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Short research contribution

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FIRE INFLUENCE ON THE GRASSLAND VEGETATION IN GOLESTAN NATIONAL PARK (ALBORZ MTS. IRAN)

ABSTRACT: Frequent wild fires in mountainous grasslands of Alborz (Iran) influenced the sustainability of habitats and ecological niches of species in this ecosystem. In fact, fire has been a constant event in Golestan National Park in Alborz for a long time (67 fires during 1957 to 1997). Due to importance of this national park in north-eastern Iran as a biosphere reserve, the research has been carried out in order to investigate the causes of the fires and the subsequent changes occurred in vegetation and habitat structure. Study was performed in two adjacent: burned and unburned areas in mountains of Alborz. The analysis showed that the vegetation coverage and the above ground biomass in the burned area were significantly greater in comparison to the control area. Whereas, the diversity of vegetation of the two areas did not show significant differences. It was also shown that the coverage of grass species like *Stipa pennata* L., *Festuca valessiana, Avena wiestii* Steud. and *Aegilops tauschii* Coss. increased with respect to the non-burned area. The coverage of woody species like *Acanthophyllum pugens, Onobrychis cornuta* (L.) Desv., *Cotoneaster ovatus* Pojark. and *Rosa persica* Michx. considerably decreased in burned area. Due to increase of annual species of grasses and decrease of woody species, it can be concluded that fire is a preventive factor in succession of ecosystem toward climax and the dominance of grasses can be regarded as a suitable condition for further fire occurrence.

KEY WORDS: grassland, fire, diversity, biomass, ecology, Golestan National Park, Iran

Fire is a natural process that has been a part of the environment for thousands of years, and can still be used under controlled circumstances to produce desirable ecological goals. Fire has both negative and positive attributes because its effects on ecosystem is complex (Bailey 1988) depending upon season, frequency, type and intensity of burning. It is an important factor in maintaining habitats for many species of plants and animals. Regular burning has long been postulated as a key management prescription for native grasslands in Australia (Stuwe and Parsons 1977). Recent studies (Morgan and Lunt 1999, Lunt and Morgan 1999) have reinforced this, illustrating that frequent fires maintain and enhance native grassland structure, diversity and vigor and help to prevent weed invasion. Wildfires, as well as prescribed burning, have to cause changes in plant cover and species composition of grasslands (Daubenmire 1968). Many researchers have studied prescribed burning and wildfire effects on vegetation. Garcia Novo (1977) concluded that in the third and fourth year after fire the number of bush plants in-

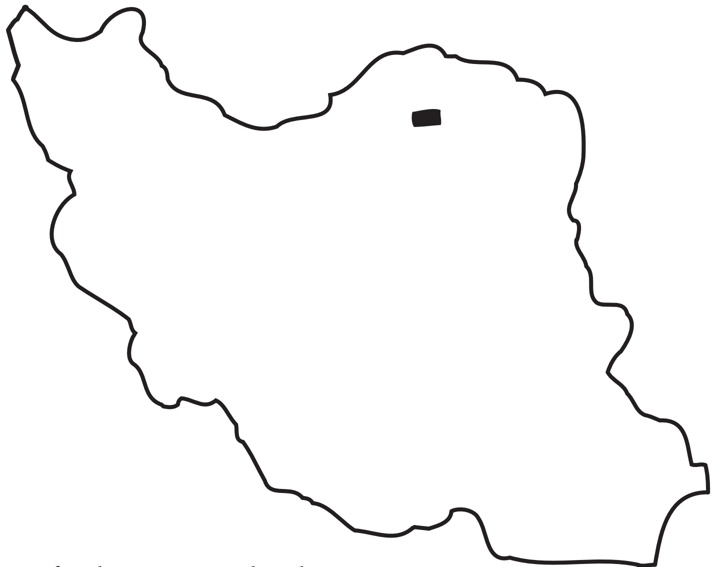

Figure 1. Location of Golestan National Park in Iran

creased in Donana National Park in Spain and the structure of this vegetation became similar to Mediterranean climax ecosystem. Ten years after the fire the plant variety and richness increased in Tasmania Forests of Australia (Fensham 1999). Fire was a factor to increase biomass and plant density in Brazilian Amazon forests (DeCastro and Kauffman 1998). Due to fire in sandy rangelands of Nebraska, the percentage of rush decreased a lot, but the forbs increased (Volesky and Cannot 2000). White and Loftin (2000) investigated the response of semiarid grasses to fire in a short-term dry climatic season and found no difference before and after the fire. Safaian and Shokri (1998) in their study of the role of fire on plain rangelands of northern Iran observed that in early years after fire, the woody species decreased while desirable plants for livestock grazing increased.

In this paper, we have focused on the effects of fire on several vegetation parameters such as cover percentage, above ground biomass, and diversity in Golestan National Park (former Mohammad Reza Shah National Park), northeastern Iran. Fires are known to occur frequently in Mediterranean types of ecosystems, but we have very little data on the history, the causes and the biological consequences of fire in Iranian plant communities. The grasslands under investigation) with some share of woody plants (occur in the Alborz Mountains in Golestan National Park in northeastern Iran. It extends from 37°16' to 37°31'N and from 55°43' to 56°17'E (Fig. 1). The area covers 91895 hectares with a circumference of 147 km and is situated on 1000–1400 m a.s.l. It is famous by presence of temperate rainy forest biome (Udvardy 1975). The park consists mainly of a transitional mountainous area and is located between the eastern extension of the Alborz Mountains and the western extension of the Khorassan – Kopetdagh Mountains. Golestan National Park was selected as a biosphere reserve in 1977. After that, it was dedicated to UNESCO's No. 8 project of Man & Biosphere (MaB) program (Madjnoonian *et al.* 1999).

Based on the existing reports, 67 fires happened in this park during 1957 to 1997 (Ghaemi 1997). As far as authors are aware, the oldest large fire which damaged large areas in the central part of the Park, happened some times between 1950–1953, before the area became protected. This fire was set deliberately and continued on the northeastern slopes of Divar-Kaji (a part of Park). It damaged large parts of of *Juniperus excelsa* woodland and *Quereus macranthera* forests (Akhani Sanjani 2000). The juniper woodland in this area has not yet regenerated. Many more small and large fires have occurred since the area came under protection.

Yelaq plain, in southern part of the Park, was selected as study area. The elevation of this area ranges between 1000–1400 m (a.s.l).

Mean annual rainfall equals 450 mm, mean monthly temperature – 11.8°C; temperate semi-arid climate prevails. Vegetation of Yelaq plain is related to the formation of "open" woodlands and shrubs, *Acer monspessulanum* and *Crataegus* sp. scrub (Frey 1980, Frey and Probst 1986). The above mentioned formation is very rich in woody and herbaceous species. Herbaceous vegetation often covers up to 100% of the ground. Species like *Festuca valesiaca, Stipa pennata, S. lessingiana, Dactylis glomerata, Elymus elongatiformis*, *Teucrium chamaedrys*, and *Melica ciliate* are the most frequent ones.

720 ha of Yelaq plain area (0.8% of total area of the Park) was burned in 1995. To find out the changes in vegetation structure during post-fire succession (5 years after burning), part of the grasslands of Yelaq plain was selected as the central nucleus of the fire. An adjacent unburned (control) area was considered to compare the vegetation parameters. The area of burned and unburned sites equals 720 and 1160 ha, respectively. The location of burned and unburned areas on Yelaq plain was determined on topographical map, scale 1:50000. The study plots with the homogenous soil, topography and vegetation have been determined as sampling stations. The sampling was made by randomized method. Thirty six samples 1 m^2 each, were established along the transect to measure the coverage of each species (Bonhamm 1989). Sampling was performed during May of 2000. The evaluation of the above ground biomass (dry weight) was performed by double sampling method (Volesky and Cannot 2000). The plant diversity in two study plots was assessed by using cover percentage and Shanon and Weaner formula:

$$H = -\Sigma\,(n_i/N \times Log\, n_i/N),$$

where: H is the Shanon and Weaner diversity index, n_i is the mean coverage of species and N is the total of the means of coverage percentage of species.

T-test and ANOVA was used to compare different variables in burned and unburned areas of grasslands. The statistical analysis was performed by SPSS ver.10.

The coverage of the annual and biennial species has increased due to fire (Table 1). These are the species: *Avena weistii, Aegilops tauschii, Artemisia annua* L., *Arabis glabra* (L.) Bernh, and *Euphorbia buhsei*. The coverage of perennial herbaceous species have also increased in post-fire period. These are the species: *Festuca valesiana, Stipa pennata, Teucrium chamaedrys* L., *Fumana proembens* and *Tragopogon longirostis.* On the contrary, a significant decrease in the following woody plant species was noticed (Table 1): *Rosa persica, Acanthophyllum pungens* (Ledeb.) Boiss., *Onobrychis cornuta* and *Cotoneaster ovatus.*

The cover percentage in burned and unburned area has been studied using the plots, and the analysis of variance was measured for total cover percentage. The total percentage of vegetation cover has increased significantly in burned area (Table 2). Total above ground biomass (dry weight) significantly increased ($P \leq 0.01$) in burned area, as well (Table 2). The Shannon and Weaner diversity index of vegetation is low in both areas: for fire area $H = 0.95$ and for the control one $H = 1.02$. There are no significant difference in the mean diversity of the two areas (Table 2). Therefore, there was no change in diversity

Table 1. Comparison of coverage (%) of the plant life-forms in two areas (burned and unburned) in Golestan National Park.

Life-form	Burned area	Unburned area	Significant level
Annual and biennial	57	21	**
Perennial herbs	12	5	**
Woody species	3	21	**

** – the difference is significant at 1% level.

Table 2. Comparison of total vegetation cover, above ground biomass (dry weight) and index of diversity (*H*), in burned and unburned areas of Golestan National Park.

Vegetation parameter	Burned area	Unburned area	Sig. level
Total vegetation cover (%)	72	47	**
Above ground biomass (kg ha^{-1})	1800	860	**
Index of diversity, *H*	0.95	1.02	ns

** – the difference is significant at 1% level, ns – difference is not significant.

of the two areas 5 years after fire. Following 22 species were found only in burned area: *Alliaria petiolata, Allium chelotum, Allium affine, Allyssum tortusum, Astragalus citrinus, Astragalus brevidens, Bromus briziformis, Buffonia sintenissi, Carex melanostachya, Centaurea kotschyi, Colutea buhsei, Cousinia decipiense, Kochia prostate, Linaria dalmatica, Ononis pusilla, Oxytropis kopetdaghensis, Petrohagia prolifera, Salvia atropatana, Scrophularia gaubae, Thesium arvensis, Verbascum sublobatum, Rhamnus spathulifolia.*

Twenty five species were recorded exclusively in unburned area. These are: *Achillea biebersteinii, Arabis glabra, Brachypodium sylvaticum, Bromus benekenii, Bupleurum exaltatum, Callicephalus nitens, Campanula latifolia, Cerasus microcarpa, Erysimum ischnostylum, Euonymus velutina, Gypsophila aretioides, Hordeum bulbosum, Inula thapsoides, Malus orientalis, Minuatia meyeri, Phleum paniculatum, Serratula latifolia, Silene coronaria, Silene tenella, Stipa bromoides, Tanacetum polycephalum, Thymus kotschyanus, Varthemia persica, Verbascum cheiranthifolium, Ziziphora tenuion*. Eighty one species were common in both areas (Table 3).

Field surveys and observations showed that the study ecosystem is very sensitive to fire. Rich herbaceous vegetation becomes dry during the hot summer months when the strong winds occur caused by the interaction of high pressure air masses from the Hyrcanian area in the west and low pressure air masses of Central Asia in the east. Any fire may easily spread and develop into uncontrollable disaster. Lightning and high number of uncontrolled visitors can be the main potential ignition sources.

The biomass of grasses showed an increase in burned site compared to unburned one, while woody species biomass decreased. Generally, herbaceous plants are favored over woody plants because of the location of perennial buds at or below ground level (Bailey 1988); in this way they are protected against fire damage. Because of the removal of competition with woody plants, grass production increases following fire (Heady and Dennis Child 1994). In the tall grass prairie of Wisconsin (Anderson 1972) and in the tobosa grass (*Hilaria mutica*) areas of Mixed Prairie in Texas (Heirman and Wright, 1973) a greater production was realized for several years after a spring fire. The C4 grasses in particular may produce more biomass for several years after burning (Bailey, 1988). The same was found by DeCastro and Kauffman (1998) and Engle *et al.* (1998). However, White and Luftin (2000) did not observe any differences in grass response to fire. The 3 years of drought in the time of fire was probably the reason for it. Mean annual rainfall in High Alborz Mountains is estimated as 450 mm, without any drought after burning. Thus, the weather plays an important role modifying the effects of fires (White and Luftin 2000). Results obtained in this research are comparable to the results of Garcia Novo (1977) in Donana National Park and Brose and Vanlear (1998). After fire and initial decline in vegetation cover, grasses respond more rapidly and achieve greater cover (White and Luftin 2000).

The species diversity index did not show any significant difference in burned and unburned areas. This result is different from

Table 3. Floristic composition of the study areas in Golestan National Park.

	Species	Burned	Unburned	LIFE FORM
1	*Acantholimon raddeanum* Czernjak	×	×	CH
2	*Acanthophyllum pungens* Boiss.	×	×	CH
3	*Acer monspessulanum* subsp. *Turcomanicum* Pojark.	×	×	PH
4	*Achillea biebersteinii* Afan		×	H
5	*Achillea nobilis* Kerner	×	×	H
6	*Aegilops tauschii* Cosson	×	×	T
7	*Alliaria petiolata* Cavara & Grande	×		H
8	*Allium chelotum* Wendelbo	×		G
9	*Allium affine* Ledeb.	×		G
10	*Allium rubellum* M.B.	×	×	G
11	*Alyssum tortusum* Wild.	×		CH
12	*Anthemis triumfettii* L.	×	×	H
13	*Arabis glabra* (L.) Bernh.		×	H
14	*Artemisia annua* L.	×	×	T
15	*Artemisia sieberi* Besser	×	×	CH
16	*Asperula gorganica* Schonb-Tem. & Ehrend.	×	×	CH
17	*Astragalus retamocarpus* Boiss.	×	×	H
18	*Astragalus khoshyailensis* Sirj. & Rech. F.	×	×	CH
19	*Astragalus citrinus* Bunge.	×		H
20	*Astragalus brevidens* Freyn. & Sint.	×		H
21	*Avena wiestii* Steud.	×	×	T
22	*Berberis integerrima* Bge.	×	×	PH
23	*Brachypodium sylvaticum* (Huds.)P. Beauv.		×	H
24	*Bromus benekenii* (Lange) Trimen		×	H
25	*Bromus briziformisb* Fisch. & C. A. Mey	×		T
26	*Bromus danthonia* Trin.	×	×	T
27	*Buffonia sintenissi* Freyn.	×		CH
28	*Bupleurum exaltatum* M. B.		×	CH
29	*Callicephalus nitens* (M. B. ex Willd.) C. A. Mey		×	T
30	*Campanula latifolia* L.		×	H
31	*Capsella bursa-pastoris* (L.) Medicus	×	×	T
32	*Carex melanostachya* L.	×		H
33	*Centaurea kotschyi* (Boiss. & Heldr.) Hayek	×		CH
34	*Centaurea virgata* Lam.	×	×	CH
35	*Cerasus pseudoprostrata* Pojark.	×	×	PH

	Species	Burned	Unburned	LIFE FORM
36	*Cerasus microcarpa* (C. A. Mey) Boiss.		×	PH
37	*Chondrilla jucea* L.	×	×	H
38	*Cirsium bornmulleri* Sint. ex Bornm.	×	×	H
39	*Colutea buhsei* (Boiss.) Shap.	×		PH
40	*Convolvulus cantabrica* L.	×	×	H
41	*Convolvulus commutatus* Boiss.	×	×	H
42	*Cornus sanguinea* L.	×	×	PH
43	*Cotoneaster ovata* Pojark.	×	×	PH
44	*Cotoneaster nummularia* Pojark.	×	×	PH
45	*Cousinia decipiense* Boiss. & Bohse	×		H
46	*Crataegus azarolus* L.	×	×	PH
47	*Crucianella sintenisii* Bornm.	×	×	H
48	*Dactylis glomerta* L.	×	×	H
49	*Dianthus orientalis* Adams	×	×	CH
50	*Elymus elongatiformis* (Drobov) Assadi	×	×	H
51	*Ephedra intermedia* Schrank et C. A. Mey	×	×	CH
52	*Eryngium caucasicum* Trautv.	×	×	H
53	*Erysimum ischnostylum* Freyn & Sint.		×	H
54	*Euonymus velutina* L.		×	PH
55	*Euphorbia buhsei* Boiss.	×	×	H
56	*Ferula ovina* (Boiss.) Boiss.	×	×	H
57	*Festuca vallesiaca* Schlech. ex Gaud.	×	×	H
58	*Fumana procumbens* (Dun.) Gren. & Godron	×	×	CH
59	*Gundelia tournefortii* L.	×	×	H
60	*Gypsophila aretioides* Boiss.		×	CH
61	*Haplophyllum acutifolium* DC.	×	×	H
62	*Heteropappus altaicus* (Willd.) Novopokr	×	×	H
63	*Hordeum bulbosum* L.		×	H
64	*Hypericum elongatum* Ledeb.	×	×	H
65	*Inula oculus-christi* L.	×	×	G
66	*Inula salicina* L.	×	×	G
67	*Inula thapsoides* (M. B. ex Willd.) Spreng.		×	G
68	*Johrenia golestanica* Rech. F.	×	×	H
69	*Juniperus excelsa* M. B.	×	×	PH
70	*Kochia prostate* (L.) Schrad.	×		CH
71	*Koeleria macrantha* (Ledeb.) Schult.	×	×	H

	Species	Burned	Unburned	LIFE FORM
72	*Leptorhabdos parviflora* (Benth.) Benth.	×	×	T
73	*Linosyris vulgaris* Cass.	×	×	G
74	*Linaria dalmatica* (L.) Mill.	×		H
75	*Lonicera bracteolaris* Boiss. & Buhse	×	×	PH
76	*Malus orientalis* Ugl.		×	PH
77	*Medicago sativa* L.	×	×	H
78	*Melica ciliata* L.	×	×	H
79	*Minuartia hamata* (Hausskn.) Mattf.	×	×	T
80	*Minuatia meyeri* (Boiss.) Bornm.		×	T
81	*Myosotis ramosissima* Rochel ex Schultes	×	×	T
82	*Noaea mucronata* (Forsk.) Aschers.	×	×	CH
83	*Onobrychis sintenissi* Bornm.	×	×	CH
84	*Onobrychis cornuta* (L.) Desv.	×	×	H
85	*Ononis pusilla* L.	×		H
86	*Opopanax hispidus* C. Koch	×	×	H
87	*Oxytropis kopetdaghensis* Gontsch.	×		H
88	*Perovskia abrotanoides* Karel.	×	×	CH
89	*Petrohagia prolifera* (L.) Ball & Heywood	×		T
90	*Phleum paniculatum* Hudson		×	T
91	*Phlomis herba-venti* L.	×	×	H
92	*Poa bulbosa* L.	×	×	H
93	*Poa pratensis* L.	×	×	H
94	*Polygonum hyrcanica* Rech. f.	×	×	H
95	*Potentilla recta* L.	×	×	H
96	*Prunus divaricata* Ledeb.	×	×	PH
97	*Rhamnus pallasii* Fisch. et Mey.	×	×	PH
98	*Rhamnus spathulifolia* Fisch. & C. A. Mey	×		PH
99	*Rosa persica* Michx. ex Juss.	×	×	CH
100	*Salvia atropatana* Bunge	×		H
101	*Salvia virgata* Jacq.	×	×	H
102	*Sanguisorba minor* Scop.	×	×	H
103	*Scabiosa columbaria* L.	×	×	H
104	*Scrophularia gaubae* Bornm.	×		H
105	*Serratula latifolia* Boiss.		×	H
106	*Silene coronaria* (L.) Clairv.		×	H
107	*Silene italica* (L.) Pers	×	×	H

	Species	Burned	Unburned	LIFE FORM
108	*Silene tenella* C. A. Mey		×	CH
109	*Stachys turcomanica* Trautv.	×	×	CH
110	*Stellaria holostea* L.	×	×	H
111	*Stipa bromoides* (L.) Dorfler		×	H
112	*Stipa holosericea* Trin.	×	×	H
113	*Stipa pennata* L.	×	×	H
114	*Tanacetum polycephalum* Schultz-Bip		×	H
115	*Teucrium chamaedrys* L.	×	×	CH
116	*Thesium arvensis* Horvatovsky	×		G
117	*Thymus kotschyanus* Boiss. & Hohen.		×	CH
118	*Tragopogon longirostris* Bisch.	×	×	H
119	*Trinia leiogona* (C. A. Mey) B. Fedscht.	×	×	H
120	*Trisetum flavescens* (L.) P. Beauv.	×	×	H
121	*Tulipa biebersteiniana* Schults & Schultes f.	×	×	G
122	*Varthemia persica* DC.		×	CH
123	*Verbascum speciosum* Schrad.	×	×	H
124	*Verbascum cheiranthifolium* Boiss.		×	H
125	*Verbascum sublobatum* Murb.	×		H
126	*Viola alba* Bess.	×	×	H
127	*Ziziphora clinopodioides* Lam.	×	×	CH
128	*Ziziphora tenuir* L.		×	T
total		22	25	–

Ph = Phanerophytes, Ch = Chamaephytes, H = Hemicryptophytes, G = Geophytes, T = Terophytes

these obtained by Fensham (1999) in Tasmania Forests. Fensham (1999) reported increase in diversity 10 years after fire, whereas in this research the diversity has been evaluated 5 years after the fire.

Since grasses show a greater cover after fire, so their dominance after each fire and accumulation of dry mass can be considered as main reason for the next fire.

In general, decrease in woody species and increase in herbaceous plants, especially annual species, in post – fire vegetation indicate the stagnation and/or return of ecosystem to the lower stages in natural trend of ecological succession. So, fire can be regarded as a preventive factor in successional dynamics of Golestan National Park grasslands toward climax. The frequent fires in Golestan National Park endanger its worldwide importance. The intentional and unintentional fireset by passengers, tourists, herd keepers, and hunters should be prevented by suitable management. To decrease the harms of natural and unexpected fires, ecological and climatic studies are required. In some cases and in particular places the fire could be recommended. The actual fire regime in this region needs a better understanding and a correction of its intensity and range.

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REFERENCES

Akhani Sanjani H. 2000 – Bio-diversity in Golestan National Park – Proceedings of paleology and biodiversity. UNEP. Kerman pp. 75–89 (in Persian).

Anderson R. C. 1972 – The use of fire as a management tool on the Curtis Prairie – Proc. Tall Timbers Fire Ecol. Conf. 12: 23–35.

Bailey A. W. 1988 – Understanding fire ecology for range management (In: Vegetation applications for rangeland analysis and management, Ed. P. T. Tueller) – vol. 14, Kluwer Academic Publishes.

Bonhamm C. 1989 – Measurement of terrestrial vegetation. 2nd edition – John Wiley and Sons Inc. New York.

Brose P. H., Vanlear D. H. 1998 – Response of hard wood advance regeneration to seasonal prescribed fires in Oax-dominated shelter wood stand – Can. J. of Forest Res. 28 (3): 331–339.

Daubenmire R. 1968 – Ecology of fire in grasslands – Advances in Ecological Research 5: 209–266.

DeCastro E. A., Kauffman J. B. 1998 – A vegetation gradient of above ground biomass, root and consumption by fire – Journal of Tropical Ecology, 14 (3): 263–283.

Engle D. M., Mitchell R. L., Stevens R. L. 1998 – Late growing season fire effect in mid succession tall grass prairie – Journal of Range Management, 51 (1): 115–121.

Fensham R. J. 1999 – Interactive effects of fire frequency and site factor in tropical Eucalyptus forest – Australian Journal of Ecology, 15 (3): 65–72.

Frey W. 1980 – Wald-und Gebuschverberitung in Nordwest-Khorasa (Nordian) – Beih. Tubinger Atlas Vorderen Orients, A, 6. Dr. Ludwig Reichter. Wiesbaden.

Frey W., Probst W. 1986 – A synopsis of the vegetation of Iran (In: Contributions to the vegetation of Southwest Asia, Ed. H. Kurschner) – Beih. Tubinger Atlas Vorderen Orients, A, 6 (24): 9–24. Dr. Ludwig Reichter. Wiesbaden.

Garcia Novo F. 1977 – The effects of fire on the vegetation of Donana National Park, Spain – Tech. Rep. 3 (1): 318–325.

Ghaemi R. 1997 – Destructive and threatening factors of Golestan National Park. Environment, seasonally – Iranian Environment Protection Organization 4 (2). (in Persian).

Hall M. 1984 – Man's historical and traditional use of fire in southern Africa (In: Ecological effects of fire in South Africa Ecosystems, Eds. P. de. V. Booyson, N. M. Tainot) – Springer-Verlag, Berlin, pp.

Headdy H. F., Dennis Child R. 1994 – Rangeland ecology and management – Weatview Press.

Heirman A. L., Wright H. A. 1973 – Fire in the medium fuels of West Texas – Journal of Range Management, 26: 331–335.

Lunt I. D., Morgan J. W. 1999 – Management of new grassland reserves: what can we learn from existing reserve at Derrimut and Laverton North? (In: Down to Grass Roots: a Conference on the Management of Native Grassy Ecosystems, Eds. V. Carigie, C. Hocking) – Proceedings of a Conference held at Victoria University of Technology St Albans July 1998, online: http://life.csu.edu.au/bushfire99/papers

Madjnoonian H., Zehzad B., Kiabi B. 1999 – Golestan National Park (Biosphere Reserve) – Department of the Environment, 130 pp. (in Persian).

Morgan J. W., Lunt I. D. 1999 – Effects of time-since-fire on the tussock dynamics of a dominant grass (*Themeda triandra*) in a temperate Australian grassland – Biological Conservation, 88: 379–386.

Safaian N., Shokri M. 1998 – The role of fire as an ecological factor in rangeland ecosystems – Iranian Journal of Natural Resources 51 (2): 51–62. (in Persian).

Stuwe J., Parsons R. F. 1977 – *Themada australis* grasslands on the Basalt Plains, Victoria: floristic and management effects – Australian Journal of Ecology, 2: 467–476.

Udvardy M. D. F. 1975 - A classification of the biogeographical provinces of the world – IUCN occasional paper. No. 18. Morges.

Volesky J. D., Cannot S. B. 2000 – Vegetation response to late growing-season wildfire on Nebraska Sandhills rangeland – Journal of Range Management, 53 (4): 421–426.

White C. S., Loftin S. R.. 2000 – Response of 2 semi-arid grassland to cool-season prescribed fire – Journal of Range Management, 53 (1): 52–61.

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