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Effects of different livestock grazing intensities on plant cover, soil properties, and above and below ground C and N pools in arid ecosystems (Jiroft rangeland, Iran)

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Abstract
This study was conducted in Jiroft rangeland, Kerman, Iran to assess the effects of different livestock grazing intensities (low, moderate, heavy) on ecological factors, soil properties, and root and shoot carbon and nitrogen pools. In each plant sampling site, five points were selected and five quadrates (a total of 75 quadrats) were investigated. Soil surface samples were taken in quadrats (75 samples). Data analysis was carried out by analysis of variance (SPSS18.0). Findings indicated that canopy cover (46.23%) had the maximum level in the low grazing site. The diversity index was maximum in the overgrazed site (1.63), while the low grazing site had the minimum species diversity (1.27). In the three sites, the nitrogen and carbon pools were higher in the roots compared to the shoots. In the low grazing site, the plants' nitrogen and carbon pools were notably more than the heavy and moderate grazing sites. Potassium (612.87 mg kg^{-1}), nitrogen (3.30 g kg^{-1}), and organic carbon (39.20 mg kg^{-1}) were considerably higher under heavy grazing conditions. However, the low grazing condition resulted in notable enrichment of phosphorus (11.44 mg kg^{-1}). The soil nitrogen and carbon pool in the overgrazed site were higher. In spite of the fact that the soil nutrients in the heavy grazed site were higher because of livestock manure; we could not interpret it as greater soil fertility. Our results suggest that low grazing can be effective for managing plant community and soil quality in arid ecosystems.

Keywords*:* Plant–soil interface, Carbon and Nitrogen storage, Species diversity, Soil fertility, Arid rangelands

Introduction
The vegetation and soil properties of biological systems change by numerous ecological factors and land use (Hanke et al., 2014). Any adjustment in the measure of these factors may change biological system properties (Guoa et al., 2016). Immediate and indirect impacts of animals on the rangeland biological systems may change numerous environment cycles and capacities such as nutrient pool and cycling, soil moisture, vegetation cover and growth, subterranean biomass, and soil microbial community (Ebrahimi et al., 2014; Wang et al., 2014; Costa et al., 2015; Tarhouni et al., 2015; Lu et al., 2015; Õnatibia and Aguiar, 2016).

Consequently, it is useful to obtain a comprehension of how grazing influences the vital properties of biological system capacity and subsequently provides ways for improved rangeland management (Wang et al., 2014; Ebrahimi et al., 2014). A few investigations have mentioned decline of soil as supplement pool and cycling in highly grazed zones with low plant biomass (He et al., 2012; Mcsherry and Ritchie, 2013; Wang et al., 2014). This recommends that in the rangelands with poor conditions, the soil is affected by above-ground grazing effects and the quality and amount of carbon contributions from plants (Lawrence and Vadakattu, 2007).

In Iran, rangelands are assets with high environmental, economic, and social significance. Totally, they provide forage for herbivores, create the chance for recreational activities, and pastime in nature (Amiri, 2009; Ebrahimi et al., 2016). In addition, they assume an incredible

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biological impact in saving biodiversity. Some studies have assessed the impacts of grazing in the rangelands of Iran. For example, soil nitrogen in the surface soil under heavy grazing conditions was diminished in dry rangeland of Bijar region, Iran (Joneidi et al., 2016). Low livestock grazing expanded plant diversity in Baharkesh rangeland of Quchan, Iran, while the latter reduced after heavy grazing (Nikan et al., 2012). However, in Iran, few studies have clearly shown the impacts of grazing on biodiversity preservation and soil properties in the natural systems. This investigation was aimed at determining the impact of various grazing pressures on the vegetation cover and soil properties of an arid rangeland of Iran. The aim was also to survey how different grazing intensities were related to changes in the plant richness and diversity, soil properties, and root and shoot carbon and nitrogen pools in the dry area of southeastern Kerman, Iran.

The hypotheses were (1) low grazing intensity has the lowest negative impacts on the vegetation cover and (2) soil physical and chemical properties in the heavily grazed site differ from the low and moderately grazed sites.

Materials and methods

Study site

The study area is located at about 30 km from Jiroft, a city in Kerman Province, Iran, between latitudes 28° 12′ 31′′–29° 13′ 00′′ N and longitudes 57° 15′ 30′′–58° 17′ 19′′E. The geology of the region is flat with an undulating plateau. The rangeland has been grazed by the domesticated animals including sheep and goats for over 50 years. The mean maximum and minimum temperatures are 45°C in June and 18°C in January. The mean annual precipitation is 150 mm. The minimum and maximum height is 400 m in the south and 600 m in the north.

Sampling method

Data was collected in April. When the rangeland community biomass peaked (in April), three sites (50 m × 50 m) with different grazing intensities (low, moderate, and heavy) were selected. At each site, we directed a complete assessment of the vegetation covers. There were no contrasts among geography and soil types of the chose sites. In each site, five stands (10 m× 10 m) were analyzed situated at the four corners and one at the center. In each stand, five points (5 m× 5 m) were chosen and five quadrats were studied. A total of 75 quadrats were surveyed.

Identification of plant species and nomenclature was done according to Rechinger references (1963a, 1963b, 1968, 1970, 1972a, 1972b, 1974a, 1974b, 1984, 1997) and Andersen (1977). Plant species chorotype was distinguished by Zohary's reference (1963). Vegetation cover was measured by quadrat method (Hanley, 1978). The plant density was estimated using the technique of Coulloudon et al. (1999). Plant species were classified in three classes according to their palatability: class I (High), II (Medium), and III (Low). Palatability is a characteristic of the plant in which the whole or parts of the plant is consumed by livestock (Heath et al., 1985).

In the current study, palatability was determined using references (Baghestani et al., 2001; Arzani et al., 2004; Bagheri et al., 2007). The percentage of bare soil and litter in each site was estimated utilizing the quadrat assessment strategies (Hanley, 1978). We estimated the importance value (IV) for the plant species based on relative density (RD) as the density of one plant species as a percent of the total density, relative cover (RC) as the ratio of the cover of a plant to the total cover of all plants, and relative frequency (RF) as the ratio of the frequency of a plant (the number of species present in the sampled quadrats) to the total frequency of all plants (Zhang et al., 2006; Arzani et al., 2004; Jiang et al., 2006; Ebrahimi et al., 2016).

The importance value shows how a plant dominates a natural ecosystem (Razavi et al., 2012). The species diversity was measured using the formula: $H' = -\sum pi.\ Lnpi$ in which pi denotes the proportion of points in a transect the plant species i was observed (Mesdaghi, 2001). Species richness was estimated by calculating the number of species per quadrat. Evenness was calculated by index of Pielou's J (H'/lnS) in which S shows the number of species in each quadrat.

In each quadrat, green aboveground portions of annual and perennial plant species were gathered. Soil samples were gathered from 0–40 cm layer inside each quadrat to determine belowground biomass. The roots were washed with water to eliminate soil and immediately moved to plastic bags. The subterranean and aboveground parts of the plants were dried in oven (MEMMERT UNB 400, Germany) at 60°C to a steady weight for 48 hours and weighed to measure the dry mass. Plant organic carbon was estimated by Nelson and Sommers (1996) method. Total plant nitrogen was measured by Kjeldahl technique (Bremner, 1996).

Soil samples were taken at each quadrat from the surface layers (0–40 cm) in five points. The samples in each quadrat were then combined as one to make one composite sample (total of 75 samples). The soils were air-dried in the laboratory for analysis of soil physical and chemical properties. The soil's texture was measured using the method of Day (1982). The soil acidity was determined using a digital pH–meter (Thomas, 1996) and electrical conductivity (EC) was determined using an EC–meter (Rhoades, 1996). Total N (N_{tot}) was measured by method of Bremner (1996). We determined Calcium carbonate ($CaCO_3$) using a calcimeter (Allison and Moodie, 1965). Organic matter content (OM) was measured using the method of Lo et al (2011). The soil phosphorus (P) was measured using Bray and Kurtz method (1954). The soil potassium (K) was measured by flame photometry technique (Knudsen et al., 1982). The soil bulk density was determined using the volumetric ring method (Wu et al., 2010; Wang et al., 2014). The soil organic carbon pool was calculated using the formula: Cp=BD×SOC×D (Deng et al., 2013, Wang et al., 2014). In this formula, Cp is the amount of organic carbon pool (kg m^{-2}), BD means the soil bulk density (g cm^{-3}), SOC is the amount of organic carbon in the soil (g kg^{-1}), and D means the soil depth (m). The soil nitrogen pool was calculated using the formula: Np = BD×TN×D (Deng et al., 2013; Wang et al., 2014). In this formula Np is the soil nitrogen pool (kg m^{-2}), BD means soil bulk density (g cm^{-3}), TN is the total soil nitrogen (g kg^{-1}); and D means the thickness of the sampled soil layer (m).

Data analysis

We applied analysis of variance (ANOVA) to the data (r=5) using SPSS 18.0 software. Normality of variances was tested by Kolmogorov–Smirnov test. Homogeneity of variances was tested by Levene's test. The significant differences among treatments was calculated by Post hoc Duncan test ($P<0.05$).

Results

Effects on plant properties

Totally, 13 plant species were collected in the study sites (Table 1) belonging to 11 families and 13 genera. The different livestock grazing intensities significantly affected the community composition of species, genera, and families ($p<0.05$; Table 1).

The greatest number of species, genera, and families were seen in the overgrazed site. The number of annual and perennial species (Table 1) were fundamentally influenced by the grazing ($p<0.05$). The heavy grazing site showed the maximum number of plant species of which around 85% were perennials. The low grazing site was identified by Graminae, Ephedraceae, and Polygonaceae families respectively (Table 2). The moderate grazing site was determined by species of Amaranthaceae, Apocynaceae, and Graminae families respectively. In the heavily grazed site there were three dominant families of Compositae, Papilionaceae, and Fabaceae respectively (Table 2).

Table 1. Number of species, genera and families

Treatment	Number of Species	Number of genera	Number of families	Annuals	Perennials
Low grazing site	$8.00±0.20^b$	$8.00±0.50^b$	$8.00±0.50^b$	$2.00±0.10^a$	$6.00±0.10^b$
Moderate grazing site	$8.00±0.50^b$	$8.00±0.50^b$	$8.00±0.50^b$	$2.00±0.10^a$	$6.00±0.10^b$
Heavy grazing site	$11.00±0.50^a$	$11.00±0.50^a$	$10.00±0.50^a$	$2.00±0.10^a$	$11.00±0.50^a$

* The different letters in each column indicate significant difference among the sites (means± SE, $p<0.05$).

Table 2. The composition of plant species at three sites

Species	Family	Growth Form	Life history	Chorotype	Palatability class	Low grazing site			Moderate grazing site			Heavy grazing site		
						Presence/ Absence	IV (%)	F (%)	Presence/ absence	IV (%)	F (%)	Presence/ absence	IV (%)	F (%)
Pteropyrum aucheri Jaub. & Spach	Polygonaceae	Ch	P	IT	III	1	16.49	100	1	11.17	40	0	0	0
Ephedra sinica Stapf.	Ephedraceae	Ph	P	IT	III	1	18.45	100	1	9.56	80	1	6.10	40
Artemisia sieberi Besser.	Compositae	Ch	P	IT	II	1	15.66	100	1	10.92	60	1	39.05	20
Alhagi camelorum Fisch.	Papilionaceae	He	P	IT, M, SS	II	1	4.81	40	1	9.56	80	1	18.58	80
Hordeum murinum L.	Graminae	Th	A	Cosm	II	1	40.01	100	1	15.00	100	1	13.01	60
Periploca aphylla Decne.	Apocynaceae	Ph	P	SS	III	1	10.10	80	1	17.13	100	1	22.18	100
Salsola kali L.	Amaranthaceae	Th	A	Cosm	I	1	5.49	40	1	20.11	40	1	6.10	40
Zygophyllum eurypterum Boiss.& Buhse.	Zygophyllaceae	Ph	P	IT, SS	II	1	2.46	20	1	12.59	80	1	3.50	20
Citrullus colocynthis (L.) Schrad.	Cucurbitaceae	He	P	SS, M	III	0	0	0	0	0	0	1	13.01	80
Peganum harmala L.	Nitrariaceae	He	P	IT	III	0	0	0	0	0	0	1	13.00	80
Scariola orientalis (Boiss.) Soják	Compositae	He	P	IT	II	0	0	0	0	0	0	1	6.10	80
Astragalus gummifer Labill.	Papilionaceae	Ch	P	IT	III	0	0	0	0	0	0	1	13.08	40
Acantholimon acmostegium Bloss. & Buhse.	Plumbaginaceae	Ch	P	IT	III	0	0	0	0	0	0	1	6.10	20

Ch: Chamaephyte, Ph: Phanerophyte, He: Hemichryptophyte, Th: Therophytes
P: Perennial, A: Annual
1: Presence of species, 0: Absence of species
IV: Importance Value, F: Frequency
Chorotype: IT: Irano –Turanian, Cosm: Cosmopolitan, SS: Saharo–Sindian, M: Mediterranean
Class I: highly palatable species; Class II: moderately palatable species; Class III: lowly palatable species

Results showed (Table 2) that the maximum extent of the flora belonged to Irano–Turanian (53.84%) and Saharo–Sindian (15.38%) components respectively.

In the low grazing site, the canopy cover and litter amount were significantly greater than the heavy and moderate grazing sites, respectively ($p<0.01$, Table 3). The bare soil percent diminished from 35.04% in the heavy grazing site to 20.89% and 25.82% in the moderate and low grazing sites, respectively ($p<0.01$, Table 3).

The plant density of class I did not show significant differences among the sites (Table 3). Also, the plant density of class II in the low grazing site (80600 plant m^{-2}) was more than those in the moderate (75600 plant m^{-2}) and overgrazed (45200 plant m^{-2}) areas. The plant density of class III increased significantly ($p<0.05$) under overgrazing sites, compared with the low and moderate sites (Table 3).

The diversity index, richness, and evenness were influenced by various grazing intensities ($p<0.01$, Table 3). The diversity of the sites increased with increase in the grazing intensity and was greatest in the overgrazed site (1.63) while the low grazing site had the lowest (1.27) diversity. The highest richness (1.82) was measured in the low grazing site. Results demonstrated that species evenness of the low and moderate grazing sites had significant differences (Table 3). The overgrazed site had the minimum evenness (0.68) of plant species and the maximum evenness (0.89) was recorded in the low grazing site.

Table 3. Plant properties at grazed sites

Treatment	Density (n ha^{-1})			Canopy cover (%)	Litter (%)	Bare soil (%)	Diversity (H′)	Richness	Evenness
	I	II	III						
Low grazing site	60200±200^a	80900±100^a	41400±300^c	46.23±1.17^a	34.80±2.30^a	20.89±3.43^c	1.27±0.09^c	1.82±0.05^a	0.89±0.00^a
Moderate grazing site	63300±200^a	75600±100^b	63100±300^b	41.48±2.11^a	18.60±2.90^b	25.82±3.21^b	1.57±0.01^b	1.38±0.05^b	0.88±0.00^a
Heavy grazing site	68500±200^a	45200±150^c	143500±300^a	25.16± 2.01^b	4.10±0.60^c	35.04±0.50^a	1.63±0.01^a	1.52±0.01^c	0.68±0.00^b

* The different letters in each column indicate significant difference among the sites (means± SE, $p<0.05$).

Effect on nitrogen and carbon pool of vegetation cover

The variations of the nitrogen and carbon stored in the root and shoot of the vegetation cover are shown in Figures 1 and 2. In three study sites, the nitrogen and carbon pools were higher in the roots than the shoots. The plants' nitrogen pool (3.70 and 4.13 g m^{-2} for the shoot and root, respectively) was notably increased ($p<0.05$) in the low grazing site compared to the heavy grazing site (3.13 and 3.49 gm^{-2} for the shoot and root, respectively) as shown in Figures 1 and 2. However, it was not significantly different between the low and moderately (3.11 and 4.04 gm^{-2} for the shoot and root respectively) grazed sites. The plants' carbon pool followed a similar trend (Figure 2). The carbon pool was discovered to be more in the low grazing site compared with the moderate and overgrazed sites. The results showed that the low and moderate grazing sites witnessed increased carbon and nitrogen in the plants' biomass. Totally, the results demonstrated that the low grazing condition in arid rangelands restored the vegetation cover and had the lowest impacts on the vegetation cover which supports our first hypothesis.

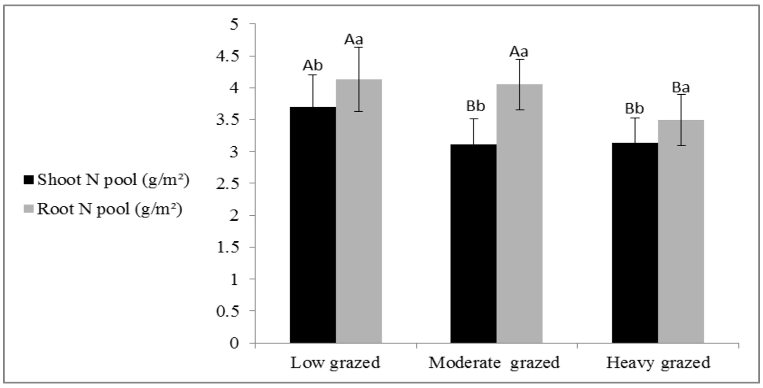

Figure 1. Plant nitrogen pool (g m^{-2}), in the root and shoot of vegetation cover. Different lower case letters show significant differences between root and shoot. Different capital letters show significant differences among the sites.

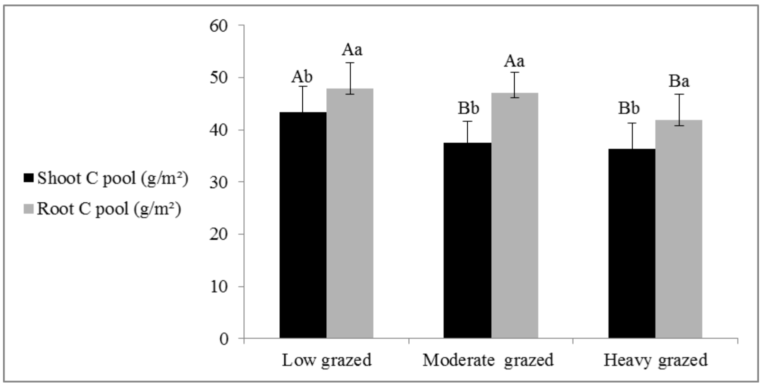

Figure 2. Plant carbon pool (g m^{-2}), in the root and shoot of vegetation cover. Different lower case letters show significant differences between root and shoot. Different capital letters show significant differences among the sites.

Effects on soil properties

The variations of soil characteristics are listed in Table 4. Results showed that the soils of heavy grazing site had significantly higher potassium, nitrogen and calcium carbonate contents ($p<0.01$). The potassium (257.02 mg kg^{-1}), nitrogen (1.80 g kg^{-1}) and calcium carbonate (7.64%) values were the lowest in the soils under low grazing condition. While, the level of phosphorus followed an opposite pattern and the low grazing condition resulted in notable enrichment of phosphorus (11.44 mg kg^{-1}) reserve in the 0–40 cm soil layer. Compared with the heavy grazing site, organic carbon values were 2.97 and 3.19 times lower in the moderate and low grazing condition respectively.

Soils of the low grazing site showed lower pH value (7.81) in the 0–40 cm soil layer ($p<0.01$) compared with the overgrazed site (8.49). The EC was significantly increased in the overgrazed site ($p<0.01$), and the lowest EC value (1.66 dS m^{-1}) was measured in the low grazing site. The soil bulk density changed under different grazing intensities (Table 4). The soil bulk density was proved to be lower in the moderate (1.28 g m^{-3}) site compared with the low grazing site (1.43 g m^{-3}). In comparison with the low and moderate grazing sites, the soil organic carbon pool level in the overgrazed site was higher. The level of nitrogen pool followed the same pattern. The soil texture showed more clay (20.40%) and less sand (50.70%) in the low grazing site (Table 4). In the low grazing site, silt (28.90%) was the highest.

Results indicated that some soil nutrient values (potassium, nitrogen, calcium carbonate, organic carbon, nitrogen and organic carbon pool) increased in the heavy grazing site due to livestock manure and were different among three sites, which proves the second hypothesis of this study.

Table 4. Characteristics of soils in three sites

Soil properties	Low grazing site	Moderate grazing site	Heavy grazing site
Potassium (mg kg^{-1})	257.02± 53.48^{b}	350.34±53.48^{b}	612.87±53.48^{a}
Nitrogen (g kg^{-1})	1.80±0.5^{ab}	1.00±0.5^{b}	3.30±0.5^{a}
Phosphorus (mg kg^{-1})	11.44±0.65^{a}	1.10±0.65^{b}	1.09±0.65^{b}
$CaCO_3$ (%)	7.64±1.73^{c}	23.45±1.73^{b}	40.97±1.73^{a}
Ph	7.81±0.66^{c}	8.24±0.66^{b}	8.49±0.66^{a}
ECe (dS m^{-1})	1.66±0.66^{c}	3.24±0.66^{b}	10.99±0.66^{a}
Organic carbon (g kg^{-1})	7.30±1.60^{b}	9.50±1.56^{b}	39.20±3.16^{a}
Nitrogen pool (g m^{-2})	7.31±4.03^{b}	4.20±4.03^{c}	14.47±4.03^{a}
Carbon pool (g m^{-2})	30.74±20.53^{b}	33.65±20.53^{b}	141.12±20.53^{a}
Bulk density (g cm^{-3})	1.43±0.06^{a}	1.28±0.06^{b}	1.41±0.06^{ab}
Silt (%)	28.90±1.90^{a}	23.70±1.90^{b}	22.00±1.90^{c}
Sand (%)	50.70±1.75^{b}	59.50±1.75^{b}	64.90±1.75^{a}
Clay (%)	20.40±0.94^{a}	16.80±0.94^{b}	13.10±0.94^{c}
Soil texture	Sandy clay loam	Sandy loam	Sandy loam

* The different letters in each row indicate significant difference among the sites (means± SE, $p<0.05$).

Discussion

Influence on vegetation cover

Increasing livestock grazing pressure in arid lands causes adverse changes in plant communities (Cingolani et al., 2005). Livestock grazing usually causes changes in the structure of plant communities; the extent of these changes depends on the intensity of livestock grazing and the amount of rangeland's production. The results showed that different grazing intensities affected the characteristics of plant diversity.

Plant diversity showed that there were differences among grazing sites in terms of species, genera, and families. The first change was observed in plant composition. The highest number of plant species in the heavy grazing site was due to the presence of toxic and invasive species compared to the other two sites. The invader plants including *Peganum harmala*, *Scariola orientalis* and *Citrullus colocynthis* were present in the heavy grazing area. The decreased species in the heavy grazing area indicate the negative impact of severe grazing in arid areas. Reduction of class II plants such as *A. sieberi* in the heavy grazing area can be due to heavy utilization such as livestock fodder, medicinal uses and so forth by local people in the rangeland. The main users of these rangelands are local ranchers, who are heavily dependent on pastures for their livelihood.

The results indicated that heavy grazing intensity had a negative impact on the canopy cover, while the low grazing intensity enhanced the cover of perennial plants. In critical areas with heavy livestock grazing, the plants cover and the soil will be drastically destroyed due to high utilization of vegetation cover. The reason is the direct impact of the grazing on the canopy cover of the plants that decreases the total vegetation cover especially dominant plants and those which are favorite food for the livestock. Heavy grazing will result in defoliation and the removal of photosynthetic parts of the plants. Therefore, the plants' capability for competition in natural ecosystems will decrease that leads to reduced canopy cover and density of plant species (Ebrahimi et al., 2016; Wang et al., 2016).

Severe grazing has a negative effect on plant establishment by reducing seed bank (Mengistu et al., 2005; Yoshihara et al., 2010; Moghbeli, 2016). Livestock trampling affects the biological surface of the soil and reduces seed survival in the soil (Bertiller and Ares, 2011). Some studies have shown that severe grazing prevents seed production of palatable species and consequently reduces the density of palatable species and increases the number of unpalatable plants (Bestelmeyer et al., 2003)

As the grazing intensity increased, the amount of vegetation litter significantly decreased and the bare soil significantly increased. In fact, in the heavy grazing site the plant cover is consumed as fresh forage. Therefore, the amount of litter in the heavy grazing site will normally decrease. The heavy livestock grazing causes incapability in seed production and decreases the plant's production power, which increases the bare soil in long terms (Ghorbani Ghahfarokhi et al., 2012). Kohandel et al. (2011) indicated that as the grazing intensity increases, the plant cover decreases and the amount of bare soil increases. The results showed that by increasing the grazing intensity, the diversity index also increased. Comparing the species composition showed that *P. aucheri* and *Periploca aphylla*, which are useful species to protect soil, were present at the low grazing site, but absent in the heavy grazing site. The invader specie *Alhagi camelorum* had the highest presence at the heavy grazing site while it had the lowest presence at the low and moderate grazing sites. Species such as *P. harmala*, *S. orientalis* and *C. colocynthis* were not present at the low and moderate grazing rangelands whereas they had a high presence at the heavy grazing locations. These species are not palatable and are not consumed by livestock. Thus, the number of invader and noxious species increase as the grazing intensity increases. Invader and noxious species find a chance to survive in heavy grazing condition which compared to the low grazing site may cause an increase in diversity index of species in the heavy grazing site.

Li et al. (2005) reported that severe grazing in steppe rangelands of Inner Mongolia significantly reduced Class I plant species. The reason for this is the grazing of these plants and the extreme sensitivity of these plants to livestock trampling. In a study of the grazing impacts on the composition and diversity of plant community of steppe rangeland of Boroujen, Iran, Maghsoudi Moghadam et al. (2012) concluded that the diversity of species increased three times as the livestock grazing increased in heavy grazing condition. They cited that there were usually invader and unpalatable species in the heavily grazed rangeland. Zarekia et al. (2014), in their study of Saveh rangelands, Iran, showed that the number of species went up due to heavy grazing and increase in the number of invader species; therefore, the diversity of species had also improved. Increasing the grazing intensity may result in an increase in diversity, but this increase along with soil degradation brings instability to the ecosystem. Augustine and Frank (2001) showed that the highest plant diversity was observed in small sites in grazed rangeland in the Yellowstone National Park in the USA.

In general, due to heavy livestock grazing and with increase in invader species, the species abundance increased. Hence, the diversity of invader species also increased. In the process, the palatable species were removed and the invader species took place. This leads to an increased invader species diversity and provides the required circumstance for the development of invaders (Hickman et al., 2004).

Our results showed that as the grazing intensity increased, species richness decreased, and the highest richness of species was measured in the low grazing area. The lower species richness in the heavy grazing area showed that the species such as *P. aucheri*, *Artemisia sieberi*, *Zygophyllum eurypterum*, *Ephedra sinica* and *Salsola kali* are very sensitive to livestock grazing, and subsequently they become dominant under low grazing condition. In arid rangelands, it is possible to protect the species richness and vegetative form through grazing management (Zarekia et al., 2014). Ebrahimi et al. (2016) in the study of short-term exclusion and heavy grazing in the arid region of southeastern Iran reported that the lowest amount of species richness was observed in the heavy grazing site. Firinioğlu et al. (2007) in assessing the impact of exclusion and livestock grazing on the plant cover reported that the rangeland exclusion would increase species richness compared to the condition with livestock grazing.

The results showed that livestock grazing impacted the evenness while the heavy grazing site showed the lowest evenness index. Livestock grazing decreases the evenness and brings chaos to plant community structure (Matus and Tothmeresz, 1990). Moghbeli (2016) in assessing the evenness of areas with different grazing management in the rangelands of Jiroft, Iran concluded that the low grazing area had more evenness compared to the heavy grazing area.

Influence on nitrogen and carbon pool in plant parts

The different grazing intensities had significant impacts on the root and shoot carbon and nitrogen pools. Generally, as the grazing intensity increased, the carbon pool of aboveground and belowground parts of vegetation cover decreased. In most cases, the livestock grazing changes carbon and nitrogen pools of an ecosystem, but the intensity and the size of changes depend on the livestock grazing intensity and the amount of plant utilization (Derner and Schuman, 2007). The aboveground tissues of the plants are the most sensitive parts which are directly influenced by livestock grazing (Van Wijnen et al., 1999). In the present study, the carbon pool of the aboveground parts decreased as the grazing intensity increased. Carbon and nitrogen pools of aboveground parts respectively decreased by 13.33% and 15% in the moderate grazing site, and 16.22% and 15.41% in the heavy grazing area. Compared to the low grazing sites, the plant cover in the moderate and heavy grazing sites had a significant decrease. As the plant covers were removed by the livestock, the carbon and nitrogen pools of the aboveground parts in moderate and heavy decreased (Hieroo et al., 2000; Abdi et al., 2008)

Livestock grazing not only impacts the aboveground parts of the plants, but also it brings negative changes to the belowground tissues of plant species (Guodong et al., 2008). Although the literature has shown ambiguous response of plants' roots to the livestock grazing (Milchunas and Lauenroth, 1993; Turner et al., 1993), it has been proved that the root of plants has a key role in storing carbon and nitrogen in the ecosystem since the roots are the biggest source of carbon and nitrogen entrance to the soil (Impithuksa et al., 1984; Ruess and Seagle, 1994) particularly in arid areas where the roots include a significant part of the plant biomass. Plant biomass is a great source of organic matter input to the soil. Compared with the low grazing site, both moderate and heavy grazing treatments decreased the carbon pool of the belowground biomass by 11.11% and 1.62% respectively. Similar results were observed for the nitrogen pool of the belowground part. The moderate and heavy grazing treatments decreased the nitrogen pool of the root by 1.93% and 13.82%. Many leaves and stems of plants are usually removed during grazing. Hence, the plants try to produce new stem by high consumption of stored materials in order to replace and restore the lost parts, therefore the development of other parts of the plants decreases. Also, due to the livestock trampling, degradation of the soil layer decrease of water infiltration, increase of runoff, and decrease of the root development in soil and eventually the carbon, and nitrogen pools of the belowground parts will drop (Gabriels et al., 2004). Azarnivand et al. (2009) reported that the carbon pool of the belowground parts of *Ar. sieberi* had a significant decrease in heavy grazing condition in Semnan rangeland of Iran. Heavy grazing, on the one hand decreased the relative share of root in terms of the total carbon and nitrogen in the ecosystem, and on the other hand, increased the relative share of root for the carbon and nitrogen stored in the whole plant biomass.

Influence on soil properties

The impact of heavy livestock grazing on plant communities is destructive because severe grazing leads to reduced vegetation canopy, soil structure degradation, and soil compaction (Manzano and Návar, 2000; Ebrahimi et al., 2016). This process increases soil crusting, decreases soil permeability, and increases soil erosion (Manzano and Návar, 2000; Yong-Zhong et al., 2005).

In our study, the heavy grazing significantly increased potassium and nitrogen levels of the soil compared to the low grazing site while the low grazing site had the lowest amount of potassium and nitrogen. The reason is that the livestock manure has positive effects on the amount of potassium and nitrogen levels of the soil. The levels of potassium and nitrogen in the heavy grazing site increased due to high numbers of livestock and more livestock manure (Steffens et al., 2008). Livestock manure is a good source for organic matter production (West and Nelson, 2003) considering the fact that typical nutrient application rate in sheep dung patches are 130 kg nitrogen ha^{-1}, 50 kg potassium ha^{-1}, and 35 kg phosphorus ha^{-1} (Chambers et al., 2001).

In the study of the impacts of livestock grazing on the soil chemical properties of Nodooshan rangelands, Iran, Gholami et al. (2013) showed that in heavy grazing condition, the amount of potassium increased. The livestock trampling buries more manure and litter under the soil surface. The high production of manure will compensate for the lost potassium in the heavy grazing area. In addition, due to low vegetation cover in the heavy grazing area, the plants consume less amount of potassium, and this will increase the potassium of the soil. As the presence of livestock was less in the low grazing site, therefore, potassium of the soil was not significant through livestock manure. Also as there is a chance for plants growth in the low grazing site, potassium consumption will increase (Jalilvand et al., 2006). The amount of potassium increased in the heavy grazing site due to the higher livestock and manure release (Moghbeli, 2016). Researchers have shown that livestock manure increases the rate of nutrients cycling in the soil. The livestock manures contain nitrogen compounds like urea. These compounds are fermented instantly in aerobic conditions and increase nitrogen in the soil. The higher amounts of manure help to recover nitrogen in the soil, and nitrogen deposition in the root acts as a mechanism to increase the nitrogen pool (Stewart et al., 2008).

Gusewell et al. (2005) in assessing the impacts of uneven distribution of livestock on the nutrients and the litter decomposition rate in Alpine pasture showed that nitrogen of the soil increased in heavy grazing sites. Kohandel et al. (2011) showed that heavy grazing increased nitrogen levels of the soil in the rangelands of Savojbolagh, Iran. In studying the impact of rangelands management, Raiesi Gahrooee et al. (2005) showed that total nitrogen of heavy grazing rangeland increased compared to excluded rangelands.

Our study showed that the highest value of phosphorus was measured at the low grazing site, and the lowest amount was observed at the heavy grazing treatment. The grazing systems are able to influence the nutrients cycling in the rangeland ecosystem by consuming the nutrients, their return through livestock manure, and redistribution. It seems that in the heavy grazing site, soil phosphorus declined by the high utilization of vegetation cover. Therefore, soil phosphorus decreased as the grazing intensity increased. Also, the plants received phosphorus from deep soil and after decomposition of plants; phosphorus was released into the soil. As the amounts cover and litter were more at the low grazing site than the moderate and heavy grazing sites, the value of soil phosphorus in the low grazing site was higher (Ahmadi et al., 2011; Ghorbani Ghahfarokhi et al., 2012). In studying the effects of grazing on the plant cover and some chemical properties of soil in Nowshahr Kojour rangelands, Jalilvand et al. (2006) cited that as the grazing intensity increased, so did soil phosphorus.

The results showed that the amount of carbonate increased with increasing grazing pressure. In studying the impacts of exclusion on soil properties in Kohneh Lashak Mazandaran, Ahmadi et al. (2011) reported that increasing the grazing intensity increased the $CaCo_3$ content of the soil. Calcium carbonate turns into soluble bicarbonate by the rainfall and moves into deeper parts of the soil. In the soil with high permeability, bicarbonate exits from the surface layer of the soil. In the heavy grazing site, the soil permeability is less than the low grazing site, therefore, the low amounts of the $CaCo_3$ enter into the soil. In the low grazing rangeland at which the soil permeability is higher due to the more vegetation cover, $CaCo_3$ is washed from the surface layer of the soil (Aghasi et al., 2006).

Our study indicated that as the grazing intensity increased, the soil salinity increased in a way that electrical conductivity (EC) was at the highest level in the heavy grazing site. The lowest value of EC was measured in the low grazing site. The plant cover increased as the grazing intensity decreased. Therefore, evapotranspiration also decreased and as a result, the soil EC declined (Moghbeli, 2016). In other words, as the grazing intensity increases, the soil trampling also increases. This brings more compaction, less permeability, less moisture, therefore, higher soil EC (Daniel and Phillips, 2000). Extensive utilization of the rangeland declines the plant cover and in turn it upsurges the evapotranspiration and the soil tendency toward more salinity (Mut and Ayan, 2011).

The results showed that the less grazed condition brought about lower pH value compared to the overgrazed site. Livestock grazing increases soil compaction by trampling. Therefore, they lead to a decrease in soil porosity and oxygen content which may diminish the microorganism activities. This can be the reason for higher pH in the heavy grazing site (Wang et al., 2014).

Khosravi (2014) in Neroon rangeland, Iran, showed that in grazed rangelands the soil pH was higher compared to excluded rangelands. Livestock grazing produced manure and acidity increased with the decomposition of urea (Raiesi and Riahi, 2014). Furthermore, reclamation of plant cover in excluded rangelands increased soil acidity (Wang et al., 2014) through the creation of hydrogen by plant, organic matter deterioration into organic acids and carbon dioxide, respiration of root, and nitrification (Binkley and Richter, 1987).

The higher plant biomass and cation take-up by the plant was another explanation behind lower soil pH (Tornquist et al., 1999). Soil pH had a positive relationship with soil calcium carbonate content (Ebrahimi et al., 2015). The soil calcium carbonate content was more in the overgrazed site than the low and moderate sites. Mirlashkari (2016) in the investigation of the impacts of exclusion on the plant cover and soil properties in Jonabad rangeland of Zahedan, Iran, reported that pH was lower in the site with higher plant biomass than the grazed area.

The highest and lowest level of organic carbon was measured in the heavy and low grazing sites respectively. The soil organic carbon could be increased through mechanisms in the heavy grazing site such as (1) compacting the soil and increasing the bulk density, the oxygen pool of the soil decreases and the decomposition rate slows down (Li et al., 2011), (2) heavy grazing affects the soil organic carbon pool by decreasing the plant biomass and the shoot to root ratio (Reeder and Schuman, 2002). In fact, animal grazing increases the share of the belowground biomass (Hui and Jackson, 2005). Increasing the share of the root increases carbon entrance into the soil and nitrogen preservation, and this will result in organic carbon accumulation in the soil. The higher number of livestock is one of the main reasons for higher levels of carbon in the heavy grazing rangeland. Crossing the area with more livestock brings more trampling and therefore water logging situation to the soil. This will increase fermentation and slows down the decomposition rate. The outcome of these processes is accumulation of organic matters on the surface layer of the soil. On the other hand, the livestock increases the amount of soil organic matters by burying plant parts in the soil and mixing these with the soil surface, and also by leaving its manure containing rich combinations of nitrogen, sulfur, and phosphorus (West and Nelson, 2003) that increases soil organic carbon (Ghazan Shahi, 1997).

The highest soil nitrogen and carbon pool were measured in the heavy grazing site while the lowest soil nitrogen and carbon pool was found in the low grazing site. Livestock grazing is capable of changing the stored carbon and nitrogen composition of the soil, but the amount of such changes is dependent on the grazing intensity. Conatn et al. (2003) showed that the stored carbon under heavy gazing management has been more than the low grazing and excluded rangeland. Ghorbani Ghahfarokhi et al. (2012) reported that the organic carbon pool of the soil was at a higher level in grazed rangeland compared to the excluded rangeland. Also, Aghamohsseni Fashami et al. (2008) in assessing the effects of short-term exclusions (5 years) of Alborz rangelands reported that soil carbon pool was at higher levels in grazed rangeland compared to the excluded rangeland.

The highest levels of soil bulk density were found in the low grazing site, and the lowest amount was measured in the moderate grazing treatments. The soil bulk density and porosity can be related to the amount of soil organic matters. The bulk density is at high levels in soils with low amounts of organic matter (Aghajantabar Ali et al., 2015). In the heavy grazing site, more organic matter due to livestock manure may result in the reduction of soil bulk density compared to the low grazing site. Kohandel et al. (2011) showed that livestock grazing results in a reduction of soil bulk density, and this happens between grazing and non-grazing treatments in the soil surface layer. Bulk density is among the factors which will change as soon as the grazing and trampling are imposed. The relation between bulk density and organic carbon is reciprocal in a way that the increase of the organic matter reduces the bulk density.

The low grazed site showed higher silt and clay compared with the moderate and heavy grazed sites. Plant cover can catch more wind–blown soil affecting soil qualities. Denser vegetation covers have a strong relationship with soil erosion reduction (Singh et al., 2005). Mofidi et al. (2013) revealed that in fenced rangelands, higher vegetation covers lower soil loss.

Conclusion

Our investigation of dry rangeland of Jiroft showed that heavy grazing changed rangeland qualities and brought about vegetation degradation.

Species diversity was increased in the heavy grazing area as a results of presence of more noxious and unpalatable plants. The number of palatable species were higher in the low grazing area than the moderate and heavy grazing areas. Canopy cover and richness were increased as well as the amount of litter in the low grazing site. Heavy grazing significantly reduced plant richness and vegetation that increased soil wind erosion.

However, the heavy grazing area showed more soil nutrients and nitrogen and carbon pool due to manure of livestock. The results indicated that the low grazing management had the potential to increase nitrogen and carbon in the plants biomass in arid rangelands. The study showed that changes in the soil and vegetation properties, plant nitrogen, and carbon contents were good indicators of the effects of grazing pressure on the rangeland. Low grazing pressure has the potential to manage plant communities and improve soil quality in arid ecosystems.

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References

Abdi, N.A., Maddah Arefi, H., and Zahedi Amiri, G.H. 2008. Estimation of carbon sequestration in Astragalus rangelands of Markazi province (case study: Malmir rangeland in Shazand region). Iranian Journal of Range and Desert Research. 15, 269-282. (In Persian)

Aghajantabar Ali, H., Mohseni Saravi, M., Chaichi, M.R., and Heidari, G. 2015. Grazing pressure effect on soil physical and chemical characteristics and vegetation cover in Vaz watershed, Mazandaran province. Journal of Watershed Management Research. 6, 111-123. (In Persian)

Aghamohsseni Fashami, M., Zahedi, GH., Farah pour, M., and Khorassani, N. 2008. Influence of exclosure and grazing on the soil organic carbon and soil bulk density Case study in the central Alborze south slopes rangelands. Iranian Journal of Agricultural Science, 4, 375-381. (In Persian)

Aghasi, 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 Resources. 4, 73-87. (In Persian)

Ahmadi, T., Malek Poor, B., and Kazemi Mazandarani, S.S. 2011. Investigation of exclosure effect upon physical and chemical properties of soil at Kohneh Lashak Mazandaran. Journal of Plant Physiology. 3, 90–100. (In Persian)

Allison, L.E., and Moodie, C.D. 1965. Carbonates, In: Black, C.A., Evans D.D., White J.L., Ensminger, L.E., Clark, F.E., Dinauer, R.C. (Eds.), Methods of Soil Analysis, American Society of Agronomy and Soil Science Society of America. Madison, Wisconsin, pp. 1379-1396.

Al-Rowaily, S.L., El-Bana, M.I., Al-Bakre, D.A., Assaeed, A.M., Hegazy, A.K., and Ali, M.B. 2015. Effects of open grazing and livestock exclusion on floristic composition and diversity in natural ecosystem of Western Saudi Arabia. Saudi Journal of Biological Science. 22, 430-437.

Amiri, F. 2009. A GIS model for classification of rangeland suitability for sheep grazing in arid and semi-arid regions of Iran. Livestock Research for Rural Development. 21, 68-82.

Andersen, J.S. 1977. Flora Iranica. Cucurbitaceae. Akademische Druck U Verlagsanstalt, Graz, Austria.

Arzani, H., Zohdi, M., Fish, E., Zahedi, A., Nikkhah, G.H.A., and Wester, D. 2004. Phenolojical effects on forage quality of five grass species. Journal of Range Management. 57, 624-630. (In Persian)

Augustine, D.J., and Frank, D.A. 2001. Effects of migratory grazers on spatial heterogeneity of soil nitrogen properties in a grassland ecosystem. Ecology. 82, 3149-3162.

Azarnivand, H., Joneidy Jafari, H., Zarechahooki, M.A., Jafari, M., and Nikoo, Sh. 2009. Investigation of livestock grazing on carbon sequestration and nitrogen reserve in rangeland with *Artemisia sieberi* in Semnan province. Rangeland. 3, 590-610.

Bagheri, H., Adnani, M., and Tavili, A. 2007. Studying the relationship between livestock and plant composition Case study: semi steppic ranges of Vesf-Qom province. Pajouhesh and Sazandegi. 74, 155-162. (In Persian)

Baghestani, N., Arzani, H., Zare, T., and Abdollahi, J. 2001. Study of forage quality the important species of stepic rangeland of Poshtkhoeh Yazd. Journal of Range and Desert Research. 11, 137-162. (In Persian)

Bertiller, M.B., and Ares, J.O. 2011. Does sheep selectivity along grazing paths negatively affect biological crusts and soil seed banks in arid shrub lands? A case study in the Patagonian Monte, Argentina. Journal of Environmental Management. 92, 2091-2096.

Bestelmeyer, B.T., Brown, J.R., Havstad, K.M., Alexander, R., Chavez, R., and Herrick, J.E. 2003. Development and use of state and transition models for rangelands. Journal of Range Management. 56, 114-126.

Binkley, D., and Richter, D. 1987. Nutrient cycles and H budgets of forest ecosystems. Advances in Ecological Research. 16, 1-51.

Bray, R.H., and Kurtz, L.T. 1954. Determination of total, organic and available forms of phosphorus in soils. European Journal of Soil Science. 39-45.

Bremner, J.M. 1996. Nitrogen total. In: Bartels, J.M. (Ed.), Methods of soil analysis. Soil Science Society of America, Madison, Wisconsin, pp. 1085-1122.

Chambers, B., Nicholson, N., and Smith, K. 2001. Managing livestock manures: Making better use of livestock manures on grassland. Institute of Grassland and Environmental Research Brian Pain Silsoe Research Institute Trevor Cumby and Ian Scotford. London, UK.

Cingolani, A.M., Posse, G., and Collantes, M.B. 2005. Plant functional traits, herbivore selectivity and response to sheep grazing in Patagonian steppe grasslands. Journal of Applied Ecology. 42, 50-59.

Conatn, R.T., Six, J., and Paustian, K. 2003. Land use effects on soil carbon fractions in the southeastern United States. I. Management-intensive versus extensive grazing. Biology and Fertility of Soils. 38, 386-392.

Costa, C., Papatheodorou, E.M., Monokrousos, N., and Stamou, G.P. 2015. Spatial variability of soil organic C, inorganic N and extractable P in a Mediterranean grazed area Land Degradation and Development. 26, 103-109.

Coulloudon, B., Eshelman, K., Gianola, J., Habich, N., Hughes, L., Johnson, C., Pellant, M., Podborny, P., Rasmussen, A., Robles, B., Shaver, P., Spehar, J., and Willoughby, J. 1999. Sampling vegetation attributes. Technical Reference, Grazing Land Technology Institute. Denver, Colorado.

Daniel, J.A., and Phillips, W.A. 2000. Impact of grazing strategies on soil compaction. ASAE Annual International Meeting, Milwaukee, Wisconsin, USA.

Day, P.R. 1982. Particle fractionation and particle-size analysis. In: Page, A.L., Miller, R.H., Keeney, D.R. (Eds.), Methods of soil analysis, American Society of Agronomy, Madison, Wisconsin, pp. 545-567.

Deng, L., Shangguan, Z.P., and Sweeney, S. 2013. Changes in soil carbon and nitrogen following land abandonment of farmland on the Loess plateau, China. PLoS One 8, e71923.

Derner, J.D., and Schuman, G.E. 2007. Carbon sequestration and rangelands: a synthesis of land management and precipitation effects. Journal of Soil and Water Conservation. 62, 77-85.

Ebrahimi, M., Arab, M., and Ajorloo, M. 2014. Effects of enclosure on ecological indexes of rangeland health using Landscape Function Analysis Method (case study: Jiroft Jbalbarez Rangeland). Rangeland. 8, 261-271. (In Persian)

Ebrahimi, M., Khosravi, H., and Rigi, M. 2016. Short-term grazing exclusion from heavy livestock rangelands affects vegetation cover and soil properties in natural ecosystems of southeastern Iran. Ecological engineering. 95, 10-18.

Firinioğlu., H.K. Seefeldt, S., and Sahin, B. 2007. The Effects of long-term grazing exclosures on range plants in the central Anatolian region of Turkey. Journal of Environmental Management. 39, 326-337.

Gabriels, D., Schiettecatte, W., Verbist, K., Cornelis, W., Ouessar, M., Wu, H., and Cai, D. 2004. Water harvesting in Southeast Tunisia and soil water storage in the semi-arid zone of the Loess Plateou of China. Sustainable Management of Marginal Dry lands. 3, 19-24.

Ghazan Shahi, J.1997. Soil and plant analysis. Aeizch publication. Tehran, Iran. (In Persian)

Gholami, P., Jahantab, E., and Fatahi, B. 2013. Changes of vegetation indices under exclosure restoration operations in mountainous rangelands of Central Zagros (case study: Dishmook in Kohgiluyeh Va Buyer Ahmad province). Journal of Plant Ecosystem Conservation. 2, 1-14. (In Persian)

Ghorbani Ghahfarokhi, N., Raiesi, F., and Ghorbani, S. 2012. Influence of livestock grazing on the distribution of organic carbon, total nitrogen and carbon mineralization within primary particle-size fractions in Shayda rangelands with cropping history. Water and Soil Science. 1, 209-222. (In Persian)

Guoa, T., Lohmannc, D., Ratzmanna, G., and Tietjen, B. 2016. Response of semi-arid savanna vegetation composition towards grazing along a precipitation gradient-The effect of including plant heterogeneity into an ecohydrological savanna model. Ecological Modelling. 325, 47-56.

Guodong, H., Xiying, Z., Mengli, W., Mingjun, H., Ben, E., Walter, W., and Mingjiu, W. 2008. Effect of grazing intensity on carbon and nitrogen in soil and vegetation in a meadow steppe in Inner Mongolia. Agriculture, Ecosystems and Environment. 125, 21-32.

Gusewell, S., Jewel, P.L., and Edwards, P.J. 2005. Effects of heterogeneous habitat use by cattle on nutrient availability and litter decomposition in soils of an alpine pasture. Plant and Soil. 268, 135-149.

Hanke, W., Bohner, J., Dreber, N., Jurgens, N., Schmiedel, U., Wesuls, D., and Dengler, J. 2014. The impact of livestock grazing on plant diversity: an analysis across dryland ecosystems and scales in southern Africa. Ecological Applications. 24, 1188-1203.

Hanley, T.A. 1978. A comparison of the line-interception and quadrat estimation methods of determining shrub canopy coverage. Journal of Range Management. 31, 60-62.

He, N., Zhang, Y., Dai, J., Han, X., Baoyin, T., and Yu, G. 2012. Land use impact on soil carbon and nitrogen sequestration in typical steppe ecosystems, Inner Mongolia. Journal of Geographical Sciences. 22, 859-873.

Hickman, K.R., Hartnett, D.C., Cochran, R.C., and Owensby, C.E. 2004. Grazing management effects on plant species diversity in tallgrass prairie. Journal of Range Management. 57: 58-65.

Hieroo, J., Branch, L., Villarrel, D., and Clark, K. 2000. Predictive equation for biomass and fuel characteristics of Argentine shrubs. Journal of Range Management. 6, 617-621.

Hui, D., and Jackson, R.B. 2005. Geographic and inter annual variability in biomass partitioning in grassland ecosystems: a synthesis of field data. New Phytologist. 169, 85-93.

Impithuksa V.W., Blue, G., and Graetz, D.A. 1984. Distribution of applied nitrogen in soil-Pensacola bahiagrass components as indicated by Nitrogen- 15. Soil Science Society of America Journal. 48, 1280-1284.

Jalilvand, H., Tamartash, R., and Heidarpour, H. 2006. Grazing effect on vegetation and some of the chemical soil properties at Nowshahr Kojour Rangelands. Journal of Rangeland. 1, 53-66. (In Persian)

Jiang, G.M., Han, X.G., and Wu, J.G. 2006. Restoration and management of the Inner Mongolia grassland require a sustainable strategy. Ambio. 35, 269-270.

Joneidi, H., Amani, S., and Karami, P. 2016. Effects of grazing intensities on carbon sequestration and storage in the rangelands of Bijar protected area. Journal of Rangeland. 1, 53-67. (In Persian)

Khosravi, H. 2014. Effect of improvement operations on reclamation of soil and vegetation cover in Taftan rangelands. M.Sc Thesis, University of Zabol, Iran. (In Persian)

Knudsen, D., Peterson, G.A., and Pratt, P. 1982. Lithium, sodium and potassium. In: Page, A.L. (Ed.), Methods of Soil Analysis, American Society of Agronomy. Madison, Wisconsin, pp. 225-246.

Kohandel, A., Arzani, H., and Hosseini Tavassol, M. 2011. Effect of grazing intensity on soil and vegetation characteristics using Principal components analysis. Iranian Journal of Range and Desert Research. 4, 518-526.

Ksiksi, T., El-Keblawy, A., Al-Ansari, F., and Elhadramy, G. 2007. Desert ecosystems vegetation and potential uses as feed sources for camels and wildlife. In: Proceeding of the 8th Annual Conference for Research Funded by UAE University, Al-Ain, United Arab Emirates.

Lawrence, L., and Vadakattu, G. 2007. Grazing system affects soil microbe diversity. Farming Ahead. 189, 1-2.

Li, J.H., Li, Z.Q., and Ren, J.Z. 2005. Effect of grazing intensity on clonal morphological plasticity and biomass allocation patterns of *Artemisia frigida* and *Potentilla acaulis* in the Inner Mongolia steppe. New Zealand Journal of Agricultural Research. 48, 57-61.

Li, W., Huang, H.Z., Zhang, Z.N., and Wu, G.L. 2011. Effects of grazing on the soil properties and c and n storage in relation to allocation in an alpine meadow. Journal of Soil Science and Plant Nutrition. 4, 27-39.

Lo, I., Tsang, D., Yip, T., Wang, F., and Zhang, W.H. 2011. Influence of injection conditions on EDDS-flushing of metal-contaminated soil. Journal of Hazardous Materials. 192, 667-675.

Lu, X., Yan, Y., Sun, J., Zhang, X., Chen, Y., Wang, X., and Cheng, G. 2015. Short-term grazing exclusion has no impact on soil properties and nutrients of degraded alpine grassland in Tibet, China. Solid Earth. 6, 1195-1205.

Maghsoudi Moghadam, M., Tahmasebi, P., Ebrahimi, A., Shahrokhi, A., and Faal, M. 2012. Effects of livestock grazing on plant community composition and diversity in steppic rangelands of Boroujen. Journal of Rangeland. 4, 410-418. (In Persian)

Manzano, M.G., and Návar, J. 2000. Processes of desertification by goats overgrazing in the Tamaulipan thorn scrub (matorral) in north-eastern Mexico. Journal of Arid Environment. 44, 1-17.

Matus, G., and Tothmeresz, B. 1990. The effect of grazing on the structure of a sandy grassland. In: Krahulec, F., Agnew, A.D.Q., Agnew, S., and Willems. J.H. (Eds.), Spatial Process in Plant Communities. Academia Press, Prague, pp. 23-30.

Mcsherry, M.E., and Ritchie, M.E. 2013. Effects of grazing on grassland soil carbon: a global review. Global Change Biology. 19, 1347-1357.

Mengistu, T., Teketay, D., Hulten, H., and Yemshaw, Y. 2005. The role of enclosures in the recovery of woody vegetation in degraded dry land hillsides of central and northern Ethiopia. Journal of Arid Environment. 60, 259-281.

Mesdaghi, M. 2001. Vegetation description and analysis. Mashhad University Press, Jahad-e–Daneshgahi, Iran. (In Persian)

Milchunas, D.G., and Lauenroth, W.K. 1993. Quantitative effects of grazing and soils over a global range of environments. Ecological Monographs. 63, 327-366.

Mirlashkari, F. 2016. The Impact of long-term grazing exclusion and different grazing intensity on some vegetation characteristics, soil carbon pool and nitrogen pool in Joonabad rangeland-Zahedan. M.Sc Thesis, University of Zabol, Iran. (In Persian)

Mofidi, M., Jafari, M., Tavili, A., Rashtbari, M., and Alijanpour, A. 2013. Grazing exclusion effect on soil and vegetation properties in Imam Kandi Rangelands, Iran, Arid Land Research and Management. 27, 32-40.

Moghbeli, Z. 2016. Effect of different grazing intensity on organic carbon storage and soil nitrogen storage in rangeland of Varamin city of Jiroft. M.Sc Thesis, University of Zabol, Iran. (In Persian)

Mut, H., and Ayan, I. 2011. Effect of different improvement methods on some soil properties in a secondary succession rangeland. Journal of Biodiversity and Environmental Sciences. 5, 11-16.

Nelson, D.W., and Sommers, L.E. 1996. Total carbon, organic carbon, and organic matter. In: Bartels, J.M. (Ed.), Methods of soil analysis. Chemical Methods. Soil Science Society of America, Madison, Wisconsin, pp. 961-1010.

Nikan, M., Ejtehadi, H., Jangju, M., Memariani, F., Hasanpour, H., and Noadoost, F. 2012. Floristic composition and plant diversity under different grazing intensities: case study semi steppe rangeland, Baharkish, Quchan. Iranian Journal of Range and Desert Research. 2, 306-320. (In Persian)

Õnatibia, G.R., and Aguiar, M.R. 2016. Continuous moderate grazing management promotes biomass production in Patagonian arid rangelands. Journal of Arid Environment. 125. 73-79.

Raiesi Gahrooee, F., Asadi, E., and Mohammadi, J. 2005. Effects of Long-term grazing on the dynamics of litter carbon in natural rangelands of Sabzkou of Chaharmahal Va Bakhtiary. Journal of Water and Soil Science. 9, 81-92. (In Persian)

Raiesi, F., and Riahi, M. 2014. The influence of grazing exclosure on soil C stocks and dynamics, and ecological indicators in upland arid and semi-arid rangelands. Ecological Indicators. 41, 145-154.

Razavi, S.M., Mattaji, A., Rahmani, R., and Naghavi, F. 2012. The assessment of plant species importance value (SIV) in Beech (*Fagus orientalis*). forests of Iran (a case study: Nav District 2 of Asalem, Guilan province). International Research Journal of Applied and Basic Sciences. 3, 433-439.

Rechinger, K.H. 1963a. Flora Iranica. Ephedraceae. Akademische Druck U Verlagsanstalt, Graz, Austria.

Rechinger, K.H. 1963b. Flora Iranica. Nitrariaceae. Akademische Druck U Verlagsanstalt, Graz, Austria.

Rechinger, K.H. 1968. Flora Iranica. Polygonaceae. Akademische Druck U Verlagsanstalt, Graz, Austria.
Rechinger, K.H. 1970. Flora Iranica. Gramineae, Akademische Druck U Verlagsanstalt, Graz, Austria.
Rechinger, K.H. 1972a. Flora Iranica. Compositae. Akademische Druck U Verlagsanstalt, Graz, Austria.
Rechinger, K.H. 1972b. Flora Iranica. Zygophyllaceae. Akademische Druck U Verlagsanstalt, Graz, Austria.
Rechinger, K.H. 1974a. Flora Iranica. Apocynaceae. Akademische Druck U Verlagsanstalt, Graz, Austria.
Rechinger, K.H. 1974b. Flora Iranica. Plumbaginaceae. Akademische Druck U Verlagsanstalt, Graz, Austria.
Rechinger, K.H. 1984. Flora Iranica. Papilionaceae, Akademische Druck U Verlagsanstalt, Graz, Austria.
Rechinger, K.H. 1997. Flora Iranica. Chenopodiaceae, Akademische Druck U Verlagsanstalt, Graz, Austria.
Reeder, J.D., and Schuman, G.E. 2002. Influence of livestock grazing on C sequestration in semi-arid mixed-grass and short-grass rangelands. Environmental Pollution. 116, 457-463.
Rhoades, J.D. 1996. Salinity: Electrical conductivity and total dissolved solids. In: Page, A.L. (Ed.), Methods of soil analysis, American Society of Agronomy, Madison, Wisconsin, pp. 417-435.
Ruess, R.W., and Seagle, S.W. 1994. Landscape patterns in soil microbial processes in the Serengeti National Park, Tanzania. Ecology. 75, 892-904.
Sheiba, A., and Wilson, M.V. 2011. Biological determinuds of species diversity at different spatial scales. Journal of Biogeography. 120, 1-20.
Singh, J.P., Soni, M.L., and Rathore, V.S. 2005. Role of shrubs in rehabilitation of degraded lands in hot arid region. In: Prasad, S.N., Singh, R.K., Kumar, A., Parandiyal, A.K., Ali, S., Somasundaram, J., Sethy, B.K., Sharda, V.N (Eds.), Natural resource management for sustainable development in Western India. Allied Publishers, India, pp. 169–170.
Snorrason, A., Sigurdsson, B.D., Gudbergsson, G., Svavardsdottir, K., and Jonsson, P.H. 2002. Carbon sequestration in forest plantations in Iceland. ICEL Journal of Agricultural Science. 15: 81-93.
Steffens, M., Kolbi, A., and Totsch, K. 2008. Grazing effects on soil chemical and physical properties in a semiarid steppe of Inner Mongolia (P.R. China). Geoderma. 143, 63-72.
Stewart, A., and Frank, D. 2008. Short sampling intervals reveal very rapid root turnover in temperate grassland. Oecologia. 157, 453-458.
Tarhouni, M., Ben Hmida, W., and Neffati, M. 2015. Long-term changes in plant life forms as a consequence of grazing exclusion under arid climatic conditions, Land Degradation and Development. doi:10.1002/ldr.2407.
Thomas, G.W. 1996. Soil pH and soil acidity. In: Sparks, D.L. (Ed.), Methods of soil analysis, American Society of Agronomy and Soil Science Society of America., Madison, Wisconsin, pp. 475-490.
Tornquist, C.G., Hons, F.M., Feagley, S.E., and Haggar, J. 1999. Agroforestry system effects on soil characteristics of the Sarapiqui region of Costa Rica. Agriculture, Ecosystems and Environment. 73, 19-28.
Turner, C.L., Seastedt, T.R., and Dyer, M.I. 1993. Maximization of aboveground grassland production: the role of defoliation frequency, intensity, and history. Ecological Applications. 3, 175-186.
van Wijnen, H., van der Wal, R., and Bakker, J. 1999. The impact of herbivores on nitrogen mineralization rate: consequences for salt-marsh succession. Oecologia. 118, 225-231.
Wang, D., Wu, G.L., Zhu, Y.J., and Shi, Z.H. 2014. Grazing exclusion effects on above- and below ground C and N pools of typical grassland on the Loess Plateau (China). Catena. 123, 113-120.

Wang, Z., Johnson, D.A., Rong, Y., and Wang, K. 2016. Grazing effects on soil characteristics and vegetation of grassland in northern China. Solid Earth. 7, 55-65.

West, C.P., and Nelson, C.J. 2003. Naturalized grassland ecosystems and their management. In: Barnes, R.F., Jerry Nelson, C., Collins, M., and Moore, K.J. (Eds.), Forages: An Introduction to Grassland Agriculture. Wiley- Blackwell Publishing. Ames, Iowa, pp. 315-337.

Wu, G.L., Liu, Z.H., Zhang, L., Chen, J.M., and Hu, T.M. 2010. Long-term fencing improved soil properties and soil organic carbon storage in an alpine swamp meadow of western China. Plant and Soil. 332, 331-337.

Yong-Zhong, S., Yu-Lin, L., Jian-Yuan, C., and Wen-Zhi, Z. 2005. Influences of continuous grazing and livestock exclusion on soil properties in a degraded sandy grassland, Inner Mongolia, northern China. Catena. 59, 267-278.

Yoshihara, Y., Ohkuro., T., Bunveibaatar, B., Jamsran, U., and Takeuchi, K. 2010. Spatial pattern of grazing affects influence of herbivores on spatial heterogeneity of plants and soils. Oecologia. 162, 427-434.

Zarekia, S., Fayaz, M., Gholami, P., Goudarzi, M., and Jafari, F. 2014. Effects of different grazing management methods on plant species diversity and richness in the steppe rangeland of Saveh, Iran. Iranian Journal of Applied Ecology. 2, 1-11. (In Persian)

Zhang, T.H., Su, Y.Z., Cui, J.Y., Zhang, Z.H., and Chang, X.X. 2006. A leguminous shrub (*Caragana microphylla*) in semi-arid sandy plain of north China. Pedosphere. 16, 319-325.

Zohary, M. 1963. On the geobotanical structure of Iran. Section D, Botany. Supplement. Bulletin of the Research Council of Israel.