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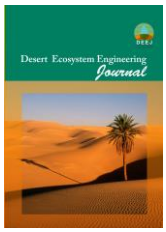

Landscape Function Analysis to Assess the Grazing Effect on Some Soil Features in Arid Ecosystem

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Abstract

Sustainable rangelands management continues to be one of the main challenges facing arid ecosystem. The function of a rangeland ecosystem depends on the conservation of resources within the ecosystem. Finding the rangeland ecosystem functions requires the knowledge of soil and vegetation characteristics to understand the ecosystem's capabilities. In this research, in order to identify the damaged areas in arid regions, the effect of grazing on the ecosystem function was investigated using the distance from the water resources. Thus, in the present study, around 3 water resources in 4 principal geographical directions and 172 plots with 4 m^2 were installed. In each plot, 11-soil surface indexes were estimated by the landscape function analysis (LFA) method. Then, using 11 soil surface indexes, three soil functional properties include stability; permeability and nutrient cycle were calculated. In order to determine the sensitivity of the LFA method and separate the functional and structural characteristics SPSS software V.19 were used and the analysis of variance and comparing the mean of common features conducted by Duncan's method. Multivariate analysis of variance and correlation showed that the three functional features had no significant relationship with the four geographical directions ($P < 0.01$) but had a significant relationship with the distance from the water resources ($P < 0.01$). These results indicated that the ecosystem functions increases with distance from the water resources. Also, the results of Duncan's test showed that the high grazing intensity near the water resources caused a critical range of 150m from the water resources.

Keywords: Grazing, Water resources, Ecosystem, Soil surface, LFA.

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Introduction

In an arid ecosystem, sustainable management of rangelands is one of the main challenges that researchers, policymakers, and managers deal with. Many problems stem from the ecological and climatic characteristics of rangelands. Uniform and unbalanced grazing are one of the problems that rangeland's managers always confront with it (Mosadghi, 2003). Water resources are the control tools affecting the distribution of livestock in arid and semi-arid regions, which have a positive and negative effect on the structure and function of the ecosystem of these areas (Hart et al., 1993). Due to the fragility of arid and semi-arid ecosystems, the sequential review of the changes in the structure and performance of these ecosystems with distance from the water resources is necessary during the trapping path.

By changing the structure and function of the ecosystem, ecosystem status is meaningful (Bastin et al., 1993). The term of the rangeland condition, which is used for many years, soil is the most important element in the rangeland ecosystem that should be considered. By examining the changes in the soil surface indexes, the ecosystem's condition can be determined, which helps the experts to identify the damaged areas. It allows the expert to judge the changes resulting from management activities and the ecological changes of the rangeland (Böllemier, 2006; Work, 1997).

Tongway and Hendli (2005) proposed the evaluation of soil surface and rangeland characteristics as a simple applied approach to assessing the rangeland's potential. The landscape function analysis (LFA) method presented by Tongway (1995) is a simple method for studying the potential quality and the ability of the natural ecosystem such as rangelands and deserts. It is assessed using the three functional properties of stability, permeability, and nutrient cycle that estimate the ecosystem function. In fact, the analysis of rangeland ecosystem performance using visible indicators of the soil surface measures the efficiency of a rangeland as a biophysical system. This method is one of the evaluation techniques in the 1620 permanent pasture sites of Australian rangelands, which is used in the western Australian rangeland assessment system (WARMS) (Watson et al., 2007).

Ahmadi et al. (2008) used the LFA method to determine the critical threshold in rangeland ecosystems using 4km distance as an ecological threshold. The results of their study showed a meaningful difference between the three functional characteristics and a structural characteristic at the beginning and the end of the three villages. Besides, the rangelands near the end of the village had fewer functional and structural values. They also suggested that managers of rangelands should consider more accuracy and cost in areas where the amount of functional and structural difference is greater. In one study, soil compressing and severe grazing of rangelands were compared as management treatments by LFA method. The results showed that with increasing grazing intensity, the structure of damaged parts and the intervals between parts were increased and permeability was decreased. Arzani et al. (2007) and Karmfs et al. (2002) compared the results of the LFA method with the results obtained from the remote sensing (RS) method. Their results showed the high accuracy of the LFA method to predict the future trend of ecosystem changes. The results of a comparison of rangeland management by Abedi et al. (2006) showed that an increase in grazing intensity results in an increase in the structure of damaged parts and the intervals between parts and a decrease in permeability.

Ghalichnia et al. (2008) evaluated the rangeland status by four-factor and LFA methods; the results indicated a significant difference between the two methods. They showed the minimum and maximum performance levels of the stability, permeability, and nutrient cycle in the critical region and reference region, respectively. Palmer et al. (2001) compared two rangeland ecosystems with different management (private and public) using LFA method and considered soil data simultaneously. Tongway and Loudind (2002) stated that LFA indicators were the best predictor of rangeland production. Lotfi Anari and Heshmati (2009) evaluated the accuracy of the LFA method to adapt this method to central Iranian rangeland ecosystems. After analyzing the sensitivity of the parameters, they were removed from the soil texture, type, and severity of erosion, which showed the least sensitivity. On the other hand, the soil gravel parameter was added to the soil surface. In this case, the accuracy of the method reached the correct accuracy ($R > 0.6$).

Mollaei et al. (2010) studied the effect of the enclosure on soil yield in rangelands using the LFA method. The results showed the overall comparison of the performance between transects inside and outside the enclosure. The stability index showed a significant difference, but the permeability and nutrient cycle showed no significant difference. Heshmati (1997) and Khosravi mashzi (2011) examined the changes in ecosystem function in shrublands of southern

Australia using this method during gradient grazing. The results showed that the ecosystem functions were increased by the distance from the water resources. In Iran, many researchers have studied this method. These studies showed that the LFA method showed a good response to ecosystem's performance against environmental disturbances, such as grazing severity.

There are various strategies and methods to identify the damaged areas, but the evaluating their success with soil properties in arid areas might not be justified. Therefore, the objective of the present study is to assess the effect of grazing on the ecosystem function in order to identify the damaged areas in arid regions.

Materials and Methods

The present study was conducted in the rangelands with an area of 4500 hectares in Isfahan province between the Kashan and Ghamsar cities, which is located between longitudes of 56° 51′ - 56° 10′ E and latitudes 29° 30′ - 29° 59′ N. The dominant species in this area is *Artemisia sieberi* and the average rainfall is 119 mm and has an irregular distribution. According to the Doumarten methodology, the climate of this region is semi-dry.

Sampling method: In order to collect data, around the 3 water resources of Garrison, rose farm, and Moslemabad village, 8 transects with 2km length in 4 main geographical directions were deployed. Plots were placed on each transect, from 50 to 100m with a distance of 50 meters, from 100 to 1000m with a distance of 200 meters, from 1000 to 2000m with a distance of 250 meters, and one plot 4 square meters (15 plots per transect). Due to the existence of some natural barriers, the sampling was not performed in some directions.

In the 172 plots, 11 soil indexes of LFA method were estimated, which include: soil cover, perennial grasses, vegetation cover of pteridophytes, vegetation cover of grasses, trees and shrubs; origin and degree of decomposition of litter, type and severity of erosion; sediment materials, soil surface roughness, destruction resistance, soil moisture stability, and soil texture test (Tongway, 1995). Three functional properties of stability, permeability, and nutrient cycle were estimated using 11 soil surface indexes. Using Pearson correlation test and multivariate analysis of variance analysis, the relationship between each functional characteristic with distance from the water resources at four directions was investigated. In the case of the significance of the treatments in the multivariate analysis of variance analysis, the Duncan multivariate test was used to determine critical areas around the water resources.

Results

As shown in Table 1, three functional properties of stability, permeability, and nutrient cycle were not correlated with the geographic direction ($P < 0.01$) but had a positive and significant correlation with the distance from the water resources ($P < 0.01$). Multivariate analysis of variance showed that the mean of each functional characteristic was not significantly different in the four directions ($P < 0.01$), but there was a significant difference with the distance from the water resources ($P < 0.01$). The results of Duncan's mean test showed two distinct functional distances in terms of average stability, nutrient cycle, and permeability, so that the percentage of stability, nutrient cycle, and permeability were reduced significantly at a distance of 100, 200 and 300 m from the water resources. (Figs 1, 2 and 3).

Table 1: Pearson Correlation and Multivariate Analysis of Variance for Functional Characteristics

Functional features	Distance	Direction	Distance	Sig	Direction	Sig	Direction* Distance	Sig
Sustainability	0.53^{**}	-0.10^{ns}	2.40^{**}	0	-0.15^{ns}	0.87^{**}	0.07^{ns}	1
Penetrability	0.49^{**}	-0.15^{ns}	2.34^{**}	0	-0.87^{ns}	0.39^{**}	0.12^{ns}	1
Nuriant cycle	0.52^{**}	-0.10^{ns}	13.17^{**}	0	-1.24^{ns}	0.2^{7**}	0.33^{ns}	1

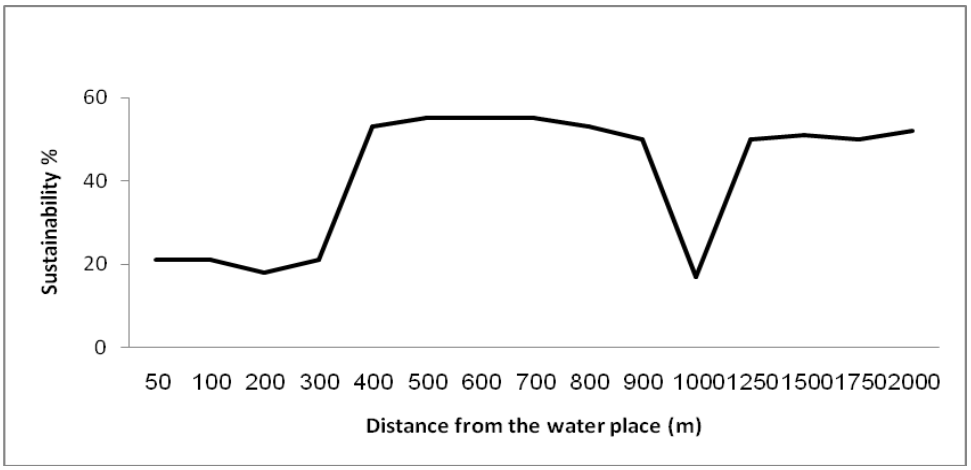

Fig 1: Duncan's mean comparison of functional stability feature

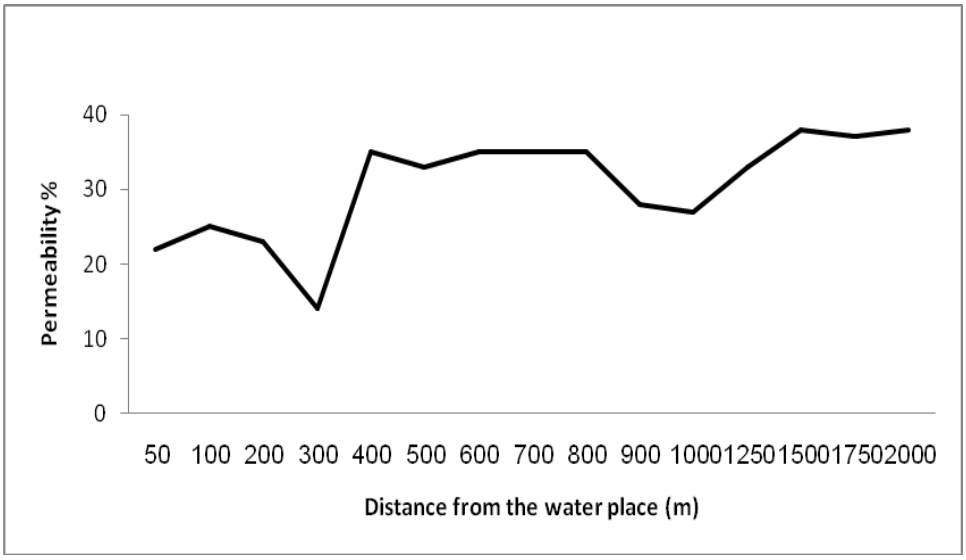

Fig 2: Duncan's mean comparison of functional permeability feature

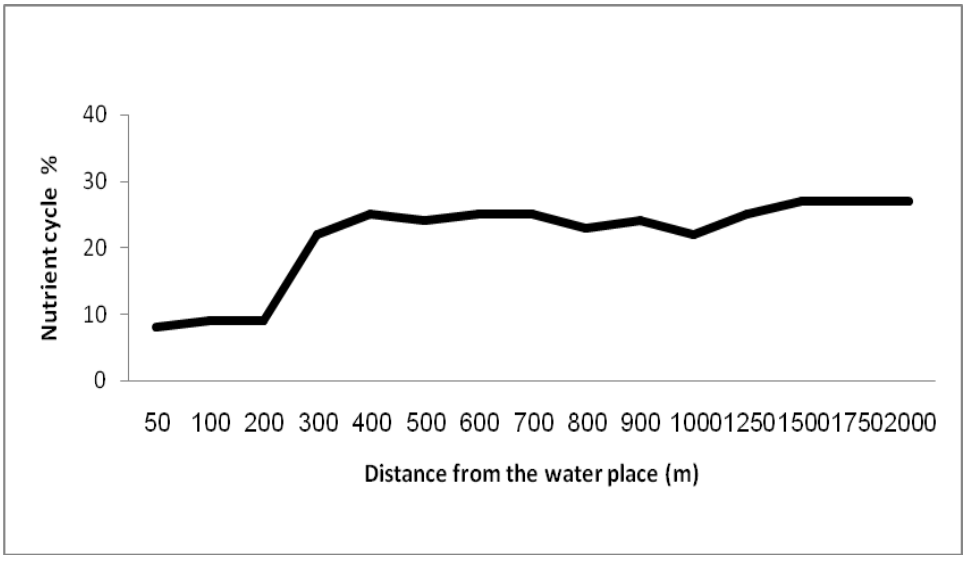

Fig 3: Duncan's mean comparison of functional nutrient cycle feature

Discussion

The results of this study showed that the geographic directions had no effect on ecosystem function, but the distance from the water resources increase the function of the ecosystem. These results were in agreement with the results of Heshmati (1997). Since grazing intensity and livestock traffic near the water resources were more severe than distances away from them, the soil surface compaction by livestock in this area caused the crusting of the surface of the soil. The compression of the soil led to breakdown of the shells and reduces the ability of nitrogen fixation, so the wind and water erosion increased. As a result, the ecosystem functions near the water resources were declined heavily. Thus, a very critical area of functional ecosystems up to 200 m radius from the water resources was created. Special attention should be provided by managers to improve the ecosystem function of this area. However, by increasing the distance from the water resources and a decrease of grazing intensity, the ecosystem performance status was improved. The results were in agreement with those of Arzani el al. (2007) and Ghalichnia et al. (2007). Based on the results of the research, the function of the ecosystem was increases by distance from the water place, but the approximately 1Km distance from the water resources, a decrease in the variation of functional characteristics and stability was observed. In short, it can be said that as livestock tends to move in certain paths, micro traces formed among plant species, therefore, the high density of micro traces in this range can be assigned to the reduction of the functional characteristics of stability.

Conclusions

The aim of this study is to assess the effect of grazing on the ecosystem function in order to identify the damaged areas in arid regions. Therefore, an approach has been taken in order to select the most representative indicators for the assessment of rangeland soil properties.

The correlations between soil properties and the distance from the water resources in diverse geographic direction were investigated and interpreted based on statistical analyses. Multivariate statistical techniques were used to determine the indicators among soil variables, as well as water resources of landscape function analyses approach. Three functional properties of stability, permeability, and nutrient cycle were not correlated with the geographic direction but had a positive and significant correlation with the distance from the water resources.

Multivariate analysis of variance showed that the mean of each functional characteristic was not significantly different in the four directions, but there was a significant difference with the distance from the water resources. The percentage of stability, nutrient cycle, and permeability was reduced significantly at a distance of 100, 200, and 300 m from the water resources. Livestock tends to move in certain paths and micro traces formed among plant species, therefore, the high density of micro traces in this range can be attributed to the reduction of the functional characteristics of stability. Besides, ecosystem functions increase with distance from the water resources. Also the results of Duncan's test showed that the high grazing intensity near the water resources caused a critical range of 150m from the water resources.

References

1. Abedi, M., Arzani, H., Shahriari, E., Tongway, D and Aminzadeh, M. 2007. Evaluation of the structure and function of plant parts rangeland in arid and semi-arid, Journal of Ecology. 40: pp. 126-117.
2. Ahmadi, Z., Heshmati, GA., Mohseni Saravi, M., Arzani, H and Bihamta, M. 2009. Determining of critical threshold in the rangeland: Case Study privacy Rangelands from three villages in the province of Golestan, Gorgan Journal of Agricultural Sciences and Natural Resources Vol. 15, No. 1, Specifics of Natural Resources, pp. 109-102.
3. Arzani, H., Abedi, M. and Shahryari, E. 2007. Investigation of soil surface indicators and rangeland functional attributes by grazing intense and land cultivation. J. range and Desert. 14: 1. 68-79.
4. Arzani, H., Abedi, M., Shahriari., E and Ghorbani, M. 2007. Investigation of changes in soil surface indexes and functional characteristics of pasture due to grazing intensity and rangeland plowing (Case study: Orazan Taleghan). Rangeland and Desert of Iran, 14(1), pp. 79-68.
5. Bastin, G.N., Sparrow, A.D. and Pearce, G. 1993. Grazing gradients in central Australian Rangelands: ground verification of Remote Sensing-Based approaches. J. Range. 15: 217-233.
6. Bestelmeyer, B.T. 2006. Threshold concepts and their use in rangeland management and restoration: the good, the bad, and the insidious. restoration ecology, 14: 325-329.

7. Ghalichnia, H., Heshmati, GA, and Chaeichi, M. 2008, Comparison of Rangeland Status Evaluation with Soil Characteristics Method and Four-factor Method in Rangelands of Golestan National Park, Journal of Research and Development (Natural Resources): 87, pp. 50-41.
8. Ghelichnia, H., Heshmati, GH.A., Chaichi, M.R. and Khorasani, N. 2007. The relation between nominal and empirical indicators of range functions in shrublands of Golestan National Park. J. Pajouhesh and Sazandegi. 74: 53-60.
9. Hart, R.H., Bissio, J., Samuel, J. and Waggoner, J.W. 1993. Grazing systems, pasture size, and cattle grazing behavior, distribution, and gains. J. Range Manage. 46: 81-87.
10. Heshmati, G.A. 1997. Plant and soil indicator for detecting zone around water points in arid perennial chenopod shrublands of South Australia. Thesis for the degree of Philosophy. University of Adelaid, 169p.
11. Heshmati, GA., Amirkhani, M., Heydari, Gh, and Hosseini, S.A. 2008. Qualitative assessment of rangeland ecosystem capability of Gomishan region of Golestan province using field functions index, Journal of Rangeland,1(1), pp: 115-103.
12. Heshmati, GA., Karimian, A., Karami, P and Amirkhani, M. 2007. Qualitative assessment of the rangeland ecosystem capability of the hilltop area of Inceh at Golestan province. Journal of Agricultural Sciences and Natural Resources of Gorgan, 14:(1), pp:89-96.
13. Karfs, R. 2002. Rangeland monitoring in tropical savanna grasslands, Northern Territory, Australia: relationships between temporal satellite data and ground data. Masters Thesis, Research School of Tropical Environment Studies and Geography, James Cook University, Townsville, Australia.
14. Karr, H. 1997. Rangeland health, for 58472. National Resources Conservation service Evolution, 3: 336-339.
15. Khosravi Mashizi, A., Heshmati, GH., Sepehri, A., Azarnivand, H. 2011, Investigating the changes of soil surface indices along grazing gradient in semi-arid lands, Jornal. of Water and Soil Conservation:17(4),45-54.
16. Lotfi Anari, P, and Heshmati, GA. 2009. Comparison of Landscape Function Analysis Method in Central Iranian Rangeland Ecosystems, Journal of Rangeland and Desert: 16(3), pp. 399-386.
17. Mesdaghi, M. 2003. Range management in Iran. Astan Ghods. Press, 320p. (In Persian).Tongway, D.J. 1995. Rangeland soil condition assessment manual. CSIRO. Melbourne.
18. Mollaeirenani, M., Bashari, H and Basiri M. 2010. Investigation of the effect of captive on surface soil indexes in rangelands of Isfahan region. First National Conference on Natural Resources Research, October 28-29, Kurdistan University, Iran.
19. Palmer, A.R., Killer, F.J., Avis, M.A., and Tongway, D.J., 2001. Defining a function in rangelands at the district eastern cape using landscape function analysis. African Journal of Range and Forage Science, 18: 53-58.
20. Pyke, D. A., Herrick, J. E., Shaver, P., and Pellant M., 2002. Rangeland health attributes and indicators for qualitative assessment. J. Range Manage (55): 584–597.
21. Tongway, D. J., and Hindley, N. L. 2005. Landscape function analysis: Procedures for monitoring and assessing landscapes, CSIRO Sustainable Ecosystems, Canberra, Australia.Pp: 80.
22. Tongway, D.J., and Ludwig, J., 2002. Desertification reversing, in Ratten Lal. Marcel Dekker, New York, 343-345.
23. Watson, I. W., Novelly, P. E., Thomas, P. W. E., 2007. Monitoring changes in pastoral rangelands the Western Australian Rangeland Monitoring System (WARMS). Rangeland Journal, 29 (2): 191-205.