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The Piosphere Effects of Livestock Grazing on Rangeland Vegetation in Ahir Mountain of Kahramanmaras Region

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ABSTRACT

Excessive grazing pressure on rangeland vegetation reduces the basal area value of vegetation and also changes the botanic composition. This study examined the piosphere effects of livestock grazing on rangeland vegetation based on distance from a natural water source. The piosphere effects were evaluated around Karagöl Lake, which is a natural water-source in Mediterranean region of Turkey. The changes in vegetation were determined within three different sites where sample plots were located at 0-1000 m, 1000-3000 m and 3000-5000 m away from the lake. The mean values of basal area in the study area were 10.71%, 14.46%, and 22.16% for three sites, respectively. The average oven-dry hay yield was 639.0 kg ha^{-1}, 1542.9 kg ha^{-1}, and 2146.3 kg ha^{-1}, respectively. The vegetation similarity indices of the sites indicated that the botanic composition changed with respect to increasing distance from the lake. The lowest similarity index was encountered between the site one and site three (30.31%).

Keywords: Piosphere; Rangeland; Basal area; Hay yield; Botanic composition

Kahramanmaraş Yöresi Ahır Dağı Meralarında Piospher'in Vejetasyon Yapısı Üzerindeki Etkileri

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ÖZET

Mera vejetasyonları üzerinde oluşan aşırı otlatma baskısı, vejetasyonun bitki ile kaplı alan değerinin azalmasına ve botanik kompozisyonun değişmesine neden olmaktadır. Yapılan bu araştırmada Türkiye'nin Akdeniz bölgesinde yer alan, doğal su kaynaklarından biri olan Karagöl gölüne olan mesafeye göre piosferin vejetasyon üzerindeki etkileri incelenmiştir. Bunun için çalışma alanında yer alan doğal su kaynaklarından biri olan Karagöl gölünün piosfer etkisi araştırılmıştır. Vejetasyonda meydana gelen değişiklikler Karagöl gölü çevresinden 0-1000 m, 1000-3000 m ve 3000-5000 m uzaklıkta seçilen üç deneme alanı alınarak belirlenmiştir. Araştırma alanında ortalama bitki ile kaplı alan değerleri sırasıyla % 10.71, % 14.46 ve % 22.16 olarak belirlenmiştir. Göl çevresinde ortalama fırın kurusu ot

verimi sırasıyla 63.90 kg da^{-1}, 154.29 kg da^{-1} ve 214.63 kg da^{-1} olarak tespit edilmiştir. Vejetasyonun benzerlik indeksi değerlerine göre göl çevresinden uzaklaştıkça vejetasyonun farklılaştığı belirlenmiştir. En düşük benzerlik oranının birinci ve üçüncü deneme alanları arasında olduğu tespit edilmiştir.

Anahtar Kelimeler: Piosfer; Mera; Bitki ile kaplı alan; Ot verimi; Botanik kompozisyon

1. Introduction

Rangelands are a type of land on which the natural vegetation is dominated by grasses, forbs and shrubs and the land is managed as a natural ecosystem (SRM 2015). Rangeland areas play important role in terms of both biological diversity and grazing, due to having wide range of plant species. In addition, rangeland vegetation is important in preventing erosion and runoff (Gökkuş & Koç 2001).

The total area of rangelands occupies 3.5 billion ha in world (FAO 2008). In Turkey, the area of rangelands is about 14.6 million hectares, while it was 50 million hectares in 1923 (TSI 2011). Within the same period, the number of animals grazing on rangelands increased from 20.3 million to 29.9 million cattle units (TSI 2011). Thus, rangelands continually decreased while the number of grazing animals per unit area increased, which led to ever-increasing grazing pressure on rangelands. The vegetation structures of rangelands were deteriorated and productivity decreased due to increasing grazing pressure. Grazing pressure also reduced the density of vegetation coverage and emerged active surface erosion. Due to excessive, non-uniform, and untimely (i.e. while plants are not mature enough for grazing and soil is humid) grazing, deterioration process of vegetation has been accelerated in last decades.

Unplanned grazing practices in Turkey resulted in non-uniform grazing which led to much greater grazing pressure in rangeland areas, especially rangeland sites located around water sources. Grazing animals on rangelands tend to stay around water sources because these animals are continuously in need of drinking water (Stoddart et al 1975). Grazing density around water sources decreases circumferentially away from the center (Andrew 1988; Pickup 1989; Pickup & Chevings 1994; Pickup et al 1998). The higher grazing density around water sources causes reduction in the basal area, changes in botanic composition and extinction of many plant species. The animal communities around a water source also result in soil compaction and consequently increased runoff.

The term "piosphere" is used to define grazing pressure in areas surrounding water sources, especially in arid rangelands areas (Lange 1969; Andrew 1988; Thrash 1998; 2000; James et al 1999). The origin of the term "piosphere" comes from Latin; "pios"= to drink and "phere"= round or ball. Tongway et al (2003) revealed that the piosphere effect can be noticed even at a distance of 1-3 km from water. ICARDA (2002) observed deterioration in vegetation within a radius of 2-5 km around well shafts due grazing practices. Therefore, the distance from water sources can be used to define grazing pressure; because the closer the water sources the greater the grazing pressure (Ludwig et al 2001).

This study examined the piosphere effect of grazing pressure on rangeland vegetation according to distance from a natural water source. Karagöl Lake located in rangelands of Ahır Mountain in Kahramanmaras region was considered as the center of piosphere. This region has an arid climate and study area has been subject to significant amount of non-uniform grazing. In the study, the basal area, hay yields and similarity indices between plant communities were analyzed in the study area.

2. Material and Methods

2.1. Study area

The rangelands of Ahır Mountain are located in the East Meditarrenean region of Turkey, average

altitude 1650 m, 25 km away from Kahramanmaras province. The study area is located between latitudes 37° 39' 38"-37° 38' 15" N and longitudes 36° 56' 20"-37° 03' 14" E (Figure 1). Karagöl Lake, located in the rangeland, has the water surface area of 15.5 ha the study area has transitional characteristics between continental and Mediterranean climates. Generally, summers are hot and dry; winters are cold and snowy. Annual precipitation is about 700 mm. Precipitation generally occurs in winter and spring. Annual average temperature is 16.7 °C with maximum and minimum temperatures of 45.2 °C (July) and -9.6 °C (February), respectively (TSMS 2012). When considering the vegetation period, it can be seen that the study area has arid climatic characteristics. The soils of the study area are generally of sandy, sandy loam, and sandy clay loam that form on the bedrocks of sandstone, limestone, and mudstone. The flora of the study area is dominated by herbaceous plants such as *Gundelia tournefortii* var. *armata, Bromus tectorum, Astragalus akmanii, Carduus nutans, Marrubium globosum* subsp. *globosum, Anthemis kotschyana, Achillea kotschiyana, Galium verum* subsp. *verum, Hypericum scabrum,* and *Allium trachycoleum*.

2.2. Methods

A preliminary survey was carried out in the area to identify potential study sites. It was observed that some features (i.e. basal area, botanic composition, etc.) of vegetation differed depending on the distance from Karagöl Lake. Random sampling method was used for determining vegetation characteristics in the study area. All sample plots were taken from same altitude (1620-1670 m), slope (10-20%) and aspect (south). The piosphere effects of livestock grazing on rangeland vegetation were evaluated for three different sites where five sample plots with 1000 m radius were located based on their proximity to the lake. In the first site, Plot I centralized the Karagöl Lake. In the second site, Plot II and III were located on west and east of Plot I, respectively. Then, Plot IV and V were located on west of Plot II and east of Plot III, respectively (Figure 2). Within each plot, 7

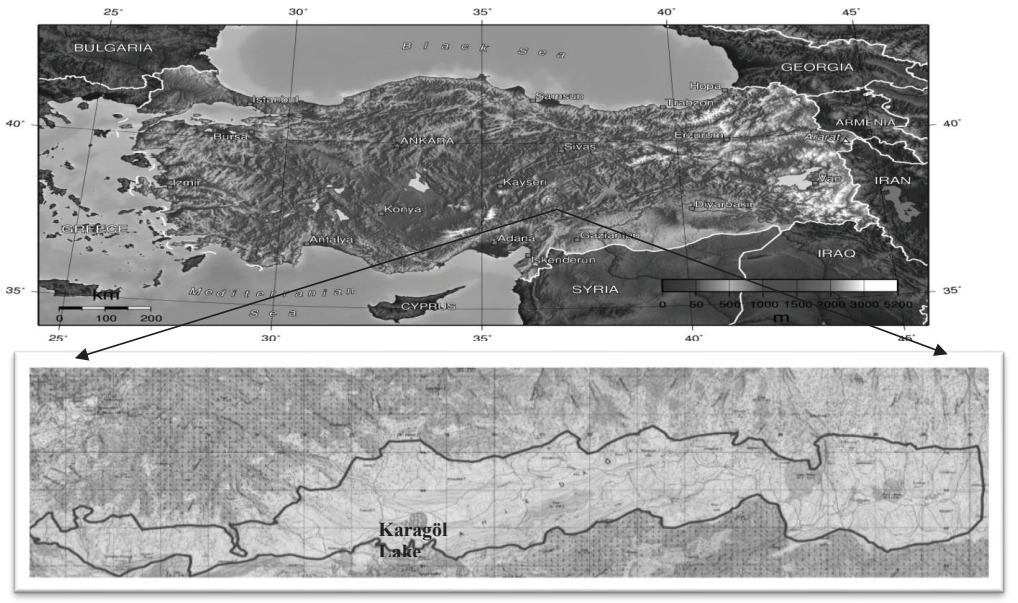

Figure 1- The location of the study area

Şekil 1- Araştırma alanının yeri

sampling areas occupying an area of 1000 m^2 (20 m x 50 m) were chosen to determine the basal area, hay yield, and similarity index. All of the vegetation measurements were conducted between 1st July and 15th August in 2012. One-way analysis of variance was applied to determine whether or not there were significant differences in the effect of distance from the lake on vegetation characteristics. Statistical analysis of the data was conducted by using SPSS (version 18.0).

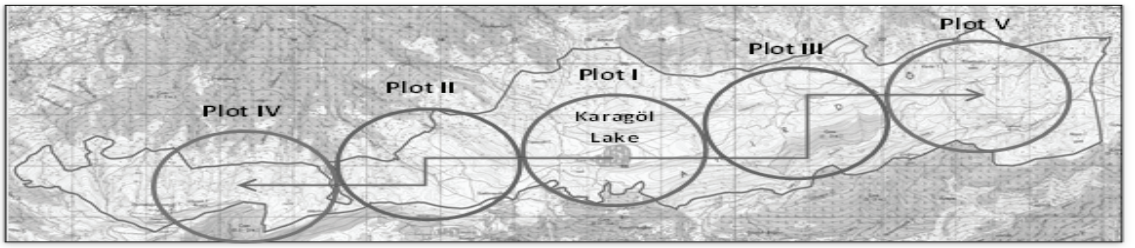

Figure 2- Sample plots located in study sites

Şekil 2- Çalışma alanı örnekleme noktalarının yeri

The loop transect method suggested by Parker & Harris (1959) was used to evaluate changes in rangelands vegetation in the study area (Figure 3). In each sampling area, 6 loop transects were conducted to estimate basal area (in %). Thus, 42 loop transects from each plot and total of 210 loop transects from the whole study area were conducted.

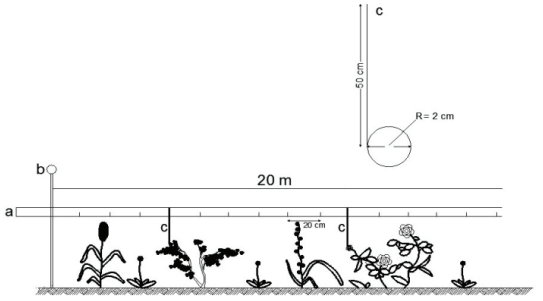

Figure 3- Application of loop transect method; a, marked rope (20 m); b, steel pins; c, loops

Şekil 3- Lup yöntemi ile çalışma; a, işaretli ip (20 m); b, tesbit çubuğu; c, lup aracı

In application of loop transect method, 20 meter long rope was marked at each 20 cm intervals to locate loops along each loop transect. Total of 100 loops were located on marked rope which was anchored on the ground at both end points by using steel pins. The loop consisted of a 50 cm of handle attached to an observation ring with about 2 cm (¾ inches) diameter. During the measurements, each loop was observed through rings to evaluate existence of plants and dominant species were considered if more than one plant exists.

To determine the hay yield in the study area, total of 175 quadrat samples (1 m x 1 m) were implemented in the study area, where 5 quadrat samples were used in each sampling area (Okatan 1987). The herbaceous within the quadrats were mowed at 5 cm height above the ground surface and then dried in a drying oven at 78 °C to determine oven dried hay yields.

A similarity index calculation was used to compare plant communities of three different sites (Sorenson 1948; Bakır 1970; Okatan 1987; Koç 1995). The similarity index value was computed to compare two different sites at once. Equation 1 that suggested by Sorenson (1948) was employed to calculate similarity index.

$$SI = \left(\frac{2W}{a+b} \right) \text{x} 100 \qquad (1)$$

Where; *SI*, similarity index value; *W*, total value of the smallest basal area consisted of common plants in compared sites; *a* and *b*, the total value of the area covered by different plants within the compared sites.

3. Results and Discussion

A total of 101 plant species were identified within the study areas, of which four were endemic. Of the total species, 8 were of the family *Poaceae*, 7 were *Fabaceae*. Rests of the species belong to other families, of which 8 species were weeds that are toxic, thorny or otherwise harmful to both animal health and the quality of animal products.

The results indicated that average basal area was 15.77% for the whole rangeland. It was also found that the study area was exposed heavy grazing pressure. The average basal area was 10.71% around the lake in the first site (0-1000 m), while it was 14.46% and 22.16% within the second (1000-3000 m) and third (3000-5000 m) sites, respectively. It was realized that the lowest basal area was in the first site due to higher grazing pressure from animals visiting the lake for watering (Figure 4). As shown in Figure 5, the shores of the lake were severely grazed and the density of animal trails increased due to the animals continuously visiting the lake for watering, thereby leading to surface erosion in this area.

Analysis of variance showed a significant difference in basal area among the three sites (P<0.05) (Table 1). The basal area was increased with greater distance from the lake. Likewise, Todd (2006) reported that perennial plant cover increased

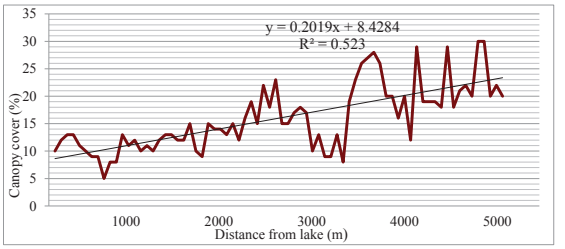

Figure 4- Average basal area of study sites

Şekil 4- Deneme alanlarının ortalama bitki ile kaplı alan değerleri

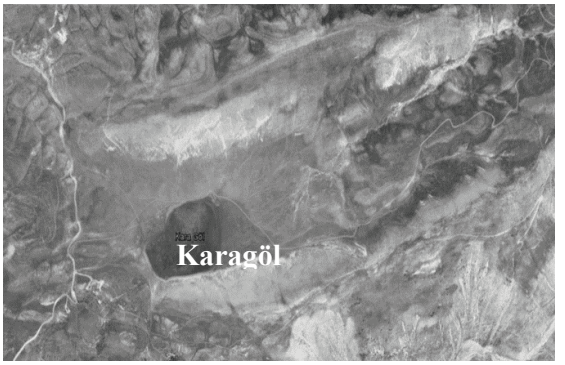

Figure 5- The center of the study area; Karagol Lake and its circumference

Şekil 5- Çalışma alanının merkezi; Karagöl ve çevresi

with distance from water sources. Fusco et al (1995) indicated that long-term cattle grazing of areas near water sources was associated with a decline in perennial *Gramineae* species. Gemedo Dalle et al (2006) found a significant correlation between distance from water sources and *Gramineae* plants, with the number of *Gramineae* species increasing

Table 1- Variance analysis (ANOVA) of basal area of sample plots

Çizelge 1- Deneme alanlarının bitki ile kaplı alan değerlerine ait varyans analizi

Sites	*Number of samples*	*Average canopy cover (%)*	*Standard deviation*	*F value*	*Significance level*
First site (Plot I)	42	10.71	2.10 a	55.161	0.000*
Second site (Plot II-III)	84	14.46	3.86 b		0.000*
Third site (Plot IV-V)	84	22.16	4.74 c		0.000*
Total	210	16.00	6.00		

*, significant at the 5% of probability level (P<0.05)

with distance from the water source. Vallentine (1990) revealed that cattle heavily grazed on fodder plants around the water sources, thereby decreasing the basal area within this area. In conclusion, the values obtained for basal area indicate heavy grazing effect circularly around the water sources while grazing effect decreases moving away from water sources (Child et al 1971; Graetz & Ludwig 1978; Tolsma et al 1987; Perkins & Thomas 1993; Brits et al 2002).

Average oven-dry hay yield for the whole study area was 911.1 kg ha^{-1}. It was also determined that the average hay yields were 639.0 kg ha^{-1}, 1542.9 kg ha^{-1}, and 2146.3 kg ha^{-1} for three sites, respectively (Figure 6). ANOVA results showed that hay yields differed significantly among the study sites (P<0.05) (Table 2). Hart et al (1989) found that 77% grazing in a 1000 ha range occur within 400 m of the water sources. Solomon et al (2007) found that heavy grazing pressure occurred circularly around water sources. They also stated that vegetation structure changed and hay yield decreased around the water source. Naveh & Whitaker (1979) found that cattle need to drink water regularly 2-3 times per day, and heavily grazed the circumferences of water sources and that changed the vegetation structure. Holechek et al (2004) found that animals spend much time around water sources, especially in dry seasons.

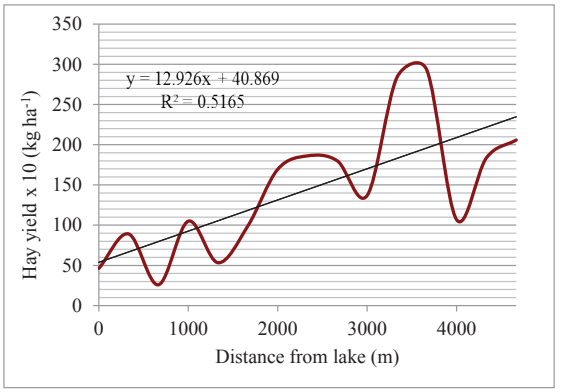

Figure 6- Average hay yields in study sites

Şekil 6- Deneme alanlarına ait kuru ot verimi ortalamaları

The similarity index of Sorenson (1948) was used to determine similarities in plant communities between the sites. The greatest similarity in vegetation was found between the second (1000-3000 m) and the third (3000-5000 m) sites (40.31%) (Table 3). The least similarity in vegetation was found when comparing the first site immediately around the lake (0-1000 m) with the third site (3000-5000 m). This finding indicated that the botanical composition of the vegetation differs according to distance from the water source.

Table 2- Variance analysis (ANOVA) of hay yield of sample plots

Çizelge 2- Deneme alanlarının verim değerlerine ait varyans analizi

Sites	*Number of samples*	*Average hay yields (kg ha^{-1})*	*Standard deviation*	*F value*	*Significance level*
First Site (Plot I)	35	639.0	323.8 a	10.45	0.002*
Second Site (Plot II-III)	70	1542.9	362.4 b		0.009*
Third Site (Plot IV-V)	70	2146.3	767.6 c		0.023*
Total	175	14427	804.3		

*, significant at the 5% of probability level (P<0.05)

Table 3- Similarity indices in the study area (%)

Çizelge 3- Araştırma alanına ait benzerlik indeksi değerleri (%)

	First site/second site	*First site/third site*	*Second site/third site*
Similarity indices	33.85	30.31	40.31

This study was carried out on the rangelands of Ahır Mountain in Kahramanmaras province, Turkey. The effect of distance from natural water sources directly affects uniform grazing, and therefore the hay yield and plant community structure. The findings indicated that basal area and hay yields decreased closer to water sources; and botanic composition changed due to the heavier grazing pressure around water sources. Therefore, survey sites with a greater difference in terms of their proximity to water sources showed less similarity between plant communities. The study also showed that the number of animal routes increased closer to water sources, with heavy grazing alongside these routes, because animals need to drink water frequently. One of the most basic issues of rangelands management is to identify the number and locations of water sources that might provide homogenous grazing within a rangeland area. It was concluded that there were insufficient or unevenly-distributed water sources within the study area to meet the needs of animals. The area therefore requires additional evenly distributed water sources and some other structures (salt-licks and scratching-posts, etc.) for animals. Besides, a new network of routes should be established to prevent animals wandering when accessing water sources.

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