0,08975
%5	11	2,05610	0,71049	-0,34179	-0,14253
%8	11	2,00257	0,67346	-0,39532	-0,16486
%10	10	2,11450	0,82854	-0,18808	-0,08168
%18	8	1,78129	0,74219	-0,29814	-0,14337

Table 2. Graphical Representation of Outputs of SHE Analysis Terms According to Rangeland Slopes



Water retention decreases with the increase in slope in rangeland areas. This situation causes the soil to dry out faster and the area covered with soil decreases. In addition, grazing can affect this situation. Although the area where the experiment was conducted does not have a high rate of rangeland area, slope was one of the main environmental factors that could affect plant species and diversity.

4. DISCUSSION AND CONCLUSIONS

Rangeland plant communities are formed in a long process with the effects of soil, topography and climate factors. Therefore, the vegetation of each rangelands are unique.

In plant succesion process, the change may be in the number of species that make up the vegetation, the proportion of each species in the botanical composition or the proportion of vegetation covering the soil. The direction of this change may be in a more desirable or productive direction, or in an undesirable or less productive direction (Blanchet et. al., 2003).

The data obtained from the experiment showed that the increase in slope has a negative impact on biodiversity. Although the area covered by soil is high, the increase in slope due to erosion affects soil depth and species diversity (İspirli et. al., 2016). This situation was observed in the study. Especially the decrease in SHE analysis results was more pronounced with the increase in slope.

It is stated that it leaves the soil surface unprotected against erosion, reduces the carbon and nitrogen storage capacity of the soil by reducing plant root mass (Han et. al., 2008). Kenneth et. al. (2009) pointed out the inverse relationship between soil coverage and erosion.

Slope in rangeland areas not only affects species diversity but also has a negative effect on yield. Severoğlu and Güllap (2020) stated that there may be a decrease in forage yield and quality after high level of slope. The fact that the increased surface flow due to the increasing slope negatively affects the moisture balance and the transportation of the nutrients by erosion can be effective in reducing the forage allowance.

It was also reported by Şentürk et al. (2019) that landforms formed by different degrees of slope have significant effects on plant species diversity.
Rangeland slope sites have been an important environmental factor in determining grazing management. In the study conducted according to SHE biodiversity analysis in six different rangeland sites, highest biodiversity was observed in the bottom rangeland area with 2% slope. As the slope percentage increases, the negative effects experienced and to be experienced will affect the plant biodiversity and the area covered with soil in the rangeland. Although the slope percentages in the experiment had lower percentages than the average slopes in Türkiye, factors such as duration of illumination, grazing time of animals, and rainfall revealed that slope may be important in plant biodiversity. Research has shown that the slope of rangelands plays a significant role in determining the utilization rate and forage quality of the area Kara (2020) and affects the vegetation dynamics (Gebremedhn et al., 2023). Specifically, high-altitude sites and slopes facing east and southwest should be given priority in rangeland rehabilitation studies due to heavy grazing pressure versus low forage production (Kara, 2020). Moreover, the unique buffering capacity of forest and rangeland ecosystems across mountainous regions helps in slope stability and enhances ecological integrity (Dhyani et al., 2022).

The slope, in conjunction with grazing practices, can have a significant impact on biodiversity conservation in rangelands. Moreover, the amount and temporal distribution of precipitation received, which can be influenced by the slope, are critical for regrowth and plant production on rangelands (Koç, 2001). Additionally, diversified vegetation types on rangelands promote multiple soil-based ecosystem services, highlighting the interconnectedness of slope, vegetation, and soil health (Waterhouse, 2023).

Taking into account different environmental factors and examining their effects on biodiversity in the long term will lead to the adoption of rangeland management policies that will adapt to the changing climate with global climate change. In addition, it was seen how important the slope can be in terms of the number of animals and animal preference according to the grazing capacity.

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