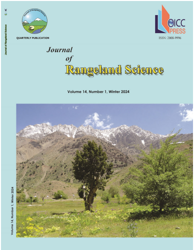

Volume 14, Issue 1, 142406 (1-10)

Journal of Rangeland Science (JRS)

https://dx.doi.org/10.57647/j.jrs.2024.1401.06

The Effect of Fire on the Structural and Functional Characteristics of Vegetation (Case Study: *Astragalus spp.* Habitat of Kabodeh, Kermanshah Province, Iran)

Borzou Yousefi[1], Mohamad Gheitury[1]*, Mosaieb Heshmati[1], Reza Siahmansour[2]

[1] *Kermanshah Agricultural and Natural Resources Research and Education Center, (AREEO), Kermanshah, Iran.*
[2] *Lorestan Agricultural and Natural Resources Research and Education Center, (AREEO), Khorramabad, Iran.*

***Corresponding author:** gheitury42@gmail.com

Research and Full Length Article

Received:
26 February 2022
Revised:
7 December 2022
Accepted:
24 December 2022
Published online:
15 January 2024

Abstract:

Wildfires annually occur as a threatening factor in natural resources at a large scale. This study was conducted with the aim of determining the effects of fire on the structural and functional characteristics of vegetation in the Kaboudeh range site, Kermanshah province, Iran during three years (2018 – 2020). An unburned range (control) was selected near the burned range. Both sites had the same characteristics. Sampling was performed at a stratified random with four 50 m transects and 20 m distances as well as 10 fixed quadrates (1 m^2). Data were collected for plant density (no/m^2), canopy cover (%), and production (g/m^2) for species and palatability classes. The range condition and range trend were evaluated using four factors and balance methods. The results showed that the palatable plants in the fire site were decreased with density (1.7 no/m^2), production (4.1 g/m^2), and canopy cover (3.9 %) compared to the control. In the first years after the fire, the number of palatable plants, range production and canopy cover decreased by approximately 75 %, but the class II plants had not significantly decreased. In the burned site, the invasive plants (Class III), dominated by annual grasses, had spread rapidly across the range. The range condition in the burned area was poor and range condition trend was positive, but in the control area range condition was medium and range condition trend was constant. In the short term, fire drastically caused the increase of annual grasses, decrease of species diversity, and subsequently led to a decrease in the stability of the range.

Keywords: Canopy cover; Density; Rangeland fire; Production; Range condition; Range trend

1. Introduction

Fire is one of the factors that greatly affect natural cycles and is one of the most important influencing factors on the structure and composition of plant communities, especially in arid and semiarid rangelands (Naghipour Borj et al., 2019).

As Yin et al. (2004) reported, wildfires are one of the most pervasive factors destroying natural ecosystems. Fire is a powerful ecological and evolutionary force that regulates organismal traits, population sizes, species interactions, community composition, carbon and nutrient cycling and ecosystem function (McLauchlan et al., 2020). Studying the effects of fire regimes and behavioral patterns improves the understanding of range ecosystems and management strategies (Tainton and Mentis, 1984).

In the report of Corbin and D'Antonio (2004), fire has rapidly reduced perennial grasses and has been cited as an effective factor in controlling shrubs and woody shrubs. Davies et al. (2008) reported that fires in the cold season of the year cause to rapidly grow the grasses and provide good vegetation in the range. Severe fires such as wildfires generally have several negative effects on soil. They cause significant removal of organic matter, deterioration of both structure and porosity, considerable loss of nutrients through volatilization, etc. (Certini, 2005).

Some species are very sensitive to fire and do not regenerate after the fire (Ravi et al., 2009). The effect of fire on vegetation in different habitats is varied and the spatial effect of the fire on its consequences is undeniable (Siahmansour, 2013). In grasslands with hardy and non-palatable perennial herbaceous species, cold fires improve palatability and increase their nutritional value (Bond and Wilgen, 1996). According to Wood and Blackburn (1981), a part of the effects of fire occurs underground. Garnier et al. (2002) believes that frequent fires create an impermeable layer under the surface soil and reduce water infiltration. The fire reduces the depth of soil surface layers and reduces the amount of organic carbon (OC) and nitrogen in the soil surface, and increases the amount of phosphorus, calcium, and soil pH (Snyman, 2004). Also, the fire caused the decreases in the amount of soil carbon sequestration (Faraji et al., 2019) and severe impact of vegetation in range (Fattahi and Tahmasebi, 2010). Siahmansour et al. (2015) reported that woody plants including shrubs suffered from more fire damage than herbaceous species, and their density and regeneration are greatly reduced. The density, canopy cover percent, and forage production of various palatability plants unless shrubs were increased significantly by fire (Mirdavoodi et al., 2019). The fire significantly reduced the vegetation cover and litter increased the bare soil surface, decreased the shrubs, and increased the proportion of perennial grasses, annual grasses, and annual forbs (Naghipour Borj et al., 2019). Sharifi and Imani (2006) stated that fire reduces the percentage of canopy cover in palatable plants (Class I), but increases it in the invader plants (Class III). The number of individual plant, the index of Menhinick's richness and the Shannon diversity index were significantly affected by fire in Sirachal research station, Karaj, Iran (Hamzeh'ee et al., 2020).

Fire and its subsequent negative effects on soil and vegetation are important for rangeland sustainability (Stavi, 2019). In range management, it is important to manage the factors of fire severity, fire season, and its recurrence (Snyman, 2004). According to Stubbenddieck et al. (2007), the effective factors in fire behavior include the amount of grass, the weather conditions in the past and present, and the target of the fire. Trollope and Trollope (1999) stated that effects of fire on savanna grassland depend on wind intensity, humidity, amounts of fuel materials, etc.

The different conclusions in literature and observations showed that the effects of fire on ecosystems are very diverse and its consequences are also different. Interactions between fire and other disturbances such as drought are likely to be the primary drivers of ecosystem change in a warming climate (Halofsky et al., 2020). Therefore, the study of the effect of fire on plant species and its consequences in different range habitats has research value as a method of improving rangelands in different ecological conditions. It should be noted that the challenge is the con-

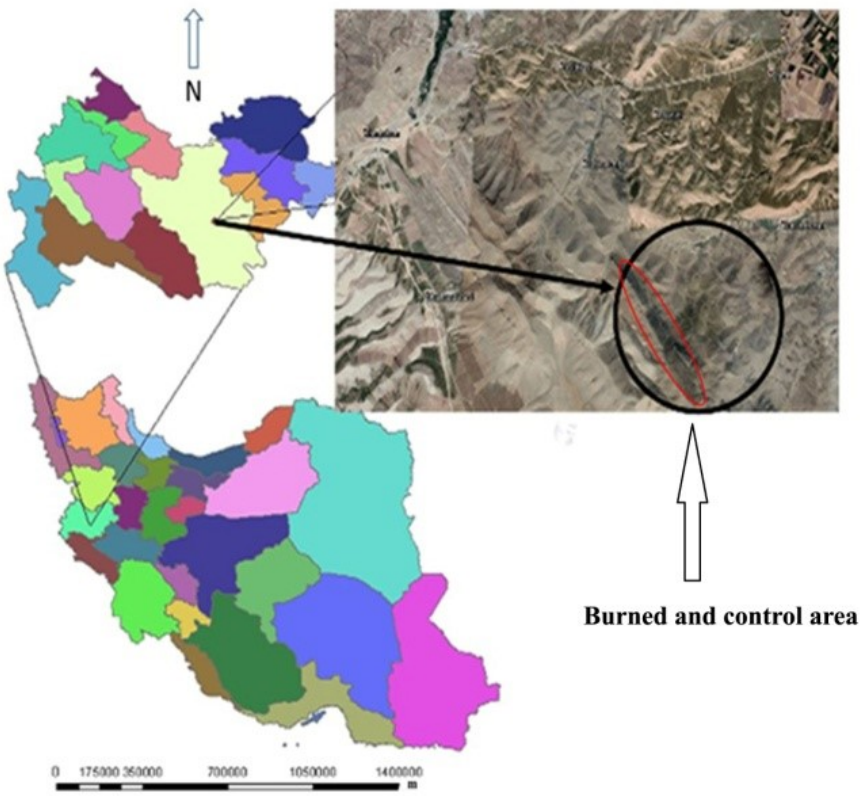

Figure 1. Geographical location of the burned and control site in Kermanshah province, Iran

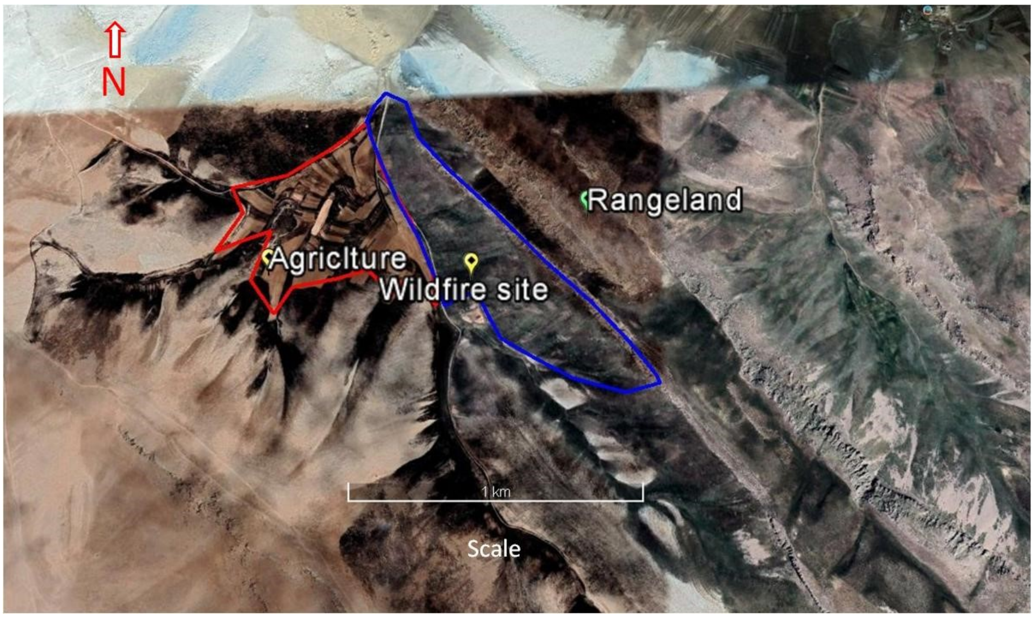

Figure 2. The land use map for the surrounding area of the studied site in Kermanshah province, Iran

servation, preventative and remedial action and ongoing management of ranges to protect biological diversity and maintain the ecological processes which provide the productive capacity of its natural resources (Mapiye et al., 2008). The unintentional or intentional fires usually occur in some area of Zagross rangeland, Iran every year by humans and affect range conditions and stability. Accidental fires (wild burning) increase fire hazards which could destroy wildlife and protected rangelands (Trollope and Trollope, 1999), cause environmental problems and affect the livelihood of the ranchers and indigenous people. There is need to validate and provide more evidence of the damage or probably benefits of fires to rangeland productivity. This study was designed to investigate sensitivity of vegetative forms to fire, effect of fire on density, canopy cover, production of palatable species and the role of fire in vegetation dynamics in semi-steppe range of Zagros region, Iran and a response to questions of what kind of quantitative and qualitative changes does the wildfire cause in the rangelands? What destructive or positive effects does wildfire have on range conditions?

2. Materials and methods

2.1 Study area

The study area at the latitude of 34°15′69″ and longitude of 47°5′60″ is located at 10 km from the southeast of Kermanshah city (Fig. 1). A part of this summer rangeland (17.7 ha) was accidentally burned by some indigenous people in June, 2017. The landuse map of the surrounding area of the studied site is shown in Fig. 2. The average annual rainfall of the study area is 470 mm, indicating a cold semi-arid region as outlined by the Köppen climate classification method.

The average slope of area is 25 % with southwest aspect. The altitude varies from 1300 to 1500 m above the sea level. The site has moderately-deep soil and loam-clay texture (Ahmadi, 2008). Before the fire, the rangeland type was *Astragalus verus* Olivier– *Festuca ovina* in both control and fire areas, but after the fire, the rangeland type in the fire area changed to *Teaniatherum caputmedusae- Avena barbata- Agrostema gittago* (Gheituri, 2005). The control area with Topographic, climatic and soil conditions almost similar to the burned area (rescued rangeland section) was 60 ha and next to the burned area.

2.2 Research methods

2.2.1 Measurement of structural and functional traits of vegetation

In the three years (2018 – 2020) based on systematic random sampling method, the four transects with 50 m long and 20 m distances accomplished and the 10 fixed quadrates (1 m^2) on each transect were used for the measurements of plant density, canopy cover and production traits. The size of quadrates was calculated using the minimal area method on the bases of vegetation size and distribution. All four transects formed a sample unit. A homogeneous area was selected in the burned site and control area. For the study of the type changes, the survey method was used for dominant species and the new types were determined and the floristic list of the area was recorded. The percentage of cover, plants composition, and density were determined. Forage production has been calculated by estimation and double sampling method (Arzani and King, 1994) during (2018 – 2020).

The species variations were studied through preparing floristic lists by survey method and comparing them with each other and the presence or absence of species in control and burned site. To determine the plant composition at the plot level, statistics methods were performed. The canopy cover of each species was recorded along transects and then examined by summing and averaging the share of each species in the plant composition of the burned and control area. The canopy cover was determined using the vertical image of the plants on the ground by each species separately within quadrates along transects. The production (growth rate of rangeland plants in the growing season) was calculated at each plot. Also, the density of plants was measured by counting the number of perennial plants by species within the quadrates along each transects (Arzani and Abedi, 2014).

The amount of production for each species and palatability classes in the control area was determined using cutting and weighing method with the estimation and double sampling method (Arzani and King, 1994) and then, repeated in the burned area. The amount of production decreases was determined for species and forage classes by calculating the difference between fire and control treatments during two vegetation periods. In the first year after the fire, the burned plant species were identified by comparing the floristic list in the control and burned area.

The condition of the rangeland was determined by the four-factor method (Soil erosion, canopy cover, plant composition, and plant vigor) and the range condition trend was determined by the balance method (Arzani and Abedi, 2014; Borhani et al., 2010).

2.3 Statistical analysis

The data were recorded for three years. The analysis of variance and the independent T-test were used to compare the burned site and control using SPPS16 software. The means of treatments were compared using the Duncan's test (Steel et al., 1997).

3. Results

3.1 Plant composition in burned and control sites

The study areas including both control and burned sites comprise 57 plant species belonging to 23 vegetation families. Totally, 44 and 30 plant species were distinguished in unburned and burned sties, respectively (Table 1). Furthermore, the respective frequent plant species in unburned and burned sties belonged to the Poaceae and Fabaceae families. In the burned area, seven species, and in the control area, nine species belong to the Poaceae family were growing. From the Fabaceae family, three species in the fire area, and eight species in the control area were found. In the burned site, no class I plant grew, but in the control area, the seven class I species were grown (Table 1).

3.2 Structural and functional traits of vegetation

The predominant vegetative form at the burned site was annual species, especially annual grasses such as *Bromus tectorum*, *Avena barbata*, *Bromus danthonia*, *Agrostamma gihtago* (annual herb), *Teaniatherum caput-medusae*, and *poa annua*. In contrast, forbs and shrub species have been severely reduced by fire. Mean comparison of production, density and canopy cover for vegetative forms between fire treatments (1, 2 and 3 years after fire) showed that there was no significant difference between burned and control area for grass production, but, there were significant differences between two sites for canopy cover and density (Table 2). While, for shrubs and forbs in terms of density, canopy cover and production there were significant differences ($P < 0.01$) between the burned site and control (Table 2).

Result of means comparison between two sits showed that for grasses, the higher and the lower values of density (25.2 vs. 10.6 $\mathrm{no/m^2}$), canopy cover (27.4 vs. 15.5 %) and production (24.6 vs. 22.7 $\mathrm{g/m^2}$) were obtained in burned site and control, respectively. In contrast, for shrubs, the higher and lower values of density (1.3 vs. 0.24 $\mathrm{no/m^2}$), canopy cover (16.6 vs. 3.0 %) and production (20.7 vs. 1.32 $\mathrm{g/m^2}$) were obtained in control and burned site, respectively.

For forbs' vegetative form, the higher and lower values of density (4.1 vs. 2.7 $\mathrm{no/m^2}$), canopy cover (12.8 vs. 7.2 %) and production (10.7 vs. 6.1 $\mathrm{g/m^2}$) were obtained in control and burned site, respectively (Table 2).

Result of means comparison for palatability classes showed that for class I species, there were significant differences between the burned area and control area for density, canopy cover and production ($P < 0.01$). For class II species, there was a significant difference only for production ($P < 0.01$) and for class III species, there were significant differences between the burned and control area for canopy cover and production ($P < 0.01$).

In class I species, the highest and lowest density (8.0 vs. 1.7 $\mathrm{no/m^2}$), canopy cover (9.7 vs. 3.9 %), and production (18.2 vs. 4.1 $\mathrm{g/m^2}$) were observed in control and burned area, respectively.

For class II plants, the highest and lowest values of production (22.8 vs. 15.1 $\mathrm{g/m^2}$) were observed in control and burned site, respectively. Similarly, for class III plants, the highest and lowest values of canopy cover (18.1 vs. 10.2 %), and production (13.7 vs. 5.7 $\mathrm{g/m^2}$) were observed in control area and burned site, respectively (Table 3).

There was a significant difference between the fire and the control for the amount of forage production in each three palatable classes for individual years (Table 4). The highest production rate with value 160 $\mathrm{kg\,ha^{-1}}$ was obtained in class I plants in the control treatment in 2019, which was higher than that in 2020. This is probably due to the appropriate rainfall in 2019. For Class II plants, the highest production (190 $\mathrm{kg\,ha^{-1}}$) and the highest harvestable forage (76 $\mathrm{kg\,ha^{-1}}$) were obtained in 2019. Also, for class III plants, the highest production (235 $\mathrm{kg\,ha^{-1}}$) was obtained in 2018, whereas, the highest harvestable forage (65 $\mathrm{kg\,ha^{-1}}$) was obtained in 2019 (Table 4).

There was a significant difference between the years for total production in the burned and control area (Table 5). The highest total production (535.95 $\mathrm{kg\,ha^{-1}}$) was obtained in the second year after the fire (2019) in the control area. The highest total production (460.93 $\mathrm{kg\,ha^{-1}}$) was obtained in the third year after the fire (2020) in the burned area (Table 5).

The study revealed that the range condition in the burned site was poor during three years of the study indicating the severe effects of fire occurrence on rangelands. In contrast, range condition trend at the first year after the fire incidence (2018) was negative while it changed to positive in the second and third years after the fire (2019 and 2020). In the control area, the range condition was medium and the range condition trend was constant in all three years of the study (2018 – 2020).

Table 1. The list of range plant species in burned and unburned site (control).

	Species	Palatable class	Burned	Unburned
Apiaceae	*Eryngium thyrsoideum* Boiss.	III	+	+
	Prangos ferulacea (L.) Lindl.	I	−	+
	Scandix stellata Banks & Sol.	II	+	−
	Smyrniopsisaucheri Boiss.	II	−	+
Asteraceae	*Anthemis odontostephana* Boiss.	II	+	−
	Centaurea intricate Boiss.	III	+	+
	Senecio vernalis Waldst. & Kit.	II	+	+
	Crupina crupinastrum (Moris) Vis.	II	+	+
	Gundelia tournefortii L.	II	+	+
	Tanacetun polycephalum (L.) Schultz-Bip.	I	−	+
Boraginaceae	*Onosma microcarpum* DC.	II	−	+
Brassicaceae	*Auberitia parviflora* Boiss.	III	+	+
	Fibigia macrocarpa (Boiss.) Boiss.	II	+	+
Campanulaceae	*Campanula perpusila* A. DC.	II	+	−
Caryophyllaceae	*Agrostemma githago* L.	II	+	−
	Velezia rigida L.	III	+	−
Crassolaceae	*Rosularia sempervivum* (M. Bieb.) A. Berger.	III	−	+
	Umbilicus intermedius Boiss.	III	−	+
Euphorbiaceae	*Euphorbia cheiradenia* Boiss. & Hohen.	III	+	+
Fabaceae	*Astragalus verus* Olivier	III	−	+
	A. gossypinu Fischer	III	−	+
	A. laguriformis Freyn	III	−	+
	A. rhodosemius Boiss. & Hausskn.	III	+	+
	A. macroplematus L.	III	−	+
	A. hamosus L.	III	+	+
	Pisum sativum L.	III	+	+
	Viciav ariabilis Grossh.	I	−	+
Fagaceae	*Quercus libani* G. Olivier	II	−	+
Iridaceae	*Cerasus microcarpa* (C.A. Mey.) Boiss.	III	−	+
Lamiaceae	*lamium amplexicaule* L.	II	+	−
	Salvia multicaulis Vahl.	II	+	+
	Stachys lavandulifolia Vahl.	I	−	+
	Stachys kurdica Boiss. & Hohen.	I	−	+
	Teucrium polium L.	II	−	+
	Ziziphora clinopodioides L.	II	−	+
Moraceae	*Ficus carica* L.	II	+	−
Plumbaginaceae	*Acantholimon olivieri* (Jaub. & Spach) Boiss.	II	+	−
Poaceae	*Agropyron intermedium* (Host) P. Beauv.	II	−	+
	Arrheratheru melatius (L.) P. Beauv. ex J. Presl & C. Presl	II	+	−
	Avena barbata Pott ex Link	III	+	−
	Bromus tomentellus Boiss.	I	−	+
	Festuca ovina L.	I	+	+
	Heteranthelium piliferum (Sol.) Hochst. ex Jaub. & Spach	II	+	−
	Hordeum bulbosum L.	II	+	+
	Melicapersica Kunth	II	−	+
	Noaea mucronata (Forssk.) Asch. & Schweinf.	III	−	+
	Poa bulbosa L.	III	+	+
	Stipa arabica Trin. & Rupr.	II	−	+
	Taeniatherum caput- medusa L.	III	+	+
Rhamnaceae	*Rhamnus pallassi* Fisch. & C.A.Mey.	III	−	+
Rosaceae	*Amygdalus orientalis* (Lam.) Rehder	III	−	+
	Cerasus microcarpa (C.A.Mey.) Boiss.	III	−	+
Rubiaceae	*Callipelti scucullaria* (L.) Steven	III	+	−
Sapindaceae	*Acer monspessulanum* L.	III	−	+
solanaceae	*Hyoscyamus niger* L.	II	+	−
Thymelaceae	*Daphena mucronata* Royle.	III	+	+
Urticaceae	*Parietaria judaica* L.	II	−	+

Table 2. Means comparison between treatments (burned and control site) for density, canopy cover and production based on plant life forms using T test.

Vegetative forms	Treatments	Forbs	Shrubs & Tress	Grasses
Density (no/m^2)	Control	4.1 ± 0.6 a	1.30 ± 0.70 a	10.6 ± 1.3 b
	burned area	2.7 ± 0.6 b	0.24 ± 0.04 b	25.2 ± 2.1 a
	T test	**	**	**
Canopy cover (%)	Control	12.8 ± 2.6 a	16.6 ± 4.3 a	15.5 ± 1.7 b
	burned area	7.2 ± 2.7 b	3.0 ± 1.6 b	27.4 ± 1.3 a
	T test	**	**	**
Production (g/m^2)	Control	10.7 ± 1.4 a	20.70 ± 2.40 a	22.7 ± 3.1 a
	burned area	6.1 ± 0.9 b	1.32 ± 0.22 b	24.6 ± 4.1 a
	T test	**	**	ns

^{ns} and **, non-significant and significant at 1 % probability level, respectively.

4. Discussion

A case of human wildfire intentionally or accidentally occurred in the Kabudeh rangeland in Kermanshah province (Iran) in 2017. In order to investigate the effects of this fire on plant vegetation and the range condition and trend, this area was studied for three years after fire.

The vegetative forms of shrubs and woody plants were severely depleted in the burned site. For density ($P < 1\,\%$) and canopy cover ($P < 5\,\%$), there were a significant difference between the two areas and the higher values observed in the control area. In the shrubs and woody plants due to the presence of flammable woody branches and stems, and the presence of buds and terminal meristems above the ground level, the susceptibility to fire was higher and its death rate was higher. Some authors reported that the fire is a strong deterrent to shrubs and woody plants (Fulé et al., 2007; Tizon et al., 2010; Stubbenddieck et al., 2007; Reinwald, 2013).

The density of annual grasses and annual herbaceous plants in the burned site was higher than the control. The predominance of grass production in this area was related to annual grasses such as *Bromus tectorum*, *Avena barbata*, *Bromus danthonia*, *Agrostama githogo*, *Teaniatherum caput-medusae*, and *poa annua*. Humphrey and Schupp (2001), and Rimer and Evans (2006) had reported an increase in annual plants in one year after the fire, but Reinwald (2013), Corbin and D'Antonio (2004), Humphrey and Schupp (2004) announced an increase in perennial plants by fire. The canopy cover in the burned area was less than the control area. The annual and perennial alfalfa, Trigonella, *Crupina crupinastrum*, *Astragalus hanisus*, especially *Euphorbia cheiradenia*, and annual species of the genus *Centaurea* were the dominant share of the canopy cover in control and burned area. These plants were able

Table 3. Means Comparison between treatments (burned and control site) for density, canopy cover and production based on palatability classes using T test.

Palatable classes	Treatments	Class I	Class II	Class III
Density (no/m^2)	Control	8.0 ± 1.2 a	21.3 ± 2.2 a	7.1 ± 1.4 a
	Fire	1.7 ± 0.9 b	23.1 ± 2.9 a	5.2 ± 0.5 a
	T test	**	ns	ns
Canopy cover (%)	Control	9.7 ± 0.9 a	21.5 ± 1.8 a	18.1 ± 1.3 a
	Fire	3.9 ± 0.6 b	21.2 ± 0.6 a	10.2 ± 1.3 b
	T test	**	ns	**
Production (g/m^2)	Control	18.2 ± 2.8 a	22.8 ± 2.7 a	13.7 ± 1.4 a
	Fire	4.1 ± 1.1 b	15.1 ± 2.3 b	5.7 ± 0.7 b
	T test	**	**	**

^{ns} and **, non-significant and significant at 1 % probability level, respectively.

Table 4. Means Comparison between treatments (burned and control site) for production based on palatability classes using T test by years (2018 – 2019).

Years	Treatments	Class I	Class II	Class III
2018	Control	145.5 ± 23.4 a	187.26 ± 26.37 a	162.88 ± 43.31 b
	burned area	65.7 ± 14.32 b	134.74 ± 19.55 b	235.41 ± 56.42 a
	T test	**	**	**
2019	Control	160.46 ± 31.27 a	190 .01 ± 59.23 a	185.48 ± 54.22 b
	burned area	80.14 ± 15.38 b	156.23 ± 43.37 b	213.33 ± 56.91 a
	T test	**	**	**
2020	Control	146.88 ± 35.26 a	182.69 ± 38.54 a	180.77 ± 44.62 a
	burned area	105.67 ± 19.81 b	160.07 ± 40.39 b	195.19 ± 45.48 a
	T test	**	**	**

ns and **, non-significant and significant at 1 % probability level, respectively.

to re-establish the first growing season after the fire, due to abundant seed production and taking advantage of the available moisture. Dale et al. (2002), Snyman (2004), and Jones et al. (2000) reported an increase in herbaceous annual plants after the fire. In annual plants, the resistance and location of the seeds during the fire were crucial, and the greater heat could increase the seed mortality. The fire, two years after onset, had severe effects on herbaceous forbs such as *Prangus ferulacea* with a sharp decline in average production. Similarly, Bennett et al. (2002), Snyman (2004), Boyd and Davies (2010), and Prevey et al. (2010) believe that herbaceous forbs are sensitive and vulnerable to fire.

In the burned area, class II and III plants had higher production and canopy cover than class I plants, and this superiority was maintained in all three years (2018 – 2020) while in the control area, palatable plants (class I) were superior, indicating that fire in the grassland increase invasive species and reduce the production and canopy cover of perennial palatable species in the short term. Boyd and Davies (2010), Dale et al. (2002), Snyman (2004), Bennett et al. (2002), Garnier et al. (2002) reported a decrease in the amount of decreasing plants (class I) in the short term. In each three years (2018 – 2020), in the control area, palatable species had a higher production and canopy cover than in the burned area. Mapiye et al. (2006) and Bebawi and Campbell (2002) reported the reduced canopy cover and production of shrubs as a result of the fire.

The density of *Bromus tomentellus* between fire and control treatments was different and it was decreased in the burned area. The *Festuca ovina* in 2018 (two years after the fire) was more dense than other perennial grasses and the average density of this species in the control field was higher than the burned site. The fire had led to the development and spread of annual grasses in the burned site. *Hordeum bulbosum* was completely removed by the fire in 2018 due to being under the canopy cover of shrubs and *Daphne mucronata*, but its density was increased to some extent by propagation by seeds in the second and third years after the fire. Badia and Marti (2003), Bennett et al. (2002), and Lesica and Martin (2003) emphasized the drastic reduction and elimination of batch grasses after the fire. Garnier et al. (2002) and Bennett et al. (2002) reported a decrease in the canopy cover for annual forbs, but vice versa, McDaniel et al. (1997), Dale et al. (2002) and Sny-

Table 5. Results of two way ANOVA and mean comparison between treatments (control and burned area) over three years years for total production (kg/ha).

Years	Control production (kg/ha)	Burned area production (kg/ha)	T test
2018	495.64 ± 86.26 c	435.89 ± 90.29 c	ns
2019	535.95 ± 144.72 a	449.70 ± 115.66 b	**
2020	510.34 ± 118.42 b	460.93 ± 105.68 a	**
F test	*	*	

ns and **, non-significant and significant at 1 % probability level, respectively.
Means followed by the same letter within a column are not significantly different according to Duncan method.

man (2004) reported an increase in annual canopy cover. Mirdavoodi et al. (2019) concluded that the density, cover percent and forage production of perennial and annual forbs, and annual grasses were increased significantly by fire but density and cover percent of shrubs decreased. The fire also increased the proportion of high and moderate palatable species (class I and II) and reduced the proportion of class III species (Naghipour Borj et al., 2019). The fire significantly increased the relative abundance of palatable grade III plants in soil seed banks but decreased the frequency of class III (Nabizadeh et al., 2020). The fire caused increases forage production, canopy cover and density of grasses and forbs but significantly decreased density and canopy cover of shrubs (Mirzaei Mossivand et al., 2015).

5. Conclusion

The fire causes the decrease in species diversity, canopy cover, rangeland production, and palatable plants, and subsequently, in the short term, it leads to a decrease in the stability and richness of the rangeland. After the fire the population of *Astragalus spp.* decreased drastically but the annual grasses increased sharply. In the short term, fire drastically caused the increase of annual grasses, and decreases of species diversity, and subsequently leads to a decrease in the stability of the range.

Acknowledgment
The authors gratefully acknowledge the financial support for this work that was provided by RIFR, Tehran, Iran.

Ethical approval:
This manuscript does not report on or involve the use of any animal or human data or tissue. So the ethical approval does not applicable.

Funding:
No funding was received to assist with conducting this study and the preparation of this manuscript.

Authors Contributions:
All authors have contributed equally to prepare the paper.

Availability of data and materials:
The data that support the findings of this study are available on request from the corresponding author.

Conflict of Interests:
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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