Turkish Journal of Range and Forage Science, 2022, 3(2): 68-74
doi: 10.51801/turkjrfs.1213268

Research

Turkish Journal of Range and Forage Science

https://dergipark.org.tr/tr/pub/turkjrfs

Short-Term and Topographic Variations in Ecological Site Description of a Semi-Arid Mountain Rangeland

Onur İLERİ[1*]

[1]Eskisehir Osmangazi University, Department of Field Crops, Eskişehir, Türkiye

A R T I C L E I N F O

Received *01/12/2022*
Accepted *19/12/2022*

Keywords:

Ecological site
Ecological indicators
Rangeland assessment
Topography

A B S T R A C T

Deficiencies in the rangeland assessment methods prompted researchers to seek new methodologies. Rangeland Ecological Site Description (RESD), is a method suggested to produce information about the sustainability of the ecological services of the rangelands. Improvability for various ecologies is an advantage of the method. In this study, the short-term variation and the effect of the topographical differences on the RESD method were determined. Suggested ecological indicators were scored at the 60 different locations (20 north, 20 south, 20 summits) of the Bozdağ Rangeland for two years (2019-2020), and the ecological indicator scores were compared using non-parametric tests. Results showed that the RESD did not change in two years but it was lower at the south face considering the north face and summit. The RESD class of the south faces was "fair", while they were "good" for north faces and summit positions. Variations in slope gradient, light exposure, and grazing practices might be responsible for this difference. RESD method provides wider information about the ecological services of the rangelands. However, this method should be improved to give information that could be used in short-term rangeland management plans, including grazing capacity.

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1. Introduction

Rangeland management practices have a significant impact on sustainable ecosystem services of these wide natural areas by protecting them from deterioration, desertification, and depletion. Management practices could change related to the number of livestock, forage resources, vegetation characteristics, climate, socio-economic status of the ranchers, etc. (DiTomaso et al., 2010; Altın et al., 2011; Garnick et al., 2018; Kamrani et al., 2019) but the condition of the rangelands is the most important factor to decide proper management practice. Several methods have been used to assess rangelands as Rangeland Condition, Rangeland Health, Rangeland Quality Degree, etc., but all of the methods are focused on vegetation characteristics, mostly the climax theory of Clements (1916) and could not be used in different ecologies (Pyke et al., 2002; Briske et al., 2005; Koç et al., 2013).

Researchers suggested the importance of other characteristics such as soil, hydrology, and wildlife for the assessment of rangeland conditions and their sustainability (USDI/USDA, 1994; Adams et al., 1995; Pyke et al., 2002). Firstly, Adams et al (1995) described a new method by using soil, hydrology, and vegetation characteristics. Subsequently, this method was developed for Rangeland Ecological Site Description that uses ecological indicators to assess

*Correspondence author: oileri@ogu.edu.tr

the rangeland and has been used by many researchers (Pyke et al., 2002; Bestelmeyer and Brown, 2010; Williams et al., 2016; Aoyama et al., 2020). The RESD method investigates the ecological characteristics of the soil, hydrology, and vegetation of the rangelands that could be used to determine the proper rangeland management method. Koç et al (2013) stated that the ecological indicators could change in different ecosystems and therefore, they adjusted the method by considering the ecological differences in Türkiye and determined 17 different ecological characteristics for rangeland assessment. Erkovan et al., (2016) and Güllap et al. (2020) used this method in East Anatolia rangelands and suggested it for the other natural rangelands in Türkiye.

Rangelands mostly have a rugged topography in Türkiye and therefore, topography-related great variations could be observed in soil, hydrology, and vegetation characteristics (Oztas et al., 2003; Ünal et al., 2014; Sürmen and Kara, 2018). It is known that these environmental factors are closely related to each other (Gökkuş, 2020) and rangeland management plans should be prepared by considering these differences. In this study, the differences in Ecological Site characteristics were investigated among the different topographical positions of Bozdağ Rangeland for two years. It was aimed to determine if ecological site characteristics change related to topography in short term.

2. Materials and Methods

The study was conducted during the 2019-2020 years on the Bozdağ Rangeland of the Sündiken Mountain Range, which is located in Eskişehir Province of Türkiye (Figure 1). Bozdağ Rangeland is located at an altitude between 1200-1400 meters and has quite rough topography. Semi-arid climate condition prevails in the region. Long-term annual total precipitation was 336.7 mm and it was 351.7 and 299.2 mm in the 2019 and 2020 years, respectively. Long-term annual average temperature was 10.8 °C, and it was 12.3 °C and 13.0 °C in the experimental years, respectively. Perennial grasses and legume shrubs are common in the vegetation and are mostly grazed by small ruminants.

Figure 1. Location of the Bozdağ Rangeland and sampling points

The Ecological Site Descriptions are recorded at the beginning of autumn in both years by using the suggested method and the ecological indicators (Koç et al 2013), which were given in Table 1. In this method, every indicator indicates soil (S), hydrology (H), and vegetation (V) characteristic (one, two and/or all of them, see Table 1) and they are evaluated by 1-5 scoring (1: very poor, 5: very good). In the study, scores are firstly separated considering their soil, hydrology, and vegetation indication and then, averaged for north, south, and summit in 2019 and 2020 years respectively. Totally 60 locations (20 north, 20 south, and 20 summits) were selected for evaluation and the ecological indicators were scored in every location.

The score-based data used in this study was not homogenous and did not distribute normally. Therefore, the data were analyzed using Kruskal Wallis and Man Whitney U tests, which are non-parametric and suggested for unevenly distributed data (Zar, 2013). These tests assign ranks to the categorical data and then compare the means over the assigned ranks. Man Whitney U test was used to compare the years because the year had only two levels as a factor and the Kruskal Wallis test was used to compare the topographical positions because the positions were independent (Zar, 2013).

Table 1. Indicators used to determine Ecological Site Description

No	Ecological Indicators
1	Numbers and width of dry rills (S, H)
2	Runoff path (S, H)
3	Foot track presence (V, S, H)
4	Bare ground (S, H)
5	The presence of soil carved and transported by wind or water on rangelands (S, H)
6	Death plant material transport (H)
7	Erosion resistance of the soil surface (V, S, H)
8	Soil loss and degradation (V, S, H,)
9	Relation of composition and species distribution with surface runoff and infiltration (H)
10	Soil compaction (V, S, H,)
11	Functional plant groups (V)
12	Plant death (V)
13	Dead material (V, H)
14	Production (V)
15	Invasive plants (V)
16	Reproductive ability of perennial plants (V)
17	Stubble height (V)

S: Soil, H: Hydrology, V: Vegetation

3. Results and Discussion

Results showed that the scores of the ecological indicators did not vary between the years (Table 2). It is known that soil characteristics could change temporally but this change occurs very slowly (Huggett, 1998). Vegetation and hydrologic conditions of the environment are also effective in the acceleration of the change. In arid and semi-arid regions, soil characteristics generally do not change in a short period, or annually as long as any intense human interference does not occur. Hydrologic characteristics are mostly dependent on the variations of precipitation. There was nearly a 50 mm difference in precipitation between the 2019 and 2020 years, which could not be assumed as great, and this variation did not affect the score of the hydrologic indicators in Bozdağ (Table 2). Variations belonging to the indicators of vegetative characteristics could be high between different ecologies, but local variations of vegetation are mostly caused by grazing differences, and climate events such as drought, flood, etc. In Bozdağ Rangeland, there was not any significant difference in climate or grazing management practices between 2019 and 2020 years. Therefore, scores of the vegetation indicators might be similar between these years

Table 2. Descriptive statistics belong to the yearly variation of ecological indicator scores at different topographical positions and the results of Mann Whitney U test

Aspect	Variable	Year	N	Mean± SE	StDev	Q1	Median	Q3	Rank mean	Indicator scores[is]	P Value
North	Soil	2019	20	3.850±0.167	0.745	3.00	4.000	4.00	18.90	4	0.398[ns]
		2020	20	4.050±0.135	0.605	4.00	4.000	4.00	22.10	4	
	Hydrology	2019	20	3.850±0.150	0.671	3.00	4.000	4.00	20.08	4	0.820[ns]
		2020	20	3.850±0.131	0.587	4.00	4.000	4.00	20.93	4	
	Vegetation	2019	20	3.750±0.099	0.444	3.25	4.000	4.00	19.50	4	0.602[ns]
		2020	20	3.850±0.082	0.366	4.00	4.000	4.00	21.50	4	
South	Soil	2019	20	3.050±0.135	0.605	3.00	3.000	3.00	17.55	3	0.114[ns]
		2020	20	3.400±0.152	0.681	3.00	3.500	4.00	23.45	3	
	Hydrology	2019	20	3.100±0.124	0.553	3.00	3.000	3.00	17.40	3	0.096[ns]
		2020	20	3.450±0.135	0.605	3.00	3.500	4.00	23.60	3	
	Vegetation	2019	20	2.950±0.170	0.759	2.00	3.000	3.75	18.00	3	0.183[ns]
		2020	20	3.300±0.179	0.801	3.00	3.500	4.00	23.00	3	
Summit	Soil	2019	20	3.950±0.153	0.686	4.00	4.000	4.00	21.60	4	0.565[ns]
		2020	20	3.850±0.167	0.745	3.00	4.000	4.00	19.40	4	
	Hydrology	2019	20	3.900±0.143	0.641	4.00	4.000	4.00	21.70	4	0.529[ns]
		2020	20	3.800±0.138	0.616	3.00	4.000	4.00	19.30	4	
	Vegetation	2019	20	3.650±0.131	0.587	3.00	4.000	4.00	21.45	3	0.620[ns]
		2020	20	3.550±0.135	0.605	3.00	4.000	4.00	19.55	3	

ns; non-significant, is; 5: Very good, 4: Good, 3: Fair, 2: Poor, 1: Very poor

Variations in topography caused significant differences ($p<0.01$) in the scores of soil, hydrology, and vegetation indicators (Table 3). Soil score was lower (fair) at the south positions of the Bozdağ Rangeland, while it was higher in the north and summit but it was similar between them (good). Soil indicator mostly consists of erosion-based parameters to evaluate (Table 1). Therefore, it should be stated that erosion risk was higher in the southern aspect. Increasing gradients of the slope could be responsible for a higher erosion rate (Fox and Bryan, 2000). In semi-arid conditions, drought cause more damage on vegetation, especially at south aspect due to higher evaporation rate (Koç, 1995). Besides, higher freezing-thawing event increases the erosion-sensibility by decreasing the soil aggregate stability (Fuss et al., 2016. Therefore, lower soil characteristics are common at south faces in arid and semi-arid regions. On the other hand, light exposure is higher at the south faces (Moeslund et al., 2013), and therefore, vegetation growth begins earlier at the south considering the north and summit. Ranchers commonly drive herds to these south face in early spring and cause an overgrazing effect (Oztas et al., 2003). Overgrazing challenges the vegetation in the south, which in turn decreases the coverage at the south faces of Bozdağ Rangeland. The erosion rate significantly increases as the soil coverage decreases in rangelands (Altın et al., 2021) and this might be the reason for the lower soil score in the south.

The score of the hydrology indicators was the lowest at the south faces, which was fair, and it was ‘‘good’’ at the north and summit (Table 3). Hydrology indicators are closely related to soil indicators naturally (Koç et al., 2013) because water erosion is the most common erosion type in Türkiye (Koç et al., 1994; Altın et al., 2021) and consequently, variation of the scores among the topographical positions was similar in terms of hydrology and soil indicators in Bozdağ Rangeland. Moreover, moisture-related characteristics might have lower quality at south faces because higher light exposure increases the evaporation at south faces (Moeslund et al., 2013). These reasons might be responsible for the lower score of hydrology indicators at the south faces of Bozdağ Rangeland.

The vegetation indicator score class was “fair” at the south faces while it was “good” at the north and summit (Table 3). Vegetative characteristics are shaped by many factors including soil, climate, grazing practices, and topography in rangelands (Altın et al., 2011; Holechek et al., 2011). Topography has a significant impact on soil and hydrologic cycle (Biswas, 2019), and consequently on vegetation (Koç, 1995; Oztas et al., 2003; Stephenson et al., 2013). This might be explaining the similar results among vegetation, soil, and hydrology indicators in Bozdağ Rangeland. Additionally, early grazing practices at south faces could also be responsible for lower vegetation scores, because heavy grazing in early spring could damage the plants, especially desirable species (Gökkuş, 2020), and therefore, the condition of the vegetation indicators may deteriorate.

Table 3. Descriptive statistics and the result of the Kruskal Wallis test belong to indicator scores among different topographical positions of Bozdag Rangeland

Variable	Aspect	N	Mean± SE	StDev.	Q1	Median	Q3	Rank mean	Indicator scores^{is}	P Value
Soil	North	40	3.950±0.107	0.677	3.25	4.000	4.00	71.03^{A}	4	<0.000**
	South	40	3.225±0.104	0.660	3.00	3.000	4.00	40.95^{B}	3	
	Summit	40	3.900±0.112	0.709	3.25	4.000	4.00	69.53^{A}	4	
Hydrology	North	40	3.850±0.098	0.622	4.00	4.000	4.00	69.71^{A}	4	<0.000**
	South	40	3.275±0.095	0.599	3.00	3.000	4.00	42.08^{B}	3	
	Summit	40	3.850±0.098	0.622	4.00	4.000	4.00	69.71^{A}	4	
Vegetation	North	40	3.800±0.064	0.405	4.00	4.000	4.00	73.20^{A}	4	<0.000**
	South	40	3.125±0.125	0.791	2.25	3.000	4.00	44.38^{B}	3	
	Summit	40	3.600±0.093	0.591	3.00	4.000	4.00	63.93^{A}	4	

(**P<0.01;A.B., is; 5: Very good, 4: Good, 3: Fair, 2: Poor, 1: Very poor)

4. Conclusion

Extreme climate events or human effect (grazing, etc.) may change the condition of the rangeland ecological indicators but results showed that the condition of these indicators do not change in consecutive two years as long as no extreme climate events or human impact occurred. However, topographical differences could significantly change the scores of the rangeland ecological indicators. South face had a lower indicator score considering the north face and summit, and were in the class of “fair” in terms of ecological site description. A higher slope gradient, higher evaporation, and early grazing practices might be responsible for the lower ecological site description class at the south face. North face and summit had similar indicator scores and the ecological site descriptions of these two positions were in the class of “good”. Ecological site description could provide site-specific information about the recent condition of the rangelands and this method might be improved to include information about grazing capacity also. Results also indicated that degradation is higher at south aspects and this risk may increase during the global warming process. Consequently, rangeland management plans should also aim to increase the soil quality at south faces of Bozdağ Rangeland. Although there was not any difference between the years, a significant variation is expected on the long-term. Therefore, RESD should be monitored between 5-10 years of period. Monitoring is essential for a sustainable rangeland management.

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