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The Consequences of Banqueting and Fire on Plant Functional Groups (Case Study: Atbatan Rangelands, Bostanabad County)

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ABSTRACT

Aims Awareness about the effects of banqueting and fire on the vegetation in rangeland ecosystems is necessary for appropriate management. Regarding the importance of sustainable rangelands management and the lack of studies about fire and banqueting, the aim of the current study is to investigate the effect of rangeland restoration practices (banqueting with seeding) and also fire on plant functional groups in semi-arid region of Atbatan Rangelands, Bostanabad.

Materials & Methods For this purpose, after choosing the treatments and control sites, via random-systematic method in each site, thirty 1-m2 plots were established along three 30-meter transects (there were 30 plots for each area and 240 plots in total). The canopy cover of plant species was recorded within the plots and categorized based on plant functional groups.

Findings The results of statistical data analysis showed that the percentage of total cover in the north and south aspects of banqueting with 69.17% and 62.03% was significantly higher than the control sites with 52.53% and 48.03%, respectively. Fire in west aspect has reduced the percentage of vegetation (53.6%) compared to the control site (72.93%) whereas it did not have a significant effect in east aspect.

Conclusion Generally, it can be stated that banqueting in the north aspect has more and increasing effect on plant functional groups but fire has a more complicated behavior in different topographic conditions (aspect) in relation to the banqueting and in west control site in term of the most studied parameters it has significantly more values than the other sites.

Keywords Banqueting; Fire; Vegetation; Atbatan Rangelands; Bostan Abad

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[1] Range and range ... [2] Range ... [3] The effect of pitting, ripping and contour furrow ... [4] Contour furrowing, pitting, and ripping on ... [5] Effects of contour furrowing on soils, vegetation ... [6] Rangeland fire risk zonation using remote sensing ... [7] Fire effect on total organic matter and soil stability ... [8] Rangeland management in ... [9] Investigate plant diversity at different times ... [10] Post-fire runoff and erosion from simulated rainfall ... [11] Effects of grazing and fire on soil and vegetation ... [12] Effect of fire and rangeland banqueting on soil ... [13] Responses of Leymus chinensis (Poaceae) ... [14] Grassland management with prescribed ... [15] Grazing-induced spatial variability of soil ... [16] Investigating the effect of different operations ... [17] Changes in soil properties and vegetation following ... [18] Effects of grazing pressure, age of enclosures and ... [19] Grazing management impacts on vegetation, soil biota and soil ... [20] Rainwater harvesting: An option for dry land ... [21] Utilization of contour furrow and pitting ... [22] Indicator significance of some shrubs in the ... [23] Desert ecosystems: environment and ... [24] Evaluating the role of cutting treatments, fire ... [25] Early post-fire regeneration dynamics of Brachypodium ... [26] Effects of fire on properties of forest soils ... [27] Fire influence on vegetation changes of Zagros ... [28] Plant biodiversity patterns on Helan Mountain ... [29] Causes and consequences of fire-induced soil water ... [30] Impact of forest fire on physical, chemical and biological ... [31] Effect of fire on soil C, N and microbial ... [32] Soil physiochemical changes following 12 years of annual burning in ... [33] Investigating the effects of natural fire on some soil ...

Introduction

Due to the wide area of rangeland ecosystems and providing services to human communities, it is very important to maintain the quality and sustainability of these lands. In the meantime, the management of the rangeland ecosystems resources including vegetation and soil is very delicate and requires more detailed scientific studies [1]. Whenever for different reasons in the rangeland, the balance between production and allowable utilization rate is disturbed, so rehabilitation and improvement plans are recommended.

Banqueting, tracing, water reserving, rangeland plantation, and enclosure are among the common management practices for restoring rangeland ecosystems [2]. Due to the obtained different results from the implementation of these plans and variety in operations and environmental factors, it is necessary to consider these issues more intensively. In this regard, Habibzadeh *et al.* [3] in a research in the effect of pitting, ripping, and banqueting for moisture reserving and increasing the vegetation in experimental plots with different treatments (pitting, ripping, and banqueting with seeding and without seeding, control, only seeding) concluded that the highest percentage of vegetation with 44.66% is related to pitting with seeding and the lowest amount with 15.89% belongs for ripping without seeding. In investigating the impact of pitting, ripping, and banqueting on the United States West rangelands, it was found that due to the operation of banqueting, pitting and *Agropyron desertorum* planting after banqueting, forage production was significantly increased related to raised soil moisture and promoted infiltration [4]. Rich [5] investigated the impact of the mechanical 20 years old project of banqueting and stated that banqueting causes a significant increase in production and coverage percentage, shrub density and grasses and these events will lead to sustainability of production and ecosystem according to the perennially of most species. Also, his results showed that water reserve operations led to an increase in grass production, so that *Agropyron* sp. in the banqueting and control sites were 27 and 5%, respectively.

The occurrence of accidental fire or purposeful fires is another event in rangelands. Fire is considered as a serious problem distressing many terrestrial ecosystems in the earth system and causing the economic damages for people such as missing income [6].

Fire as an ecological factor always changes the vegetation structure. In some cases, fire can act as an improver for vegetation and soil or, in some circumstances, perform as a destructive agent of the rangeland. In any way, the fire causes a series of positive and negative changes in vegetation and soil [7]. In Iran's semi-arid natural ecosystems, most of the fires occur in the dry summer season and the purposeful fire is one of the oldest methods of rangeland restoration that humans use to control and replace and destroy aggressive and harmful plants and change vegetation around the grazing lands. The importance and effects of the fire are changed with the general weather conditions in each region and using the fire is suggested mainly for humid and semi-humid regions [1]. However, the fire is also an important factor in shaping and changing the sequence of vegetation cover of arid and semi-arid regions, but there are still different views on its effects [8], which can increase or decrease species diversity and vegetation cover [9]. In this case, on studying the amount of runoff and erosion in previously burned rangeland, Benavides-Solorio and MacDonald [10] concluded that fire in rangelands increases the runoff and soil erosion by about 50% compared to non-burned rangeland. Although, the fire creates some changes, especially in plant composition, most of the rangeland vegetation communities are flexible against the fire and its impacts depend on plant characteristics, as well as, plant moisture, the height of bud, plant yield in maturity, temperature, humidity, wind speed, season, repetition, severity, extent of expansion amount of fuel and succession stage. In a study conducted by Akhzari *et al.* [11], about the effect of fire on plant characteristics, the results indicated that the highest and the lowest above-ground biomass production (630 and 117kg ha^{-1}), Shannon-Wiener diversity index (2.37 and 1.07), soil total organic carbon (18.34 and 6.66g kg^{-1}) values were found in the unburned rangelands with 2000m distance from the water source and the one year post burned rangelands with 10m distance from the water source, respectively. The results of Faraji *et al.* [12] in surveying the effect of fire and rangeland banqueting on soil carbon sequestration showed the occurrence of fire in rangelands can reduce the amount of soil organic carbon. The rangeland banqueting increases the amount of soil organic carbon in both aspects.

By burning the vegetation, the fire significantly reduces the amount of woody, furrowed, and bushy plants and may provide a favorable environment for the growth and development of lower floor plants [13]. If the surface material is heated by fire and combined with waxiness material, it may create an impermeable layer on the soil, which ultimately leads to increased erosion. In general, the above-mentioned discussion shows that studies on the effect of fire on the ecosystem and the ecology of fire, especially in Iran, are limited and still there is less recognition on different aspects. The effects of fire on rangeland have shown both negative and positive effects in different studies. Therefore, it is possible to use the strengths and potential benefits of fire in rangeland improvement practices by recognizing the fire ecology. Regarding the new issues of fire in the country, there is still no accurate understanding about its effect on the various aspects of rangeland ecosystems.

Also, in order to better understand the intervention of the management agent and considering the necessity of evaluating the effects of banqueting improvement practices, it is unavoidable to evaluate such executive plans to be used in various management cases. Studies have been done on the effects of these factors on vegetation that have different situations in different environmental conditions. On the other hand, different plant functional groups have a different response to fire [14]. Hence, with more extensive studies in these fields, it is possible to recognize the realities to have better management decisions [2].

In Atbatan rangelands of Bostanabad, the banqueting operation and the occurred fire in recent years, provide an opportunity to conduct research and answer the mentioned questions. Therefore, by carrying out the current study, it is possible to evaluate the implementation of rangeland projects for the improvement and development of rangelands and determine whether the proposed restoration practices in the range management project would improve the conditions and characteristics of vegetation in the region. Also, it is possible to explain the effect of fire on rangeland characteristics and possible uses in rangeland improvement. With obtaining the results the rangeland improvement planners can select the best areas for implementing the banqueting project. Furthermore, the results will be used in applying the fire as an improvement tool in rangelands.

Materials and Methods

Study area

In this study, the rangeland of Atbatan village of Bostanabad, as the semi-steppe rangelands was selected. Based on country divisions it is located in East Azerbaijan Province. The study area is located in 75km northeast of Tabriz City and 7km from Bostanabad City, between 46°53'1" to 46°40'17" east longitude and 37°52'10" to 37°53'20'' north latitude and at elevation gradient of 1700 to 1930m above sea level. The dominant species in the rangelands are *Stipa barbata*, *Astragalus gossypinus*, and *Artemisia fragrans*. Based on the physiognomy, the vegetation structure of the region is a grass-shrub. Based on the 11-year meteorological data from the synoptic station of Bostanabad, the average annual precipitation is 325.2mm and the average annual temperature is 8.7°C. The minimum and maximum absolute temperatures are -10.4°C in December and 28.5°C in July. The region's climate is semi-arid based on the Amberger climatic classification.

In some parts of the rangelands of this area, banqueting with seeding as restoration operation has been carried out in the form of a rangeland management project about 25 years ago. *Bromus tomentellus* seeds have been planted in the farrows. The banquets in the region have been mainly conducted on the north and south slopes. The average height of the banquets is 30cm and the depth of the furrow is about 25cm.

Also, in surveying the available maps in the Google Earth and based on local people's information, two years before the sampling year, in 2014, the fire occurred in another part of the rangeland including west and east slopes. Thus, in the studied rangelands, treatments including biomechanical operations (banqueting with *Bromus tomentellus* seeds, in two geographical slopes of north and south) and the fire in two aspects of east and west were selected.

In order to investigate the effect of each treatment on the plant functional groups, control areas (without fire or banqueting) were selected in the vicinity of each treatment. In this regard, control sites are similar to treated areas in terms of environmental factors. Eight sites including four treatment sites and four control sites were selected as sampling sites (Figure 1).

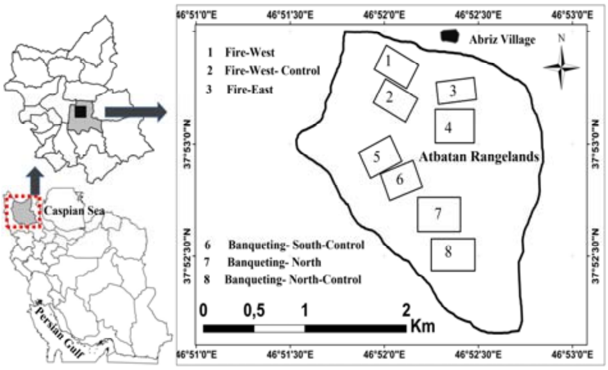

Figure 1) Location of the studied sites in the province and country

Vegetation data collecting

In each of the sampling sites, three 30-m transects were established systematically. Along each transect, ten 1-m^2 plots were used randomly, then the canopy cover of plant species was recorded within each plot. Finally, in this study, 24 transects and 240 plots were used for data collection of vegetation. After the collecting data, plant species were classified into functional groups in terms of growth form, life form, palatability class, and life span. In the end, the percentage of each group including the percentage of total vegetation, annual, biennial, perennial plants cover as life span, vegetation palatability class including I, II, III, life form such as percentage of hemicryptophyte, chamaephyte, geophyte, therophyte, and growth form including percentage of forbs, shrubs, and grasses were obtained.

Data analysis

Excel 2010 software was used to process the data. In statistical software SPSS 21, One-way ANOVA was used to investigate the differences of various plant functional groups among the sites in each treatment of fire and the banqueting (including operation and control sites in both aspects) separately. Duncan test was used to compare the means of functional groups among the sites.

Findings

Comparing the mean of the plant functional groups in the banqueting and control treatment in both north and south aspects has been done by Duncan test and presented in Table 1.

The results of one-way ANOVA (Table 1) for each of the plant functional groups show that banqueting in both north and south aspects in comparison with their control sites increased the total canopy cover, perennials, geophytes, and hemicryptophytes. While banqueting in both north and south aspects did not change significantly the percentage of shrubs, plants class III and class I. Banqueting increased the biennials, plants class II, forbs, and grasses only in the north aspect. On the other hand, banqueting led to an increase the chamaephyte only in the south aspect. In general, banqueting was more effective in the north aspect than south aspect site.

Table 2 shows the comparison of the mean of plant functional groups in fire and control treatment in both east and west aspects by the Duncan test. The results show that the occurrence of fire in both east and west aspects has reduced the shrub plants and chamaephyte and had no effect on the forbs, grasses, and plants class II in any of the aspects. Fire has a different effect on different aspects in terms of biennial and hemicryptophytes, so they decreased in the west and increased in the east aspect.

Table 1) The mean of plant functional groups in the treatment of banqueting and control in both north and south aspects

Parameters	South banqueting control	South banqueting	North banqueting control	North banqueting
Annual	13.07±6.31^{a}	7.96±4.36^{b}	9.1±7.06^{b}	10.0±5.32^{ab}
Biennial	3.26±0.85^{ab}	6.1±4.43^{a}	0.83±0.74^{b}	4.30±0.9^{b}
Perennial	31.7±12.07^{c}	49.63±15.59^{ab}	42.6±16.4^{b}	54.37±13.1^{a}
Class I	13.27±8.11^{ab}	18.03±11.96^{ab}	15.47±6.86^{ab}	10.2±7.25^{b}
Class II	17.1±8.05^{b}	19.8±12.11^{b}	18.63±12.98^{b}	33.73±12.26^{a}
Class III	17.67±13.22^{a}	24.2±12.14^{a}	18.43±12.43^{a}	25.23±12.54^{a}
Forb	17.8±6.44^{a}	19.3±9.51a	12.17±7.23^{b}	20.33±8.4^{a}
Grass	15.97±6.7^{b}	21.8±10.9^{ab}	16.37±8.33^{b}	23.47±10.1^{a}
Shrub	14.27±11.9^{b}	20.93±8.83^{ab}	24.0±14.86^{a}	25.37±12.34^{a}
Therophyte	12.83±6.13^{a}	7.5±3.9^{b}	8.43±6.39^{b}	10.0±5.32^{ab}
Geophyte	1.46±0.3^{bc}	4.13±0.6^{a}	0.83±1.74^{c}	4.06±3.6^{ab}
Hemicryptophyte	26.97±4.9^{bc}	35.57±14.2^{a}	21.97±9.3^{c}	31.6±10.4^{ab}
Chamaephyte	6.77±2.08^{c}	14.83±7.83^{b}	21.3±2.98^{ab}	23.5±12.03^{a}
Total canopy cover	48.03±14.1^{c}	62.03±15.14^{ab}	52.53±17.55^{ab}	69.17±12.95^{a}

Different letters in the row indicate a significant difference at 95% confidence level.

Table 2) The mean of plant functional groups in fire and control sites at both east and west aspects

Parameters	East fire control	East fire	West fire control	West fire
Annual	19.07±5.48^{b}	12.57±5.83^{c}	13.73±8.41^{bc}	27.73±11.81^{a}
Biennial	0.07±0.03^{b}	8.0±4.8^{a}	15.89±12.53^{a}	0.47±1.7^{b}
Perennial	36.63±10.25^{b}	32.17±10.98^{bc}	46.67±16.94^{a}	25.40±8.82^{c}
Class I	4.16±3.78^{b}	10.06±4.71^{a}	12.17±10.11^{a}	11.56±5.40^{a}
Class II	31.23±7.53^{a}	25.1±5.62^{a}	28.97±20.34^{a}	28.53±11.44^{a}
Class III	20.37±7.98^{b}	17.57±10.08^{b}	31.8±13.76^{a}	13.5±8.17^{b}
Forb	21.37±7.05^{a}	24.63±9.7^{a}	22.87±11.7^{a}	20.0±8.6^{a}
Grass	19.63±6.9^{b}	19.50±5.73^{b}	24.57±17.62^{ab}	28.33±11.8^{a}
Shrub	14.87±7.01^{a}	8.60±7.32^{c}	25.50±11.72^{a}	5.27±4.93^{c}
Therophyte	19.07±5.48^{b}	12.57±5.83^{c}	13.73±8.41^{bc}	27.73±11.81^{c}
Geophyte	1.40±0.26^{b}	5.53±3.9^{b}	15.70±6.56^{a}	5.43±4.2b
Hemicryptophyte	22.47±7.96^{bc}	29.0±8.7^{a}	28.50±11.24^{ab}	16.87±7.75c
Chamaephyte	12.83±6.95^{a}	5.63±4.7^{b}	15.0±10.35^{a}	3.57±3.36^{b}
Total Canopy Cover	55.77±11.94^{b}	52.73±12.38^{b}	72.93±22.0^{a}	16.55±53.6^{b}

Different letters in the row indicate a significant difference at 95% confidence level.

On the other hand, fire in the west has increased annuals and therophytes, and it has decreased the annual and therophyte in the east aspect.
Fire reduces the total canopy, geophytes, perennials, plants class III only in the west aspect and there was no effect on these plant groups in the east aspect. The fire has led to an increase in plants class I only in the east aspect. Totally, it can be mentioned, fire has a more complex behavior than banqueting and west control site, in terms of most of the studied functional plant groups, has significantly more values than other sites.

Discussion

The structure and function of vegetation have always been in strong interaction with the natural environment and management factors and can be changed under different conditions and eventually affects the livelihood of rangeland exploiters [15]. In this study, the effects of two treatments including fire and banqueting on plant functional groups were investigated in rangelands ecosystems.
The results of one-way ANOVA for each of plant functional groups show that banqueting in both northern and southern aspects compared to their control sites increased the total canopy cover, perennials, geophytes, and hemicryophytes. The results of this study on the positive effect of banqueting on plant characteristics are similar with results of Jafari *et al.* [16], Jeddi and Chaieb [17], Angassa and Oba [18], Teaguea *et al.* [19], and Yosef and Asmamaw [20]. They expressed the reason for increasing the average percentage of vegetation cover at banqueting site is because of increasing soil permeability and decreasing soil erosion. So that the creation of rippling in the contour lines gives the opportunity of penetration into the soil. Finally, with sufficient moisture content, the vegetation cover will enhance. Habibzadeh *et al.* [3] and Jahantigh and Pessarakli [21] stated that the increasing of vegetation in banqueting sites of arid and semi-arid regions is in result of the presence of large roughness in the soil surface which greatly reduces the flow of the outlet and allows more penetration and creating a safe environment for the collection of seeds and litter. Finally, this can lead to better coverage in the area of banqueting compared to the control area.
According to the results, the banqueting in both north and south aspects did not change significantly the percentage of shrubs, plants class III and class I, and only in the north aspect the biennials and plants class II, forbs and grasses were increased. On the other hand, the results of this study showed that the banqueting increased only the chamaephytes in the southern slope. As a result, it can be claimed that topography can interact with the response of the management factor. In this regard, it is stated that after the climate, the topography is the second controlling factor in ecosystem characterization in a region [13]. Topography through the effect water distribution and energy intake is counted as one of the important factors that, in the short term, it has a great influence on the variability of soil properties such as organic carbon [22]. In this regard, Rich [5] reports that banqueting after 20 years increased the percentage of grass and shrubs cover, and this will lead to the sustainability of ecosystem production. He also argued that the water reserving operation increased the production of grasses so that the *Agropyron* sp. has increased in the banqueting site compared with the control site and the reason for the increase in the average of total vegetation, biennial, perennial, plants class II, class III,

forbs, in the recent study are in line with these findings.

Also, Noy-Meir [23] has shown that banqueting in relation to the control area has the highest mean in terms of the indicators, which suggests that the restoration practices improve the rangeland. In particular, banqueting improves the vegetation cover. In confirmation of this, Habibzadeh *et al.* [3] reported that the restoration operation of banqueting and seeding compared to other restoration operations had the greatest impact on the improvement of rangeland cover. In this regard, Azarnivand and Zare Chahouki [2] stated that the banqueting is possible to increase the water permeability in the soil in different regions and finally increasing the coverage is one of the banqueting results. Therefore, the north aspect is more suitable for constructing banquets.

Effect of fire on vegetation properties

According to the results, the occurrence of fire in both east and west aspects has reduced shrubs and chamaephytes and has no effect on forbs, grasses, and plants class II in any of the aspects. In this regard, it is mentioned that fire with burning vegetation reduces significantly the number of woody plants and shrubs in the upper floor and provides a favorable situation for the growth and development of lower understory plants [24]. The main reason for the persistence and increasing of perennial grasses is related to its resistance to fire and their location of growth buds on the ground or underground [14], but growth buds of shrubs are higher than the ground surface, and they are more vulnerable to fire and additionally the stem stickiness intensify the effect of burning.

The results of the current study show that fire has a different effect on biennials and hemicryptophytes, which decreased in the west aspect and increased in the east. On the other hand, fire in the west aspect has increased annuals and therophytes, and in the eastern aspect, it has decreased the annuals and therophytes. As a brief explanation, it should be noted that the effects of fire on natural ecosystems are very complicated because the plants response variously to fire depending on the climate, type, time, fire intensity, the inherent potential of species in fire resistance, and the opportunity to regenerate [25]. According to the findings of Fireman and Hayward [22], because of the lower moisture content and greater evapotranspiration in the west part compared with the east aspect, annual plants grow faster and finally have less stress in fire conditions because they have seeded before the fire occurrence. So in the following year, the west slopes had more annual cover. Easily regeneration and low stresses in annuals in the years after the fire and on the other hand damaging biennial plants and hemicryptophytes in the year of fire caused annuals to be dominated in competition with biannual and hemicryptophytes. According to the results of Certini [26], another reason for this claim is the lack of opportunity for biannual plants and hemicryptophytes to store materials and restructure between the time after the fire and the end of the growing season. On the other hand, Fattahi and Tahmasebi [27] explained that annual plants in the early years after the fire will reduce by about 15%, if fire happens before the end of the growing season and their seed production.

The results showed that fire reduced the total canopy cover, geophytes, perennials, plants class III only in west aspect and did not have an effect on these plant groups in the east aspect. Due to the long-term and severe radiation of the sun to the west slopes in summer, soil moisture evaporates more than the east slope, and as a result, the moisture content of the soil and even the plants will be less than the east aspect [28]. Hence, these conditions mainly will damage the perennial, geophytes and soil organic matter. On this basis, it is concluded that the negative effect of fire in such a drought environment is intensive. Finally, it will reduce the potential for moisture reserving in soil and environment [29]. In line with the results of this study, Wang [13], concluded that soil cover will be decreased due to the burning of litters and the reduction of the organic matter input in the soil. The direct heat of fire on the soil causes to destroy the root and seeds of the plants and oxidize soil nutrients [30]. The severity of fire affects the soil microbial community and the availability of nutrient. Both factors affect the development of plant species in the burned area [31].

The results of the current study showed that fire in the east aspect increased the plants class I. This finding is consistent with the results of Kristofor [32], Javadi and Mamon [33] researches. In this regard, it is mentioned that along with the reduction of shrubs, most of which are class III, the conditions are more suitable for increasing class I and palatable plants.

Conclusion

As a result of the banqueting operation and fire in the rangelands of Bostanabad, Atbatan area, the functional groups of vegetation increased in the treatment area compared to the control site and it is suitable for establishing suitable forage species such as *Agropyron elongatum*, *Bromus tomentellus*, *Cynodon dactylon*, and *Dactylis glomerata*, and providing seeding conditions in the field and restoring plant life. It should be noted that the effect of fire on the grass is bilateral, which has both positive and negative effects. In general, provided the possibility of establishing plant species and the formation of secondary sequences, the evolution of soil, the formation of appropriate micro-climax and the conditions for the presence of forage, as a result, the condition of the vegetation and litter content improved in comparing with the control site.

It can be concluded that the implementation of banqueting with seeding has been successful in the rangelands of the region and had a positive effect on the vegetation characteristics of the region. The fire has a more complicated behavior than banqueting, and the west control site has significantly higher values for most of the parameters compared to other sites. Although there was a negative effect of fire for some functional groups, it is suggested that more research must be done on other aspects of this factor. Overall, the results indicated that the implementation of restoration practices in rangelands could have different effects depending on the type of practices, aspect, and vegetation cover structure. Therefore, if correct restoration operation of rangelands is selected in accordance with the conditions of the region, its positive effects can be used to restore the rangelands.

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