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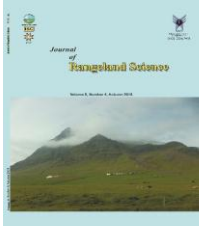

**Research and Full Length Article:**

# Relationships between Soil Properties and Plant Species Diversity in Natural and Disturbed Ecosystems (Case Study: Jamilabad Region, Kerman Province, Iran)

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Received on: 02/11/2017

Accepted on: 21/01/2018

**Abstract.** Reduction of species diversity which is a significant threat to the earth has been found more important and has attracted attention among ecologists over recent years. This research was carried out to determine the relationships between plant species diversity indices and soil properties by multivariate regression methods in Jamilabad region, Baft, Kerman province, Iran in 2016. Different sites of natural ecosystem (including non-grazed, moderate grazed and over-grazed rangeland) and disturbed ecosystem [including rangelands plowed to Glycyrrhiza glabra root harvesting and abandoned dry land for ten years (Fallow) sites] were selected by fieldwork with the same climate, topography and geological factors. Abundance and canopy of species and soil samples (0-20 cm) were taken from each site contemporary for multivariate regression model and its validation. Determination of species diversity indices was done by PAST and BIO-DAP packages. Results revealed that regression models had higher accuracy in the disturbed ecosystem. In this regard, soil erodibility factor as well as soil total nitrogen explained 80% and 77% total variation in both Shannon-Wiener and Margarof indices, respectively. Results showed that even though the soil erodibility was excluded from the model, its components such as organic matter (in Berger-Parker index) had an important role in plant diversity. Therefore, soil erodibility or its components were strongly affected by plowing in the disturbed ecosystem and led to the formation of strong regression models between soil properties and species diversity indices.

**Key words:** Soil, Regression, Shannon, Evenness, Erodibility, Fallow, Dry land

## Introduction

Plant species diversity reduction is one of the three major threats to the earth planet (Hayek *et al.,* 2007), which has attracted more attention among ecologists in recent years. This factor in vegetation studies and environmental assessments is one of the most important and fastest indicators for determining the status of ecosystem conditions (Zare Chahouki *et al.,* 2008; Erfanzadeh *et al.,* 2015; Mohamadi, 2016). Quantitative diversity values provide an image of the ecological conditions of the area under study (Lexer *et al.,* 2000). Increase of species diversity leads to longer nutritional chains and more vital networks which make the ecosystem and its self-regulations stable. Therefore, diversity must be considered as the key to sustainability and the environmental health of the ecosystem (Jouri *et al.,* 2011; Fattahi *et al.,* 2017).

Various factors can affect species diversity of plants. Regression models are considered as one of the most important multivariate methods through which researchers can find a mathematical relation between species diversity indices and environmental factors. Mligo (2006) studied the effects of grazing on the composition and diversity of semi-arid rangelands in Tanzania. There was a significant difference between species diversity in areas with different grazing intensities such that most varieties occurred at the lowest grazing pressure. Jang *et al.* (2007) investigated the diversity patterns in mountain ecosystems of desert areas of China using the CCA (Canonical Corresponding Analysis) method and determined the effect of environmental factors on the characteristics of plant communities. The results showed that elevation factor had a strong correlation with the first axis and justifies 50% of variations, and the slope had a strong correlation with the second axis and justifies 21.4% of the variations. Zamora *et al.* (2007) studied temporal and spatial variations of biodiversity in Mediterranean region and showed that a close correlation exists between grazing intensity and traditional human activities with species diversity and richness. Angassa and Oba (2010) in their study acknowledged that light grazed and enclosure areas increase species diversity and richness whereas the heavy or overgrazed site decreases species diversity and richness. Mahdavi *et al.* (2010) investigated biodiversity and plant species richness in relation to physiographic and physicochemical factors of soil in Kebirkouh protected area, Iran and declared that in the southern slopes, the diversity of herbaceous species had a negative correlation with clay and sandy soil and a positive correlation with silt and lime of soil factors. Khatibi *et al.* (2012) pointed the relationship between soil characteristics affecting the vegetation types of Khash-Taftan Djing rangeland and concluded that the organic matter and clay content and available potassium were the most important factors affecting the distribution of indigenous species in the studied area. Yari *et al.* (2012) stated that electrical conductivity, gypsum, organic matter, slope and sand percentage had the significant effect on plant diversity in the rangelands of Sarchah Amari, Birjand. Ebrahimi *et al.* (2015) reported that the most important and effective factors in vegetation distribution were slope, altitude, soil texture (silt and sand) and total nitrogen. Prober *et al.* (2015) in an investigation on the relationship between plant diversity and soil microbial diversity showed a correlation between plant beta diversity and the diversity of bacterial and fungal communities for environmental factors. Abbasi-kesbi *et al.* (2017) reported that among soil parameters, silt, OC and OM had positive and significant effects on species diversity and richness whereas lime, clay and sand contents had an inverse relationship with plant diversity indices.

According to literature review, even though phytosociological techniques such as CCA and DCA are able to identify factors affecting species diversity among the numerous environmental factors, they do not provide an equation for determining the relationship between environmental factors and species diversity. This problem will be palliated by providing predictive models to species diversity, where multivariate regression is one of the most extensively used ones (Farshadfar, 2005). Determining the role of effective environmental factors on species diversity in an equation framework and providing a mathematical model can be used as a tool to prevent the reduction of species diversity and increase it at ecosystem level by policy makers. Therefore, the option of providing predictive models is necessary for executive administrators to comprehend the effects of the correct and incorrect policies (human involvement in their natural ecosystems) on the indices of species diversity in ecosystems. Since each of the various indices of species diversity emphasizes the particular function of plant species (including rare, dominant, key, etc); thus, it is important to investigate the different indices of species diversity with regard to environmental factors to determine the most widely used ones.

Components of species diversity in different types of ecosystems in Kerman province have been damaged due to human interference and changes of land use in comparison to other provinces of the country (Safari, 2004; Esmaeili and Abdollahi, 2010). On the contrary, harsh conditions of environmental factors lead to vulnerable and fragile conditions of Kerman province ecosystems. Therefore, the present study was conducted to determine the relationship between species diversity indices with soil factors in natural and disturbed ecosystems in Jamilabad region, Baft, Kerman province, Iran.

## Materials and Methods

### Study area

Due to the fact that different amounts of data must be involved in the model (Farshadfar, 2005), sites selection was done with completely different structure and vegetation perspectives. Therefore, three sites of the natural ecosystem including Non-Grazed (NG), Heavy Grazed (HG), Moderate Grazed (MG) sites, and the two sites of the disturbed ecosystem including rangelands plowed to *Glycyrrhiza glabra* root harvesting (Gl T) and abandoned dry land for ten years or Fallow (F) sites were selected by fieldwork with the same climate, topography and geological factors. The sites are located at 3 km west of Baft city (between eastern longitudes of 56˚32'17 " to 56˚32'17 "and northern latitudes of 29˚14'14 "to 29˚14'44".

### Research methodology

After selecting the above sites, an area of at least two hectares from each site was selected for soil sampling and species diversity indices. In this way, the sampling site of each site was divided into blocks based on the dominant slope of the region from top to bottom. In this regard, the natural ecosystem due to having more sites (three sites) were divided into two blocks and the sites of disturbed ecosystem (two sites) were divided into three blocks, and a total of 12 blocks were used for sampling.

Each block was used for taking a soil sample and vegetation cover to provide a regression model (randomized). It should be noted that in 50 m of the western side of the random points, the other vegetation and soil samples (with 12 replications) were systematically taken to validate the model. In this way, the presence of species and their percentage of canopy cover in 24 rectangular plots that were randomly and systematically located in each layer were used to measure species diversity indicators. Plot levels at each site were determined using minimum area that was obtained for 8 and 4 $m^2$ for NG and MG sites, respectively and $2m^2$ for the other sites in a rectangle shape. The data collected from the vegetation cover of the sites were analyzed to determine the diversity indices in the PAST and BIO-DAP software packages (Table 1).

**Table 1.** Formula of diversity, richness, and evenness and dominance indices

| Parameter | Indicator | Formula | References |
|---|---|---|---|
| Richness | Margarof | $R1 = \frac{s-1}{\ln(n)}$ | (Margarof, 1957) |
| Diversity | Shannon-Wiener | $H^{-} - \sum_{i=1}^{n}\left[\left[\frac{n1}{n}\right] Ln \left[\frac{n1}{n}\right]\right]$ | (Shannon and Wiener, 1949) |
| Evenness | Jakard's uniformity | $J = \frac{e^{H}}{S}$ | (Jaccard, 1908) |
| Dominance | Berger-Parker | $D = Nmax/N$ | (Berger and Parker, 1970) |

S=number of species, n= total numbers of individuals in sampling unit, n: total numbers of individuals in *i* species

Soil samples were taken using metal cylinders with a diameter of 4 cm at the center of each vegetation sampling plot at a depth of 0-20cm. Then, soil samples were moved to laboratory of the agricultural and natural resources research center of Kerman province to analyze soil chemical and physical properties including soil organic matter via burning method (Walkley and Black, 1934), total nitrogen via Kjeldahl method (McGill and Figueiredo, 1993), available phosphorus by Olsen experimental method (Olsen *et al.*, 1954), available potassium via extraction method with 1 molar ammonium acetate with pH=7 (Simard, 1993), and the soil pH and electrical conductivity (EC) through Carter method (Zarinkafsh, 1993). Soil physical properties including soil bulk density, porosity and soil moisture were measured after weighting the samples in an oven at 70°C for 48 hours. Parameters such as the amount of gravel (0.0-0.1 mm) and coarse sand (over 0.1 mm) were measured by passing through the mesh. Soil texture and distribution of silt, clay and sand size were measured by the hydrometric method. The class of soil structure was determined by the guidance of Wischmeier and the infiltration class was calculated indirectly based on the soil texture and the regional observations of the limiting layers using the SCS method (Wischmeier *et al.*, 1971; Shabani *et al.*, 2010). At the end, soil erodibility parameters were determined according to Equations 1 and 2 (Esmaeili and Abdollahi, 2010).

$$100K = 2.1M^{1.14} * 10^{-4} * (12 - \%OM) + 3.25(S-2) + 2.5(P-3) \quad (1)$$

$$M = (100 - \%Clay) * (\%Silt + \%Smallsand) \quad (2)$$

Where:
K=soil erodibility coefficient,
OM=organic matter percent,
S=class of soil structure,
P=infiltration class,
Clay=clay percent,
Silt=silt percent and Small sand; percentage of sand (0.1 to 0.05 mm),
M=(100 - clay content percent)*(silt percent + percentage of fine sand).

Finally, the amount of 50% of data which were sampled randomly was analyzed by the stepwise regression analysis in SPSS16 software package. The other data which were sampled systematically were used to validate the regression model with Mean Absolute Error (MAE) and Mean Bias Error (MBE) criteria according to the observed and estimated values based on Equations 3 and 4 (Issak and Srivastava, 1989).

$$MAE = \frac{1}{n}\sum_{i=1}^{n}\left|Z*(x_i) - Z(x_i)\right| \quad (3)$$

$$MBE = \frac{1}{n}\sum_{i=1}^{n}(Z*(x_i) - Z(x_i)) \quad (4)$$

Where:
$Z*(x_i)$ =the estimated value of the desired variable,
n is number of data
$Z(x_i)$ =the measured value of the desired variable.

# Results

## Floristic list

According to field operation, floristic list of sites is illustrated in Table 2. It should be noted that in the table below, the dominant types of sites are shown in bold. *Amygdalus scoparia* is the dominant type of NG, *Glycyrrhiza glabra* is the dominant type of MG and GlT sites and *Launaea acanthodes- Lactuca orientalis* type is the dominant type of F site.

**Table 2.** Floristic list of different studied sites

| Species name | Studied sites | Family | Vegetative form |
|---|---|---|---|
| *Acantholimon festucaceum* | NG | Plumbaginaceae | Shrub |
| *Achillea wilhelmsii* | NG | Asteraceae | Forb |
| *Alyssum marginatum* | GlT, MG, F, NG | *Cruciferae* | Forb |
| *Amygdalus scoparia* | NG | Rosaceae | Bushy Tree |
| *Astragalus albascolinus* | GlT, MG, F | Papilionaceae | Shrub |
| *Astragalus parrowianus* | MG, NG | Papilionaceae | Shrub |
| *Bromus tectorum* | GlT, MG, F, NG | Gramineae | Grass |
| *Boissiera squarrosa* | GlT, MG, F, NG, HG | Gramineae | Grass |
| *Centaurea grabertli* | HG | Asteraceae | Forb |
| *Dendorostellera lessertii* | MG | Thymellaeaceae | Shrub |
| *Echinops gedrosiacus* | GlT, F, HG | Asteraceae | Forb |
| *Euphorbia connata* | NG | Ephorbiaceae | Forb |
| *Glycyrrhiza glabra* | GlT, MG, F | Papilionaceae | Forb |
| *Heliotropium europaeum* | HG | Boraginaceae | Forb |
| *Hertia intermedia* | F | Asteraceae | Shrub |
| *Lactuca orientalis* | F, NG | Asteraceae | Shrub |
| *Launaea acanthodes* | GlT,F, HG | Asteraceae | Shrub |
| *Malcolmia taraxacifolia* | F | Cruciferae | Forb |
| *Noaea mucronata* | GlT, MG, NG | Chenopodiaceae | Shrub |
| *Nonnea persica* | GlT, MG, F, HG | Boraginaceae | Forb |
| *Stipa barbata* | NG | Gramineae | Grass |
| *Peganum harmala* | HG | Zygophyllaceae | Forb |

NG= non-grazed, HG)=Heavy grazed, MG=moderate grazed, GLT=*Glycyrrhiza glabra* area and F= fallow area for ten years

## Diversity Indices and soil properties

The results of studying the diversity indices of each site in the study area are presented in Table 3. According to these findings, in non-grazed site, the Shannon-Wiener diversity index with average value of 1.09 had higher values than other treatments. For uniformity index, the highest value of (0.75) was belong to NG site; however, there was not a significant difference with other sites. There was no significant difference between treatments for dominance index; however, higher value of (0.80.) was obtained in heavy grazed site (Table3).

**Table 3.** Mean comparisons between plant species diversity indicators at different studied sites

| Diversity indices | Disturbed ecosystem | | Natural ecosystem | | |
|---|---|---|---|---|---|
| | *G. glabra* area | Fallow area | Moderate grazed | Non-grazed | Heavy grazed |
| Shannon-Wiener (diversity) | 0.84 ab ±0.16 | 0.68 ab ±0.15 | 0.92 ab ±0.15 | 1.09 a ±0.21 | 0.50 b ±0.19 |
| Margarof (richness) | 1.24 ab ±0.17 | 0.91 b ±0.17 | 1.61 a ±0.15 | 1.05 ab ±0.21 | 0.64 b ±0.27 |
| Jakard's uniformity (Evenness) | 0.67 a ±0.11 | 0.61 a ±0.09 | 0.66 a ±0.11 | 0.75 a ±0.10 | 0.56 a ±0.12 |
| Berger-Parker (Dominance) | 0.62 a ±0.08 | 0.74 a ±0.07 | 0.61 a ±0.07 | 0.56 a ±0.09 | 0.80 a ±0.10 |

The means of rows followed by the same letters are not significantly different based on Duncan test (P<0.05).

Means comparisons between soil characteristics of sites as input factors to regression models are shown in Table 4. According to Duncan test, soil variables including pH and clay content, there was no significant difference between sites. For soil porosity, a lower value (16.83%) was observed in HG site. For electrical conductivity (Ec) and bulk density, higher values of 1.57 ds/m and 1.69 g/m$^3$ respectively were obtained in HG site. Soil fertility factors including organic matter content, absorbable potassium and total nitrogen content with average values of 1.57, 0.79, 389.67 and 9.9 were placed in the highest rank at NG site and significantly differed with other sites. In addition, for soil moisture, the highest value (3.45%) obtained in NG site had a significant difference with other sites. Soil erodibility factor of sites changed significantly between sites in which the highest value belonged to F site. In this regard, the lowest value of soil erodibility (0.4) was obtained in Gl T site (Table 4).

**Table 4.** Means comparison between soil characteristics at five studied sites

| Soil factors | Disturbed ecosystem | | Natural ecosystem | | |
|---|---|---|---|---|---|
| | *G. glabra* area | Fallow area | Non-grazed | Heavy grazed | Moderate grazed |
| pH | 7.20 a ±0.16 | 7.16 a±0.11 | 7.11 a±0.12 | 7.12 a±0.23 | 7.15 a±0.13 |
| Electrical conductivity | 0.89 b ±0.23 | 0.86 b ±0.2 | 1.16 b ±0.24 | 1.57 a ±0.4 | 0.94 b ±0.16 |
| Organic matter content of soil(%) | 0.25 d ±0.08 | 0.32 cd ±0.08 | 0.79 a ±0.05 | 0.45 c ±0.05 | 0.59 b ±0.8 |
| Absorbable potassium of soil | 300.00 c ±25 | 316.17 c ±69 | 389.67 a ±74 | 309.00 c ±99 | 369.00 b ±58 |
| Absorbable phosphorus of soil | 6.83 bc ±1.17 | 6.50 c ±1 | 9.90 a ±1.6 | 6.97 bc ±1.1 | 8.20 b ±1.2 |
| Total nitrogen content of soil (%) | 0.05 c ±0.01 | 0.06 c ±.01 | 0.16 a ±0.01 | 0.11 b ±0.01 | 0.12 b ±0.03 |
| Silt content (%) | 21.60 ab ±1.1 | 25.67 a ±4.3 | 21.77 ab ±3.5 | 23.93 ab ±5 | 19.60 b ±2 |
| Clay content (%) | 6.93 a ±1.6 | 6.27 a ±2.7 | 5.27 a ±1.5 | 5.93 a ±2.3 | 4.60 a ±1 |
| Fine sand content (%) | 37.82 b ±4 | 41.65 a ±1.9 | 40.95 ab ±2.3 | 40.77 ab ±1.1 | 39.85 ab ±3.8 |
| Course sand content (%) | 33.98 ab ±4 | 26.42 b ±6.6 | 32.02 ab ±5.2 | 29.37 b ±6.8 | 35.95 a ±4.2 |
| Moist content (%) | 2.01 b ±0.57 | 1.73 bc ±0.23 | 3.45 a ±0.65 | 1.21 c ±0.15 | 2.18 b ±0.51 |
| Bulk density | 1.23 b ±0.23 | 1.24 b ±0.15 | 1.41 b ±0.05 | 1.69 a ±0.1 | 1.39 b ±0.1 |
| Porosity (%) | 43.36 a ±6.8 | 38.04 b ±2.4 | 29.58 c ±2.7 | 16.83 d ±2.6 | 28.81 c ±3.5 |
| Soil erodibility | 0.40 d ±0.04 | 0.47 a ±0.06 | 0.41 c ±0.04 | 0.44b ±0.04 | 0.39 d ±0.04 |

The means of rows followed by the same letters are not significantly different based on Duncan test (P<0.05).

## Regression model between diversity indices and soil factors

The regression models between diversity indices and soil factors for disturbed and natural ecosystems are presented in Tables 5 and 6, respectively. According to the multivariate regression model, in the disturbed ecosystem, all four diversity indices had regression models with two soil variables coupled with higher coefficient of determination ($R^2$) ranged from 64 to 80%. In the disturbed ecosystem, the Shannon-Wiener and Margarof regression models, the variables of soil erodibility and total nitrogen were entered in the final models. Similarly, for Jakard's uniformity, the soil erodibility and soil moisture for Berger-Parker, the soil erodibility and organic matter were entered in the final models (Table 5).

For natural ecosystem, only the Shannon-Wiener and Margarof indices provided regression model with only one soil variable with low coefficient of determination ($R^2$=29%). In natural ecosystem, there was a significant relationship between Shannon-Wiener index and soil moisture and between Margarof index and Soil Porosity (Table 6). There was no significant regression model for Jakard's uniformity and Berger-Parker indicators in natural ecosystem.

**Table 5.** Regression models between soil properties and diversity indicators in disturbed ecosystem.

| Diversity Indicators | Regression model | $R^2$ | Model factors | Validation model criteria | |
|---|---|---|---|---|---|
| | | | | MBE | MAE |
| Shannon-Wiener | $Y= 1.92 – 4.09 X_1 + 10.7 X_2$ | 80 | $X_1$: Soil erodibility<br>$X_2$:Total nitrogen% | 0.0021 | 0.1488 |
| Margarof | $Y= 2.8 – 5.3 X_1 + 9.8 X_2$ | 77 | $X_1$: Soil erodibility<br>$X_2$:Total nitrogen % | 0.1093 | 0.1792 |
| Jakard's uniformity | $Y= 2.3 – 2.7 X_1 – 0.27 X_2$ | 64 | $X_1$: Soil erodibility<br>$X_2$: Soil Moisture | -0.0823 | 0.1293 |
| Berger-Parker | $Y= – 0.09+2.4 X_1– 0.9 X_2$ | 80 | $X_1$: Soil erodibility<br>$X_2$: Organic matter % | 0.0096 | 0.0750 |

MAE= Mean Absolute Error
MBE=Mean Bias Error

**Table 6.** Regression models between soil characteristics and diversity indicators in natural ecosystem.

| Diversity Indicators | Regression model | $R^2$ | Model factors | Validation model criteria | |
|---|---|---|---|---|---|
| | | | | MBE | MAE |
| Shannon-Wiener | $Y= 0.25 X_1 + 0.25$ | 29 | $X_1$: Soil Moisture% | 0.3514 | -0.0135 |
| Margarof | $Y= 0.05 X_1 – 0.21$ | 29 | $X_1$:Soil Porosity% | 0.4292 | -0.0582 |

MAE= Mean Absolute Error
MBE=Mean Bias Error

## Validation of regression model

Validation graph of models in the disturbed and natural ecosystems is illustrated in Fig. 1. It reveals that there was a high agreement between the observed and estimated data of disturbed ecosystem models. In contrast, there was a low agreement between the observed and estimated data for natural ecosystem models. This was confirmed by MAE and MBE criteria presented in Tables 5 and 6.

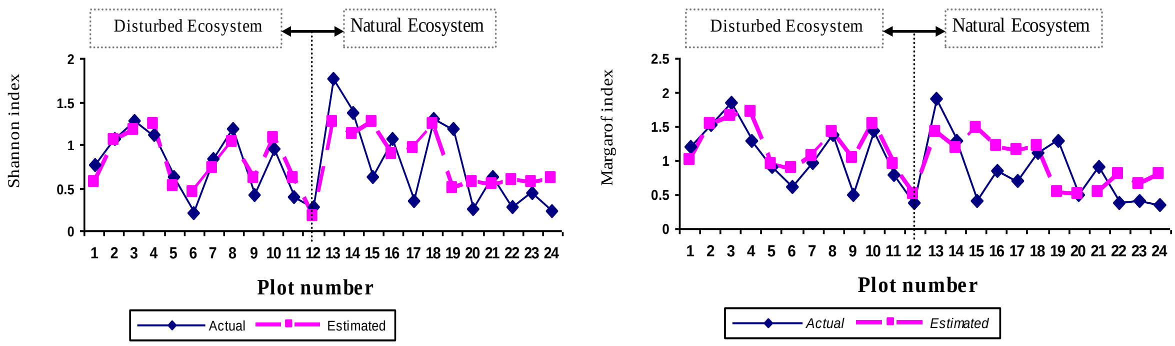


**Fig. 1.** Observed and estimated data of diversity indicators in disturbed and natural ecosystems

## Discussion

Results indicated that almost all species diversity indices in the disturbed ecosystem had coefficient of determinations ($R^2$) over 50%. In this ecosystem, the Shannon-Wiener index was correlated with erosion factors and soil nitrogen content ($R^2$=80%). Soil erodibility factor interpreted 70% of total variation in the index of Menhinick. The Margarf index explained 77% of variation for soil erodibility factors and soil nitrogen. Similarly, Jaccard's uniformity index was correlated with soil erodibility and soil moisture content ($R^2$=64%). The Berger-Parker index explained 80% of soil organic matter and soil erodibility variation. Therefore, all soil factors mentioned were introduced in the relevant models as predictors of species diversity in the disturbed ecosystem with regard to the fact that in most of the proposed models, soil erodibility had a major contribution to the variation of species diversity. In cases where soil erodibility is excluded from models, the components of this factor such as soil organic material (Berger index) in the models justify a significant contribution to the variation of species diversity indicators. The effect of species diversity through soil texture (Friedel *et al.,* 1993; Ali *et al*., 2000; Hie *et al.*, 2007; Zare Chahouki *et al.,* 2008), soil total nitrogen (Ebrahimi *et al.*, 2015), soil absorbable potassium and clay content (Khatibi *et al.,* 2012), gypsum and sand amounts (Yari *et al.,* 2012) and annual average temperature (Mirzaei and Karami, 2015; Ghehsareh Ardestani *et al.,* 2010) have been reported previously. Heydari *et al.* **(**2013) also concluded that soil bulk density and soil gravel percent in upstream areas and soil absorbable phosphorus and potassium as well as soil pH in lower lands were the most important factors affecting rangeland plant types under oak forest strata (*Quercus libani*). Although there was an agreement with other researches on the effect of diversity indicators by some of the soil parameters such as available phosphorus, but scrutinizing of disagreements with other studies can be construed by the kind and characteristics of sites studied in this research which some of sites like rangelands plowed to *Glycyrrhiza glabra* root harvesting are regarded first time in the country. Since in the present study, strong regression models were obtained in the disturbed ecosystem than natural ecosystem (due to the latter low $R^2$ values); therefore, it seems that soil erodibility factor or its components are strongly influenced by human through plowing activities over time, undesirable and invader species with lower ecological function (such as *Ajuga* sp., *Marrubium vulgar*is, *Cirsium* sp., *Nepeta* sp.) capture the ecosystem. They do not allow the presence of other species and in this way, they affect the species diversity of this ecosystem called disturbed ecosystem. On the other hand, soil erodibility factor has not formed a strong relationship with species diversity indicators in natural ecosystem.

Considering the important role of soil erodibility factor and its components, it is suggested that this factor is considered to be evaluated in species diversity studies in the ecosystems disturbed in other parts of the country. In this research, the predictive regression models differed in the species diversity indices, and the reason for the difference can be related to the emphasis of some formulas on the function of the species. For example, Simpson's index has particular emphasis on dominant species but Shannon-Wiener's index emphasizes on rare species. Based on the validity of models of disturbed ecosystem and their lower estimation error, the proposed models of species diversity indices in the disturbed ecosystems can be applied in the executive related offices and it is recommended that experts utilize them to manage or predict the species diversity indicators depending on purposes, importance and function of species.

Considering that these models are presented in the form of a pilot in Baft, it is suggested that the sensitivity of these models should be studied in other ecosystems of semi-arid regions of the country.

Regarding unsuitable models of species diversity in natural ecosystem, it is recommended to increase data collection of soil and vegetation factors as contemporary. In this regard, the use of nonlinear relationships (artificial neural network models, etc.) can be more efficient for the creation of predictive models because of their complex relation.

## Conclusion

According to the results of this research, soil erodibility or its components such as organic matter are strongly affected by plowing in the disturbed ecosystem and lead to the formation of strong regression models between soil properties and species diversity indices.

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# رابطه بین خصوصیات خاک با شاخص‌های تنوع گونه‌های گیاهی در اکوسیستم‌های طبیعی و دست‌خورده (مطالعه موردی: منطقه جمیل‌آباد، استان کرمان)

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تاریخ دریافت: ۱۳۹۵/۰۸/۱۰

تاریخ پذیرش: ۱۳۹۶/۱۱/۰۱

**چکیده.** کاهش تنوع گونه‌ای به عنوان یکی از سه خطر مهم تهدید کننده کره زمین می‌باشد که این مهم باعث شده تا در سال‌های اخیر، بیشتر مورد توجه اکولوژیست‌ها قرار گیرد. این تحقیق با هدف تعیین رابطه شاخص‌های تنوع گونه‌ای با خصوصیات خاک در منطقه جمیل‌آباد شهرستان بافت، استان کرمان در سال ۱۳۹۵ به کمک مدل رگرسیونی چند متغیره انجام شد. سایت‌های مختلفی از اکوسیستم‌های طبیعی(شامل سایت مرتع بکر و دست‌نخورده، مرتع تخریب‌یافته و مرتع تحت چرای متوسط) و دست‌خورده(شامل سایت اراضی شخم‌خورده جهت برداشت شیرین‌بیان و سایت دیمزار رها شده به مدت ده سال) مدنظر قرار گرفتند. حضور گونه‌ها و درصد پوشش آن‌ها و نمونه‌های خاک(عمق ۲۰-۰سانتی‌متری) به طور متناظر از هر سایت برداشت شدند. پس از تعیین شاخص‌های تنوع در نرم‌افزارهای PAST و BIO-DAP، از مدل‌های رگرسیونی چندمتغیره جهت ارائه مدل و اعتبارسنجی آن استفاده شد. مدل‌های پیشنهادی رگرسیونی از ضریب تبیین بالاتری در اکوسیستم‌های دست‌خورده برخوردار بود. در این رابطه عامل فرسایش‌پذیری خاک به همراه نیتروژن کل خاک به ترتیب ۸۰ و ۷۷ درصد تغییرات کل شاخص‌های شانون-وینر و مارگارف را توجیه کردند. طبق نتایج حتی در مواقعی که فرسایش‌پذیری به طور مستقیم در مدل برخی از شاخص‌های تنوع گونه‌ای تأثیر نداشته و در مدل حفظ نشده است، اجزای تشکیل دهنده فرسایش‌پذیری از جمله ماده آلی خاک(شاخص برگر-پارکر) در مدل‌ها سهم بسزایی از تغییرات تنوع گونه‌ای را توجیه می‌کنند. لذا فرسایش‌پذیری خاک یا اجزای این عامل در اکوسیستم‌های مرتعی دست خورده به شدت تحت تأثیر پدیده شخم قرار می‌گیرند و باعث برقراری ارتباط قوی رگرسیونی شاخص‌های مختلف غنا و تنوع گونه‌ای با عوامل خاکی می‌شوند.

**کلمات کلیدی**: خاک، رگرسیون، شانون، یکنواختی، فرسایش‌پذیری، آیش، دیمزار