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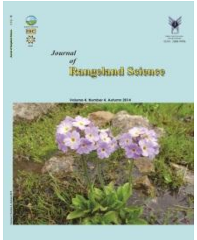

Research and Full Length Article:

Investigation of Vegetation Dynamics and Range Conditions in Central Desert of Iran (Case Study: Haftooman, Khoor and Biabanak)

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Abstract. The purpose of this study was to investigate vegetation dynamics and range conditions considering the climatic conditions and soil properties in Haftooman, Khoor and Biabanak deserts, Iran. For this purpose, after determining vegetation types and the associated species, the type of rangeland utilization, grazing season, the livestock type, the other relevant information, vegetation data including annual canopy cover, perennial forbs, shrubs, total canopy cover, soil moisture and carbon percent were determined over four years. Data were collected along three transects in each vegetation type. For each transect, 10 plots were established. The size of plots was 2.5 x 2.0 m^2 considering the life form of dominant species. Embrothermic diagram was drawn according to the monthly temperature and precipitation data of Choopanan synoptic station. Data were analyzed and means comparisons were made using Duncan method. According to the results, significant differences were observed between the years for the annual canopy cover, soil moisture of the second depth, soil cover, soil organic carbon ($P<0.01$) and *Zygophyllum atriplicoides*, *Artemisia sieberi*, *Carex stenophylla*, shrubs, forbs, total canopy cover, soil moisture of the first depth and the average soil moisture content ($P<0.05$). In this site, due to the desert conditions, the amount of vegetation and its variation are affected by the precipitation changes.

Key words: Vegetation dynamics, Range conditions, Variation trend, Canopy cover, Haftooman

Introduction

Factors affecting rangeland changes can be divided into two categories including natural and anthropogenic ones which among natural factors, climate could be considered as the most important factor. Over time, rangelands have adopted the natural conditions and climate without human interventions. Range management is considered as an effective human factor in the rangeland which could be led to its stabilization or degradation. Therefore, the investigation and determination of rangeland changes indicate the management mode applied on the rangeland which is of utmost importance.

Range conditions classification is also an attempt to separate the changes occurring in a habitat, vegetation type or rangeland site (Pamo *et al.*, 1991). To study the trend of changes and recognize the contribution of climatic variations and management, a long-term assessment is needed. Range conditions may be the most important factor for range management (Pieper and Beck, 1990). The value of awareness of range conditions is that if the range conditions are excellent or good, management strategies are continued and if the range conditions are moderate or weak, management policies need to be changed (Pendelton, 1989 and Risser, 1989). Moghaddam (1998) believes that in the arid and semi-arid regions like Iran, climate constraints do not allow the vegetation cover to be higher than a certain extent for example 50%. He also believes that in each region, different range conditions from very poor to excellent may be separated. Akbarzadeh (1996) reported that the vegetation cover of an arid region with a precipitation of 150 mm could be reached to maximum 20%. Therefore, the methods of range conditions assessment should be prepared so that maximum available vegetation cover with regard to the ecological potential of the region is taken into consideration in these methods. Four-factor and six-factor methods are conventional ones in the determination of range conditions in Iran. However, new concepts such as rangeland health including different classes of the healthy, exposed to risk, unhealthy, and threshold have been presented. However, rangeland dynamic as a comprehensive and flexible method has long been experienced in the developed countries as a strong method for monitoring the qualitative and quantitative changes of vegetation.

The determination of range conditions has been investigated by some researchers who are mentioned as follows: Yorks *et al.* (1992) investigated the differences of vegetation in the shrub lands of Utah, USA during 1933-1989, and reported that livestock grazing balance was the most influential factor in the improvement of range conditions and range trend. Mohamadi Golrang (1994) in a study on vegetation changes of Karaj watershed, Iran stated that overgrazing was the main cause of the observed changes in the vegetation types of the region. Oconner and Roux (1995) studied the effects of precipitation and livestock grazing on the vegetation changes of Carov in shrub lands in South Africa during 1949-1971. They showed that the changes in vegetation community were mainly affected by the changes of precipitation as compared to livestock grazing which was more important in long periods. Rostami (1995) introduced the overgrazing as the most important factor in the reduction of vegetation density of Kbootarkhan of Kerman region over the past 40 years. Alzerreca *et al.* (1998) investigated the effects of livestock grazing on vegetation dynamics in a vegetation community located in desert rangelands of Southwest Utah during 1935-1994. They concluded that vegetation dynamics were affected by grazing as compared to climate. Arzani *et* *al.* (2005) investigated the changes trend of range conditions in steppe regions of Yazd province, Iran during a five-year period using a four-factor method. Results showed that no significant difference was observed between vigor and vitality indices and the score of range conditions. As a result, in the arid regions, these factors do not play a significant role in the determination of range conditions. Baghestani Maibodi *et al.* (2006) studied the effects of exclosure on the vegetation changes of steppe rangelands in Yazd province, Iran in two decades. Their results showed that canopy cover percent and total yield were significantly affected by exclosure. They concluded that in general, the changes trend of vegetation in the rangelands of arid regions was slow. Akbarzadeh *et al.* (2006) investigated vegetation changes in Koohrang exclosure, Iran and reported good and very poor range conditions for inside and outside the exclosure, respectively. They concluded that exclosure caused an increase in the number of forage species. Khatirnamni (2007) conducted a research on the vegetation changes of Gonbad rangelands under grazing and exclosure conditions. Results showed a significant difference for canopy cover inside and outside the exclosure while no significant difference was observed for forage yield. As a result, they concluded that exclosure in the rangelands of arid regions would not be effective in short term. Fadzayi *et al.* (2008) studied short and long term vegetation changes related to the grazing systems, precipitation and Mesquite cover. They reported that the absence of a detectable grazing effect on vegetation changes may be due to overriding influences of grazing intensity, pasture size, precipitation variability and few replicates. Tietjen *et al.* (2010) investigated the effects of climatic changes on the coupled dynamics of water and vegetation in drylands. Their results showed that two main factors controlled the response of plant types towards the climatic change, namely a change in water availability and a change in water allocation to a specific plant type. Noori *et al.* (2010) determined the relationships between the drought and rangeland yield changes in Sistan and Balouchestan province, Iran during 1991-2007. According to their results, a significant difference was found between the amount of forage yield and precipitation. Range health changes were assessed in semi-arid rangelands of Zagros, Semirom, Iran by Moradi *et al.* (2012). The results of their study highlighted the difficulty of detecting changes over the extensive areas of rangeland while separating management induced the effects resulting from climatic impacts in an environment which experienced wide spatial and temporal variations in rainfall. Ghaemi *et al.* (2012) studied the vegetation changes of semi-steppe rangelands in west Azarbayejan, Iran. They measured vegetation changes under grazing and exclosure conditions during 1995 to 2005. According to the results in the exclosure site, total canopy cover increased and the highest values were observed in perennial grasses (more than 3.5 times) and perennial forbs (more than 2.5 times). Outside the exclosure, total vegetation remained constant. In addition, a significant correlation was found between the changes of precipitation and canopy cover in most of the species. In general, knowledge on the changes' trend of range conditions is necessary for the principal management of desert rangelands to achieve sustainable utilization. This research was aimed to determine range conditions through studying vegetation dynamics and change trends considering climatic conditions and soil properties in Khoor and Biabanak located in Iranian central desert.

Materials and Methods

Case study

Khoor and Biabanak with an area more than 12 thousand km^2 is located at longitude of 55° E and latitude of 33° 47' N in the northern hemisphere desert belt. The study area has an arid climate and absolute minimum and maximum temperatures of -14 and +47°C. The soil of the study area is gypsum, salt and limestone. The average altitude is 980 m above sea level (Abtahi, 2014). Haftooman site is located at 385 km of East of Esfahan and 45 km of Southwestern Khoor and Biabanak at the altitude of 1080 m with the slope of 2-10% and the general direction of south-south east. This site is located in plains and foothills with a shallow depth and light-textured soil. The mean annual precipitation is 85 mm and the mean daily temperature is 19.5°C. Goats, sheep and camels are the main livestock of the Haftooman site with a rural animal husbandry. Rangeland utilization is from October to April and almost all year round. *Artemisia sieberi-Zygophyllum atriplicoides* was identified as the vegetation type of the study area and the associated species were included *Fortuynia bungei*, *Salsola tomentosa*, *Salsola arbuscula*, *Pteropyrum aucheri*, *Pteropyrum olivieri*, *Gymnocarpus decanter*, *Scariola orientalis*, *Carex stenophylla*, *Scorzonera* sp., *Launaea acanthodes*, *Peganum harmala*, *Euphorbia* sp., *Anabasis setifera*, annual grass and annual forbs (Abtahi, 2014).

An area of 25 km^2 (dimensions of 5×5 km) was selected to investigate the vegetation cover of the Haftooman site (Fig. 1).

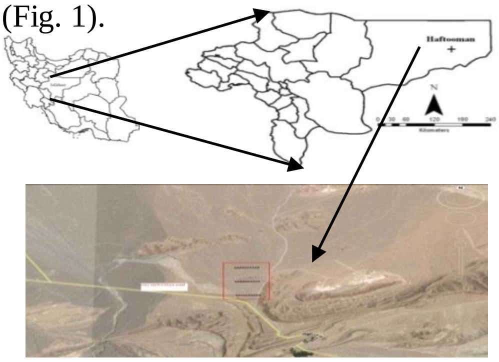

Fig. 1. Site location of the study area (Haftooman site) and plot position

Methods

After identifying vegetation types and the associated species, the type of rangeland utilization, grazing season and livestock type were determined. Vegetation and soil sampling was performed in mid-May at the end of vegetative growth before the livestock enter the rangeland. Vegetation parameters including the canopy cover percent of perennial forbs and shrubs and total canopy cover were estimated. Soil moisture content at 0-15 and 15-30 cm depth, soil organic carbon percent and soil cover (sum of gravel, stone, litter and total canopy cover percent) were also determined. Data were collected using three transects along the changes of vegetation type. On each transect, ten quadrates (in total, 30 quadrates) with the dimensions of 2.5 × 2.0 m^2 were established. Climatic data including precipitation and temperature were collected from the nearest synoptic station, and the Embrothermic curves were drawn. The collected data related to vegetation cover, soil moisture and organic carbon were transferred to Excel software and data were analyzed using SPSS software. Means comparisons were made using Duncan method. Interpreting the results of data analysis was performed with regard to the distribution of rainfall and effective cumulative rainfall (from the early October until the time of collecting field data) as well as precipitation and temperature during the growing season (from the early October to the end of growing season).

Results

Embrothermic curves of the nearest synoptic station (Choupanan) to the study area during 2008-2012 are presented in Figs. 2-5. The precipitation value of the studied years is presented in Table 1.

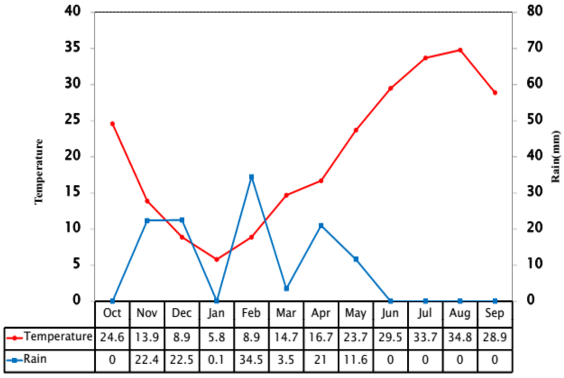

Fig. 2. Temperature and rain Curves of Choupanan synoptic station (2008-2009)

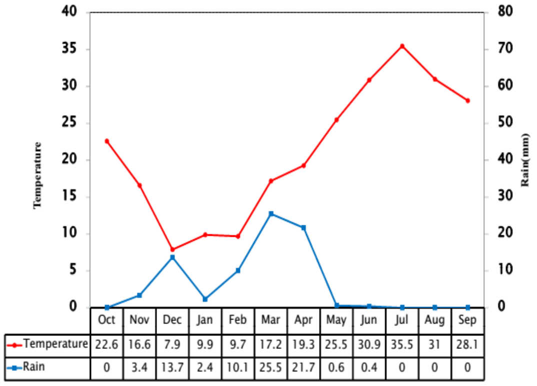

Fig. 3. Temperature and rain Curves of Choupanan synoptic station (2009-2010)

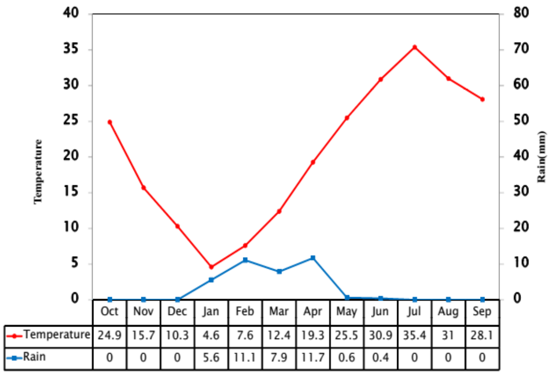

Fig. 4. Temperature and rain Curves of Choupanan synoptic station (2010-2011)

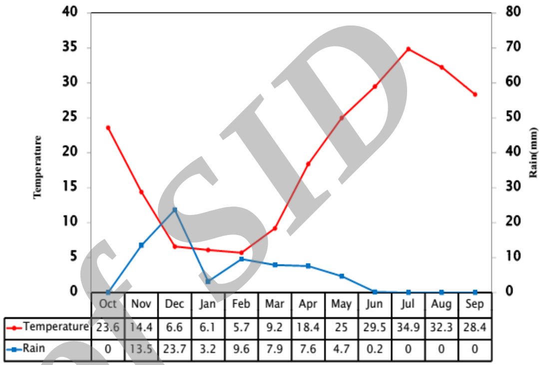

Fig. 5. Temperature and rain Curves of Choupanan synoptic station (2011-2012)

Table 1. Precipitation (mm) of Haftooman site

Date	26 April 2009	5 May 2010	3 May 2011	30 Apr 2012
Effective cumulative precipitation	115.6	77.4	36.9	70.2
Precipitation of the growing year	115.6	77.8	37.3	70.4

According to the results of analysis of variance, significant differences were obtained between the years for the annual canopy cover (Table 1), soil cover, soil organic carbon and soil moisture at the depth of 30 cm (P<0.01, Table 2). There were also significant differences between years for the average soil moisture, soil moisture at the depth of 15 cm (Table 2) and canopy cover of forbs and shrubs, total canopy cover and the canopy cover of dominant species including *Zygophyllum atriplicoides*, *Artemisia sieberi* and *Carex stenophylla* (P<0.05, Table 3).

Means comparisons among the years showed the highest and lowest values of soil moisture percent (0-15 cm) at the depth of 9.34 (2010) and 7.88 (2011), soil moisture percent (15-30 cm) at the depth of 10.25 (2009) and 8.65 (2010), the average soil moisture as 9.42 (2009) and 8.32 (2011), soil organic carbon as 0.41 (2011) and 0.10 (2009), soil cover as 56.14 (2011) and 23.26 (2009), shrubs as 10.17 (2011) and 5.37 (2009), forbs as 3.47 (2009) and 0.55 (2011), annual as 1.81 (2009) and 0 (2011), total canopy cover as 10.72(2011) and 8.34 (2010) presented in Tables 2 and 3.

Table 2. Analysis of variance and means comparisons between years for soil characteristics (%)

Source of Variation	F Values				
	Soil Cover	Soil Moisture Depth (0-15 cm)	Soil Moisture Depth (15-30 cm)	Soil Moisture Mean	Soil Organic Carbon
Between years	567.2**	2.1*	2.31**	1.51*	0.017**
Years	Means values				
2009	23.26 b	8.58 ab	10.25 a	9.42 a	0.10 b
2010	32.23 b	9.34 a	8.65 b	8.99 a	0.12 b
2011	56.14 a	7.88 b	8.76 b	8.32 b	0.41 a
2012	54.20 a	8.65 ab	10.14 a	9.39 a	0.13 b

*, **= Significant at 5%, 1%, respectively
Means followed by the same letters in each column are not significantly different (P<0.05)

Table 3. Analysis of variance and means comparisons between years for canopy covers (%) of plant species and vegetative types

Source of Variation	F Values						
	Zygophyllum atriplicoides	*Artemisia sieberi*	*Carex stenophylla*	Shrubs	Forbs	Annual	Total
Between years	125.94*	8.5*	12.75*	120.4*	15.0*	0.76**	142.04*
Years	Means values						
2009	2.70 b	2.60 a	2.40 a	5.37 b	3.47 a	1.81 a	10.65 a
2010	5.64 ab	1.64 ab	0.94 ab	7.10 ab	1.07 b	0.17 b	8.34 b
2011	7.60 a	2.40 a	0.03 b	10.17 a	0.55 b	0.00 b	10.72 a
2012	5.14 ab	1.02 b	1.02 ab	6.30 ab	1.31 b	1.53 a	9.14 ab

*, **= Significant at 5%, 1%, respectively
Means followed by the same letters in each column are not significantly different (P<0.05)

Discussion

Climatic factors including precipitation and temperature affect the amount of canopy cover and forage production. Therefore, in the study site, precipitation in the months of March, April and May is of great importance. The impacts of spring precipitation on the emergence and establishment of annual species are substantial. Thus, it is possible that precipitation is high in a year; however, due to the mismatch with growing season, it is not of much importance. The type of livestock grazing, grazing time and intensity are the other human factors affecting the rangeland vegetation. According to the Embrothermic curve of Choupanan (Figs. 2-5) synoptic station, wet period in this region is very limited even without a wet month in some years. Therefore, sparse vegetation and plant species unique to desert are observed. In the first year, wet month was observed alone in February and on a limited basis in December. Most precipitation was occurred in February. In the second year, no wet month was recorded meaning that precipitation was below the average monthly temperature and maximum precipitation occurred in March.

During 2010-2011, there was no wet month and maximum precipitation was recorded in April. Eventually, during 2011-2012, December was the only wet month in which maximum precipitation was observed. The average temperature in July was over 35°C and no below-freezing temperatures and frost were observed. According to the results of analysis of variance, there was a significant difference between the years for soil moisture. Soil moisture has a direct relationship with precipitation. Soil texture affects the moisture maintenance; however, given the lack of change in soil texture, precipitation is the only effective factor over the past few years. According to the obtained results, maximum and minimum precipitation occurred in 2009 and 2011, respectively. Significant differences were found in the canopy cover of both annuals ($P<0.01$) and forbs ($P<0.05$). The annual growth of forbs' species also was depended on the amount of precipitation so that the highest and lowest canopy cover percent of forbs was recorded in 2009 and 2011, respectively. The annual species have no strong and extensive root systems such as shrubs. Since shrubs in the arid regions have deep roots, they are less affected by short-term and annual rainfalls. The changes in canopy cover of this group indicated significant differences ($P<0.05$). The changes trend of shrub species depended on long-term changes in rainfall. Annual precipitation changes only affected the growth rate of the same year. Soil cover changes were also significant ($P<0.01$). The highest soil cover was measured in 2011 and 2012. It was due to the reduced rainfall in 2011 and 2012 as compared to the other years and early deciduous leading to the accumulation of litter on soil surface. The ANOVA of total canopy cover showed a significant difference among the means between the years. Since shrub species are dominant in the study area, the changes in total canopy cover follow the cover of shrubs. Differences in soil organic carbon were significant ($P<0.01$). Organic carbon is affected by plant residues in the soil; therefore, its effects will be evident with a rain delay of one year. Despite the reduced rainfall and vegetation cover, the highest values of soil organic carbon was observed in 2011 that was caused by the residues of plants accumulated during past years.

In terms of vegetation dynamics in a four-year period, our results clearly indicate that shrubs comprise (form) the predominant cover of these rangelands showing less sensitivity to the changes in annual precipitation and less have undergone a change under wet or drought conditions. Navarro *et al.* (2002) in their studies on the rangelands of New Mexico found that the canopy cover of *Bouteloua eriopoda* and *Hilaria mutica* were similar and did not change significantly under dry and wet conditions in a 48-year period (1999-1952). In other words, the occurrence of drought neutralized the positive effects of wet period. Zare and Baghestani Maibodi (2012) investigated the vegetation changes in steppe rangelands of Yazd province. They found that the changes in dry areas were slow and vegetation improvement could be expected only in the areas having an appropriate management. Similarly, according to Yorks *et al.* (1992), the balanced grazing was identified as the most effective factor in improving the trend of range conditions. Our results are in accordance with the findings of Oconner and Roux (1995) reporting that the changes of rangeland vegetation in South Africa were under the influence of climate. In contrast, our results are contradicted by the studies performed by Alzerreca *et al.* (1998) reporting that the changes of Southwestern Utah desert rangelands are under the influence of grazing.

In this site, the perennial forbs and also annuals responded to the changes in annual precipitation and in addition to maintaining vitality, their frequency increased. Fluctuations in soil moisture at Haftooman site showed that with increasing rainfall, the water storage of shallow depths demonstrated a significant increase and therefore, led to natural regeneration of plants. At Haftooman site, some changes in soil organic carbon were not significant since the canopy cover of perennial species was low and its decreasing trend was intensified in droughts. Therefore, in the short term, it cannot be used to assess vegetation changes. However, in the long term (periods of ten years or more), it can be considered as one of the appropriate criteria to monitor the range conditions and trend.

Conclusion

In general, the study of vegetation dynamics show that the canopy cover of dominant species which mainly consists of shrubs has less undergone major changes in dry or wet years. In such a rangeland, a rainfall incident within a specified period sometimes makes up all shortages of the dry period and the revitalization and vegetation development become possible with the rise of natural regeneration. In vegetation dynamics, range management is important as much as the positive effects of a rainfall incident since the increased grazing pressure reduces the opportunity of revitalization and alters the species composition in favor of woody and unpalatable species. Changes in soil organic carbon was very slow while soil moisture appeared as a changeable factor in accordance with soil texture and variations in rainfall. Thus, to evaluate the vegetation of rangelands, there are major items that need to be considered. The items include soil moisture and texture, distribution and amount of rainfall, physiological characteristics of different plant groups (shrubs, perennial grasses, forbs and annuals) in the ecosystem, current local management for grazing and of course the time at which vegetation and soil variables are measured. Based on the assessment of such items, it is possible to monitor vegetation dynamics for the purpose of scientific management of rangeland ecosystems. In general, since the study area has a desert climate and livestock density and grazing pressure are not so considerable, it can be concluded that vegetation cover and its changes' trend are highly correlated with rainfall.

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بررسی پویایی پوشش گیاهی و وضعیت مرتــع در کــویر مرکــزی ایــران (مطالعــه موردی: هفتومان خور و بیابانک)

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چکیده. هدف از اجرای این تحقیق، بررسی پویایی پوشش گیاهی و وضـعیت مرتـع بـا در نظـر گـرفتن شرایط اقلیمی و خصوصیات خاک در منطقه هفتومان خور و بیابانک، بعنوان مرتع شاخص مناطق بیابانی، می‌باشد. بدین منظور پس از تعیین تیپ گیاهی و گونه‌های همراه، نوع بهره‌بـرداری از مرتـع، فصـل چـرا، نوع دام و دیگر اطلاعات در خصوص مرتع مذکور، نسبت به جمع‌آوری اطلاعـاتی از قبیـل پوشـش تـاجی یک ساله‌ها، فورب‌های چند ساله، بوته‌ای‌ها، گندمیان چند ساله، پوشش تاجی کل و رطوبت و کـربن آلـی خاک طی ۴ سال اقدام گردید. برداشت‌ها در امتداد ۳ ترانسکت در جهت تغییـرات تیـپ گیـاهی صـورت گرفت. بر روی هر ترانسکت ۱۰ پلات و در کل ۳۰ پلات تعیین گردید. ابعـاد پـلات‌هـا بـا توجـه بـه فـرم رویشی گیاهان غالب، ۲ × ۲/۵ متر انتخاب شد. منحنی آمبروترمیک سال‌های رویشی بر اساس آمار دما و بارش ماهانه ایستگاه چوپانان ترسیم گردید. تغییرات به وجود آمـده در پارامترهـای انـدازه‌گیـری شـده از سالی به سال دیگر به کمک تجزیه واریانس بررسی و پس از معنی‌دار بودن تغییرات، مقایسه میانگین هـر پارامتر از هر سال به سال دیگر با روش دانکن انجام گردید. نتایج نشان داد که تفاوت معنـی دار در سـطح ۹۹ درصد در مولفه های رطوبت عمق ۲، پوشش تاجی یک ساله‌ها، پوشش خاک، کـربن آلـی خـاک و در سطح ۹۵ درصد در میانگین رطوبت، رطوبت عمق ۱، پوشش تاجی بوته‌ای‌ها، فورب‌های چنـد سـاله، کـل گونه‌ها، گونه‌های ***Zygophyllum atriplicoides***، ***Artemisia sieberi*** و ***Carex stenophylla*** وجـود دارد. در این سایت به خاطر حاکمیت شرایط بیابانی، میزان پوشش گیاهی و تغییرات آن متـاثر از تغییـرات بـارش است.

کلمات کلیدی: پویایی پوشش‌گیاهی، وضعیت مرتع، روند تغییرات، تاج پوشش‌گیاهی، هفتومان