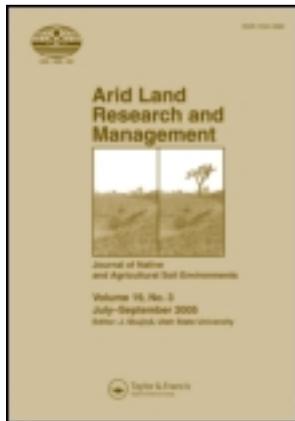


This article was downloaded by: [Morteza Mofidi]

On: 18 January 2013, At: 07:31

Publisher: Taylor & Francis

Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK



Arid Land Research and Management

Publication details, including instructions for authors and subscription information:

<http://www.tandfonline.com/loi/uasr20>

Grazing Exclusion Effect on Soil and Vegetation Properties in Imam Kandi Rangelands, Iran

Morteza Mofidi ^a, Mohammad Jafari ^a, Ali Tavili ^a, Mehdi Rashtbari ^b & Ahmad Alijanpour ^c

^a Department of Natural Resources, Tehran University, Iran

^b Department of Soil Science, Tehran University, Iran

^c Department of Natural Resources, University of Urmia, Iran

To cite this article: Morteza Mofidi , Mohammad Jafari , Ali Tavili , Mehdi Rashtbari & Ahmad Alijanpour (2013): Grazing Exclusion Effect on Soil and Vegetation Properties in Imam Kandi Rangelands, Iran, *Arid Land Research and Management*, 27:1, 32-40

To link to this article: <http://dx.doi.org/10.1080/15324982.2012.719575>

PLEASE SCROLL DOWN FOR ARTICLE

Full terms and conditions of use: <http://www.tandfonline.com/page/terms-and-conditions>

This article may be used for research, teaching, and private study purposes. Any substantial or systematic reproduction, redistribution, reselling, loan, sub-licensing, systematic supply, or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae, and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand, or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Grazing Exclusion Effect on Soil and Vegetation Properties in Imam Kandi Rangelands, Iran

Morteza Mofidi¹, Mohammad Jafari¹, Ali Tavili¹, Mehdi Rashtbari², and Ahmad Alijanpour³

¹Department of Natural Resources, Tehran University, Iran

²Department of Soil Science, Tehran University, Iran

³Department of Natural Resources, University of Urmia, Iran

Most of the rangeland of Urmia in Iran is degraded and will require considerable reclamation to achieve a desirable state. The aim of this study was to evaluate the effects of 14 years of grazing exclusion on vegetation and soil properties in Imam Kandi rangelands. Sampling in both grazing exclosure and grazed areas were conducted using a systematic randomized sampling method. Six 100-m long transects were randomly located in each area and ten 1 × 1 m sampling plots were located along each transect. Within each plot, species presence, canopy cover, species yield, and plant densities were measured. Soil cores were taken in the center of each vegetation sampling plot at 0–30 cm and 30–60 cm depths. Organic matter, nitrogen content, the amounts of phosphorus and potassium, electrical conductivity (EC_e), pH, the percentage of $CaCO_3$, and soil texture were determined for each sample. Results indicate differences in plant canopy cover, species composition, and yield between the grazing exclosure and the control site. All plant growth forms at the exclusion site differed from those at the grazed site. Biomass of perennial grasses, perennial forbs and annual forbs was greater at the exclusion site than at the grazed site, and biomass of annual grasses and shrubs at the control site was greater than at the exclusion site. Overall grazing exclosure site improved the vegetation composition and soil quality parameters EC_e , pH, organic matter, nitrogen, phosphorus, and potassium content relative to the grazed site.

Keywords grazing exclusion, soil properties, vegetation properties

Rangelands comprise 45% of 165 million hectares in Iran. Due to excessive exploitation, palatable species have declined over time and been replaced by less desirable and sometimes toxic species (*Peganum harmala* L., *Avena sativa* L., *Cenchrus ciliaris* L., *Sorghum spp.*, etc.) (Azarnivand & Zare Chahoki, 2008). In many areas, desirable species have disappeared and soil is exposed to wind and water erosion (Mesdaghi, 2007).

Received 21 November 2011; accepted 5 May 2012.

The researchers acknowledge Professor W. R. Teague, Texas AgriLife Research and the Texas A & M University System for comments that significantly improved the manuscript. We also thank Esmail Sheidai Karkaj, Ph. D student of rangeland sciences in Gorgan University of Agricultural Sciences and Natural Resources, Iran, for his assistance with statistical data analysis and valuable comments of this manuscript.

Address correspondence to M. Mofidi, Department of Natural Resources, Tehran University, Iran. E-mail: Mofidi.morteza@gmail.com

Numerous studies have shown that overgrazing of rangeland strongly degrades soil's physical, chemical, and biological properties, causing dramatic changes in vegetation and nutrient cycling (Lindsay & Cunningham, 2009), and permanent decline of land productivity and ecosystem degradation (Su et al., 2004). Results have also shown that with increasing duration of exclusion, calcium and potassium levels increase, with the lowest values seen under continuous grazing, while sodium concentration, electrical conductivity (EC_e), and pH show a decreasing trend with increasing exclusion duration (Jeddi & Chaieb, 2010).

The vegetation on degraded rangelands in the studied area is dominated by invasive, thorny, or toxic plants, and the size and number of vegetation patches are reduced and often eliminated (Perveen & Hussain, 2007). To prevent this continuing degradation on these rangelands, it is essential to conduct restoration operations to improve the vegetation and stabilize the soil surface to reduce wind and water erosion and improve ecosystem functions (Moghaddam, 2007).

The main goal of restoration is to achieve a plant community that stabilizes the soil surface against water and wind erosion and is nutritious and productive for animal production and resilient for grazing (Mesdaghi, 2007). This usually involves reclamation operations (Jeddi & Chaieb, 2010) such as excluding livestock grazing and planting indigenous trees, shrubs, and grasses to improve productivity and ecological function in the area (Tefera, 2001) and improve the quality and quantity of forage and livestock products. Additional but more costly operations include livestock management, mechanical operations (cultivation, pitting, counter furrow, flooding), biological enhancement (planting of native and alien rangeland seeds, fertilization, fire), and livestock facilities (Holechek et al., 1989).

We tested the following hypothesis: grazing enclosure results in: (i) increase in fertility status of soil, cover percentage, yield, and litter percentage; (ii) a shift from grasses and annual forbs to grasses and perennial forbs; (iii) improvement of both soil and vegetation properties in the region; and (iv) more rapid vegetation changes than soil changes.

Generally, most studies in the region have evaluated the soil and vegetation changes separately in response to management and reclamation operations. In this study, we determine the effect of grazing exclusion on yield, cover percentage of growth forms of the vegetation, and changes in soil fertility on Imam Kandi rangelands.

Method and Materials

The Imam Kandi basin is located in West Azerbaijan province within the political limits of Urmia town, Iran. The study area is located at $37^{\circ} 48' 40''$ S to $37^{\circ} 51' 9''$ N and $45^{\circ} 3' 42.5''$ W to $44^{\circ} 59' 47''$ E. The average altitude is 1539 m ranging from 2230 m to 1280 m and the catchment area is 14.2 square kilometers with average slope of 28.6° . This region has a cold semi-arid climate with mean long-term rainfall of 386 mm. Mean annual temperature is 11.3°C . The regional soil type is classified as Typic Haploxerept.

The 8.4 ha Imam Kandi grazing enclosure was established in 1996. To ensure grazing exclusion from livestock and wild animals such as rabbits, a 50×50 m sized mesh fence was used. In order to evaluate the effect of grazing exclusion on vegetation and soil properties after 14 years of grazing enclosure, and a grazed control site was selected in the region in summer 2010. The enclosure and control sites were in close proximity and were located in the same homogeneous ecological units.

Dominant grazing animal in the region is sheep and grazing intensity in the rangeland is considered to be high.

Sampling in each area was conducted using a systematic randomized method. Six 100-m long transects were randomly located in each area and ten 1 m² plots (n = 120) were placed at equal distances along each transect (n = 12). Within each plot we determined the species present, canopy cover percentage, plant species yield and density, percentage of ground covered by litter, and percentage of bare ground. Canopy cover percentage, yield, and growth forms (perennial grasses, annual grasses, perennial forbs, annual forbs, and shrubs) were determined separately in each plot. Yield was estimated by clipping at the end of the flowering phase of dominant species. Grasses were clipped at 1 cm height before weighing while forbs were clipped at basal height and shrubs were clipped to remove current season's growth.

Plot size and number of plots were determined using the minimal area method (Kent & Coker, 1999) and a flexible systematic model (Smartt, 1987). The plants were weighed after drying and separated into growth form before calculation of biomass in kg per hectare for each study site. Canopy cover percentage for each plot was estimated per species (Moghaddam, 2007). Plant species' density per square meter was calculated by counting the number of each plant in each plot.

Soil sampling was conducted in the center of vegetation plots. In both grazing exclusion and control sites two randomly selected plots per vegetation transect were sampled by taking cores at depths of 0–30 cm and 30–60 cm. A composite sample was made for each transect, giving a total of 24 samples. The soil samples for each depth per site were analyzed in the laboratory of the department of Natural Resources, Tehran University. The samples were passed through a two millimeter sieve before analyzing for organic matter (Walkley & Black, 1934), total nitrogen content using Kjeldal (Bremmer & Mulvaney, 1982), the amount of available phosphorus by P-Olsen (Olsen & Sommers, 1982), potassium (Boltz & Howel, 1978), EC_e and pH, carbonate calcium equivalent (CCE) percentage (Sparks, 1996), and soil texture (sand, clay and silt percent), using the hydrometer method (Gee & Bauder, 1982).

Data were tested for normality before statistical analysis using the Anderson Darling test (Steel & Torrie, 1980). Differences between vegetation and soil properties of the grazing enclosure treatment and control were analyzed using the t-test in a completely randomized design with SPSS software. Significance was assessed at 5% probability level unless otherwise noted.

Principal component analysis (PCA) was performed on the normalized data sets to determine which factor(s) of soil and vegetation could explain the differences between grazing enclosure and control sites (Hotelling, 1933; Deb et al., 2008).

Results

Results indicate differences in canopy cover percent and biomass yield between the grazing exclusion and control sites. The mean canopy cover percent and biomass yield of the unpalatable vegetation class is significantly less at the exclusion site.

Means and t-test mean comparisons of growth form properties at the exclusion and control sites are presented in Table 1. Independent t-test results show that all growth forms at the exclusion treatment were different from those of the control treatment ($P < 0.01$). Cover of perennial grasses, perennial forbs, and annual forbs increased in exclusion treatment relative to the control treatment while cover of

Table 1. Means and independent t-test results of mean comparison of growth forms properties in exclusion site with control

Growth form	Site	Yield (kg/ha)	Canopy cover (%)	Density (m) ⁻²	Sig
Perennial grasses	Exclusion	270.95	27.11	53.9	0.000**
	Control	64.62	9.37	11.32	
Annual grasses	Exclusion	56.14	10.52	9.38	0.000**
	Control	72.75	11.34	12.28	
Perennial forbs	Exclusion	157.85	21.46	14.31	0.000**
	Control	48.97	9.2	4.69	
Annual forbs	Exclusion	87.20	7.29	14.74	0.000**
	Control	38.22	2.59	10.71	
Shrubs	Exclusion	36.73	7.68	4.33	0.000**
	Control	59.31	10.07	8.41	

**Significant difference at one percent level.

annual grasses and shrubs in the control treatment were greater than in the exclusion treatment ($P < 0.01$).

Table 2 shows the mean values of soil properties in the grazing enclosure and grazed control treatments in the 0–30 and 3–60 cm depths. Multivariate analysis of variance shows that soil properties differed between both sites and soil depths and there was an interaction between grazing treatment and soil depth ($P < 0.01$).

Results showed that grazing enclosure influenced EC_e , pH, organic matter, nitrogen, phosphorus, and potassium content, but not $CaCO_3$ content. Soil depth had a significant effect on pH, EC_e , lime, organic matter, nitrogen, phosphorus, and potassium content. There was an interaction between treatment and soil depth

Table 2. Means and standard errors of soil properties in exclusion and control site

Properties	0–30 (cm)		30–60 (cm)	
	Grazed control	Exclusion	Grazed control	Exclusion
pH	7.84 ± 0.02a	7.60 ± 0.04c	7.71 ± 0.04b	7.42 ± 0.02d
EC_e (dS/m)	0.23 ± 0.01d	0.25 ± 0.01c	0.29 ± 0.01b	0.33 ± 0.01a
Calcium Carbonate Equivalent (CCE) (%)	8.30 ± 0.30a	11.25 ± 0.31a	6.01 ± 0.32b	2.28 ± 0.27c
Organic matter (%)	1.17 ± 0.04d	1.71 ± 0.06c	2.09 ± 0.06b	2.89 ± 0.09a
Nitrogen (%)	0.02 ± 0.00d	0.06 ± 0.01c	0.13 ± 0.00b	0.21 ± 0.01a
Phosphorous (ppm)	2.08 ± 0.11d	3.84 ± 0.10c	6.85 ± 0.28b	12.96 ± 0.51
Potassium (ppm)	103.66 ± 3.57c	79.80 ± 4.49d	190.7 ± 7.7b	339.4 ± 19.9a
Sand (%)	73.22 ± 2.27c	68.60 ± 2.55d	75.75 ± 1.71a	74.91 ± 1.75b
Clay (%)	16.96 ± 2.55b	17.14 ± 1.38a	12.08 ± 1.37d	13.75 ± 1.14c
Silt (%)	9.81 ± 1.16d	14.25 ± 1.98a	12.16 ± 0.47b	11.33 ± 0.88c
Soil texture	Sandy loam	Sandy loam	Sandy loam	Sandy loam

Note: Means differ if they have a different letter at $p < 0.01$.

with CaCO_3 , phosphorus, and potassium content ($P < 0.01$). However, there were no treatment \times soil depth differences between enclosure and grazing on EC_e , pH, organic matter, and nitrogen content.

Results of PCA yielded two principal components with eigenvalues >1 , explaining more than 92% of the total variance between the two studied sites. Eigenvalue gives a measure of the significance of the Principal Component (PC); the PCs with the highest eigenvalues are the most significant (Shrestha & Kazama, 2007). Results of PCA showed that the first component is related to vegetation properties and the second component to soil properties with grazing enclosure accounting for 84% of the differences in vegetation properties and only 8% of the differences in soil properties due to grazing exclusion.

Discussion

The results of this study indicate that grazing exclusion has a positive and significant impact on vegetation and soil properties in the area. These results are consistent with the findings of Teague et al. (2011).

Vegetation

Grazing exclusion significantly increased the canopy cover percent, yield of forage, density, and percentage cover of litter compared with the control site, which is in agreement with other published works on grazing enclosure showing the increase in biomass (Oba et al., 2001) and litter percent (Burke et al., 1998). Yates et al. (2000) stated that increased vegetation in the exclusion could be due to soil conditions improvement (temperature, moisture, and nutrient cycling). Canopy cover percent, density, and yield of perennial grasses under exclusion increased compared with the control site and animals perform scarification of the soil by trampling in this treatment. Reeder and Schuman (2002) reported that exclusion increased the growth of perennial grasses, canopy cover, and plant density.

The restoration of the desirable species has also been achieved by reduction of animal numbers (sheep, goats, cattle, and wild animals), application of appropriate grazing systems, complete grazing exclusion and water resources development (Teague et al., 2011). Excessive grazing causes the removal of biomass from rangeland ecosystems that reduce soil organic matter and nutrients content. As soil is the sole supplier of nutrients for plant growth, this has a long-term negative feedback on rangeland forage production. In addition, when removed nutrients are not returned to the soil by animals it will cause a reduction in the quality of forage, which will negatively impact livestock production (Moghaddam, 2007).

Soil Properties

Reduction of soil pH due to exclusion could result from high vegetation biomass or dense root system and high soil organic matter, due to more active microorganism metabolism in the rhizosphere (David et al., 2004), organic acids secretion from the roots and large amounts of CO_2 released from roots and micro-organisms (Hinsinger et al., 2003), increased leaching, and decreases in carbonate calcium equivalent (CCE) percentage. With increasing organic matter content, more mineral and organic acids are produced with carbonic acid being the most abundant.

Although this is a weak acid, its continuous production in soil with high root density causes lime dissolution and leaching from soil. Dissolving the CaCO_3 causes pH reduction (Al-Seekh et al., 2009). Therefore, soil pH reduction compared with control site could be related to high root biomass and organic matter accumulation and metabolism of hyperactive microorganisms in rhizosphere in regions where reclamation has been conducted. This affects the lower depth of soil resulting in lower pH. Somda et al. (1997) reported that urine pH of ruminants is about 8.4 to 8.6; therefore, animal urine accumulation may have contributed to increased pH in the control area. In addition, the high organic matter of the surface layer in conjunction with lower pH than the deeper soil is consistent with the findings of Eldridge and Robson (1997).

The EC increase in the grazing exclusion treatment could be due to increasing soil cation exchange capability (Abdallah et al., 2008). Due to increasing vegetation canopy cover percentage and denser vegetation cover with grazing exclusion, organic matter is enhanced and pH is lowered. Improvement in soil structure, a decrease in runoff, and increased water infiltration could cause a reduction in CCE in the surface soil depths due to dissolving by pH reduction. The increased CCE in deeper soil layers could be attributed to its dissolving from upper soil layers and accumulation deeper in the soil profile, with high amounts of CaCO_3 in the parent material.

Organic matter at both soil depths increased in the grazing enclosure compared with the control. These results are in agreement with the findings of Teague et al. (2011). Grazing enclosure soils have more dense grasses cover, more organic matter and available water, more plant roots and better aeration than grazed soils with less cover (Mesdaghi, 2007). Excessive grazing that degrades the vegetation has a negative effect on soil physical properties and soil fertility (Mikola et al., 2001). Heavy grazing due to excessive reduction of vegetative cover, and changes in plant growth form and animal trampling affect the amount of soil nutrients (Steffens et al., 2008).

Vegetation cover strongly influences soil nitrogen content. Soils having good plant cover, aerial biomass and high root biomass usually have more organic matter and nitrogen (Foth et al., 1997). Therefore, where grazing is excluded, vegetation cover and root volume in soil result in an increase in nitrogen content compared with the grazed area. Heavy grazing results in a reduction of plant residues in soil which affects the supply of nitrogen and phosphorous (Fernández-Lugo et al., 2009). Changes in the number of plant species and form with grazing exclusion relative to grazed treatments result in differences in root type and volume, leading to changes in soil chemical properties (Foth et al., 1997). This is probably why the PCAs indicated that exclusion from grazing had a much greater influence on changing vegetation than changing soil properties. Burke et al. (1998) indicate that it takes a long time under consistent, improved vegetation management to improve soil properties.

Grazing exclusion caused phosphorous levels to increase in the upper and lower layer of soil compared with the control. This is likely due to the fact that rangeland vegetation exploits phosphorous from lower depths so when vegetation cover and biomass are restored with grazing enclosure phosphorous accessed at deeper soil depths is brought to the surface and accumulates at the soil surface (Azarnivand & Zare Chahoki, 2011).

Exclusion also increased the mean potassium concentration in the upper soil layer compared to the grazed control site. This is likely due to an increase in potassium transfer by plants to the upper soil layers accessed from deeper soil layers compared to the control as discussed above for phosphorous. The increase in potassium

amount is also likely due to the increased vegetation and litter cover and improved soil properties in the exclusion treatment. As lowering of pH results in higher potassium levels (Foth et al., 1997; Somda et al., 1997), the lower pH levels in the exclusion treatment likely contributed to an increase in potassium.

Conclusion

Our findings illustrate that grazing enclosure enhances vegetation recovery of annual and perennial grasses, and enhances soil physical and chemical properties in this environment. This indicates that it is possible to improve Imam Kandi rangeland. To do so, range managers should focus on getting local stock permit holders to establish grazing enclosures in degraded portions of the rangeland they graze to improve the vegetation and soil to enhance productivity and restore natural resources.

The observed variations in vegetation and soil properties via PCA analyses indicate that the vegetation is more sensitive than soil to changing management strategies in this semi-arid rangeland. This is likely due to the fact that changes in vegetation strongly influence soil properties and that in dry environments it takes a long time under consistent, improved vegetation management to improve soil properties (Burke et al., 1998). Yong-Zhong et al. (2005) also found that although soil restoration is a slow process the vegetation can recover rapidly after removal of livestock on overgrazed rangeland.

Further studies are needed to develop management protocols that would provide growing season exclusion of grazing from a different portion of the entire grazing management area each year to improve the vegetation and soil health for the whole area as indicated by Müller et al. (2007) to enhance sustainability.

References

- Abdallah, F., Z. Noumi, B. Touzard, A. Ouled Belgacem, M. Neffati, and M. Chaieb. 2008. The influence of *Acacia tortilis* (Forssk.) subsp. *raddiana* (Savi) and livestock grazing on grass species composition, yield and soil nutrients in arid environments of South Tunisia. *Flora* 203: 116–125.
- Al-Seekh, S. H., G. Mohammad, and A. Amro. 2009. Effect of grazing on soil properties at southern part of West Bank Rangeland. *Hebron University Research Journal* 4: 35–53.
- Azarnivand, H., and M. A. Zare Chahoki. 2008. *Range Improvement*. Tehran University Press, Tehran. P. 354. (In Persian)
- Azarnivand, H., and M. A. Zare Chahoki. 2011. *Rangeland Ecology*. Tehran University Press, Tehran. P. 345. (In Persian)
- Boltz, D. F., and J. A. Howel. 1978. *Colorimetric determination of non-metals*. John Wiley and sons, New York, pp. 197–202.
- Bremner, J. M., and C. S. Mulvaney. 1982. Nitrogen total, pp. 595–624, in A. L. Pageet al, eds., *Methods of soil analysis, part 2: chemical and microbiological properties, vol. 9*. ASA Monograph, Madison, WI.
- Burke, I. C., W. K. Lauenroth, M. A. Vinton, P. B. Hook, R. H. Kelly, H. E. Epstein, M. R. Aguiar, M. D. Robles, M. O. Aguilera, K. L. Murphy, and R. A. Gill. 1998. Plant–soil interactions in temperate grasslands. *Biogeochemistry* 42: 121–143.
- David, L. J., A. Hodge, and Y. Kuzyakov. 2004. Plant and mycorrhizal regulation of rhizo deposition. *New Phytologist* 163: 459–480.
- Deb, D., V. N. Deshpande, and K. Ch. Das. 2008. Assessment of water quality around surface coal mines using principal component analysis and fuzzy reasoning techniques. *Mine Water Environment* 27: 183–193.

- Eldridge, D. J., and A. D. Robson. 1997. Blade ploughing and enclosure influence soil properties in a semi-arid Australian woodland. *Journal of Range Management* 50: 191–198.
- Fernández-Lugo, S., L. de Nascimento, M. Mellado, L. A. Bermejo, and J. R. Arévalo. 2009. Vegetation change and chemical soil composition after four years of goat grazing exclusion in a Canary Islands pasture. *Agriculture Ecosystems and Environment* 132: 276–282.
- Foth, H. D., B. G. Ellis. 1997. *Soil fertility*, p. 290. ISBN 1566702437. CRC Lewis Publishers, Boston, MA.
- Gee, G. W., and J. W. Bauder. 1982. Particle size analysis, pp. 383–411, in A. Klute, ed., *Methods of soil analysis, part 1: physical and mineralogical methods*. ASA Monograph, vol. 9, pp. 383–411.
- Hinsinger, P., C. Plassard, B. Jaillard, and C. X. Tang. 2003. Origins of root-mediated pH changes in the rhizosphere and their responses to environmental constraints: a review. *Plant and Soil* 248: 43–59.
- Holechek, J., R. Pieper, and C. Herbel. 1989. *Range management principles and practices*. 2nd ed. Prentice Hall, Englewood Cliffs, New Jersey.
- Hotelling, H. 1933. Analysis of a complex of statistical variables into principal components. *Journal of Educational Psychology* 24 (417–441): 498–520.
- Jeddi, K., and M. Chaieb. 2010. Changes in soil properties and vegetation following livestock grazing exclusion in degraded arid environments of South Tunisia. *Flora* 205: 184–189.
- Kent, M., and P. Coker. 1996. *Vegetation description and analysis: A practical approach*. Belhaven Press, London, p. 363.
- Lindsay, E. A., and S. A. Cunningham. 2009. Livestock grazing exclusion and microhabitat variation affect invertebrates and litter decomposition rates in woodland remnants. *Forest Ecology and Management* 258: 178–187.
- Mesdaghi, M. 2007. *Range management in Iran*. 3rd ed. Iman Reza Publications, Mashhad, p. 333. (In Persian)
- Mikola, J., G. W. Yeates, G. M. Barker, D. A. Wardle, and K. I. Bonner. 2001. Effects of defoliation intensity on soil food-web properties in an experimental grassland community. *Oikos* 92: 333–343.
- Moghaddam, M. R. 2007. *Range and range management*. 4th ed. Tehran University Press, Tehran, p. 470. (In Persian)
- Müller, B., K. Frank, and C. Wissel. 2007. Relevance of rest periods in non-equilibrium rangeland systems - a modeling analysis. *Agricultural systems* 92: 295–317.
- Oba, G., O. R. Vetaas, and N. C. Stenseth. 2001. Relationships between biomass and plant species richness in arid-zone grazing lands. *Journal of Applied Ecology* 38: 836–846.
- Olsen, S. R., and L. E. Sommers. 1982. Phosphorus, pp. 403–430, in A. L. Page et al. eds., *Methods of soil analysis, part 2: chemical and microbiological properties, vol. 9*. ASA Monograph, Madison, WI.
- Perveen, A., and M. I. Hussain. 2007. Plant biodiversity and phytosociological attributes of Gorakh Hill (Khirthar Range). *Pakistan Journal of Botany* 39: 691–698.
- Reeder, J. D., and G. E. Schuman. 2002. Influence of livestock grazing on C sequestration in semi-arid mixed-grass and short-grass rangelands. *Environmental Pollution* 116: 457–463.
- Shrestha, S., and F. Kazama. 2007. Assessment of surface water quality using multivariate statistical techniques: A case study of the Fuji river basin, Japan. *Environmental Modeling Software* 22(4): 464–475.
- Smartt, P. F. M. 1987. Sampling for vegetation survey; a flexible systematic model for sample location. *Journal of Biogeography* 5: 43–56.
- Somda, Z. C., J. M. Powell, and A. Bationo. 1997. Soil pH and nitrogen changes following cattle and sheep urine deposition. *Communications in Soil Science and Plant Analysis* 28: 1253–1268.
- Sparks, D. L. 1996. *Methods of soil analysis. part 3. chemical methods*. Soil Science Society American, Inc. American Society of Agronomy, Inc., Madison, Wisconsin.

- Steel, R. G. D., and J. H. Torrie. 1997. *Principles and procedures of statistics: a biometrical approach*. 3rd ed. McGraw-Hill, New York. P. 666.
- Steffens, M., A. Kolbl, K. U. Totsche, and I. Kogel-Knabner. 2008. Grazing effects on soil chemical and physical properties in a semiarid steppe of Inner Mongolia (P.R. China). *Geoderma* 143: 63–72.
- Su, Y. Z., H. L. Zhao, T. H. Zhang, and X. Y. Zhao. 2004. Soil properties following cultivation and non-grazing of a semiarid sandy grassland in northern China. *Soil Tillage Research* 75: 27–36.
- Teague, W. R., S. L. Dowhower, S. A. Baker, N. Haile, P. B. De Laune, and D. M. Conover. 2011. Grazing management impacts on vegetation, soil biota and soil chemical, physical and hydrological properties in tall grass prairie. *Agriculture Ecosystems and Environment* 141: 310–322.
- Tefera, M. 2001. The role of area closures on the recovery of vegetation in degraded hillsides of Biyo and Tiya, central and Northern Ethiopia. M.Sc. Thesis, Swedish University of Agricultural Sciences.
- Walkley, A., and I. A. Black. 1934. Chromic acid titration for determination of soil organic matter. *Soil Science* 63: 251.
- Yates, C. J., D. A. Norton, and R. J. Hobbs. 2000. Grazing effects on plant cover, soil and microclimate in fragmented woodlands in south-western Australia: implications for restoration. *Australasian Ecology* 25: 36–47.
- Yong-Zhong, S., L. Yu-Lin, C. Jian-Yuan, and Z. Wen-Zhi. 2005. Influences of continuous grazing and livestock exclusion on soil properties in degraded sandy grassland, Inner Mongolia, northern China. *Catena* 59: 267–278.