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ECOLOGICAL INTERPRETATIONS OF RANGELAND CONDITION OF SOME VILLAGES IN KIRIKKALE PROVINCE OF TURKEY

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ABSTRACT

This study was undertaken to determine rangeland condition in three selected villages of Kırıkkale province in the highlands of Central Anatolia and to identify the common management techniques for the dominant steppe vegetation of these villages, in which rangeland deterioration is a serious problem because of long term over-grazing. The rangeland conditions of units called Karakeçili, Mahmutlar Şarklısı and Pazarcık were found as poor (20.00 %), fair (40.03 %), and good (52.00 %), respectively. However, the rangeland health of villages were unhealthy. Indirect gradient analysis with Correspondence Analysis produced that the four axes have explained 71.2 % of the variance of species data and direct gradient analysis with Canonical Correspondence Analysis produced that the four axes have explained 57.5 % and 96.5 % of the variance of species data and of species-environment relationship, respectively. Each unit or village was placed in a different area on the biplot graph and a triplot showed that altitude and aspect had a negative correlation. However, grazing intensity, erosion and slope had the same dimensions and the similar relationships.

Key words: rangeland condition, rangeland health, correspondence analysis, canonical correspondence analysis,

INTRODUCTION

Turkey has 14.6 million hectares of rangelands - meadows and 33 % of which is located in Central Anatolia (Anonim, 2006). Crop plant acreage had sharply increased in between 1950 and 1960 in the county, this situation negatively reflected rangelands and caused the decrease of rangeland areas at the same time. After that, some parts of rangelands were recorded as Forest area at during 1960-1970 period (Koç et al., 2000). At the same time, increased numbers of livestock on the decreased rangeland have led to overgrazing and deterioration in rangeland condition.

Rangelands have been used as main feeding sources for livestock section. Therefore, the bad effects of past mismanagements and heavy grazing on rangelands have to be recovered of the proper techniques of rehabilitation and management. An assessment study of rangeland potential (Koç et al.,1994) showed that rangelands in Turkey are overgrazed 2- 3 times more than their carrying capacity. Mismanagement of rangelands leads to 90 percentages of loss of the original vegetation on rangelands (Gençkan et al. 1990).

Heavy grazing is the most important factor causing the deterioration on botanical composition of rangelands. There are no samples of having maintenance ability of the present rangeland condition under high grazing pressure (Holechek et al. 2004). Öztaş et al (2003) compared the rangeland conditions under the different grazing impacts and found that rangelands are going to poor conditions with the increasing grazing intensity. Moreover, heavy grazing or high grazing pressure caused a shift to lower succession stages and reduction or absence of grazing allowed succession to proceed to higher stages.

Many studies in Turkey showed that most public rangelands are in poor or moderate condition (Çakal et al., 2007; Şimşek et al., 2007) and it can be concluded that this situation indicates a failure of current management and a need for a drastic action (Anonymous, 2008). A new sound rangeland management system is to be set up and practically implemented on the farm village level. It should contain all kind information on the status of rangelands (dry, wet, carrying capacity, plant species etc.) and livestock section (animal type, number and age, etc.). Various methods have been used for determination of the rangeland condition based on vegetation. However, the current Rangeland Act recommends to use for rangeland condition method suggested by Dyksterhuis (1949), but it doesn't contain any knowledge on the combination of vegetation cover and bare ground onto soil. The use of rangeland condition was replaced by the rangeland health concept in United State of America. For this reason, Koç et al. (2003) suggested that another concept which is combination of rangeland condition and health for Turkey. Development of a knowledge base on degradation processes through long-term grazing trials would be ideal for the purposes of constructing and validating the degradation gradient and interpreting condition assessments. Greater emphasis on the influence of vegetation deterioration on habitat condition is required in future research. Understanding of edaphic changes during the process of degradation is a prerequisite for meaningful interpretation of the assessment of rangeland condition.

This study is aimed at (1) determination of rangeland status and application of the most suitable rangeland management system at village level, (2) match of the similar sites of species and environmental factors, (3) observation of species, sites, environmental features in a graph or an ordination gradient, and (4) draw of conclusions for implementation.

MATERIALS AND METHODS

Experiment area

This study was performed on the three different rangeland villages of Kırıkkale province as Karakeçili, Mahmutlar Şarklısı and Pazarcık. Three study villages under the heavy grazing condition were selected for representing typical steppe vegetation of rangelands of Kırıkkale province.

Available grazing period of the Central Anatolia is six months (180 days, from 15 April to 15 October in a year) but this period lasts for seven months and more because of prevailing uncontrolled grazing systems. Under the rangelands conditions of Turkey, the required rangeland area per livestock unit (LU refers to 500 kg live weight of lactating cow) was estimated to be 3.5 ha for whole growing season (Koç et al.,2000) but the rangeland area per LU in Kırıkkale province was 0.67- 1.20 ha. This means that the study villages are extremely overgrazed nearly 3-7 times more intensely than their carrying capacity.

A Modified Wheel Point Method with Loop (Koç ve Çakal, 2004) was used to determine the basal cover of existing species on rangeland vegetation and bare ground at the fixed sites. A vegetation survey was carried out in these units with the site numbers following as 5, 10 and 8 , respectively. Two transects of each sites were undertaken of 100 m long distance, one meter distance between them and 100 points were recorded on each one (total 200 points). In addition, habitat factors (altitude, aspect, slope angle) and impact of rangeland use (grazing intensity (1-5, not to severely grazed)) with soil features, and erosion influence (1-5, not to severely eroded) and soil compaction class (1-5, not to severely compacted) were recorded for each the unit sites.

The soils of the study area are of loam and clay loam texture, slightly salty (Karakeçili village and Mahmutlar Şarklısı village), slightly alkaline (Pazarcık village), low in organic matter and phosphorous (Karakeçili village) and moderately calcareous (Karakeçili village) (Anonymous, 2004).

Long term average rainfall is 399.2 mm and for the survey year (2004) was 315.8 mm (Anonymous, 2005). Long term average temperature is 13.1 ^{o} C while average temperature in 2004 was 12.7 ^{o} C . The long term average relative humidity is 67,7 % and average relative humidity in 2004 was 55,7 %

Data Analysis

All data were analyzed with available computer software programs. The determination of rangeland condition required some knowledge of the rangeland sites such as rainfall zone, rangeland site, mapping rangeland and rangeland botanical composition (Bakır, 1987). Vegetation survey was made and plant species and environmental variables were recorded in site information form and vegetation survey form.

The rangeland condition (only cover of decreasers and increasers used) and health (vegetation cover) of villages were calculated with the basal cover of rangeland vegetation (Koç et al., 2003). All plant species were classified into three groups as decreasers, increasers and invaders for different response to grazing impact (Serin, 2005). Rangeland condition was rated as poor (1-25 %), fair (26-50 %), good (51-75 %) and excellent (76-100 %) (Koç et al. 2003; Holechek et al. 2004). Rangeland health was ranges in one of three categories: healthy, at risk, and unhealthy (Koç et al. 2003).

Ordination (correspondence analysis) procedure of multivariate statistical methods was used for the development of ecological condition assessment methodologies (Manly, 1995). Ordination is relatively easy to interpret for ecologists analyzing data on the abundance of different species at the different sites.

Canonical correspondence analysis (CCA) is introduced as a multivariate extension of weighted averaging ordination, which is a simple method for arranging species along environmental variables . A simple method is therefore needed to analyze and visualize the relationships between many species and many environmental variables. CCA is an eigenvector ordination technique that also produces a multivariate direct gradient analysis (Ter Braak, 1987). CCA aims to visualize (1) a pattern of community variation, as in standard ordination, and also (2) the main features of species' distributions along the environmental variables. CCA considerably extends the analytical power of ecological ordination.

RESULTS AND DISCUSSIONS

Rangeland condition and health

There were three villages with various features. Rangeland condition of Karakeçili village was poor (20.00 %), the villages of Mahmutlar Şarklısı and Pazarcık became as fair and good in rangeland conditions, respectively (Table 1).

Table 1. Rangeland conditions and rangeland health values of villages

	Karakeçili Village	**Mahmutlar Şarklısı village**	**Pazarcık village**
Sites	5	10	8
Transect lines	10	20	16
Decreasers (%)	0.00	20.03	22.00
Increasers (%)	20.0	20.00	30.00
Invaders (%)	26.6	10.45	7.46
Total (D+I)* (%)	20.0	40.03	52.00
Rangeland condition	Poor	Fair	Good
Vegetation cover (%)	22.10	34.70	39.69
Rangeland health	Unhealthy	Unhealthy	Unhealthy

(*) Total (D+I) (%) = Decreasers (%) + Increasers (%)

Karakeçili village had only increaser plant species and no decreaser plant species (Table 2). We noticed there was no

Table 2. Decreasers, increasers and invaders plant species of three villages

Karakeçili village Sites 1-5 (transect lines 1-10)		
Decreaser	**Increaser**	**Invader**
-	*Cynodon dactylon* *Artemisia fragrans* *Thymus squarrosus* *Teucrium polium*	*Astragalus strigillosus* *Eryngium campestre* *Euphorbia macroclada*
Mahmutlar Şarklısı village Sites 6- 15 (transect lines 11-30)		
Decreaser	**Increaser**	**Invader**
Hyparhaenia hirta Bromus tomentellus Onobrychis armena	*Cynodon dactylon* *Festuca ovina* *Stipa holosericea* *Artemisia fragrans* *Thymus squarrosus*	*Astragalus condensatus* *Eryngium campestre* *Peganum harmala*
Pazarcık village Sites 16-23 (transect lines 31 - 46)		
Decreaser	**Increaser**	**Invader**
Elymus hispidus *Hyparhaenia hirta* *Koelaria cristata* *Onobrychis armena*	*Festuca ovina* *Stipa holosericea* *Thymus squarrosus* *Teucrium polium* *Medicago lupulina*	*Astragalus vulnerariae* *Eryngium campestre* *Phlomis armenica*

any decreaser plant species, only increaser and invader plant species in Karakeçili village (the consisting of 5 sites with 10 transect lines). The increaaser plant species played an important role for the determination of rangeland condition. These plant species were *Cynodon dactylon* as a grass, *Artemisia fragrans* and *Thymus squarrosus* as shrubs which commonly dominate this region described by Bakır (1970); Özmen (1977) and Tokluoğlu (1979).

Rangeland condition of Mahmutlar Şarklısı village appeared as fair (Table 1). At the village of Mahmutlar Şarklısı (having 10 sites with 20 samples), we observed the occurrence of decreaser plant species such as *Hyparhaenia hirta, Bromus tomentellus, Onobrychis armena* and increaser as *Cynodon dactylon, Festuca ovina, Stipa holosericea, Artemisia fragrans* and *Thymus squarrosus* and invader plant species of *Astragalus condensatus, Eryngium campestre* and *Peganum harmala* (Table 2).

Pazarcık village (including in 8 sites with 16 transect lines) was in a good rangeland condition (Table 1). At the village of Pazarcık, we observed the occurrence of decreaser plant species such as *Elymus hispidus Hyparhaenia hirta, Medicago lupulina* and *Onobrychis armena* and increaser as *Festuca ovina, Koelaria cristata , Stipa holosericea* and *Thymus squarrosus* (Table 2). Some plant species as *Festuca ovina, Koelaria cristata, Onobrychis armena, Cynodon dactylon, Artemisia fragrans* and *Thymus squarrosus* were obtained in the previous studies of rangelands of Central Anatolian (Bakır,1970; Özmen, 1977). Some plant species with good forage quality and high herbage yield such as *Agropyron* spp. (Büyükburç, 1983; Bakır, 1970; Davies,1970), *Phleum pretense* (Bakır, 1970), *Dactylis glomerata* (Davies,1970) were observed in the previous studies in the Central Anatolia Region, but they weren't found in this work.

Grazing impact effects first desired plant species called decreaser, later less desired plants. Grazing generally reduced leaf length, basal diameter, culm (stem) length, and culm numbers of plant species (Wikeem and Pitt, 1991) . Then the rangelands are degraded and destroyed by soil erosion, losing biodiversity, damaging wildlife habitat and breaking down nutrient re-cycle. Consequently, fair and poor condition rangelands are lost their productivity, in case which are low in diversity, are poor habitat for wildlife, and are unsustainable. After that reduction or removal of livestock would result in the restoration or improvement of these rangelands.

Rangeland health values of villages were in an unhealthy. The percentages of basal cover on the villages of Karakeçili, Mahmutlar Şarklısı, and Pazarcık were 22.10 %, 34.70 %, and 39.69 %, respectively. Ecological assessment of rangelands is based upon current vegetation and botanical composition . It is important to monitor and distinguish changes in vegetation over time on one site from vegetation differences from site to site at the same time.

The figures of this study showed that the present rangeland condition and health were commonly poor or fair and unhealthy in the Kırıkkale province, respectively. The most public rangelands in Turkey are also in poor or moderate condition (Çakal et al., 2007; Şimşek et al., 2007) and it can be concluded that this situation indicates a failure of current management and a need for drastic action.

Ordination (without environmental variables)

Indirect gradient analysis with CA produced eigenvalues of 0.849, 0.402, 0.266, 0.180 for the first four axes

respectively. The eigenvalue represents the variance in the sites x species data set that is attributed to a particular axis (Jongman et al. 1995). In our case, the four axes explained 71.2 % of the cumulative variance in the community matrix (Table 3).

Table 3. The results of Correspondence Analysis of Species

Axes	1	2	3	4	Total inertia
Eigenvalues	0.849	0.402	0.266	0.180	2.383
Cumulative percentage variance of species data	35.6	52.5	63.7	71.2	
Sum of all eigenvalues					2.383

Species and sites appeared on the ordination gradient suggested that rangeland sites with the same plant species matched each other and formed the three groups (units=villages) (Figure 1) , such as: *Artemisia fragrans* formed the first group of the site 1-5 (unit one)*; Bromus tomentellus, Hyparnia hyrta, Cynodon dactylon,* and *Stipa* spp. formed the second site 6-15 (unit two); and finally *Festuca ovina, Medicago lupulina, Onobrychis armena, Astragalus* spp., sites formed the third group of the 16-23 (unit three) (Figure 1).

As observed the placing of units in the degradation gradient, unit two and unit three were almost in the same vertical position, but unit one seemed completely in a different place. So unit one was degraded rangeland and poor condition. In the figure, it is indicated that unit 1 was beyond the relative positions of the groups to degradation gradient (arrow). It means that unit 1 seemed to be crossed to other side of threshold line.

Rangelands converted from grassland to shrubland as *Artemisia fragrans* dominated in unit 1. Schlesinger et al. (1990) and Parizek et al. (2002) reported that in semi-arid rangelands, intense grazing can remove drought- tolerant, highly palatable grasses, which can facilitate the increase of shrub cover (shrub encroachment) and soil degradation (Marcelo and Rostagno 2006).

Both Unit 2 and unit 3 had good quality plant species, and also some invader species which were the indicators of overgrazing or misuse of the rangelands. Marcelo and Rostagno (2006) point out that a decrease in the perennial grass cover may provide an early indicator of the potential for ecosystem deterioration. Grazing by removing perennial grasses and cultivating the soil surface can also have a major impact on soil erosion. The degradation gradient, unit 2 and unit 3 were behind it (the degradation gradient). This means that unit 1 was more degraded rangeland than the other rangelands. Vegetation changes of rangelands are regularly monitored to make the ecological interpretations that it are needed for determination of the proper rangeland management and its implementation in a practical way. The decrease in the perennial grass cover may provide an early indicator of the potential for ecosystem deterioration. A high percentage of perennial grass cover as well as a low distance between perennial plants indicates a high potential for a site to recover from periods of stress, i.e., the ability to re-establish a grass cover over bare patches generated after grazing disturbance or during a period of environmental stress (de Soyza et al. 2000).

Erosion is a big problem in a poor rangeland condition. Restoration of grasslands is immediately needed for achieving vegetation cover intercepts raindrops, protects soil aggregates from raindrop impact, and reduces erosion (Carleton et al. 2006).

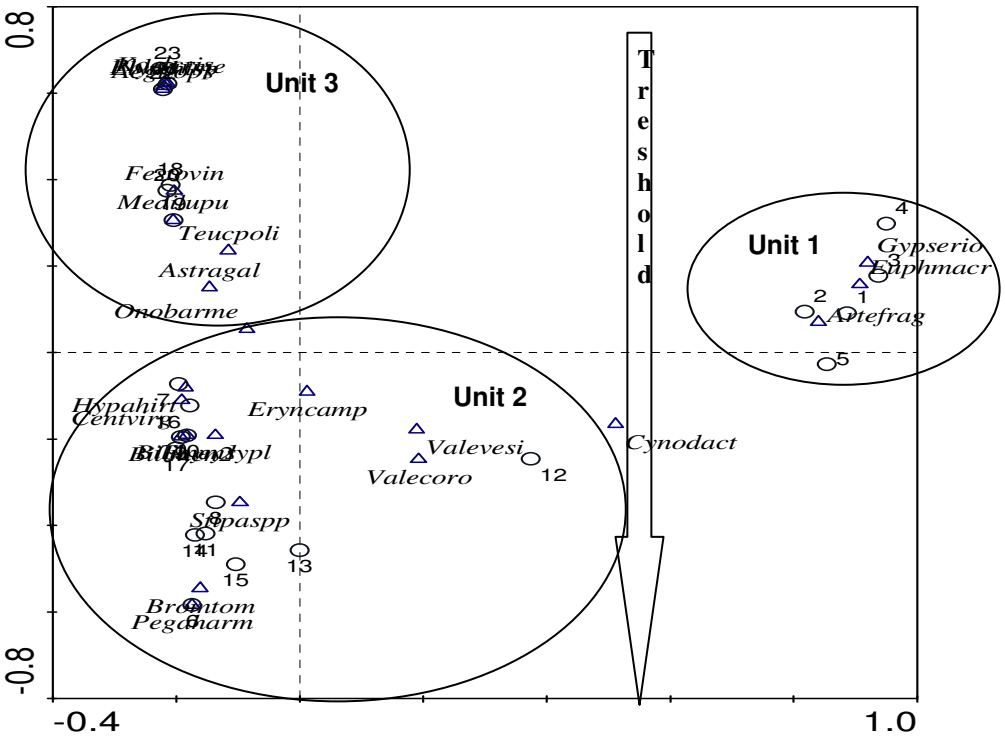
As going to right side of the ordination axis, bare ground and invader plant species were increasing and the occurrence of degraded rangeland stimulate erosion (Figure 1).

Ordination with environmental variables

Direct gradient analysis with Canonical Correspondence Analysis produced species-environment correlations, cumulative percentage variance of species-environment relation and sum of all canonical eigenvalues (Table 4). Sum of all eigenvalues and sum of all canonical eigenvalues were 2.383 and 1.419, respectively. Species-environment correlations were obtained as 0.969, 0.899, 0.772 and 0.848 for axis 1, 2, 3, and 4, respectively. The axis one explained 33.3 and 55.8 % of the cumulative percentages of variance of species data and species-environment relation, respectively. The four axes explained 57.5 and 96.5 % of the cumulative percentages of variance of species data and species-environment relation, respectively. The four axes of species data didn't contribute much to total variance. The variations explained by the species – environment is much more than the variations explained by the species. This indicates that the sites and the species were much more influenced by environmental factors. Changes in environmental conditions can potentially change dominance patterns and species composition, effectively changing the habitat type or potential natural community (Robin et al. 1993).

Table 4. The results of Canonical Correspondence Analysis of Species and Environment

Axes	1	2	3	4	Total inertia
Eigenvalues	0.792	0.316	0.150	0.111	2.383
Species-environment orrelations	0.969	0.899	0.772	0.848	
Cumulative percentage variance of species data	33.3	46.5	52.8	57.5	
Cumulative percentage variance of species-environment relation	55.8	78.1	88.7	96.5	
Sum of all eigenvalues					2.383
Sum of all canonical eigenvalues					1.419



← Deteriorated →		← Degraded →	**Rangeland trend**
Unhealthy =Problematic			**Rangeland health**
Good	Moderate	Poor	**Rangeland condition**
Grass Grassland domain		Shrub Shrubland domain	**Domain**

(*) Unit
1= Karakeçili village, Unit 2= Mahmutlar Şarklısı village, Unit 3 = Pazarcık village

Figure 1 Biplot of species and sites and comments of the current situation

Relationships of sites, species and environmental variables

Relationships of sites, species and environmental variables are clearly seen in Figure 2. Such a figure shows the patterns of variation in community composition that can be explained best by the environmental variables and also visualizes approximately the "centers" of the species distributions along each of the environmental variables (Ter Braak , 1986).

Altitude and aspect of environmental variables have adverse direction. This means two factors acts in an opposite manner. Some environmental factors such as grazing intensity, erosion and slope have the same dimensions and the similar relations (Figure 2). Increaser plant species *Cynodon dactylon* had a close relationship with aspect. Soil compactness and altitude were closely and positively related to some species such as *Medicago lupulina, Onobrychis armena* and *Festuca ovina* (Figure 2).

Sites 16, 18, 19, 21, 22 and 23 were high altitude areas. Some environment factors such as grazing intensity and soil erosion appeared at the similar sites to 7 and 10 . Sites 1-5 and 8- 15 had the same aspect. Aspect and altitude was in opposite dimensions that mean they had adverse relation. Grazing intensity, soil erosion and slope of which had the same dimensions that mean they had close relation.

Cynıdact: Cynodon dactylon
Artefrag: Artemisia fragrans
Thymsqua : Thymus squarrosus
Bromtom: Bromus tomentellus
Onobarme: Onobrychis armena
Elymhisp: Elymus hispidus
Hypahirt: Hyparhaenia hirta
Astragal :Astragalus strigillosus
Astragalus condensatus
Astragalus vulnerariae

Eryncamp: Eryngium campestre
Pegaharm: Peganum harmala
Festovin: Festuca ovina
Koelcris: Koelaria cristata
Phloarme: Phlomis armenica
Teucpoli: Teucrium polium
Euphmacr: Euphorbia macroclada
Medilupu: Medicago lupulina
Stipaspp: Stipa holosericea

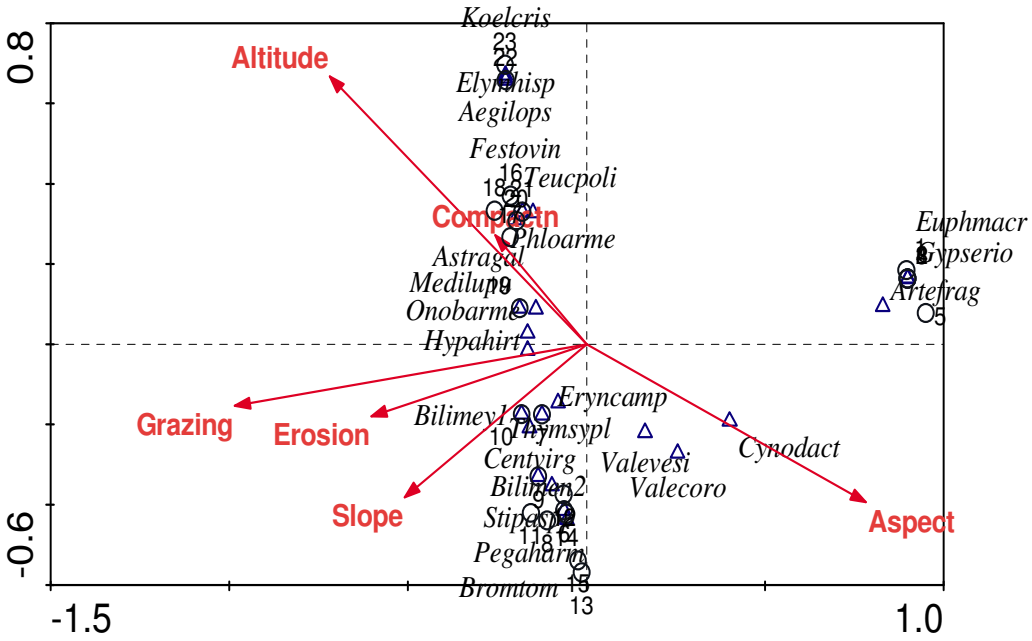


Figure 2 Triplot of species, sites, and environmental variables

Grazing intensity in sites with high slope value stimulated high soil erosion. This situation caused to disappear desired plant species on vegetations of rangelands. Some measures should be immediately taken for preventing rangeland condition from going worse and worse.

Consequently, the rangeland status was correctly defined and described with based on rangeland condition and rangeland health. Ordination techniques, Correspondence Analysis (CA) and Canonical Correspondence Analysis (CCA), were more suitable for finding and commenting the relations among sites, species and environmental variables. Ecological interpretations were contributed for understanding changes on vegetation in detail. Further studies are needed to obtain more comments and conclusions on the rangelands of the Central Anatolia Region.

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