ISSN: 2476-6909; ECOPERSIA. 2021;9(2):139-152.

Effect of Grazing Exclosure on Vegetation Characteristics and Soil Properties in the Mahabad Sabzepoush Rangelands, Iran

ARTICLE INFO

Article Type
Original Research

Authors
Samadi-Khangah S.[1] *MSc,*
Ghorbani A.*[1] *PhD,*
Choukali M.[1] *MSc,*
Moameri M.[2] *PhD,*
Badrzadeh M.[1] *MSc,*
Moatamedi J.[3] *PhD*

How to cite this article
Samadi-Khangah S, Ghorbani A, Choukali M, Moameri M, Badrzadeh M, Moatamedi J. Effect of Grazing Exclosure on Vegetation Characteristics and Soil Properties in the Mahabad Sabzepoush Rangelands, Iran. ECOPERSIA. 2021;9(2):139-152.

[1]Department of Natural Resources, Faculty of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Ardabil, Iran
[2]Department of Plant Sciences and Medicinal Plants, Faculty of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Meshginshahr, Iran
[3]Rangeland Research Division, Research Institute of Forests and Rangelands, Agricultural Research Education and Extension Organization (AREEO), Tehran, Iran

***Correspondence**
Address: Faculty of Agriculture and Natural Resources, University of Mohaghegh Ardabili, Daneshgah Street, Ardabil, Iran. Postal Code: 56199 13131
Postal Code: 4361996196
Phone: +98 (45) 33510136
Fax: +98 (45) 33510136
a_ghorbaniuma.ac.ir

Article History
Received: August 12, 2020
Accepted: September 27, 2020
ePublished: October 31, 2020

ABSTRACT

Aim Most rangelands of Urmia in Iran have been destroyed and need significant restoration to achieve favorable conditions. This study aimed to investigate the impacts of a 19-years research exclosure on vegetation and soil features in Mahabad Sabzepoush rangelands of Iran.
Materials & Methods To conduct research using the random-systematic method, three reference sites inside the exclosure and three reference sites outside the exclosure were selected with similar conditions. In each site, three linear transects, and along each transect, ten plots of one square meter were established. The percentage of canopy cover and the number of plants in each plot were measured using estimation and counting methods. From the beginning, middle, and end of each transect, soil samples were collected from a depth of 30 cm. An independent t-test was used to compare data on quantitative vegetation factors, land surface cover, richness characteristics, species diversity, evenness, and soil characteristics both inside and outside the enclosure.
Findings Based on the results, 75 species belonging to 60 genera and 19 families were identified in the selected sites. Results showed that vegetation factors such as density and canopy cover of forbs and grasses and total canopy cover had a significant difference between the outside and inside of exclosure ($p<0.05$). The total density, density, and canopy cover of shrubs were not significantly different between exclosure and control sites ($p>0.05$). In the grazing area, the value of plant density of forbs, grasses, and shrubs was 43.84, 40.62, and 1.10number/m2, respectively. After 19 years of the exclosure, the forbs' density (57.45number/m2) and shrubs (2.17number/m2) were increased. Besides, forbs canopy cover increased from 18.14 to 24.88 (percentage) and shrubs canopy cover increased from 0.91 to 0.97% in 19 years exclosure. Richness, diversity, and evenness did not differ significantly between the exclosure and open grazing sites ($p>0.05$). The richness and diversity index was increased by 0.03 and 0.05 in the exclosure sites, but the evenness index increased by 0.01 in the open grazing sites. Nitrogen, electrical conductivity (EC), available phosphorus, organic matter, silt, and potassium in the exclosure and open grazing areas, had a significant difference ($p<0.05$). In the grazing area, EC and potassium's value was 1.35ds/m and 464.24ppm, respectively. After 19 years of the exclosure, the value of EC (1.10ds/m) and potassium (464.24ppm) were increased. Nevertheless, the values of other factors were decreased.
Conclusion Although exclosure has increased the percentage of canopy cover, density, and diversity of species, but in some cases, non-observance of exclusion will prevent the achievement of the expected goals and desired results. These results indicate that grazing exclosure plays a crucial role in vegetation recovery and soil protection of destroyed rangelands.

Keywords Grazing Impacts; Species Diversity; Life Cycle; Palatability clAss

CITATION LINKS

[1] Potential ... [2] Effects ... [3] Differentiating ... [4] Dynamics ... [5] Grazing ... [6] Grazing-induced ... [7] Grazing ... [8] Elevated ... [9] Insights ... [10] Soil bacterial ... [11] Effect ... [12] Carbon ... [13] One-year ... [14] Effectiveness ... [15] Effects ... [16] Effects ... [17] Effects ... [18] Changes ... [19] Grazing ... [20] Grazing ... [21] Vegetation ... [22] Grazing ... [23] Long-term ... [24] Long-term ... [25] Suitable ... [26] Adaptive ... [27] Cumulative ... [28] Effect ... [29] Effect ... [30] Grazing ... [31] Effects ... [32] Determining ... [33] Study ... [34] Plant ... [35] Soil ... [36] Comparison ... [37] Drift ... [38] Vegetation ... [39] Rangeland ... [40] Flora ... [41] Flora ... [42] Flora ... [43] Flora ... [44] The life ... [45] Phenological ... [46] Studio ... [47] Introduction ... [48] Investigating ... [49] A mathematical ... [50] A comparison ... [51] How relevant ... [52] The impact ... [53] Soil analysis ... [54] Flora ... [55] Introduction ... [56] Comparison ... [57] Vegetation ... [58] Investigate ... [59] Comparison ... [60] Spatial ... [61] Assessment ... [62] The effects ... [63] The effect ... [64] Effect ... [65] Livestock ... [66] Effects ... [67] Short-term ... [68] Plant ... [69] Composition ... [70] Development ... [71] The role ... [72] Livestock ... [73] Spatial ... [74] Effects ... [75] Rangeland ... [76] Suitable ... [77] Effect ... [78] Hemicryptophytes ... [79] A selective ... [80] Spatial ... [81] Relationships ... [82] Comparison ... [83] Factors ... [84] Grazing ... [85] The effect ... [86] Critical ...

Introduction

The arid and semiarid regions cover about 30% of the Earth's land, about 4 billion hectares [1, 2]. These lands have been endangered due to various interventions such as climate change and human disturbances (overgrazing for a long time, over-cultivation, and the use of plants as firewood) [3, 4], which may lead to a range of severe environmental problems, including soil erosion, biodiversity loss and waste of global carbon soil and nutrient cycles [1, 2].

Livestock grazing is a culturally and economically important activity everywhere [5, 6]. In arid land ecosystems, especially in dry conditions, the effect of livestock on plants and soil is intensified and leading to heightened water and wind erosion [7, 8]. Livestock grazing impacts change plants' cover and quality and change the soil's physical condition by trampling [9].

Exclosure is an efficient management method to increase rangeland carbon sequestration and reclamation of degraded ecosystems [10]. In recent years, several studies have been conducted to evaluate the rehabilitation of degraded rangelands using grazing exclosure (GE) [11, 12, 13]. However, there is disagreement about the result of fencing on rangeland rehabilitation. Gao *et al.* [14] and Yuan *et al.* [15] stated that grazing exclosure (GE) improved the soil water holding capacity. Other studies have shown that exclosure, plant evapotranspiration increases and absorb by shallow roots, thus reducing the soil water content [16, 17]. Therefore, by increasing in organic matter input, GE can significantly increase soil carbon's nitrogen and concentration [18]. However, depending on the soil, local climate, or type of vegetation, grazing intensity has an unknown or even negative impact on soil nitrogen, soil carbon, and the other soil nutrients [19, 20]. Concerning the effect of GE on plants, studies have shown that exclosure has positive effects on plant biomass, as it improves the availability of water and soil nutrients and prevents its use by grazers [21]; while due to the short duration of the exclosure, the belowground biomass has not changed [22].

Moreover, GE may have a negative effect on species diversity [23], or have little effect on species diversity [24], or even increase species diversity [16]. Contradiction in the effects of exclosure on different rangelands depends on various factors, for example, rangeland type [25], the degree of degradation before exclosure [26], duration of exclosure [27], and local climatic conditions [28]. Thus, finding an equilibrium between the beneficial and negative impacts of exclosure on community structure and species diversity of rangeland ecosystems has become the focus of discussion. Scientifically, finding this equilibrium is of great importance for the sustainable use of rangelands [29].

About 45% of 165 million hectares area in Iran is covered by rangelands, which is mainly distributed in arid ecosystems (up to 85% of rangeland ecosystems), and they serve as main natural resources by valuable economic, social and ecological importance to supporting more than 65 million people, and also their crucial role in sustaining rural and nomadic livelihood [30, 31]. Rangelands provide many services such as forage for livestock, soil conservation, offer recreational activities, and have great ecological contributions in biodiversity conservation [31]. Besides, in Iran, improper rangeland management is one of the most important problems that lead to unprincipled exploitation, disregarding the timing of entry and exit of livestock and overgrazing of its capacity [32]. For this reason, some rangelands have been destroyed and are classified into poor and very poor classes in terms of rangeland conditions. In Iran, the grazing exclosure method follows two purposes. The first grazing exclosure for research purposes sheds light on the effectiveness of this method for rangeland reclamation. Second, once the first step is approved for habitat, it is applied to reclaim rangelands to increase soil fertility and canopy cover, and plant diversity, which have been highlighted as appropriate approaches for protection purposes [30, 33]. Moreover, they found that grazing exclosure is a promising management action in rangelands.

In many regions, such as Mahabad Sabzepoush rangelands in West Azerbaijan province, Iran, palatable, even unpalatable, and toxic plants have experienced extinction, and the soil is exposed to water and wind erosion [34]. There is also some evidence that overgrazing strongly affects soil's chemical, physical and biological features, which causes significant changes in plants and nutrient cycle, and declining permanently land efficiency and lead to ecosystem destruction [35]. Mostly rangelands in Urmia-Iran have been destroyed and need significant restoration to gain a favorable condition. In Iran's four climatic zones, the study area of this research is located in semiarid areas. This region has cold winters and relatively mild summers [36]. So far, vegetation and soil characteristics' reaction to grazing exclosure is not fully understood in this area. To fill this research gap, this research aims to compare and evaluate vegetation changes and physicochemical soil features in the exclosure area with open grazing areas with similar climatic and physiographic conditions in Mahabad Sabzepoush rangelands. These results can supply technical support for the restoration and scientific management of semiarid rangelands. The main research question is whether there is a significant difference between species' composition and diversity inside and outside the exclosure in the Mahabad Sabzepoush rangelands. Moreover, one of the hypotheses of this research is that exclosure has an effective role in vegetation and soil restoration.

Materials and Methods

Study area

The study was conducted in Mahabad Sabzepoush rangelands, coordinated over 36° 54′ 58′′ north latitude and 45° 49′ 14′′ east longitude in West Azerbaijan province of Iran, 16km from Mahabad city, central part, Makrian Gharbi village and allotments of Haji Khosh village (Figure 1). The total area of allotments is 1260 hectares, of which 747.4 hectares are rangeland and livestock grazing, and the remainder are exceptions [36]. The average annual temperature is -20 to +40 Cº, and precipitation is 200 to 350 mm [36]. The minimum and maximum elevation above sea level are 1358 and 1580 m, respectively. There is numerous stratigraphic unit in the province of West Azerbaijan from the Precambrian to Quaternary periods, which Mahabad region includes 6.01% of the intrusive rock, 15.50% of metamorphic rock and 4.50% of sedimentary rock [37]. Based on the province's geographical location, various plant compositions have been created in different topography levels [36] (Table 1). Also, dominant species include *Crepis alpestris*, *Lolium rigidum,* and *Bromus tectorum*.

In the Mahabad region, there are more than 197000 hectares of rangelands, of which 50000 hectares have suitable coverage, 70000 hectares have moderate coverage, and the rest of the rangelands have poor coverage. In this region, 170000 head of livestock is allowed to use rangelands, while now there are three times this amount of livestock in these rangelands. Rangeland management projects have covered more than 21000 hectares of rangelands in the region in recent years.

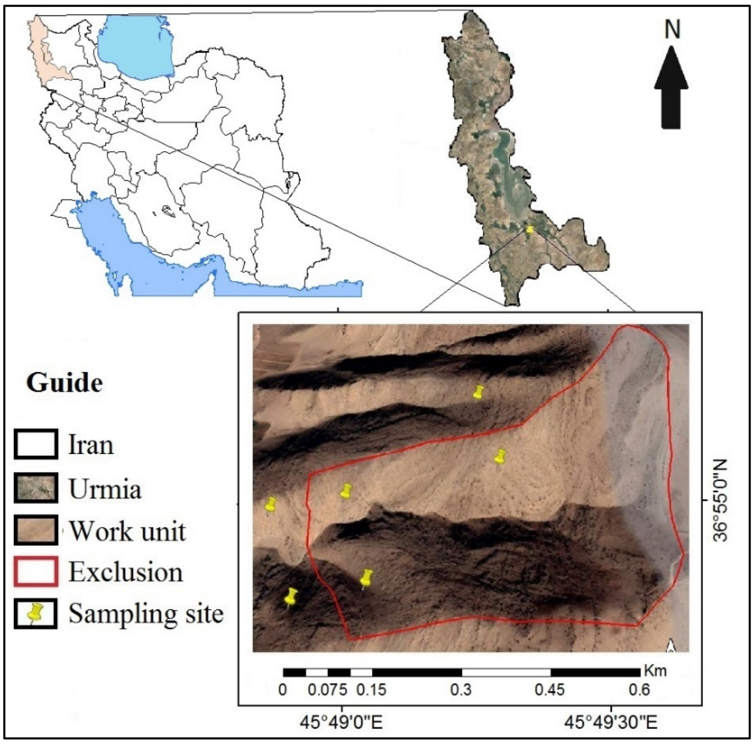

Figure 1) Location of the study area in Iran and West Azerbaijan province and sampling sites

Table 1) Plant species recorded at inside and outside of grazing exclosure

Family and species	Chorotypes	Life form	Vegetation form	Life cycle	Palatability class	Presence/Absence	
						Inside of exclosure	Outside of exclosure
Apiaceae							
Bupleurum gerardi Pollini *	IT	Th	F	A	II	✓	✓
Eryngium campestre L. *	IT, ES, M	He	F	P	III	✓	✓
Scandix aucheri Boiss.	IT	Th	F	A	II	✓	✓
Torilis stocksiana (Boiss.) Drude *	IT, ES	He	F	P	III	✓	✓
Asteraceae							
Achillea santolinoides subsp. wilhelmsii (K.Koch) Greuter *	IT, ES	He	F	P	III	✓	✓
Carduus pycnocephalus L. *	IT, ES, M	He	F	P	III	✓	-
Carthamus oxyacantha M.Bieb. *	IT	He	F	P	III	✓	✓
Chardinia orientalis (L.) Kuntze *	IT	Th	F	A	III	✓	✓
Cousinia eriocephala Boiss. & Hausskn ex Boiss.	IT	He	F	P	III	✓	✓
Crepis alpestris (Jacq.) Tausch	Cosm	Th	F	A	III	✓	✓
Crepis alpina L.	IT, ES, M	Th	F	A	III	✓	✓
Crepis kotschyana (Boiss.) Boiss.	IT	Th	F	A	III	✓	-
Crepis sancta (L) Babc.	IT, M	Th	F	A	III	-	✓
Crupina crupinastrum (Moris) Vis.	IT, M	Th	F	A	III	✓	✓
Echinops ritrodes Bunge *	IT, ES	He	F	P	III	✓	✓
Garhadiolus hedypnois (Fisch. & Mey.) Jaub. & Spach	IT, M	Th	F	A	III	✓	✓
Lactuca orientalis (Boiss.) Boiss.	IT	He	F	P	III	✓	✓
Picnomon acarna (L.) Cass.	IT, M	Th	F	A	III	✓	✓
Tragopogon carcifolius Boiss. *	IT	He	F	P	I	✓	-
Boraginaceae							
Nonea caspica (willd.) G. Don *	IT, ES	Th	F	A	II	✓	✓
Rochelia disperma (L. f.) K. Koch	IT	Th	F	A	III	✓	✓
Brassicaceae							
Alyssum desertorum Stapf *	IT, ES	Th	F	A	III	✓	✓
Erysimum repandum L. *	IT, ES, M	Th	F	A	III	-	✓
Isatis tinctoria L. *	IT	He	F	P	III	✓	-
Caryophyllaceae							
Arenaria gypsophiloides L.	IT	He	G	P	I	-	✓
Minuartia meyeri (Boiss.) Bornm.	IT	Th	F	A	III	✓	✓
Petrorhagia cretica (L.) P.W.Ball & Heywood	IT	Th	F	A	III	✓	-
Cistaceae							
Helianthemum salicifolium (L.) Mill.	IT, ES, M	Th	F	A	III	✓	✓
Dipsacaceae							
Pterocephalus canus Coult. ex DC.	IT	He	F	P	III	✓	✓
Scabiosa macrochaete Boiss.& Hausskn.	IT	Th	F	A	II	✓	✓
Valerianella coronata (L.) DC	IT, ES	Th	F	A	III	✓	✓
Valerianella oxyrhyncha Fisch & C.A. Mey	IT	Th	F	A	III	✓	-
Valerianella vesicaria Moench	IT, ES	Th	F	A	III	✓	✓
Ephedraceae							
Ephedra procera Fisch. Et Mey. *	IT	Ch	Sh	P	II	✓	✓
Fabaceae							
Astragalus effusus Bunge *	IT	He	F	P	I	✓	✓
Astragalus campylorrhynchus Fisch. & C. A. Mey	IT	Th	F	A	I	✓	✓
Astragalus guttatus Banks & Sol.	IT	Th	F	A	I	✓	-
Astragalus kirrindicus Boiss.	IT	He	F	P	I	✓	✓
lathyrus pratensis L.	IT, ES, M	He	F	P	I	✓	-
Lens culinaris Medik. *	IT	Th	F	A	I	✓	✓
Medicago radiata L. *	IT	Th	F	A	I	✓	✓
Medicago rigidula (L.) All.	IT, ES	Th	F	A	I	✓	-
Trigonella calliceras Fisch. ex M.Bieb.	Cosm	Th	F	A	I	✓	✓
Trigonella grandiflora Bunge *	IT	Th	F	A	I	✓	✓

Continue of Table 1) Plant species recorded at inside and outside of grazing exclosure

Family and species	Chorotypes	Life form	Vegetation form	Life cycle	Palatability class	Presence/Absence	
Geraniaceae							
Erodium cicutarium (L.) L'Her. *	IT,ES,M	Th	F	A	III	✓	✓
Lamiaceae							
Salvia multicaulis Vahl *	IT	He	F	P	III	✓	✓
Scutellaria pinnatifida A. Hamilt *	IT	He	F	P	II	-	✓
Sideritis montana L. *	IT, ES, M	He	F	P	III	✓	✓
Stachys inflata Benth. *	IT, M	He	F	P	III	✓	✓
Teucrium polium L. *	IT	Ch	Sh	P	III	✓	✓
Thymus kotschyanus Boiss. & Hohen. *	IT	Ch	Sh	P	II	✓	✓
Ziziphora capitata L. *	IT	Th	F	A	III	✓	✓
Papaveraceae							
Fumaria officinalis L. *	IT, ES, M	Th	F	A	III	✓	✓
Papaver dubium L.	IT	Th	F	A	III	✓	✓
Papaver laevigatum M.Bieb.	IT	Th	F	A	III	✓	-
Poaceae							
Aegilops crassa Boiss.	Cosm	Th	G	A	II	✓	-
Aegilops geniculata Roth	Cosm	Th	G	A	III	-	✓
Avena eriantha Durieu	IT, ES	Th	G	A	II	✓	✓
Boissiera squarrosa (Banks & Sol.) Nevski	IT	Th	G	A	II	✓	✓
Bromus danthoniae Trin.	IT	Th	G	A	III	✓	✓
Bromus tectorum L.	Cosm	Th	G	A	III	✓	✓
Eremopyrum triticeum (Gaertn.) Nevski	Cosm	Th	G	A	III	-	✓
Lolium rigidum Gaudin	IT, M	Th	G	A	I	✓	✓
Poa bulbosa L.	IT, M	Ge	G	P	II	✓	✓
Rostraria cristata (L.) Tzvelev	IT, ES, M	Th	G	A	III	✓	✓
Taeniatherum caput-medusae (L.) Nevski	IT, ES, M	Th	G	A	III	✓	✓
Primulaceae							
Androsace maxima L.	IT, ES	Th	F	A	II	✓	✓
Ranunculaceae							
Nigella arvensis L. *	IT	Th	F	A	III	✓	✓
Rosaceae							
Sanguisorba minor Scop. *	IT, ES, M	He	F	P	I	✓	✓
Rubiaceae							
Asperula glomerata (M.Bieb.) Griseb *	IT	Ch	Sh	P	II	✓	-
Callipeltis cucullaris (L.) Steven	IT	Th	F	A	III	✓	✓
Galium setaceum Lam.	IT, M	Th	F	A	III	✓	✓
Galium spurium L.	IT, ES	Th	F	A	I	✓	-
Scrophulariaceae							
Verbascum orientale (L.) All. *	IT, ES	Th	F	A	I	✓	✓
Violaceae							
Viola occulta Lehm.	IT, M	Th	F	A	II	✓	✓

Note: * Medicinal plants; Cosm: Cosmopolite, ES: European-Siberian, IT: Irano-Turonian, M: Mediterranean, Th: Therophytes, He: Hemicryptophytes, Ge: Geophytes, Ch: Chamaephytes; F: Forbs, G: Grasses, Sh: Shrubs, A: Annual, P: Perennial; Class I: Highly palatable species; Class II: Moderately palatable species; Class III: Lowly palatable species; × presence of species, - Absence of species

Sampling

To evaluate the effects of grazing exclosure on soil and vegetation characteristics, grazed and non-grazed (19-year) sites were selected. The control and exclosure sites were near each other, and they were almost similar in terms of geology, geography, distribution of traits, and relationship across the area or event. A multi-site review during the growing season of dominant plants from April to June 2018-2019 was conducted to select study sites. A grazed rangeland was considered as a control. Such enclosures are managed publicly in a conventional manner.

Therefore, using a random systematic method was selected three grazing exclosure sites and three control sites as sampling sites. Three 100m long transects were established in grazing and exclosure sites (in total 18 transects) and ten 1m^2 plots were established spaced equally (10m) along each transect. A flexible systematic model and minimal area method were considered to determine the size and number of plots [38]. In each plot, we measured species' presence, plant densities, canopy cover, and percentage of stone, gravel, and bare soil. Density and canopy cover percentage (forbs, shrubs, and grasses) were estimated singly in each plot. Plant species' density was calculated by counting the number of species per plot [39]. Also, the surface or plot method was used to measure the percentage of canopy cover. In this way, the plot's total area was considered 100%, and the area of the plot occupied by the canopy of the species was determined as the percentage of canopy cover [39].

Vegetation surveys

Species identification was performed in the herbarium of the University of Mohaghegh Ardabili. The naming and identification corresponded to the Flora of Tukey [40], Flora Iranica [41], and Flora of Iran [42]. Chorotypes of the plant species were determined according to Zohary [43]. The life form of plant species according to Raunkier's method [44] was identified, and it was classified into seven specific biological types (phanerophytes, chamaephytes, hemicryptophytes, cryptophyte, therophytes, aerophytes, and epiphytes). The vegetation form (forbs, grasses, and shrubs) and life cycle (annual, perennial) and plants' palatability degree were also determined. For this purpose, plants were divided into classes I (high palatability), II (medium palatability), and III (low palatability) according to their palatability. Class I plants form the main part of the plant community in the climax stage and are rapidly reduced in heavy grazing conditions. Class II plants first increase their biomass under heavy grazing conditions and later decreases due to higher grazing intensity. Class III or invasive plants rapidly increase their biomass under heavy grazing conditions. These plants limit soil protection and have a negative effect on the yield of neighboring plants and soil erosion [45]. Moreover, to identify medicinal plants, the resources of medicinal plants and local knowledge were used [46, 47]. Finally, the species composition (floristic, chorotypes, life form, vegetative form, life cycle, and palatability class) were compared in two regions of grazing exclosure and control sites [48].

To examine plant diversity, Shannon's diversity index was calculated using equation 1, where *pi* is the proportion of points in the transect, where plant species *i* was observed [49]. Menhinick richness index was measured using equation 2, where *S* is the number of species, and n is the number of persons [50]. The evenness index was calculated by Pielou's *J* index using equation 3, where H′ is Shannon's diversity index, and *S* is the number of species sampled per quadrat [51].

$H' = \Sigma pi * Ln(pi)$ (Equation 1)

$S/\sqrt{n}$ (Equation 2)

(H'/lnS) (Equation 2)

Soil sampling

In grazing exclosure and control sites, soil samples were taken from the center of plots at the beginning, middle, and end of each transects at depths of 0-30 cm (depth of roots activity) [52]. A mixed sample was prepared for each transect, giving a total of 18 samples. Then soil samples transferred to the Faculty of Agriculture and Natural Resources' soil laboratory, University of Mohaghegh Ardabili. Soil samples were dried to analyze soil features. Samples were passed through a two-millimeter sieve. Then the organic matter (by calculating organic carbon using the modified Walkley–Black wet oxidation procedure), total nitrogen content (using Kjeldahl), the amount of available phosphorus (using Olsen method with a spectrophotometer), potassium content (using flame photometer), electrical conductivity (using EC meter in saturated extracts), pH (using pH meter in saturated extracts) and soil texture (using two hydrometer readings method) were measured [53].

Data Analysis

Data were tested for normality using the Kolmogorov– Smirnov test before statistical analysis, and Levene's test was used to examine the homogeneity of variances. Differences between ground cover, vegetation characteristics, species diversity index, and soil features of the control plots and grazing exclosure were analyzed using the Independent-Samples T-Test in the form of a completely random design using SPSS 26 software. Significance was determined at the 5% probability level unless otherwise stated. The species diversity index using PAST3.04 software was performed.

Findings

Grazing exclosure effect on floristic composition

In general, 75 species from 19 families and 65 genera were observed in the study area (Table 1). The numbers of species and genera in the grazing exclosure sites were increased. The maximum number of species were observed in the long-term exclosure, while the minimum number of species and genera was recorded in the grazing rangeland (Table 2). The region was dominated by plant families of the Asteraceae (18.75%), Poaceae (13.75%), Fabaceae (12.50%), and Lamiaceae (8.75%), respectively (Table 1). The results of the chorotypes showed that the highest percentage of the flora belongs to the Irano-Turonian elements (48%), followed by Irano–Turonian, and European-Siberian (16%), Irano-Turonian and European-Siberian and Mediterranean (16%) elements (Table 1). The results of plant classification of life form showed that therophytes with 66.66% and hemicryptophytes with 26.66% were the most abundant life forms in the area and chamaephytes with 5.33% and geophytes with 1.33% were next in terms of importance and number of species (Table 1). The results of plant classification in terms of vegetative form in the area showed that forbs with 78.66% and grasses with 16% were the most abundant vegetative forms and shrubs with 5.33 percent were next in terms of the number of species (Table 1). The results of plant classification in terms of life cycle showed that annual plants with 66.66% and perennial plants with 33.33%, formed the plant species in the area (Table 1). The palatability class results showed that 60% of the species included class III, 21.33% of species included class I, and 18.66% of species included class II (Table 1).

Grazing exclosure effect on plant cover and species diversity

The grazing exclosure significantly impacted plant species characteristics (Table 2). The independent t-test analysis results showed that vegetation factors such as density and canopy cover of forbs and grasses and total canopy cover had significantly different between the grazing exclosure and control sites ($p<0.05$). The total density, density, and canopy cover of shrubs were not significantly different between exclosure and control sites ($p>0.05$). In the grazing area, the value of plant density of forbs, grasses, and shrubs was 43.84, 40.62, and 1.10 (number/m^2), respectively. After 19 years of the exclosure, the density of forbs (57.45number/m^2) and shrubs (2.17number/m^2) were increased (Table 2). Besides, forbs canopy cover increased from 18.14 to 24.88%, and shrubs canopy cover increased from 0.91 to 0.97% in 19 years exclosure (Table 2).

Mean comparison of the land surface factors showed a significant difference between exclosure and control sites in terms of percentage of bare soil ($p<0.05$), but there was no significant difference in terms of percentage of stone and gravels. After 19 years of the exclosure, the percentage of bare soil was decreased (Table 2). The grazing exclosure had no significant effect on indicators of diversity, richness, and evenness ($p>0.05$). The values of richness, diversity, and evenness indices were 2.05, 1.96, and 0.77 in the exclosure area, respectively. Furthermore, these indices' values were 2.02, 1.91, and 0.78 in the open grazing area, respectively. Thus, the richness and diversity index (H′) was increased during the 19 years exclosure, and the evenness index was decreased during the exclosure (Table 2).

Grazing exclosure effect on the highly palatable species (class I)

The results showed in Table 3 that grazing exclosure effects on characteristics of plant communities. Table 3 presents the results of density and canopy cover analysis of class I species in grazing and exclosure rangelands. Density and canopy cover of *Lens culinaris*, *L. rigidum*, *Medicago radiata*, *Trigonella grandiflora*, *Verbascum orientale* species had significant differences between two areas ($p<0.05$), but *Astragalus campylorrhynchus*, *Astragalus effusus*, *Astragalus kirrindicus*, *Sanguisorba minor*, *Trigonella calliceras* species had no significant differences between two areas ($p>0.05$; Table 3). The plant species of *A. campylorrhynchus*, *A. effusus*, *S. kirrindicus*, *L. culinaris*, *M. radiata*, *S. minor*, *T. calliceras*, *T. grandiflora*, *V. orientale* had more density and canopy cover in the exclosure than in the grazing area (Table 3). The *Aegilops geniculata*, *Arenaria gypsophiloides*, *Crepis sancta*, *Eremopyrum triticeum*, *Erysimum repandum*, and *Scutellaria pinnatifida* were not detected in the 19-year rangeland exclosure. However, these plants were recorded in the grazing rangeland (Table 3).

Grazing exclosure effect on plant density and canopy cover of life cycles and life forms

The density of perennial species was significantly affected by exclosure ($p<0.05$; Table 4). The 19-year exclosure showed the largest numbers of plant species, of which 9.21% were perennials. So that the density and canopy cover of annual plants in the grazing rangeland was more than the exclosure area, and the density and canopy cover of the perennial species in the exclosure area was higher than the grazing area (Table 4). The grazing exclosure had significant effects on the density and canopy cover of geophytes (Table 4). So that, the density and canopy of geophytes inside the exclosure were 2.43 and 0.05 and outside the exclosure were 0.98 and 0.03, respectively. Also, density and canopy cover of hemicryptophytes and chamaephytes in exclosure were more than grazing rangelands, while the density of therophytes decreased after 19-year exclosure (Table 4).

Grazing exclosure effect on soil physical and chemical properties

Table 5 presents the values of measured soil properties. The soil pH showed a lower value (7.71) in the 19-years exclosure soils in comparison to grazing area soils (7.75), and no significant difference between the sampled soils ($p>0.05$; Table 5). The electrical conductivity (EC) values had a significant difference between the grazing (1.10ds/m) and exclosure (1.35 ds/m) sites (Table 5). As the results showed, there was a significant ($p<0.05$) enrichment of available phosphorus and potassium reserves in the exclosure (Table 5). Potassium and available do not follow each other's patterns. The organic matter content and nitrogen were significantly in the grazing rangeland compared to the exclosure (Table 5). The amount of clay (14.73%) was greater in the soils of 19-years exclosure than the soils of grazing rangeland, whereas the amount of sand and silt was low at these sites (Table 5).

Table 2) Comparison of plant cover, richness, diversity, and evenness at inside and outside of grazing exclosure

Sites	19-years exclosure	Grazing rangelands	t
Number of species	69	62	-
Number of genera	57	55	-
Number of families	19	19	-
Density of total species (number/m^2)	83.92±51.11	85.56 ±47.46	-0.22^{ns}
Density of forbs (number/m^2)	57.45±38.22	43.84±24.73	2.83**
Density of grasses (number/m^2)	24.28±24.86	40.62±38.32	-3.39**
Density of shrubs (number/m^2)	2.17±4.62	1.10±3.65	1.73^{ns}
Canopy cover of total species (%)	32.62±12.47	28.06±12.31	2.30**
Canopy cover of forbs (%)	24.88±12.03	18.14±9.14	4.23**
Canopy cover of grasses (%)	6.77±4.82	9.01±6.56	-2.60**
Canopy cover of shrubs (%)	0.97±2.79	0.91±1.74	-0.19^{ns}
Stone and gravels (%)	44.94±17.70	40.58±19.11	1.58^{ns}
Bare soil (%)	22.47±15.31	31.27±16.47	-3.71**
Richness	2.05±0.97	2.02±1.01	0.08^{ns}
Diversity	1.96±1.21	1.91±1.26	0.23^{ns}
Evenness	0.77±0.31	0.78±0.32	-0.21 ^{ns}

** $p<0.05$, ^{ns} represents nonsignificance (means±SD)

Table 3) Comparison of density and canopy cover of Class I species at inside and outside of grazing exclosure

Species	**Density** (number/m^2)			**Canopy cover** (%)		
	19-years exclosure	**grazing rangelands**	**t**	**19-years exclosure**	**grazing rangelands**	**t**
Astragalus campylorrhynchus	0.04	0.01	1.14^{ns}	0.05	0.01	1.66^{ns}
Astragalus effusus	0.13	0.11	-0.26^{ns}	0.14	0.12	0.25^{ns}
Astragalus kirrindicus	0.10	0.07	-0.52^{ns}	0.88	0.82	-0.11^{ns}
Lens culinaris	2.03	0.04	6.90**	1.05	0.04	6.88**
Lolium rigidum	6.54	18.27	-2/76**	1.12	3.10	-3.25**
Medicago radiata	0.81	0.06	2.68**	0.34	0.05	3.70**
Sanguisorba minor	0.11	0.07	0.36^{ns}	0.13	0.07	0.59^{ns}
Trigonella calliceras	1.53	0.96	1.15^{ns}	0.96	0.55	1.32^{ns}
Trigonella grandiflora	0.68	0.32	1.85**	0.55	0.23	2.11**
Verbascum orientale	1.00	0.27	2.47**	0.43	0.17	2.14**
Limited species in 19-years exclosure						
Aegilops geniculata	*Arenaria gypsophiloides*		*Crepis sancta*		*Eremopyrum triticeum*	
Erysimum repandum	*Scutellaria pinnatifida*					
Limited species in grazing rangelands						
Aegilops crassa	*Asperula glomerata*		*Astragalus guttatus*		*Carduus pycnocephalus*	
Crepis kotschyana	*Galium spurium*		*Isatis tinctoria*		*lathyrus pratensis*	
Medicago rigidula	*Papaver laevigatum*		*Petrorhagia cretica*		*Tragopogon* carcifolius	
Valerianella oxyrhyncha						

** $p<0.05$, ns represents nonsignificance (Means)

Table 4) Comparison of density and canopy cover of the life cycle and life forms properties at inside and outside of grazing exclosure

	Annual	Perennial	Hemicryptophytes	Geophytes	Chamaephytes	Therophytes
Density (number/m2)						
19-years exclosure	74.71±49.02	9.21±7.85	4.82±6.77	2.43±5.01	2.17±4.62	74.82±49.05
grazing rangelands	79.58±47.00	5.97±7.65	4.48±4.26	0.05±0.27	1.10±3.65	79.58±47.00
t	-0.68^{ns}	2.79**	-0.39^{ns}	4.49**	1.73^{ns}	-0.66^{ns}
Canopy cover (%)						
19-years exclosure	22.72±9.97	7.16±8.48	5.26±7.68	0.98±2.25	0.97±2.79	22.72±9.97
grazing rangelands	25.41±12.70	5.41±6.26	4.40±5.75	0.03±0.18	0.91±1.74	25.41±12.70
t	1.57^{ns}	1.57^{ns}	0.85^{ns}	4.00**	-0.19^{ns}	1.57^{ns}

** $p<0.05$, ^{ns} represents nonsignificance (Means±SD)

Table 5) Comparison of soil features inside and outside of grazing exclosure

Soil properties	19-years exclosure	Grazing rangelands	t
Sand (%)	71.39±4.19	72.10±4.89	-0.90^{ns}
Silt (%)	13.87±0.23	13.99±0.30	-3.11**
Clay (%)	14.73±4.20	13.95±4.87	1.15^{ns}
Soil texture class	Sandy loam	Sandy loam	-
pH	7.71±0.21	7.75±3.66	-1.23^{ns}
EC (ds/m)	1.35±0.78	1.10±0.39	3.70**
Nitrogen (%)	0.27±0.03	0.30±0.07	-3.79**
Available Phosphorus (ppm)	8.82±3.56	12.53±3.56	-6.97**
Potassium (ppm)	783.23±458.05	464.24±154.80	6.25**
Organic Matter (%)	2.88±0.56	3.13±0.65	-2.75**

** $p<0.05$, ^{ns} is no significant (Means ± SD)

Discussion

Effect of exclosure on vegetation composition

The introduction of the flora of the Mahabad Sabzepoush rangelands of Iran indicates 19 families and 75 species. The family of Asteraceae, Poaceae, Fabaceae, Lamiaceae, Dipsacaceae, due to better adaptation to semiarid and semi-humid climates, have a larger share of vegetation. These families have been introduced as the most important plant families in the study of Nejadhabibvash *et al.* [54], Shikh Kanlooie Millan *et al.* [55], Ahmadkhani *et al.* [48], which were conducted in West Azerbaijan.

When grazing intensity on the dominant species in the area increases, the strain and the amount of its presence decrease, resulting in spreading species with highly competitive and high-resistance species [56]. Rangeland exclosure through the reservoir of soil seed banks creates favorable conditions for soil and plant growth [57] and changes plant composition. In this survey, the first change was observed in species composition in the exclosure and grazed rangeland. The number of plant species increased from 62 species in the free grazing area to 69 species in the exclosure area, classified into three classes I, II, and III. Amousi *et al.* [58] and Mirzaei Mossivand *et al.* [59] in their studies stated that exclosure had increased the number of species, and the results of this study are consistent with their results. The results showed that the Asteraceae and some other families were more in the free grazing area than the exclosure area. These species' widespread presence in the exclosure region can indicate the full vegetative growth of these species due to favorable conditions such as the prevention of livestock grazing in the exclosure region.

Effect of exclosure on plant cover and species diversity

The exclosure provides the conditions for natural regeneration of natural ecosystems by creating opportunities to grow seedlings of plant species [60]. As can be seen, the exclosure had a useful effect on the plant cover of forbs and shrubs. Livestock grazing has a significant impact on the density and canopy cover of forbs and shrubs compared to the enclosed areas, so that by reducing the pressure of grazing in the exclosure area, the density and canopy cover of forbs and shrubs has increased, which indicates the desired effect of protection. Therefore, sexual and asexual reproduction in forb species have increased them in the exclosure region and considering that the shrubs have some moderate forage value, exclosure has caused this type of plant to have enough opportunity to regenerate and increase their number. In plants of the Poaceae family, the final bud is located on the soil surface, the damage caused by grazing is much less than other plants [61], which is a reason for the higher density of grasses in the free grazing area. Firinioğlu *et al.* [62] studied the effects of long-term grazing exposures on rangeland plants in the central Anatolian region of Turkey concluded that exclosure increases the percentage of vegetation cover of forbs, and the results of this study are consistent with their results. Haydaryan Aghakhani *et al.* [63] and Ghazani [64] also stated that the canopy cover of plants inside the exclosure was significantly higher than outside the exclosure. The results of this study are consistent with their results. Mirzaei Mossivand *et al.* [59] concluded in their study that the density and percentage of canopy cover of perennial grasses and forbs inside the exclosure increased compared to the outside of the enclosure. The density and percentage of canopy cover of annual grasses decreased, following the results of this research, and exclosure in Mahabad Sabzepoush rangelands has led to an increase in the density and canopy cover of the perennial grass species such as *Poa bulbosa*.

Livestock grazing causes bare soil surfaces. With the reduction of the surface layer of the soil and the reduction of the organic matter of the soil, eventually, an increase in surface runoff occurs [65]. In various studies, such as Siahmansour *et al.* [66], it has been stated that the soil conditions improved by applying the exclusion.

Many reports have indicated that the beneficial effects of grazing exclosure on arid lands include an increase in biodiversity and species richness [67]. Ebrahimi *et al.* [67] stated that the number of species in the exclosure area is more than the grazing rangelands. In arid lands, increased grazing intensity causes species extinction and soil degradation and causes irreversible damage to biodiversity [68]. As results showed, grazing exclosure affects the characteristics of vegetation diversity. Plant diversity reflects differences between grazing and exclosure areas at the family, genus, and species levels. Grazing exclosure had effective results on the total number of species and species richness. The diversity and richness of species in grazing rangeland had decreased. This means that the plant species Class I, such as *Astragalus guttatus*, *Galium spurium*, *lathyrus pratensis*, *Medicago rigidula,* and *Tragopogon carcifolius,* are sensitive and intolerant to grazing; consequently, they are present in protected condition. The high level of richness and diversity species in the exclosure area indicates the non-use of the local ranchers within 19 years after exclosure and the lack of livestock and humans. Heavy grazing reduces litter, plant biomass, soil cover and degrading soil compaction and structure due to trampling [69].

Effect of exclosure on the highly palatable species (class I)

In some studies, it has been stated that heavy grazing reduces the palatable species density by preventing the seeding of this species, and as a result, the number of non- palatable species increases [70]. In this study, the number of classes I and II species is high in the exclosure area. The number of class III was decreased with exclusion exclosure, which implies the positive impacts of rangeland exclosure. Because the residents are mostly ranchmen and are highly dependent on the region's rangelands, less palatable species in the heavy grazing area reduce soil bank seeds [71]. Derner & Hart [72] showed that grazing livestock affects plant community composition and increases annual and invaders such as *B. tectorum* that one of the important reasons for this problem is attributed to the degradation of soil and moisture in habitat. There is a high frequency of some species in our study, such as *B. tectorum*, *Bromus danthoniae*, *Callipeltis cucullaris*, *Rochelia disperma,* and *Torilis stocksiana* in the grazing area, but their frequency was lower in the exclosure area. These plants are not preferred by livestock. Also, an increase of palatable-perennial species such as *A. effusus* and *A. kirrindicus* and palatable-annual species such as *L. culinaris*, *L. rigidum, M. radiata, T. grandiflora, and V. orientale* in the exclosure area showed that exclosure could improve both quantity and quality of vegetation. Changes in the plant community through succession lead to an increase in trapping seed dispersers, ecological niches, and increasing plant establishment and colonization of new plant species [57, 73].

Effect of exclosure on density and canopy cover of the life cycle and life forms properties

The exclosure by increasing perennial plants' vegetation creates herbaceous and annual species under their canopies [74]. Woody plants help increase plant cover in arid lands by accumulating the seeds of other plants. Seedling establishment under the canopy cover of woody species would lead to herbaceous plants' stability and colonization [75]. Finally, plants' development makes fertile soil with high permeability and forms a suitable environment for seed germination and plant growth in the region with unfavorable conditions [35, 57, 75]. In this research, higher the density and canopy cover of perennial plants in the exclosure area, higher the density and canopy cover of annual plants in the grazing rangelands.

Plant life-form has the same reaction to climatic, edaphic, topographic, and management factors [69]. As climate and topography in both areas (grazing and exclosure) are similar, plant life-forms in the two areas are due to type management. In this study, density and canopy cover of therophytes in the grazing area was more than exclosure. These species are annual, and some research showed that premature grazing and grazing increases therophytes [76]. The therophytes reflect the severe climatic conditions and human activities that have weakened other perennial species [77]. Followed by therophytes, hemicryptophytes have the most frequency in both areas. As a whole, in most research about life forms in areas of Iran, because of arid and semiarid conditions, therophytes and hemicryptophytes have dominated. Hemicryptophytes density and canopy cover in the exclosure area is more than the grazing area. Houessou *et al.* [78] showed that the more grazing intensity, the lower hemicryptophytes canopy cover is. Chamaephytes and geophytes in the exclosure area were more than in the grazing area that corresponds with the results of Benaradj *et al.* [77]. Plants whose buds are above the ground, such as chamaephytes are damaged from grazing more than those whose buds are underground [79], thus in the grazing area; their number was decreased.

Effect of exclosure on soil properties

Comprehensive soil information is essential for managing, conserving, monitoring, and restoring rangelands, natural ecosystems, and specially protected areas [80]. The result of this research showed that exclosure is an effect on some soil properties. There was a significant difference in the value of potassium, electrical conductivity, organic matter, available phosphorus, nitrogen, and the percentage of silt in the two areas of grazing and exclosure.

The higher soil salinity is related to minerals. The minerals conduct the electricity; whatever the amount of soil salinity higher, the greater its electrical conductivity [81]. Therefore, the increase in Ec may be due to the increase in soil fertility factors and increased cations exchange capacity in the exclosure area [82]. Besides, one of the reasons for an increase in K in exclosure is related to using K by vegetation, and the percentage of vegetation cover in exclosure is high; as a result, the absorption of nutrients by vegetation from the soil increased, so the value of K was increased at the soil surface. Potassium is a moving ion in the soil, and as a result, significant amounts of this ion can be released by leaching [83].

Grazing led to an increase in organic matter, available phosphorus, nitrogen, and silt percentage. Organic matter impresses many of the chemical, physical, and biological features of the soil. The low level of organic matter in the exclosure area indicates that exclosure has not been well observed in the Mahabad Sabzepoush rangelands and may have been grazed by the wild animals, which has reduced plant biomass and reduced the return of organic matter to the soil, resulting in reduced organic matter in the region. Haydaryan Aghakhani *et al.* [63] examined the effect of exclosure on soil chemical properties in Sisab rangelands of Bojnurd, Iran. They stated that the percentage of carbon and organic matter in the exclosure region shows a significant increase, that the results of this study do not match their results. In the area under grazing, soil nitrogen's value has increased, and these changes have a similar trend to changes in soil organic matter. The high level of nitrogen in the soil is due to the fact that nitrogen in the soil is mostly in the form of organic compounds, so the process of nitrogen accumulation in the soil is closely related to the accumulation of organic matter.

Vegetation plays an important role in soil nitrogen content in terms of type and density of cover. Soils covered with abundant roots usually contain a lot of nitrogen and organic matter [84]. So, in the under grazing area, due to the higher density of grasses and the high volume root in the soil, nitrogen in the grazing area is more than the exclosure area. Phosphorus plays an essential role in photosynthesis, protein metabolism, breathing, and enzyme synthesis [85]. This element is more common in the open grazing area than in the exclosure area. Most of the soil phosphorus is combined with organic matter, and therefore soils rich in organic matter have more phosphorus [84]. Also, silt significantly in the grazing area is more than the exclosure area, but the value of clay and sand is similar. Abdalla *et al.* [86] showed that the value of soil and silt did not vary significantly ($p<0.01$) between the exclosure and grazing area. As soil texture is an intrinsic soil property and is affected by original rock and grazing livestock, it does not affect it.

Conclusion

In Iran, unmanaged grazing is one of the important reasons for soil degradation and natural rangelands. Grazing exclosure is one of the good management strategies used to reduce soil erosion and re-establish vegetation. The results showed that exclosure improved habitat characteristics and enriched vegetation in the rangelands of Mahabad Sabzepoush rangelands. Mahabad Sabzepoush rangelands' exclosure improved soil fertility and the vegetation cover and the emergence of new species, especially palatable plants (class I), compared to the heavy grazing conditions. Thus, exclosure can be the most economical and promising method of rehabilitation in semiarid rangelands. Rangelands exclosure can be an effective strategy for the restoration of soil conditions and vegetation cover. These results indicate that grazing exclosure plays a crucial role in vegetation recovery and soil protection of destroyed rangelands, confirming the research hypothesis. However, further studies are needed to evaluate the impact of exclosure on the regeneration process in semiarid rangelands.

Acknowledgements: The authors thank and appreciate the University of Mohaghegh Ardabili authorities, who provided the present study facilities.
Ethical Permissions: The authors ensure that they have written entirely original works, and if the authors have used the work or words of others, they have been appropriately cited or quoted.
Conflict of Interests: The authors have no conflict of interest.
Authors' Contributions: Samadi-Khangah S. (First author), Original researcher/Statistical analyst (25%); Ghorbani A. (Second author), Introduction author/Methodologist/Assistant researcher (25%); Choukali M. (Third author), Introduction author/Methodologist (20%); Moameri M. (Fourth author), Methodologist (10%); Badrzadeh M. (Fifth author), Methodologist (10%); Moatamedi J. (Sixth author), Methodologist (10%)
Funding/Sources: This research has funded by University of Mohaghegh Ardabili.

References

1- Lal R. Potential of desertification control to sequester carbon and mitigate the greenhouse effect. Clim Change. 2001;51(1):35-72.
2- Deng J, Zhou Y, Zhu W, Yin Y. Effects of afforestation with Pinus sylvestris var mongolica plantations combined with enclosure management on soil microbial community. Peer J. 2020;8(6):8857.
3- He C, Tian J, Gao B, Zhao Y. Differentiating climate-and human-induced drivers of grassland degradation in the Liao river basin, China. Environ Monit Assess. 2015;187(1):4199.
4- Li J, Tong X, Awasthi MK, Wu F, Ha S, Ma J, et al. Dynamics of soil microbial biomass and enzyme activities along a chronosequence of desertified land revegetation. Ecol Eng. 2018;111:22-30.
5- Asner GP, Elmore AJ, Olander LP, Martin RE, Harris AT. Grazing systems, ecosystem responses, and global change. Annu Rev Environ Res. 2004;29(26):261-99.
6- Fick SE, Belnap J, Duniway MC. Grazing-induced changes to biological soil crust cover mediate hillslope erosion in long-term exclosure experiment. Rangel Ecol Manag. 2020;73(1):61-72.
7- Aubault H, Webb NP, Strong CL, Mc Tainsh GH, Leys JF, Scanlan JC. Grazing impacts on the susceptibility of rangelands to wind erosion: The effects of stocking rate, stocking strategy and land condition. Aeolian Res. 2015;17:89-99.
8- Nauman TW, Duniway MC, Webb NP, Belnap J. Elevated aeolian sediment transport on the Colorado plateau, USA: The role of grazing, vehicle disturbance, and increasing aridity. Earth Surf Process Landf. 2018;43(14):2897-914.
9- Duniway MC, Geiger EL, Minnick TJ, Phillips SL, Belnap J. Insights from long-term ungrazed and grazed watersheds in a salt desert Colorado plateau ecosystem. Rangel Ecol Manag. 2018;71(4):492-505.
10- Yao M, Rui J, Li J, Wang J, Cao W, Li X. Soil bacterial community shifts driven by restoration time and steppe types in the degraded steppe of inner Mongolia. Catena. 2018;165:228-36.
11- Zhao J, Li X, Li R, Tian L, Zhang T. Effect of grazing exclusion on ecosystem respiration among three different alpine grasslands on the central Tibetan plateau. Ecol Eng. 2016;94:599-607.
12- Gebregergs T, Tessema ZK, Solomon N, Birhane E. Carbon sequestration and soil restoration potential of grazing lands under exclosure management in a semiarid environment of northern Ethiopia. Ecol Evolut. 2019;9(11):6468-79.
13- Liu M, Zhang Z, Sun J, Wang Y, Wang J, Tsunekawa A, et al. One-year grazing exclusion remarkably restores degraded alpine meadow at Zoige, eastern Tibetan plateau. Glob Ecol Conserv. 2020;22:00951.
14- Gao Y, Zeng X, Schumann M, Chen H. Effectiveness of exclosures on restoration of degraded alpine meadow in the eastern Tibetan plateau. Arid Land Res Manag. 2011;25(2):164-75.
15- Yuan J, Ouyang Z, Zheng H, Xu W. Effects of different grassland restoration approaches on soil properties in the southeastern Horqin sandy land, northern China. Appl Soil Ecol. 2012;61:34-9.
16- Zhu GY, Deng L, Zhang XB, Shangguan ZP. Effects of grazing exclusion on plant community and soil physicochemical properties in a desert steppe on the Loess plateau, China. Ecol Eng. 2016;90:372-81.
17- Zhang Y, Gao Q, Dong S, Liu S, Wang XX, Su X, et al. Effects of grazing and climate warming on plant diversity, productivity and living state in the alpine rangelands and cultivated grasslands of the Qinghai-Tibetan plateau. Rangel J. 2014;37:57-65.

18- Jing Z, Cheng J, Su J, Bai Y, Jin J. Changes in plant community composition and soil properties under 3-decade grazing exclusion in semiarid grassland. Ecol Eng. 2014;64:171-8.
19- Shi XM, Li XG, Li CT, Zhao Y, Shang ZH, Ma Q. Grazing exclusion decreases soil organic C storage at an alpine grassland of the Qinghaie-Tibetan plateau. Ecol Eng. 2013;57:183-7.
20- Wang D, Wu GL, Zhu YJ, Shi ZH. Grazing exclusion effects on above-and belowground C and N pools of typical grassland on the Loess plateau (China). Catena. 2014;123:113-20.
21- Liu M, Liu G, Wu X, Wang H, Chen L. Vegetation traits and soil properties in response to utilization patterns of grassland in Hulun Buir city, inner Mongolia, China. Chin Geogr Sci. 2014;24:471-8.
22- Niu D, Hall SJ, Fu H, Kang J, Qin Y, Elser JJ. Grazing exclusion alters ecosystem carbon pools in Alxa desert steppe. N.Z. J Agric Res. 2011;54(3):127-42.
23- Su H, Liu W, Xu H, Wang Z, Zhang H, Hu H, et al. Long-term livestock exclusion facilitates native woody plant encroachment in a sandy semiarid rangeland. Ecol Evol. 2015;5(12):2445-56.
24- Lunt ID, Jansen A, Binns DL, Kenny SA. Long-term effects of exclusion of grazing stock on degraded herbaceous plant communities in a riparian Eucalyptus camaldulensis forest in south-eastern Australia. Austral Ecol. 2010;32(8):937-49.
25- Cao J, Li G, Adamowski JF, Holden NM, Deo RC, Hu Z, et al. Suitable exclosure duration for the restoration of degraded alpine grasslands on the Qinghai-Tibetan plateau. Land Use Policy. 2019;86:261-7.
26- Sun J, Zhang ZC, Dong SK. Adaptive management of alpine grassland ecosystems over Tibetan plateau. Pratac Sci. 2019;36(4):933-8. [Chinese]
27- Cheng J, Wu GL, Zhao LP, Li Y, Li W, Cheng JM. Cumulative effects of 20-year exclusion of livestock grazing on above-and belowground biomass of typical steppe communities in arid areas of the Loess plateau, China. Plant Soil Environ. 2011;57(1):40-4.
28- Wu GL, Du GZ, Liu ZH, Thirgood S. Effect of fencing and grazing on a kobresia-dominated meadow in the Qinghai-Tibetan plateau. Plant Soil. 2009;319(1):115-26.
29- Xu L, Nie Y, Chen B, Xin X, Yang G, Xu D, et al. Effects of fence enclosure on vegetation community characteristics and productivity of a degraded temperate meadow steppe in northern China. Appl Sci. 2020;10(8):1-16.
30- Mofidi M, Jafari M, Tavili A, Rashtbari M, Alijanpour A. Grazing exclosure effect on soil and vegetation properties in Imam Kandi rangelands, Iran. Arid Land Res Manag. 2013;27(1):32-40.
31- Khosravi H, Ebrahimi E, Rigi M. Effects of rangeland exclusion on plant cover and soil properties in a steppe rangeland of southeastern Iran. Arid Land Res Manag. 2017;31(3):352-71.
32- Yazdanshenas H, Ehsani A, Ghaemi M, Shafeian E, Yeganeh H. Determining suitable grazing time for Puccinella distans Parl based on its phenology in west Azerbaijan province of Iran. J Plant Interact. 2016;11(1):67-73.
33- Yeilaghi SH, Ghorbani A, Asghari A, Heidari M. Study of species richness and evenness in different aspects of inside and outside of the exclosure in rangelands of Qushchy Ghat of Uremia. Nat Ecosyst Iran. 2013;4(1):33-43. [Persian]
34- Mesdaghi M. Plant Ecology. Mashhad: University of Mashhad; 2003.
35- Su YZ, Zhao HL, Zhang TH, Zhao XY. Soil properties following cultivation and non-grazing of a semiarid sandy grassland in northern China. Soil Tillage Res. 2004;75(1):27-36.
36- Choukali M. Comparison of the composition and species diversity of inside and outside the exclosure in Mahabad Sabzepoush reserve [dissertation]. Ardabil: University of Mohaghegh Ardabili; 2020. [Persian]
37- Planned budget organization of Iran. Drift analysis, climatic and geological conditions and mineral capabilities [Internet]. Tehran: Planned Budget Organization of Iran; 2009 [Unknown Cited]. Available from: https://www.mporg.ir/en
38- Kent M, Coker P. Vegetation description and analysis: A practical approach. Boca Raton: CRC-Press; 1992.
39- Arzani H, Abedi M. Rangeland assessment: Vegetation measurement. Tehran: University of Tehran Press; 2015. [Persian]
40- Davis P. Flora of Tukey. Edinburgh: Edinburgh University Press; 1984.
41- Rechinger KH. Flora Iranica. Graz: Akademische Druck-u Verlagsanstalt; 1975.
42- Assadi M. Flora of Iran. Tehran: Research Institute of Forests and Rangelands; 2015.
43- Zohary M. On the geobotanical structure of Iran. Jerusalem: Weizman Science Press of Israel; 1963.
44- Raunkiaer C. The life forms of plants and statistical plant geography. New York: Arno Press; 1977.
45- Arzani H, Zohdi M, Fish E, Zahedi Amiri G, Nikkhah A, Wester D. Phenological effects on forage quality of five grass species. Rangel Ecol Manag. 2004;57:624-9.
46- Saadati S. Studio medicinal plants of Mahabad Hamzehabad. International Conference on Research in Science and Technology, 14 December 2015, Tehran, Iran. Tehran: Civilica; 2015. [Persian]
47- Heidari Rikan M, Rahimdokht R. Introduction of a number of medicinal plants with economic importance in west Azerbaijan province. J Iran Nat. 2017;2(3):46-51. [Persian]
48- Ahmadkhani R, Moameri M, Samadi S. Investigating the structural and functional changes of vegetation in two areas of exclosure and under grazing in the around Urmia lake. J Rangel. 2020;14(2):299-312. [Persian]
49- Shannon CE. A mathematical theory of communication. Bell Syst Tech J. 1948;27(3):379-423.
50- Menhinick EF. A comparison of some species individual diversity indices applied to samples of field insects. Ecology. 1964;45(4):859-61.
51- Sanjit L, Bhatt D. How relevant are the concepts of species diversity and species richness?. J Biosci. 2005;30(5):557-60.
52- Aghajanlou F, Ghorbani A, Zare Chahouki MA, Mostafazadeh R, Hashemimajd K. The impact of environmental factors on distribution of Ferula ovina (Boiss.) Boiss in northwest Iran. Appl Ecol Environ Res. 2018;16(2):977-92.
53- Jafari Haghighi M. Soil analysis methods: Sampling and important physical and chemical analyses. Sari: NEDAYE ZOHA. 2003. [Persian]
54- Nejadhabibvash F, Makali H, Rezaei Chiyaneh E. Flora, life form and chorology of plants in Razhan protected area in west Azerbaijan province. Taxon Biosyst. 2016;8(27):85-95. [Persian]
55- Shikh Kanlooie Millan B, Rajamand MA, Motamedi J. Introduction to the flora, life form and chorology of the Avrin mountains rangelands in Khoy, west Azerbaijan.

PAJOUHESH VA SAZANDEGI. 2017;30(3):3-17. [Persian]
56- Ghorbani A, Mashkoori L. Comparison of quantitative parameters of Festuca ovina species in different grazing intensity in north and southeast rangelands of Sabalan. Rangeland. 2017;10(4):398-408. [Persain]
57- Salarian F, Ghorbani J, Safaeian NA. Vegetation changes under enclosure and livestock grazing in Chahar Bagh rangelands in Golestan province. Iran J Range Desert Res. 2013;20(1):115-29. [Persain]
58- Amousi O, Ghollasimood S, Fattahi B. Investigate and compare the plant diversity in two areas of semi-steppe grazed and enclosed sites in the Zagros (case study: Rangeland of Prdanan-Piranshahr). Desert Ecosyst Eng J. 2014;2(3):37-44. [Persain]
59- Mirzaei Mossivand A, Zandi Esfahan E, Keivan Behjou F. Comparison of plant species diversity in two rangelands under grazing and exclosure conditions, Lorestan province (case study: Northeast Delfan county). Iran J Range Desert Res. 2016;23(3):606-17. [Persain]
60- Yoshihara Y, Ohkuro T, Bunveibaatar B, Jamsran U, Takeuchi K. Spatial pattern of grazing affects influence of herbivores on spatial heterogeneity of plants and soils. Oecologia. 2010;162:427-34.
61- Sharifi Niarag J. Assessment of grassland diversity in Ardabil. Sci Inf Cent. 1995;1(1):26-31.
62- Firinioglu HK, Seefeldt SS, Sahin B. The effects of long-term grazing exclosures on range plants in the central Anatolian region of Turkey. Environ Manag. 2007;39(3):326-37.
63- Haydaryan Aghakhani M, Naghipour Borj AA, Tavakoli H. The effect of grazing on vegetation and soil in Sisab rangelands, Bojnord, Iran. Iran J Range Desert Res. 2010;17(2):243-55. [Persian]
64- Farahnak Ghazani M, Najibzadeh MR, Ghahramani MA. Effects of exclosure on vegetation changes in Sahand rangelands. Iran J Range Desert Res. 2015;22(3):525-36. [Persian]
65- Bari F, Wood MK, Murray L. Livestock grazing impacts on infiltration rates in a temperate range of Pakistan. J Range Manag Arch. 1993;46(4):367-72.
66- Siahmansour R, Akbarzadeh M, Zandi Esfahan E, Khademi K, Javadi SA. Effects of exclosure on vegetation characteristics and soil conservation in summer rangelands of Gardaneh Zagheh. Iran J Range Desert Res. 2015;22(3):417-25. [Persian]
67- Ebrahimi M, Khosravi H, Rigi M. Short-term grazing exclosure from heavy livestock rangelands affects vegetation cover and soil properties in natural ecosystems of southeastern Iran. Ecol Eng. 2016;95:10-8.
68- Cingolani AM, Posse G, Collantes MB. Plant functional traits, herbivore selectivity and response to sheep grazing in Patagonian steppe grasslands. J Appl Ecol. 2005;42(1):50-9.
69- Ghafari S, Ghorbani A, Moameri M, Mostafazadeh R, Bidarlord M. Composition and structure of species along altitude gradient in Moghan-Sabalan rangelands, Iran. J Mt Sci. 2018;15(6):1209-28.
70- Bestelmeyer B, Brown JR, Havstad KM, Alexander R, Chavez R, Herrick JE. Development and use of state and transition models for rangelands. J Range Managt. 2003;56(2):114-26.
71- Mengistu T, Teketay D, Hulten H, Yemshaw Y. The role of enclosures in the recovery of woody vegetation in degraded dry land hillsides of central and northern Ethiopia. J Arid Environ. 2005;60(2):259-81.
72- Derner JD, Hart RH. Livestock and vegetation responses to rotational grazing in short-grass steppe. West North Am Nat. 2007;67(3):359-67.
73- Liu M, Liu G, Zheng X. Spatial pattern changes of biomass, litter fall and coverage with environmental factors across temperate grassland subjected to various management practices. Landsc Ecol. 2015;30:477-86.
74- Al-Rowaily SL, El-Bana MI, Al-Bakre DA, Assaeed AM, Hegazy AK, Ali MB. Effects of open grazing and livestock exclusion on floristic composition and diversity in natural ecosystem of western Saudi Arabia. Saudi J Biol Sci. 2015;22(4):430-7.
75- Azarnivand H, Zare Chahouki MA. Rangeland ecology. Tehran: Tehran University Press; 2010. [Persian]
76- Motamedi J, Sheidai Karkaj E. Suitable species diversity abundance model in three grazing intensities in Dizaj Batchi rangelands of west Azerbaijan. J Range Watershed Manag. 2014;67(1):103-15. [Persian]
77- Benaradj A, Boucherit H, Mederbal K, Benabdeli K, Baghdadi D. Effect the exclosure on plant diversity of the Hammada scoparia steppe in the Naama steppe courses (Algeria). J Mater Environ Sci. 2013;2(1):564-71.
78- Houessou LG, Teka A, Oumorou M, Sinsin B. Hemicryptophytes plant species as indicator of grassland state in semiarid region: Case study of W biosphere reserve and its surroundings area in Benin (west Africa). Int J Biol Chem Sci. 2012;6(3):1271-80.
79- Liddle MJ. A selective review of the ecological effects of human trampling on natural ecosystems. Biol Conserv. 1975;7(1):17-36.
80- Ghorbani A, Mohammadi Moghaddam S, Hashemi Majd K, Dadgar D. Spatial variation analysis of soil properties using spatial statistics: A case study in the region of Sabalan mountain, Iran. J Prot Mt Areas Res. 2018;10(1):70-80.
81- Jafari M, Javadi SA, Bagherpoor MA, Tahmoures M. Relationships between Soil characteristics and vegetation in Nodoushan rangelands of Yazd province. Rangeland. 2009;3(1):29-40. [Persian]
82- Aghasi MJ, Bahmaniar MA, Akbarzadeh M. Comparison of the effects of exclusion and water spreading on vegetation and soil parameters in Kyasar rangelands, Mazandaran province. J Agric Sci Nat Resour. 2006;13(4):73-87. [Persian]
83- Alfaro MA, Jarvis SC, Gregory PJ. Factors affecting potassium leaching in different soils. Soil Use Manag. 2004;20(2):182-9.
84- Jalilvand H, Tamartash R, Heydarpour H. Grazing impact on vegetation and some soil chemical properties in Kojour rangelands, Noushahr, Iran. Rangeland. 2007;1(1):53-66. [Persian]
85- Gavili Kilaneh E, Vahabi MR. The effect of some soil characteristics on range vegetation distribution in central Zagros, Iran. J Sci Technol Agric Nat Resour. 2012;16(59):245-58. [Persian]
86- Abdalla M, Hastings A, Chadwick DR, Jones DL, Evans CD, Jones MB, et al. Critical review of the impacts of grazing intensity on soil organic carbon storage and other soil quality indicators in extensively managed grasslands. Agric Ecosyst Environ. 2018;253:62-81.