International Journal of Agricultural Technology 2013 Vol. 9(2): 461-478
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

The use of diversity indices to assess the effect of restoration and conservation on plant diversity of a rangeland in South Khorasan Province, Iran

Jabbar Fallahi[1*], Parviz Rezvani Moghaddam[1], Mahdi Nassiri Mahallati[1] and Mohammad Ali Behdani[2]

[1]Ferdowsi University of Mashhad, P.O.Box 91775-1163, Iran, [2]University of Birjand, P.O.Box 97175-331, Iran

Jabbar Fallahi, Parviz Rezvani Moghaddam, Mahdi Nassiri Mahallati and Mohammad Ali Behdani (2013) The use of diversity indices to assess the effect of restoration and conservation on plant diversity of a rangeland in South Khorasan Province, Iran. International Journal of Agricultural Technology 9(2): 461-478.

Abstract Due to the damages to global biodiversity by human interferences in recent decades and the role of biodiversity in ecosystems sustainability, restoring and protecting of natural resources is a necessity. In order to understand the roles of replanting and protecting natural ecosystems in dry land condition, this research was conducted in the experimental site of the international Carbon Sequestration Project in Hussein Abad rangelands, South Khorasan province, Iran in April and June, 2011. In this study the effects of eight years conservation on biodiversity indices of four vegetation types including *Haloxylon persicum, Atriplex canescens*, *Haloxylon persicum* + *Atriplex canescens* and *Zygophyllum eurypterum* along with a control type (no regeneration and conservation programs) were investigated. The highest amounts of species number (Hill's N0) and vegetation cover were observed in *Haloxylon persicum* + *Atriplex canescens* type (30 species and 22.5%, respectively) and the lowest amounts were obtained in control type (20 species and 5.5%, respectively). Amount of vegetation percentage in protected areas was on average 3.3 times more than non-protected area. The highest and the lowest values of density were obtained in *Atriplex canescens* (54 plants m^{-2}) and control (18 plants m^{-2}) vegetation types, respectively. There was not any plant species with frequency of higher than 60% in control, while about 13% of plant species had frequency above 60% in protected vegetation types. The highest and the lowest plant species in all studied vegetation types were belonged to therophytes and phanerophytes groups. The mean Margalef's richness index in protected vegetation types (4.39) was higher than control (3.62). While, all plant diversity indices were higher in the control type because of more evenness index. Our results indicated that the most of recorded species in the studied area were belong to ephemeral flora. Overall, results showed that vegetation richness and coverage of desert rangelands can be restored with proper management programs.

Key words: Biodiversity; Carbon Sequestration; Richness Index; Uniformity Index; Dominance Index.

[*] **Corresponding author**: Jabbar Fallahi; **e-mail:** Agroecology86@yahoo.com

Introduction

Concerns about global warming and regional and global climatic and environmental changes in response to increasing concentrations of CO_2 and other greenhouse gases have led to a significant interest in carbon sequestration in terrestrial ecosystems (Tschakert *et al*., 2004; Spargo *et al*., 2008; Shi *et al*., 2009). According to the Kyoto Protocol carbon emissions must be offset by demonstrable removal of carbon from the atmosphere by the ways such as afforestation and reforestation (Yokozava *et al*., 2010). Because of these issues, attention towards desertification was increased in recent decades so that United Nations General Assembly named 2006 as the international year of deserts and desertification to increase public awareness and to help enhancement of biodiversity in arid regions (Stringer, 2008; Amiraslani and Dragovich, 2011).

Besides climate change, biodiversity loss has been recognized as one of the leading themes of environmental sustainability agenda (Haines-Young, 2009; Vackár *et al*., 2012). Deforestation and damage to biodiversity by modern human activities are occurring in Asia especially in South East and dry land areas, Amazon, Siberia and other parts of the word (Nielsen *et al*., 2007; Haines-Young, 2009). The need for rehabilitation of rangelands has increased with greater public awareness and it is clear that maintenance of biodiversity is so important, as its erosion will result in less stable ecosystems with reduced function (Simons and Allsopp, 2007; Nielsen *et al*., 2007). The inability to revert degraded rangelands to former productive states by removing grazing pressure alone has necessitated the use of a more active approach to the rehabilitation of rangelands such as use of hand planting species (Simons and Allsopp, 2007). It has been suggested that a proper management programs, could optimize the restoration potential of degraded rangelands, revive palatable species, restore the integrity of ecosystems and increase species diversity (Call and Roundy, 1991; Visser *et al*., 2004; Witbooi and Esler, 2004; Simons and Allsopp, 2007). Protected areas frequently serve to insulate biodiversity from the impacts of human development and generally, it is perceived that the human impacts on protected areas have inevitably led to a decrease in biodiversity relative to the nearby protected areas (Shackleton, 2000). Mligo (2006) found that protection programs affect the species composition and diversity, positively. Chaudhry *et al*., (2011) in a study on the rangelands biodiversity in a hot arid region of India emphasized an urgent need to rehabilitate the degraded areas in an efficient and cost-effective manner.

It is estimated that 85% of Iran is classified under dryland categories and deserts covers approximately 20% of the country (Le Houérou, 1992; Amiraslani and Dragovich, 2011). It has been stated that the main causes of desertification in the country involve climatic factors, population pressure, excessive grazing and over-exploitation of soil and water resources (Amiraslani and Dragovich, 2011). A major strategy for desertification programs in Iran is cultivation of plants that are adaptable to the unfavorable environmental conditions in arid and semi-arid areas such as: *Atriplex canescens*, *Haloxylon persicum*, *Calligonum comosum* and *Haloxylon ammodendron* (Amiraslani and Dragovich, 2011; Javadi *et al*., 2011). In several studies conducted at national level it was shown that vegetation cover, density, species richness and diversity indices were improved by restoration and conservation programs. Asghari *et al*., (2006) showed that there was a significant difference between exclusion and free grazing rangelands in terms of canopy cover, density and diversity. Another study suggested that vegetation cover in 25 years protected and non-protected rangeland vegetation types were 46% and 25%, respectively (Alizadeh *et al*., 2010). In similar research on 26 years protected rangelands in arid zone of the country, increase in vegetation parameters was concluded (Amiri and basiri, 2008). Abbasi *et al*., (2009) reported that protected and buffer zones had more suitable conditions compared to the areas located at outside of protected border in terms of richness, diversity, landscape and biological structures.

Recently a large-scale regional and global climate change is happening. Since the restoration and conservation of deserts biodiversity is an important and effective strategy in reducing impacts of these changes. The aim of this study was to investigate the effects of degraded rangelands restoration on plant diversity in a region within the International Carbon Sequestration Project, South Khorasan province, Iran.

Materials and methods

Experimental site

The study was conducted in the region of the International Carbon Sequestration Project (32^o N, 59^o E, 1700 m above sea level) in 1500 ha area of Hussein Abad rangelands located in Sarbisheh, South Khorasan province, Eastern part of Iran. The climate of study area is characterized by semi-arid conditions with an average annual precipitation of 188 mm and a mean annual temperature of 14.5 ^oC (Max. 40.5 ^oC, Min. – 16 ^oC) (GEF, 2003; FAO, 2004).

International Carbon Sequestration Project

The International Carbon Sequestration Project was started in 148,000 hectares of heavily degraded rangelands of Hussein Abad by the Government of the Islamic Republic of Iran (GIRI), Global Environment Facility (GEF) and

United Nations Development Program (UNDP) in 2003 (GEF, 2003). The objectives of the project were: increase animal fodder production, expanding the storage of carbon, enhancement the flora and fauna, improving biodiversity and ecosystem rehabilitation (FAO, 2004).

Vegetation types

The study area was under restoring and protecting programs since 2003 (GEF, 2003). Before starting the initial project in 2003, the dominant species in all study areas was *Artemisia sieberi* (with less than 5% vegetation cover). Then, *Haloxylon persicum*, *Atriplex canescens*, *H. persicum* + *A. canescens* (based on 150 plants per ha) and lily (*Lilium sp*) species (based on 500 plants per ha) were cultivated in 230, 190, 510 and 70 ha, respectively in 2003. All cultivated areas were kept protected from herbivores and human interference after the recovery operations till 2011. Also, 500 ha was used as a control (non-restoration and non-protection, means being under herbivores and human intervention) near to the restoration region. The dominant types of vegetation at studied areas (protected and non protected areas) in 2011 were: 1- *Artemisia sieberi* + *Haloxylon persicum* (Ar.si-Ha.pe) 2- *Artemisia sieberi* + *Atriplex canescens* (Ar.si-At.ca) 3- *Artemisia sieberi* + *Haloxylon persicum* + *Atriplex canescens* (Ar.si-Ha.pe-At.ca) 4- *Artemisia sieberi* + *Zygophyllum eurypterum* (Ar.si-Zy.eu) and 5- *Artemisia sieberi* (control = Ar.si). (Fallahi *et al*., in preparation). Lily species could not be established very well in the cultivated area during 2003 till 2011. Lily species then gradually disappeared and *Zygophyllum eurypterum* as a native species gradually interred to the protected sites from nearby areas.

Sampling method

Vegetation sampling was conducted by using random quadrate procedure in the spring of 2011, eight years after the onset of protection programs. The number of quadrates (2 × 2 m) in each vegetation type was increased until the recorded plant species did not increase (according to the species increase curve). Sampling was done at 21 April and then re-visit was taken at 7 June to record the newly established species. Identification of species in collected samples was done at the Herbarium of Faculty of Agriculture, University of Birjand.

Studied indices

The density and frequency of each plant species in each quadrate were measured separately. The aerial cover of each vegetation types was estimated by visual method. According to Raunkiaer's method, each plant species based on its frequency was categorized in one of the five introduced classes (A, B, C, D and E) and then frequency spectrum of each vegetation type was drawn and compared with normal curve of frequency (McIntosh, 1962). Raunkiaer classified plant species in five frequency classes as follow: A: including those species occurring in 1-20%, B: in 21-40%, C: in 41-60%, D: in 61-80% and E: in 81-100% of the samples (Gleason, 1939; McIntosh, 1962; Hong-bing *et al*., 2000). In addition, observed plants in all vegetation types were classified based on Raunkiaer's life-form system (Raunkiaer, 1934). Finally, species richness, evenness, diversity, dominance and similarity indices were calculated using equations in Table 1.

Table 1. Indices used for evaluation of different vegetative characteristics.

Index	**Equations**	**Reference**	**Index**	**Equations**	**Reference**
Richness indices					
Menhinick	$D_{Mn} = \frac{S}{\sqrt{N}}$	Menhinick, 1964	Margalef	$M = \frac{S-1}{\log N}$	Margalef, 1958
Evenness indices					
Shannon	$E = \frac{H'}{\log S}$	Shaheen *et al.*, 2012	Simpson	$E_{1/D} = \frac{1/D}{S}$	Smith and Wilson, 1996
E2= Sheldon	$E_2 = \frac{N_1}{N_0}$	Sheldon, 1969	E1= Pielou	$E_1 = \frac{\ln(N_1)}{\ln(N_0)}$	Pielou, 1975
E4= Hill	$E_4 = \frac{N_2}{N_1}$	Hill, 1973	E3= Heip	$E_3 = \frac{N_1 - 1}{N_0 - 1}$	Heip, 1974
			E5= Alatalo	$E_5 = \frac{N_2 - 1}{N_1 - 1}$	Alatalo, 1981
Diversity indices					
Simpson	$1 - D = 1 - \sum_{i=1}^{S} \left(\frac{ni}{N}\right)^2$	Simpson, 1949	Shannon	$H' = -\sum_{i=0}^{n} \left(\frac{n_i}{N}\right) \log\left(\frac{n_i}{N}\right)$	Shannon, 1948
Hill's N0	$N_0 = S$	Hill, 1973	Berger-Parker	$\frac{1}{d} = \frac{1}{\frac{Nmax}{N}}$	Merigot *et al.*, 2007
Hill's N2	$N_2 = \frac{1}{D}$	Hill, 1973	Hill's N1	$N_1 = e^{H'}$	Hill, 1973
Dominance indices					
Simpson	$D = \sum_{i=1}^{S} \left(\frac{ni}{N}\right)^2$	Simpson, 1949	Berger-Parker	$d = \frac{Nmax}{N}$	Berger and Parker, 1970
Similarity index					
Sorensen				$\frac{2a}{2a + b + c}$	Sorensen, 1948

S= Total number of species, N= Total number of individual, N_{max}= Individual number of the most dominant species, n_i= Number of individual of i species (i=1-s), D= Simpson's Dominant index, H' =Shannon- Wiener diversity index , N_0= Hill's N0, N_1= Hill's N1, N_2= Hill's N2, e= 2.71828, a= The number of shared species between A and B vegetation types, b= The number of species only in type A and c= The number of species only in type B.

Results and discussions

Vegetation richness and coverage

The numbers of plant species in all protected vegetation types were more than control. Species number in Ar.si-Ha.pe-At.ca, Ar.si-Zy.eu, Ar.si-Ha.pe and Ar.si-At.ca were 35%, 20%, 14% and 14% more than control, respectively (Table 2). A similar result was observed for vegetation cover percentage. The plant coverage percentage significantly increased in all protected vegetation types compared to control. Amount of vegetation percentage in Ar.si-Ha.pe-At.ca, Ar.si-Zy.eu, Ar.si-Ha.pe and Ar.si-At.ca were 4.10, 4.05, 2.58 and 2.52 times more than non-protected type (control), respectively (Table 2). In addition, plant densities in four conservation types were significantly higher than control. The highest amount of plant density was observed in Ar.si-At.ca type, but a large share of plant density in this vegetation type was belonged to the annual species of *Roemeria hybrida*. Plant densities in Ar.si-At.ca, Ar.si-Ha.pe-At.ca and Ar.si-Zy.eu were 3, 2.2 and 1.5 times more than control, respectively (Table 2).

Many studies have reported the positive role of conservation on vegetation parameters of rangelands. Yorks *et al*., (1992) concluded that 59 years rangeland protection in Utha State dramatically increased the vegetation cover. In two similar works, communal lands had significantly lower herbaceous plant cover, litter cover and herbaceous plant height while, a higher deal of bare ground than protected lands (Shackleton, 2000, Tefera *et al*., 2007). Asghari *et al*., (2006) reported a remarkable difference in terms of canopy cover and density among protected and non-protected rangelands in Kiasar, Iran. In another study it was concluded that 25 years conservation was improved the vegetation cover of rangelands about 55% more than non-protected lands (Alizadeh *et al*., 2010). Results of Amiri and Basiri (2008) on the positive effects of 26 years protection on vegetation parameters of rangelands in an arid zone of Iran were significant. The study of Holechek *et al*., (2003) in a desert ecosystem in U.S.-Mexico border showed that light conservative grazing intensities can promote improvement in rangeland ecological condition, even when accompanied by drought. It has been reported that the time required to achieve significant changes in the result of protection, depends on edaphic and climatic factors (York's *et al*., 1992). This time for dry areas is between 30 to 40 years. Therefore, considering that only eight years has been elapsed from beginning of protection, it seems that vegetation indices of exclusion studied types will improve in future.

Table 2. Comparisons of number of plant species, vegetation cover percentage and density between protected and non-protected types

	Ar.si. - Ha.pe.	Ar.si.- At.ca.	Ar.si.- At.ca. Ha.pe.-	Ar.si.- Zy.eu.	Ar.si. (Control)
Number of plant species	23.0	23.0	30.0	25.0	20.0
Percentage of vegetation cover	14.2	13.9	22.5	22.3	05.5
Total number of plant per m^2	19.2	53.9	39.8	27.4	17.9

Frequency of plant species

Raunkiaer proposed a normal frequency distribution curve that is useful in different studies in testing the uniformity of vegetation (McIntosh, 1962). Frequency reflects not only the important of population, but also the uniformity of spatial distribution in plant communities (Hong-bing *et al*., 2000). Results of the frequency spectrum of plant species in the study area showed that most plant species do not have a uniform distribution over the rangeland in all vegetation types. On average, 65% of species had a frequency of less than 20% (class A) and only 4.5% of species had a frequency above 80% (class E) (Table 3). By comparing the results of frequency spectrum of studied ecosystem with Raunkiaer standard frequency curve (McIntosh, 1962), it was concluded that in the studied region, the number of species with a frequency of less than 20% was about 20% higher and the number of species with a frequency of more than 80%, was about 78% less, compared with standard curve (Table 3). No species in D and E classes (frequency of above 60%) were observed in control (unprotected area), while the number of species in class C was the highest in this vegetation type (Table 3). The absence of certain frequency classes reflect the heterogeneity of the vegetation, which is either due to biotic disturbance or the floral poverty (Iqbal and Shafiq, 1996). It was suggested that the higher number of species in class E shows the grater homogeneity (McIntosh, 1962). Therefore, homogeneity in the studied vegetation types was poor, especially in control vegetation type. Hong-Bing *et al*., (2000) stated that widespread species with high frequency are usually dominant species in relevant community, these species spread all over the community, building the basement of the community; associated species which possess of middling frequency compose the main body of community and the rare species with low frequency shows the complexity of community. Therefore, the richness of community in the studied rangeland was poor and rare species were higher than normal curve.

Table 3. Frequency distribution of plant species in the studied vegetation types compared with Raunkiaer standard frequency spectrum. Hussein Abad

Sarbisheh protected rangeland, South Khorasan province, Iran (the first sampling in April 2011)

	A*=1-20%	**B*=21-40%**	**C*= 41-60%**	**D*= 61-80**	**E*=81-100%**
Numbers of Raunkiaer standard	53	14	9	8	16
Ar.si. - Ha.pe.	56.5	30.5	0	8.7	4.3
Ar.si. - At.ca.	65.2	8.7	13	13	0
Ar.si. - Ha.pe. - At.ca.	70	13.3	3.3	3.3	10
Ar.si. - Zy.eu.	72	4	12	8	4
Mean of protected types	65.9	14.1	7	8.2	4.5
Ar.si. (Control)	60	10	30	0	0

*A including plant species occurring in 1-20% of the samples, * B in 21-40%,* C in 41-60%,* D in 61-80% and * E in 81-100 percent

Plant life-forms

According to Raunkiaer system, plant life-forms are classified based on the position and degree of protection of renewing buds, which are responsible for the renewal of the aerial organs of plant in the beginning of favorable season (Batalha and Martins, 2004; Van Der Merwe and Rooyen, 2011). In the first sampling date, the highest and the lowest plant species in all studied vegetation types were belonged to therophytes and phanerophytes. Most observed phanerophyte species have also been hand planted. Life-form spectrum of Ar.si-Ha.pe-At.ca and Ar.si-Zy.eu vegetation types had better distribution compared with other types. The percentage of therophyte species was lower and the percentage of other life-forms were higher in Ar.si-Ha.pe-At.ca and Ar.si-Zy.eu vegetation types. The percentage of phanerophytes and chamaephytes in non-protected type were lower, while the percentage of hemi-cryptophytes and therophytes were more than mean values of protected types (Table 4). These results could be an indication for replacement of perennials with annual species in the unprotected land which was subjected to higher grazing pressure than the protected sites (Tefera *et al*., 2007). Shackleton *et al*., (1994) found that attributes of woody plant community within the region increased with increasing distance from human settlement. In another study annual plants (therophyte) were abundant in communal and perennial species in protected zone (Tefera *et al*., 2007). Life-forms have close relationships with climatic factors, so that climatic conditions of terrestrial biomes are distinguished from one another primarily on the basis of the dominant life-forms (Raunkiaer 1934; Chiarucci *et al*., 2001; Carvalho da Costa *et al*., 2007; Naqinezhad *et al*., 2009; Van Der Merwe and Rooyen, 2011). In the studied area therophytes were dominant which indicates that life-forms spectrum were different compared with Raunkiaer's normal spectrum (Carvalho da Costa *et al*., 2007). In general, dominance of therophytes indicates the desert nature of the climate and an effective plant strategy for avoiding water losses due to humidity extremes and water deficiencies in a study area (Carvalho da Costa *et al*., 2007; Van Der Merwe and Van Rooyen, 2011). Therophytes are believed to show more avoidance to drought than the hemicryptophytes and geophytes, since the former spend the summer in the form of seeds and the latter in the form of vegetative organs (Van Der Merwe and Rooyen, 2011). Overall, estimated life-form spectra, or ratios between selected life forms, may be useful indicators for comparing different sites and/or evaluating a given site over time (Chiarucci *et al*., 2001). Accordingly, Hussein Abad rangelands have desert and dry conditions and hence dominance of therophytic life-form plants is expected.

Table 4. The distribution of life-forms of plant species in five vegetation types according to Raunkiaer category - Hussein Abad Sarbisheh protected rangeland, South Khorasan province, Iran (the first sampling in April 2011)

Life-Forms	**Ar.si-Ha.pe**	**Ar.si-At.ca**	**Ar.si-Ha.pe-At.ca**	**Ar.si-Zy.eu**	**Mean of protected types**	**Ar.si (Control)**	**Raunkiaer's normal spectrum**
Phanerophyte	4.3	4.3	10	4	5.6	0	46
Chamaephyte	13	17.4	23.3	24	19.4	10	9
Hemicryptophyte	13	21.7	20	24	19.6	30	26
Cryptophyte	8.6	8.6	13.3	12	10.6	10	6
Therophyte	60.8	47.8	33.3	36	44.4	50	13

Plant diversity indices

Margalef's richness index (which commonly shows the number of plant species) in all protected vegetation types were more than non-protected vegetation type, while evenness indices (that show distribution pattern of species) in control (non-protected vegetation type) were remarkably higher than four conservation vegetation types (Table 5, 6). All plant diversity indices which are generally indicating vegetation heterogeneity were higher in control compared to four protected vegetation types (Table 7). Moreover, Simpson and

Berger- Parker dominance indices in rehabilitate and conservation vegetation types were higher than control (Table 8).

Table 5. Mean values of some richness indices of five vegetation types in Hussein Abad Sarbisheh protected rangeland, South Khorasan province, Iran (the first sampling in April 2011)

Richness index	Ar.si.-Ha.pe.	Ar.si.-At.ca.	Ar.si.-Ha.pe. - At.ca.	Ar.si.-Zy.eu.	Mean of conservative types	Ar.si. (Control)
Margalef	4.16	3.83	5.18	4.41	4.39	3.62
Menhinick	0.052	0.031	0.047	0.047	0.044	0.047

Table 6. Values of some evenness indices of five vegetation types in Hussein Abad Sarbisheh protected rangeland, South Khorasan province, Iran (the first sampling in April 2011)

Evenness index	Ar.si.-Ha.pe.	Ar.si.-At.ca.	Ar.si.-Ha.pe. - At.ca.	Ar.si.-Zy.eu.	Mean of conservative types	Ar.si. (Control)
Simpson	0.14	0.09	0.08	0.12	0.10	0.23
Shannon	0.59	0.43	0.45	0.54	0.50	0.64
Pielou = E1	0.25	0.18	0.19	0.23	0.21	0.29
Sheldon= E2	0.09	0.07	0.06	0.08	0.07	0.12
Heip= E3	0.05	0.03	0.03	0.04	0.04	0.07
Hill= E4	1.50	1.20	1.24	1.42	1.34	1.95
Alatalo= E5	1.90	1.46	1.50	1.79	1.66	2.62

Table 7. Values of some diversity indices of five vegetation types in Hussein Abad Sarbisheh protected rangeland, South Khorasan province, Iran (the first sampling in April 2011)

Diversity index	Ar.si.-Ha.pe.	Ar.s.i-At.ca.	Ar.si.-Ha.pe. - At.ca.	Ar.si.-Zy.eu.	Mean of conservative types	Ar.si.(Control)
Shannon	0.80	0.59	0.67	0.76	0.70	0.89
Simpson	0.70	0.54	0.59	0.67	0.62	0.79
Berger-Parker	1.92	1.51	1.58	1.81	1.70	2.50
Hill's N0	23	23	30	25	25.2	20
Hill's N1= Exp H'	2.22	1.80	1.95	2.13	2.02	2.43
Hill's N2	3.33	2.17	2.43	3.03	2.74	4.76

Table 8. Values of some dominance indices of five vegetation types in Hussein Abad Sarbisheh protected rangeland, South Khorasan province, Iran (the first sampling in April 2011)

Dominance index	Ar.si.-Ha.pe.	Ar.si.-At.ca.	Ar.si.-Ha.pe. - At.ca.	Ar.si.-Zy.eu.	Mean of conservative types	Ar.si (Control)
Simpson	0.30	0.46	0.41	0.33	0.37	0.21
Berger-Parker	0.52	0.66	0.63	0.55	0.59	0.4

Most biodiversity indices are consisted of two richness and evenness components (Ejtehadi *et al.*, 2009). Despite the higher richness index in protected areas the plant diversity indices were lower in protected than non-protected vegetation types. This shows that, evenness component had a higher contribution compared to the richness component in determining the final value of plant diversity indices. The higher impact of evenness than richness in the value of the plant diversity indices have been reported by Stirling and Wilsey (2001), Duelli and Obrist (2003) and Grunewald and Schubert (2007). In addition Wilsey and Stirling (2007) suggested that species evenness and diversity indices do not always positively co-vary with richness. In another study they concluded that in plant communities, richness and evenness were negatively correlated and evenness accounted for more variation in Shannon's diversity index than richness (Stirling and Wilsey, 2001). Grunewald and

Schubert (2007) showed that the common usage of plant diversity indices are not appropriate measure for studying disturbance in plant communities, because these indices are strongly dependent on evenness, whereas species richness and species density are not adequately incorporated. In our study amounts of plant cover percentage, species number and plant density in protected vegetation types were remarkably more than control type, while all diversity indices were higher in control. This shows that the used plant diversity indices are very sensitive to evenness and underestimate other factors. Therefore, it is necessary to take into account the others factors to calculate plant diversity, as Grunewald and Schubert (2007) showed some limitations of plant diversity indices and introduced a new index to reduce defects of those indices.

Duelli and Obrist (2003) suggested that the favor of indices involving evenness in recent years have essentially declined, mostly because of the difficulty in their interpretation, particularly in studies where a single species are often collected in huge numbers, which results in a severe drop of evenness and thus yields low plant diversity values, in spite of comparatively high species richness. As in our research two species of *Carex* sp. and *Roemeria hybrida* were included more than 50% of the total plant density in protected vegetation types while these species were in a normal density (less than 5%) in control vegetation type. Noss (1983) stressed that all species should not be considered equal in plant diversity indices calculation, and therefore, numbers alone provide an incomplete picture. As in our study two species of *Carex* sp. and *Roemeria hybrida* with high density occupied less than 1% of plant cover of protected vegetation types, while the amounts of diversity indices in these types were decreased. On the other hand, diversity indices are not according to the quality of the species, as in present study similar to the other reports (Mligo, 2006, Simons and Allsopp, 2007, Tefera *et al*., 2007) non-palatable and invasive species such as *Peganum harmala*, *Alhagi maurorum* and *Echinops persicus* were observed in non protected vegetation type frequently and these plant exert an equal role comparing desirable species in final amounts of diversity indices.

In similar study Mligo (2006) reported that grazing pressure negatively affected the species diversity and resulted into patchy distribution of the common semi-arid plant species in the rangelands. But in another work there was a little increase in regard of beta diversity in the communal than protected range areas but this different was no significant (Shackleton, 2000). Abbasi *et al*., (2009) stated that despite of higher biological structures richness in protected area, severe protection will be increased the species dominance and followed by low biodiversity. It has been reported that high grazing intensity reduced the diversity and production of rangeland, moderate grazing intensity increased diversity and no- grazing decreased diversity while increased production (Ghlichnia, 2000). In a study, the Shannon index was not correlated with the successional gradient so that diversity was decreased from short grasslands to shrub communities (Chabrerie *et al*., 2003). It seems that maximum plant species diversity can be obtained at moderate stress and damage intensity (intermediate disturbance hypothesis) (Shackleton, 2000; Mligo, 2006; Grunewald and Schubert, 2007).

Moreover, results of Sorensen Similarity Index showed that the highest amount of similarity was obtained between Ar.si.-Ha.pe.-At.ca and Ar.si.-Zy.eu vegetation types (72%) which they were in close proximity. This is in accord to results of Mligo (2006), who introduced the vicinity and grazing pressure as the similarity factors. In addition, the percentage of similarity between all studied vegetation types was about 53% on average (Table 9). This shows that change in vegetation type could affect the species composition in community.

Table 9. Values of Sorensen similarity index between all vegetation types in Hussein Abad Sarbisheh protected rangeland, South Khorasan province, Iran (the first sampling in April 2011)

Vegetation types	**Ar.si.-Ha.pe.**	**Ar.si.-At.ca.**	**Ar.si.-Ha.pe. - At.ca.**	**Ar.si.-Zy.eu.**	**Ar.si. (Control)**
Ar.si.-Ha.pe.	1.00				
Ar.si.-At.ca.	0.52	1.00			
Ar.si.-Ha.pe. - At.ca.	0.56	0.52	1.00		
Ar.si.-Zy.eu.	0.54	0.45	0.69	1.00	
Ar.si. (Control)	0.41	0.51	0.52	0.62	1.00

Observations of the second visit

The rangeland was re-visited at 7 June 2011. New plant species was not found in all studied vegetation types. Moreover, almost all annual species recorded in the first sampling date (21 April) were disappeared. These annual plants have synchronous growth and are classified in ephemeral flora. Ephemeral flora is an important and unique component of arid and semi-arid regions that can take the advantage of water, resources and temperature conditions in spring to rapidly complete their life-cycle (Vidiella and Armesto, 1989; Steyn *et al*., 1996b; Xueqin *et al*., 2003). These plants have a tendency to accelerate their phonological stages for increasing the probability of seed set before the end of the wet season. However, in arid environments, the unpredictable nature of rainfall, both in terms of quantity and distribution, imposes several restrictions on the ability of an individual to survive or reproduce successfully (Steyn *et al*., 1996a). In a similar study in desert parts of China, ephemeral plants sprouted in early April and completed their life-cycle within two months. Their coverage in April, May and June were 13.9, 40.2 and 14.1 percent, respectively (Xueqin *et al*., 2003).

Conclusion

Overall, the results indicated that restoration and protection programs can be improved vegetation coverage and richness of degraded rangelands of dry regions. So that, after eight years of protection, in protected vegetation types the number of plant species and plant density were on average 20% and 95% more than non protected type, respectively. Moreover, vegetation cover in protected vegetation types was 3.3 times more than control. Despite of higher species richness in protected vegetation types, all plant diversity indices were higher in the control type because of more evenness index. It seems that in the protected areas, successional stages are allowed to occur and in the intermediate serial stages, the higher competitive species dominate the community, decreasing the evenness index. As, two ephemeral species including *Carex* sp. and *Roemeria hybrida* were included more than 50% of the total plant density with below only 1% of vegetation percentage in protected areas, while these species had low densities (less than 5%) in non protected areas, because of livestock grazing. Therefore, it seems that moderate grazing or other weak perturbations reduce the dominance of some plant species and subsequently increase evenness (according to the intermediate disturbance hypothesis). Moreover, intermediate disturbance can release some niches that can be colonized by initial or intermediate plant stages, increasing the overall species richness and evenness.

Acknowledgements

We are grateful to Ferdowsi University of Mashhad, Faculty of Agriculture for financial support. We wish to thank General Office of Natural Resources and Watershed Management in provincial South Khorasan, Iran. M. Sc Alireza Yari Executive Director of International Carbon Sequestration Project, Mr. Mohammad Fathi, Mr. Gholamreza Khorashadizadeh and Mr. Mohammad Kermani staffs of Department of Natural Resources of Birjand for their helps on this research.

References

Abbasi, S., Hosseini, S. M., Pilevar, B. and Zare, H. (2009). Effects of conservation on woody species diversity in Oshtorankooh region, Lorestan. Iranian Journal of Forest 1(1):1-10.

Alatalo, R. V. (1981). Problems in the measurement of evenness in ecology. Oikos 37:199-204.

Alizadeh, M., Mahdavi, M. and Jouri, M. H. (2010). Capability investigation of carbon sequestration in two species (*Artemisia sieberi* Besser & *Stipa barbata* Desf) under different treatments of vegetation management (Saveh, Iran). World Academy of Science, Engineering and Technology 70: 295-298.

Amiraslani, F. and Dragovich, D. (2011). Combating desertification in Iran over the last 50 years: An overview of changing approaches. Journal of Environmental Management 92: 1-13.

Amiri, F. and Basiri, M. (2008). Comparison of some soil properties and vegetation characteristics in grazed and ungrazed range site. Rangeland 2(3): 237-253.

Asghari, M. J., Bahmaniar, M. A. and Akbarzadeh, M. (2006). Comparison of the effects of exclusion and water spreading on vegetation and soil parameters in Kyasar rangelands, Mazandaran province. Journal of Agricultural Sciences and Natural Resource 13(4): 1-12.

Batalha, M. A. and Martins, F. R. (2004). Floristic, frequency and vegetation life- form spectra of a Cerrado site. Brazilian Journal of Biology 64(2): 203-209.

Berger, W. H. and Parker, F. L. (1970). Diversity of planktonic foraminifera in deep-sea sediments. Science 168: 1345–1347.

Call, C. A. and Roundy, B. A. (1991). Perspectives and processes in revegetation of arid and semiarid rangelands. Journal of Range Management 44: 543–549.

Carvalho da Costa, R., Soares de Araujo, F. and Wilson Lima-Verde, L. (2007). Flora and life-form spectrum in an area of deciduous thorn woodland (caatinga) in northeastern, Brazil. Journal of Arid Environments 68: 237–247.

Chabrerie, O., Laval, K., Puget, P., Desaire, S. and Alard, D. (2003). Relationship between plant and soil microbial communities along a successional gradient in a chalk grassland in north-western France. Applied Soil Ecology 24: 43–56.

Chaudhry, P., K.Bohra, N. and Choudhary, K. R. (2011). Conserving biodiversity of community forests and rangelands of a hot arid region of India. Land Use Policy 28: 506–513.

Chiarucc, A., Maccherini, S. and De Dominicis, V. (2001). Evaluation and monitoring of the flora in a nature reserve by estimation methods. Biological Conservation 101: 305–314.

Duelli, P. and Obrist, M. K. (2003). Biodiversity indicators: the choice of values and measures. Agriculture, Ecosystems and Environment 98:87–98.

Ejtehadi, H., Sepehry, A. and Akkafi, H. R. (2009). Methods of measuring biodiversity. 1nd ed. Mashhad: Ferdowsi University of Mashhad Press. Iran. 228p.

FAO. (20040. A review of carbon sequestration projects. Rome: FAO, 95p.

Javadi, S. A., Naseri, S., Jafari, M. and Zadbar, M. (2011). Estimating the production in two shrub species of *Atriplex canescens* and *Haloxylon ammodendron* using some morphological parameters. African Journal of Agricultural Research 6(2):313-317.

Haines-Young, R. (2009). Land use and biodiversity relationships. Land Use Policy 26:178–186.

Heip, C. (1974). A new index measuring evenness. Journal of UK Marine Biological Association 54:555-557.

Hill, M. O. (1973). Diversity and evenness: A unifying notation and its consequences. Ecology 54(2): 427-432.

Holechek, J., Galt, D., Joseph, J., Navarro, J., Kumalo, G., Molinar, F. and Thomas, M. (2003). Moderate and light cattle grazing effects on Chihuahuan desert rangelands. Journal of Range Management 56: 133-139.

Hong-bing, D., Zhan-qing, H., Ping, J. and Qing-li, W. (2000). Species frequency of communities along northern slope of Changbai mountain, northeast China. Journal of Forestry Research 11(3): 187-190.
Iqbal, M. Z. and Shafiq, M. (1996). Plant communities on the sandy areas of Karachi university campus. Journal of Islamic Academy of Sciences 9(3): 89-98.
GEF. (2003). Carbon sequestration in the decertified rangelands of Hossein Abbad. UNDP, 86p.
Gleason, H. A. (1939). The Significance of Raunkiaer's Law of Frequency. Ecology 10(4):406-408.
Grunewald, R. and Schubert, H. (2007). The definition of a new plant diversity index ‘‘H'_{dune}’’ for assessing human damage on coastal dunes-Derived from the Shannon index of entropy H'. Ecological Indicators 7: 1–21.
Le Houérou, H. N. (1992). An overview of vegetation and land degradation in world arid lands, In: Dregne, H.E. (Eds.), Degradation and Restoration of Arid Lands. Texas Tech University, pp 127-163.
Margalef, R. (1958). Information theory in ecology. General Systems 3: 36-71.
McIntosh, R. P. (1962). Raunkiaer's "Law of Frequency. Ecology 43(3): 533-535.
Menhinick, E. P. (1964). A comparison of some species-individuals diversity indices applied to samples of field insects. Ecology 45: 859- 861.
Merigot, B., Bertrand, J. A., Mazouni, N., Mante, C., Durbec, J. P. and Garetner, J. C. (2007). A multi- component analysis of species diversity of groundfish assemblages on the continental shelf of the Gulf of Lions (north-western Mediterranean Sea). Estuarine, Coastal and Shelf Science 73: 123-136.
Mligo, C. (2006). Effect of grazing pressure on plant species composition and diversity in the semi-arid rangelands of Mbulu district, Tanzania. Agricultural Journal 1(4):277-283.
Naqinezhad, A., Jalilid, A., Attara, F., Ghahremana, A., D.Wheeler, B., G.Hodgson, J., C.Shaw, S. and Maassoumi, A. A. (2009). Floristic characteristics of the wetland sites on dry southern slopes of the Alborz Mts., N. Iran: The role of altitude in floristic composition. Flora 204: 254–269.
Nielsen, S. E., Bayne, E. M., Schieck, J., Herbers, J. and Boutin, S. (2007). A new method to estimate species and biodiversity intactness using empirically derived reference conditions. Biological Conservation 137: 403-414.
Noss, R. F. (1983). A regional landscape approach to maintain diversity. BioScience 33: 700-706.
Pielou, E. C. (1975). Ecological diversity. New York: Wiley.
Raunkiaer, C. (1934). The life form of plants and statistical plant geography. London: Oxford Clarendon Press, 632p.
Shackleton, C. M., Grin, N. J., Banks, D. I., Mavrandonis, J. M. and Shackleton, S. E. (1994). Community structure and species composition along a disturbance gradient in a communally managed South African savanna. Plant Ecology 115 (2): 157-167.
Shackleton, C. M. (2000). Comparison of plant diversity in protected and communal lands in the Bushbuckridge lowveld savanna, South Africa. Biological Conservation 94: 273-285.
Shaheen, H., Ullah, Z., Khan, S. M. and Harper, D. M. (2012). Species composition and community structure of western Himalayan moist temperate forests in Kashmir. Forest Ecology and Management 278: 138–145.
Shannon, C.E. (1948). A mathematical theory of communication. Bell System Technical Journal, 27: 379 -423.
Sheldon, A .L. (1969). Equitability indices: dependence on the species count. Ecology 50: 466-467.

Shi, X. Z., Wang, H. J., Yu, D. S., C.Weindorf, D., Cheng, X. F., Pan, X. Z., Sun, W. X. and Chen, J. M. (2009). Potential for soil carbon sequestration of eroded areas in subtropical China. Soil and Tillage Research 105: 322–327.

Simons, L. and Allsopp, N. (2007). Rehabilitation of rangelands in Paulshoek, Namaqualand: Understanding vegetation change using biophysical manipulations. Journal of Arid Environments 70: 755–766.

Simpson, E. H. (1949). Measurement of diversity. Nature 163: 688.

Smith, B. and Wilson, J. B. (1996). A consumer's guide to evenness indices. Oikos 76: 70-82.

Sorensen, T. (1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation on Danish commons. Videnski Selskab Biologiske Skrifter 5: 1– 34.

Spargo, J. T., Alley, M. M., Follett, R. F. and Wallace, V. J. (2008). Soil carbon sequestration with continuous no-till management of grain cropping systems in the Virginia coastal plain. Soil and Tillage Research 100: 133–140.

Steyn, H. M., Van Rooyen, N., Van Rooyen, M. W. and Theron, G. K. (1996a). The phonology of Namaqualand ephemeral species: The effect of sowing date. Journal of Arid Environments 32: 407–420.

Steyn, H. M., Van Rooyen, N., Van Rooyen, M W. and Theron, G. K. (1996b). The phonology of Namaqualand ephemeral species: The effect of water stress. Journal of Arid Environments 33: 49–62.

Stringer, L. C. (2008). Reviewing the international year of deserts and desertification 2006: what contribution towards combating global desertification and implementing the United Nationm Convention to combat desertification? Journal of Arid Environments 72: 2065-2074.

Stirling, G. and Wilsey, B. (2001). Empirical relationships between species richness, evenness, and proportional diversity. The American Naturalist 158: 86–299.

Tefera, S., Snyman, H. A. and Smit, G. N. (2007). Rangeland dynamics in southern Ethiopia: (1) Botanical composition of grasses and soil characteristics in relation to land-use and distance from water in semi-arid Borana rangelands. Journal of Environmental Management 85: 429-442.

Tschakert, P., Khouma, M. and Sene, M. (2004). Biophysical potential for soil carbon sequestration in agricultural systems of the Old Peanut Basin of Senegal. Journal of Arid Environments 59: 511–533.

Vacká r, D., Brink, B., Loh, J. E. M., Baillie, J. and Reyerse, B. (2012). Review of multispecies indices for monitoring human impacts on biodiversity. Ecological Indicators 17: 58-67.

Van Der Merwe, H. and Van Rooyen, M. W. (2011). Life form spectra in the Hantam-Tanqua-Roggeveld, South Africa. South African Journal of Botany 77: 371–380.

Vidiella, P. E. and Armesto, J. J. (1989). Emergence of ephemeral plant species from soil samples of the Chilean coastal desert in response to experimental irrigation. Revista Chilena de Historia Natural 62: 99-107.

Visser, N., Botha, J. C. and Hardy, M. B. (2004). Re-establishing vegetation on bare patches in the Nama-Karoo, South Africa. Journal of Arid Environments 57: 15–37.

Wilsey, B. and Stirling, G. (2007). Species richness and evenness respond in a different manner to propagule density in developing prairie microcosm communities. Plant Ecology 190: 259–273.

Witbooi, B. and Esler, K. (2004). Old field restoration: an assessment of the influence of restoration techniques on the establishment of selected succulent Karoo species. Elsenburg Journal 1: 3–7.

Xueqin, W., Jin, J., Jiaqiang, L., Weimin, Z. and Yibing, Q. (2003). Distribution of ephemeral plants and their significance in dune stabilization in Gurbantunggut desert. Journal of Geographical Sciences 13(3): 323-330.

Yokozava, M., Shirato, Y., Sakamoto, T., Yonemura, S., Nakai, M. and Ohkura, T. (2010). Use of the RothC model to estimate the carbon sequestration potential of organic matter application in Japanese arable soils. Soil Science and Plant Nutrition 56: 168–176.

Yorks, T. P., West, N. E. and Kaples, K. M. (1992). Vegetation differences in desert shrublands of west Utha, spine valley, between 1933 and 1989. Journal of Range Management 45(6): 569-577.

(Received 26 July 2012; accepted 28 Febuary 2013)