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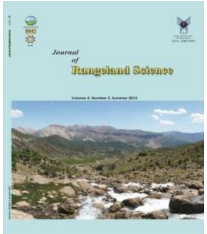

Research and Full Length Article:

Investigation of Stability and Relationships between Species Diversity Indices and Topographical Factors (Case Study: Ghorkhud Mountainous Rangeland, Northern Khorasan Province, Iran)

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Abstract. One of the main objectives of ecosystem management is to preserve the species diversity. Many researchers regard higher species diversity as the stability of ecological systems. The aim of this study is to investigate the stability and relationships between topographical factors with diversity indices in Ghorkhud mountainous rangeland in northern Khorasan province, Iran. For data sampling (2012), land units were specified. Floristic list was prepared and minimal area was determined based on the nested plot (Braun-Blanquet method). 120 plots of $1m^2$ were selected and within each plot, the presence of species and cover percent were estimated. For data analysis and means comparison of species diversity between the study sites, One-way ANOVA and Duncan tests were used. The species diversity was investigated using numerical indices and stability of the habitat was determined using parametric indices. The results showed that species diversity was decreased due to the increased altitude. Diversity indices were increased by the increased slope percent. Also, eastern slopes had the most diversity as compared to the other driving directions since the communities with high and low diversities generally follow the Log-Normal and Geometric models, respectively. According to our results, the areas with light slopes, middle altitudes and north and west directions followed the Log Normal distribution which had the most stable levels. It was concluded that the area with Log-Normal model represents a relatively stable communities with medium to high species richness.

Key words: Diversity, Topographic factors, Ghorkhud mountainous rangelands

Introduction

Rangelands are natural ecosystems that include large reserves of genetic resources and higher diversity of plant species. Such a high diversity may ensure the stability of rangelands against the environmental and biological constrains. Therefore, preserving high diversity of rangelands is so important (Dengler *et al*., 2008). Species diversity is composed of two components including species richness and species evenness. The first one is related to the number of observing species in the plots and the second one is the distribution of species individuals (Maguran, 1988 and Mesdaghi, 2005).

In order to investigate species diversity in plant communities, parametric and non-parametric models are used. Non-parametric models include the experimental indicators of diversity such as Simpson, Shannon and Hill. Parametric models include the fitting of frequency distribution model using a statistical theory related to sampling in order to determine the structure of communities (Magurran, 2003; Mesdaghi, 2003; Vandermeer, 1981). Motomura's Geometric series (1932), the Log series (Fisher *et al*., 1943) and Log-Normal and Broken stick are among the species abundance models.

Due to variable components of species richness and evenness in society, no special model can be generalized to all the ecological societies and each society obeys a specific model (Mesdaghi, 2003; Magurran, 2003).

Diversity of a community can be described by these models, each of which reflects special characteristics from the community. The Geometric series represents societies from the destructive environments, Log series represents a society with a large number of species with intermediate frequency and finally, Broken stick model represents homogeneous and relatively poor societies of the species which have the same frequency (Stiling, 2000).

Hosseini (1995) investigated the relationship between the plant diversity and topographical factors in Golestan National Park, Iran. Their results showed that species diversity increases by the increases of slope percent and altitude. In contrast, species diversity decreases with changing the direction from north to south.

Ebrahimi Kebria (2002) investigated the effects of topography on the changes of vegetation cover and plant diversity. He found the maximum correlation between the total vegetation cover with altitude changes and slope so that in higher altitude and lower slope, total vegetation cover was increased. Also, in lower altitude and higher slope, the species diversity increases.

Grytness & Vetaas (2002) in investigating the altitudinal gradients in the Himalayas concluded that maximum diversity was observed at intermediate altitudes. However, by increasing the altitude, diversity was decreased due to higher altitude and lower temperature.

Bharali *et al.* (2011) investigated the effects of the altitudinal gradients on species diversity in Arunachal Pradesh India and concluded that the diversity of trees and shrubs had a positive correlation with increasing altitude and herbaceous species diversity had a negative correlation with the increased altitude.

Hund (2002) studied the effects of slope on the environment conditions and vegetation and concluded that the northern and southern slopes of vegetation composition had significant differences and arboreal plants were mostly seen in the slopes facing north and shrubs were mostly seen in south-facing slopes.

Oliveria & Batalha (2004) studied the abundance species models in south eastern Brazil and introduced Log Normal model as the best abundance model of plant communities with high species richness. Mirdavoodi and

Zahedipoor (2005) investigated the Meyghan plant communities in Iran; they have considered diversity as one of the most important properties which demonstrates the changes in ecosystems. They also assessed different distribution models and showed that communities with low species diversity follow Geometric series and communities with high species diversity follow the Log-Normal model.

Since the protected areas are significantly important, Ghorkhud protected area in northern Khorasan province, Iran was studied. The aim of this study is to determine the diversity of the province and the country as much as possible. Also, the devastated and protected areas can be compared in terms of diversity. Deploying plans can provide a model for the restoration of degraded areas which are qualified to provide the desired area. According to importance of species diversity as a suitable tool for decision making, protection and management of vegetation cover, sustainable development is gained in natural areas.

Materials and Methods

Study area

Ghorkhud area is located between 37°20'27" to 37°30'30" N latitude and 56°08'48" to 56°17'36" E longitude (Fig. 1). Elevation range is between 1000-2700 m. Mean annual rainfall and temperature are 400 mm and 9°C, respectively. Regional climate based on method of De Martone (1942) is semi-arid cold. General slope of the district is 0-12% and major vegetation of the area includes perennial herbaceous with dominance grasses and forbs (Keshtkar, 2007).

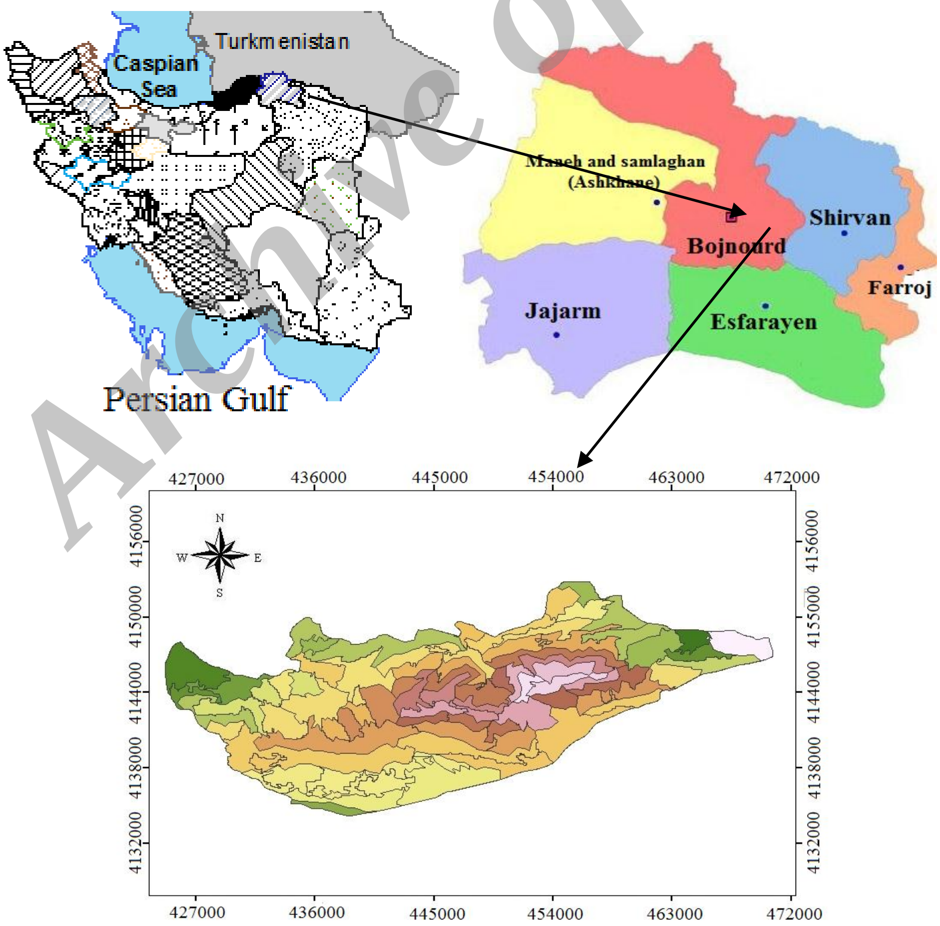

Fig. 1. Map of location of the study sites in the north eastern Khorasan

Sampling method

For sampling (2012), digital maps of sea level, slope of vegetation and land use were first prepared. Then, maps were combined using GIS software version 9.3 and land units were identified. They were recorded in the study units with ground survey Floristic list. Minimal area was determined based on the nested plots. 120 plots of 1 m^2 were selected and within each plot, presence and absence of the species and cover percent were estimated.

In this study, the Shannon-Wiener and Simpson indices were used due to the greater ability of these indices in order to recognize species diversity (Magurran, 1988). Also, parametric indices were applied (Geometric model, Log series, Log-Normal, Broken stick) to determine the stability of the habitat. Geometric series and Log series models represent the immature communities with low species diversity with unstable and fragile communities. Log-Normal model represents the communities with high diversity, richness and stability. Broken stick model shows the species with relatively equal frequency and maximum species diversity. These indices were calculated according to Magurran equation (2003) in PAST ecological software, version 2.17 (Hammer *et al.*, 2001). One-way ANOVA and Duncan tests were used to examine all the statistical analyses. The SPSS version 16 software was used for a statistical analysis. Also, chi-square model parameters were estimated using the observed and expected data. Goodness of fit test statistical comparison of observed and expected values might be determined using Chi-square test. The calculated values of the Chi-square with Chi-square Table values were compared. If the difference between these two values is statistically significant, the null hypothesis will be rejected based on the fit of the model; otherwise, society will follow the parametric model. All the calculations were performed using BIO-DAP software (Thomas, 2000).

Results

The perennial species with 74.7% coverage had the highest plant composition. The biological spectrum of the study area indicates the prevailing of hemicryptophytes (51.81%) and therophytes (18.07%). The life forms contain forbs (63.86%), grasses (21.69%) and shrubs (14.46%). As the results showed, the forbs had the highest percentage of life forms (Table 1).

Table 1. Cover percent based on species, biological type, life form and Growth form

Factor	Class	Cover Percentage
Biological type	Hemicryptophyte	51.81
	Therophytes	18.07
	Chamephyte	13.25
	Geophyte	7.23
	Phanerophyte	8.43
Life form	Forbs	63.86
	Grass	21.69
	Shrub	14.46
Growth form	Annual	25.30
	Perennial	74.70

Duncan multiple comparisons showed that the altitudinal range of 1500-1300 m had the most diversity. The species diversity decreases with increasing the altitude. Altitudinal ranges of 1500-1300 m, 1900-1700 m and 2100-1900 m showed no significant differences in terms of diversity (Shannon and Simpson indices) with each other. Also, the altitudinal class of 1300-1500 m with the average values of 0.63 had the most amount of evenness and the altitudinal class of 1500-1700 m with the average values of 1.92 had the lowest richness. However, it had no significant differences with the altitude up to 2100 m; in other words, species richness and diversity had a negative relationship with increasing altitude and also, the Simpson index had a significant correlation with the altitude of sea level (P<0.05) (Table 2).

Table 2. Variance analyses (ANOVA) of diversity, richness and evenness indices in different altitude classes

Altitude Classes (m)	Shannon Index	Simpson Index	Richness (Margalef)	Evenness
1300-1500	1.73 a	0.75 a	2.38 a	0.63 a
1500-1700	1.18 b	0.49 b	1.92 b	0.54 ab
1700-1900	1.50 a	0.66 a	1.95 b	0.56 ab
1900-2100	1.35 a	0.65 a	2.13 b	0.47 c
P value	0.001	0.000	0.013	0.001

Means of column with letter are not significantly different (P<0.05)

Based on the results of the variance analysis, a significant difference was observed between slope classes (P<0.05). With increasing the slope percent, species diversity has been increased. Means comparisons among slope classes showed that the steep slope of 65-30% had a higher diversity than the other classes. The slope class of 5-12% with the average values of 2.35 was of higher species richness. Slope class of 0-5% with the average values of 0.57 had the lowest diversity level and slope class of 30-12 % with the average values of 1.81 had the lowest species richness (Table 3).

Table 3. Variance analyses (ANOVA) of diversity, richness and evenness indices in different slope classes

Slope Classes	Shannon Index	Simpson Index	Richness (Margalef)	Evenness
0-5	1.36 a	0.57 b	2.10 ab	0.61 a
5-12	1.43 a	0.59 ab	2.35 a	0.46 ab
12-30	1.48 a	0.65 ab	1.81 b	0.57 bc
30-65	1.63 a	0.70 a	2.11 ab	0.57 c
P value	0. 100	0.050	0.010	0.012

Means with letter are not significantly different (P<0.05)

The results showed that in the study area except Margalef richness and evenness, there was a significant correlation between Shannon and Simpson diversity indices and aspect classes (Table 4). Also, the results of analyses of variance between the aspect classes showed that eastern direction with the average values of 1.65 (Shannon index) and 0.71 (Simpson index) had the most diversity among the driving directions and then, west and south slopes were ranked as the second and third ones for diversity, respectively. The north slopes had always the least amount of diversity between different directions in the study area (Table 4).

Table 4. Variance analyses (ANOVA) of diversity, richness and evenness indices in the different aspect classes

Aspect Classes	Shannon Index	Simpson Index	Richness (Margalef)	Evenness
North	1.24 b	0.55 b	1.83 a	0.46 b
South	1.43 b	0.61 ab	2.09 a	0.50 ab
East	1.65 a	0.71 a	2.13 a	0.59 a
West	1.60 a	0.68 a	2.14 a	0.59 a
P value	0.005	0.007	0.267	0.090

Means with letter are not significantly different (P<0.05)

Parametric indices

Broken stick, log normal, logarithmic series and geometric series models were fitted for each site whose results of measurements are shown in Tables 5 to 8, respectively.

According to the results obtained from the parametric indices analysis, slope class of (0-5%) followed log-normal distribution and log series (Tables 6 and 7) and other slope classes followed log series (Table 6).

For aspect classes, the results of parametric analysis showed that the western and northern aspects followed log-normal distribution and log series (Tables 6 and 7) and other aspect classes followed log series (Table 6). Also, altitudinal class of (1700-1500 m) followed log-normal distribution and log series (Tables 6 and 7) and other altitudinal classes followed log series (Table 6).

Table 5. Results related to species abundance models using geometric series in the region

Topographic Factors	Class	Observed	Expected	Chi-Squared
Slope (percent)	0-5	240	240	254.02*
	5-12	206	206	362.08*
	12-30	211	211	184.18*
	30-65	166	166	161.34*
Altitude (meter)	1300-1500	211	211	119.62*
	1500-1700	240	240	241.10*
	1700-1900	191	191	106.91*
	1900-2100	147	147	74.16*
Aspect	North	189	189	163.29*
	South	197	197	133.95*
	East	201	201	83.64*
	West	224	224	204.29*

*: Indicates statistical difference at the level of 95% (P<0.05)

Table 6. Results related to species abundance models using log series in the region

Topographic Factors	Class	Observed	Expected	Chi-Squared
Slope (percent)	0-5	41	41	14.99^{ns}
	5-12	57	57	11.26^{ns}
	12-30	55	55	4.94^{ns}
	30-65	37	37	3.82^{ns}
Altitude (meter)	1300-1500	50	50	8.18^{ns}
	1500-1700	58	58	7.52^{ns}
	1700-1900	48	48	6.22^{ns}
	1900-2100	30	30	4.71^{ns}
Aspect	North	41	41	7.59^{ns}
	South	45	45	5.28^{ns}
	East	45	45	6.10^{ns}
	West	54	54	4.81^{ns}

Ns: Indicates no significant difference

Table 7. Results related to species abundance models using log normal series in the region

Topographic Factors	Class	Observed	Expected	Chi-Squared
Slope (%)	0-5	41	52.4	4.49^{ns}
	5-12	57	66.9	7.52*
	12-30	55	67.5	7.88*
	30-65	37	41.7	7.96*
Altitude (m)	1300-1500	50	68.4	8.87*
	1500-1700	58	76.7	4.03^{ns}
	1700-1900	48	57.4	8.75*
	1900-2100	30	31.0	7.93*
Aspect	North	41	53.8	6.81^{ns}
	South	45	56.0	7.97*
	East	45	48.4	8.66*
	West	54	62.9	3.94^{ns}

*: Indicates statistical difference at the level of 95% (P<0.05). Ns: Indicates no significant difference

Table 8. Results related to species abundance models using broken stick in the region

Topographic factors	Class	Observed	Expected	Chi-Squared
Slope (%)	0-5	41	37.7	671.62*
	5-12	57	49.6	283.92*
	12-30	55	48.3	170.15*
	30-65	37	33.1	76.83*
Altitude (m)	1300-1500	50	44.4	101.22*
	1500-1700	58	51.4	96.06*
	1700-1900	48	42.3	141.89*
	1900-2100	30	27.1	50.94*
Aspect	North	41	36.8	61.68*
	South	45	40.2	82.04*
	East	45	40.3	57.05*
	West	54	47.9	90.73*

*: Indicates statistical difference at the level of 95% (P<0.05)

Discussion and Conclusion

The effects of topographic factors on species diversity

Floristic analysis showed that because of mountainous conditions, perennial plants with life form of forbs existed more than the others; also, hemicryptophytes plants had the highest frequencies. According to Archibold (1995), the abundance of hemicryptophytes plants in an area indicates cold climates in altitudes. According to the results with the increased altitude, the species diversity decreases and altitudinal class of (1300-1500 m) had a higher species diversity which is due to favorable conditions and high temperatures in lower altitudes.

The influence of altitude on species diversity could be due to the effects of temperature and rainfall since hard climate conditions in higher elevations reduce the diversity of plant species, especially cold weather. As a result, considering the plant location in higher elevations (lower temperature), growth rate is decreased.

In this context, Ebrahimi Kebria (2002) investigated the effects of topographic factors on the changes of vegetation. Species diversity showed that the reduced altitude and increased slope percent led to the increase of species diversity. Fakhimi Abrghui *et al.* (2011), Grytness &Vetaas (2002) and Bharali *et al*. (2011) came to the same conclusions. The results showed that with the increased slope percent, the species diversity increases so that maximum diversity and evenness were observed in the slope class of (65-30%). The reason is that it makes steep slopes, unstable soils and light texture to have more density and distribution. On the other hand, there is more rainfall in these slopes which secondary succession forms. In this respect, Hosseini (1995) investigated the relationship between plant diversity and topographical factors in Mirzabailo and Almeh Plains of Golestan National Park, Iran and his results showed that the correlation between species diversity increases with increasing the slope percent and altitude. Also, it decreases with changing the direction from north to south. Also, the results showed that the eastern slopes had the greatest diversity followed by west and south slopes. Considering that the study area is mountainous and sampling was performed in semi-steppe grassland sites which are dispersal mostly in the highland Irano-Turanian region because Northern and western slopes include humid Hyrcanian area located in the border of two climates of Irano-Turan and Euro-Siberian; hence, it can be stated that the moisture was the reason for the evenness of vegetation in these two directions. In this context, Hund (2002) studied the effects of slope on the environmental conditions and vegetation. He concluded that slope direction influences the local climate and vegetation cover so that northern and southern slopes had significant differences in terms of vegetation composition and arboreal plants are mostly seen in the slopes facing north and shrubs more seen in south-facing slopes.

Parametric indices

According to the measurements using four main models including geometric distribution, log series, normal log series and MacArthur`s broken stick, intermediate altitudes (1700-1500 m) followed log-normal series because in the intermediate altitudes due to the environmental favorable conditions, the vegetation had more evenness and stability. On the other hand, due to moderate and controlled grazing, the area is in progressive succession and forms a relatively balanced and uniform community. In lower altitudes due to overgrazing of livestock, the environment is under stress and is less stable than intermediate altitude. In high altitudes, hard climatic conditions, especially extremely cold temperatures reduce the stability and evenness.

According to the results, low slopes had greater stability and evenness than steep slopes. Soil is deeper in the areas with low slope due to sediment accumulation and level of organic material is high. As a result, they are more stable.

The northern and western slopes of the studying area had higher levels of stability and evenness than the south and east slopes due to receiving humidity from Hyrcanian Area. In this respect, studying the abundance models in south-eastern Brazil, Oliveria & Batalha (2004) introduced log normal model as the best species abundance model of plant communities with high species richness. Also, Mirdavoodi and Zahedipoor (2005) investigated the Meyghan desert vegetation cover as the most important criterion which indicates the changes in ecosystems. They also used and assessed different distribution models including Brocken stick, normal log, logarithmic series and geometric series. The results indicated that communities with low level of species diversity followed geometric series and the communities with high level of species diversity followed normal log series. Generally, log normal model for the study area in light slopes, middle altitudes and north and west directions was selected as the best parametric model that is indicative of stable societies. The rest of the study units have followed log series indicating that the immature societies with low species diversity and societies are fragile and unstable.

Literature Cited

Archibold, O. W., 1995. Ecology of world vegetation. Chapman and Hall Inc. London, 509p.

Bharali, S., Paul, A., Khan, M. L. and Singha, L. B., 2011. Species diversity and community structure of a temperate mixed rhododendron forest along an altitudinal gradient in West Siang District of Arunachal Pradesh, India. *Nature and Science*, 9(12): 125-140.

De Martone, M., 1942. Geographie universelle, Vol. I, 140.

Dengler, J. Janisova, M. and Rusina, S., 2008. World grasslands and biodiversity patterns, 29: 3-5.

Ebrahimi Kebria, KH., 2002. Investigated the effects of topography and vegetation and diversity grazing on the cover percent changes in the sub basin Sefidab Haraz, M.Sc. thesis, University of Mazandaran, 82 p. (In Persian).

Fakhimi Abarghui, A., Mesdaghi, M., Gholami, P., Naderi Nasrabadi, H., 2011. Effect of some topographic characteristics on the plant diversity (Case Study: Yazd Nadooshan steppe grasslands). *Iranian Jour. Range and Desert Research*, 18(3): 419-408. (In Persian).

Grytness, J. A. and Vetaas, O. R., 2002. Species richness and altitude: A comparison between along the Himalayana altitudinal gradient, Nepal, the American Naturalist. 159(3): 294-304.

Hammer, Q., Harper, D. A. T. and Ryan, P. D., 2001. PAST: Paleontological Statistical Software Package for Education and Data Analysis, Palaeontologia Electronica, 4(1): 9.

Hosseini, A., 1995. Investigated of plant communities Mirzabylo and Almeh Golestan National Park. Range management master's thesis, Tarbiat Modarres University, 128 p. (In Persian).

Hund, K. C., 2002. The effect of slope aspect on environmental conditions and vegetation, California state science fair.

Keshtkar, H., 2007. Investigated the ability of satellites to map land cover (case study: Ghorkhud protected area in northern Khorasan province). Range management M.Sc. thesis, department of natural resources, Tehran university. 141 p. (In Persian).

Magurran, A. E., 1988. Ecological Diversity and its Measurement. Chapman and Hall, London.

Magurran, A. E., 2003. Measuring Biological Diversity, Wiley-Blackwell, London, 260 p.

Mesdaghi, M., 2003. Vegetation description and analysis. Mashhad University Publications, Mashhad, Iran 287P. (In Persian).

Mesdaghi, M., 2005. Plant ecology, Jahad Daneshgahi of Mashhad press, Mashhad, Iran 187 p. (In Persian).

Mirdavoodi, H. R. and Zahedi Poor, H., 2005. Determination of suitable species diversity model for Meyghan playa plant association and effect of some ecological factors on diversity change. *Pajouhesh & Sazandegi*, 68: 56-65. (In Persian).

Motomura, I., 1932. On the statistical treatment of communities. Zool. Tokyo, 44: 379-383.

Oliveira, F. F. and Batalha, M. A., 2004. Lognormal abundance distribution of woody species in a cerrado fragment. *Revista Brazil. Bot.*, 28(1): 39-45.

Stiling, P., 2000. Ecology. Theories and Applications. Prentice Hall Inc. 395 p.

Thomas, G., 2000. BIO-DAP: A program for Ecological Diversity and its measurement. Parks Canada and Fundy National Park.

Vandermeer, J. H., 1981. Elementary mathematical ecology. Wiley Publishers, 294 p.

بررسی پایداری و رابطه بین تنوع گونه‌ای و عوامل توپوگرافی مراتع کوهستانی قرخود، در استان خراسان شمالی، ایران

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چکیده. حفظ تنوع گونه‌ای یکی از اهداف اصلی مدیریت اکوسیستم است. بسیاری از پژوهشگران تنوع گونه‌ای بالا را به عنوان پایداری سامانه‌های اکولوژیک در نظر می‌گیرند. هدف از این پژوهش بررسی پایداری و رابطه بین عوامل توپوگرافی با شاخص‌های تنوع گونه ای در مراتع کوهستانی قرخود در استان خراسان شمالی می‌باشد. برای نمونه‌برداری (۲۰۱۲)، واحدهای کاری مشخص شدند. لیست فلوریستیکی تهیه شده و سطح حداقل نمونه به روش پلات‌های تو در تو (روش براون-بلانکه) مشخص گردید. تعداد ۱۲۰ پلات ۱ مترمربعی برداشت شد. در داخل هر قطعه نمونه حضور و درصد تاج پوشش گیاهان برآورد گردید. برای تحلیل داده‌ها و مقایسه تنوع گونه‌ای بین واحدهای مطالعاتی آزمون واریانس یک طرفه و دانکن به کار برده شد. هم چنین برای بررسی تنوع از شاخص‌های عددی و تعیین پایداری زیستگاه از شاخص‌های پارامتریک استفاده شد. نتایج نشان داد که با افزایش ارتفاع از سطح دریا، میزان تنوع گونه‌ای کاهش می‌یابد. با افزایش درصد شیب نیز تنوع گونه‌ای افزایش می‌یابد. همچنین در بین جهات جغرافیایی دامنه‌های شرقی بیشترین تنوع را دارند. از آنجایی که جوامع با تنوع گونه‌ای بالا از مدل لوگ نرمال و با تنوع گونه‌ای کم از مدل هندسی پیروی می‌کند با توجه به نتایج آنالیز شاخص‌های پارامتریک، مناطق با شیب‌های ملایم در ارتفاعات میانی با جهت‌های غربی و شمالی از توزیع لوگ نرمال تبعیت کرده است و بیشترین پایداری را دارد که مدل لوگ نرمال بیانگر حضور جوامعی به نسبت پایدار با فراوانی گونه‌ای متوسط تا زیاد است.

کلمات کلیدی: تنوع گونه‌ای، عوامل توپوگرافی، مراتع کوهستانی قرخود