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Effect of Fire on Vegetation Cover of Steppe Rangelands (A Case Study in Yazd Province, Iran)

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Abstract

The effectiveness of prescribed fire as a range management tool was examined in this study in the Yazd province of Iran. One hectare of land was divided into four 20 x 125 m blocks. Blocks were split into five 20 x 25 m experimental plots. Seasonal burning was randomly applied on each plot in 2004. One plot was also left unburnt as a control. Data were collected in 2005 and 2006 and analyzed. The results show that the response of species to fire varies within the season as well as among seasons. The minimum burning effect on vegetation cover was observed for the most desirable plant (*Salsola rigida)* in response to winter fire treatment. Fire eliminated both *Artemisia sieberi* and *Stipa barbata*, the two other important species found on the range. Reduction of undesirable species, such as *Noaea mucronata* and *Cousinia deserti* was also considerable. The percentage cover of other undesirable species, i.e. *Scariola orientalis*, did not change significantly ($p< 0.05$). We concluded that, although it burning eliminated some species, it could not eradicate all undesirable species. It also failed to promote the desired species in terms of vegetation cover. So, at least in the short term, burning is not considered a range improvement tool for steppe rangelands in Iran.

Keywords: Fire, Cover, Desirable and undesirable species, Range improvement, Steppe.

اثرات آتش‌سوزی بر درصد پوشش گیاهی مراتع استپی ایران (مطالعه موردی در مراتع استان یزد)

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چکیده

آتش‌سوزی از جمله راهکارهای مدیریتی برای اصلاح مراتع محسوب می‌شود. در این پژوهش به بررسی اثرات آتش بر گونه‌های گیاهی مهم در مراتع استپی استان یزد پرداخته شده است. برای این منظور، محدوده‌ای به وسعت یک هکتار درون ایستگاه تحقیقاتی مرتع نیر یزد انتخاب گردید. این عرصه به ۴ بلوک ۱۲۵×۲۰ متر و هر بلوک به ۵ قطعه آزمایشی ۲۵×۲۰ متری تفکیک شد. هر قطعه بطور تصادفی به هر یک از تیمارهای ۴ گانه زمان آتش‌سوزی (بهار، تابستان، پائیز، زمستان) و تیمار آزمایشی بدون آتش‌سوزی (شاهد) اختصاص داده شد. عملیات آتش‌سوزی در سال ۱۳۸۳ و اولین آمار برداری از درصد پوشش گیاهان در اوایل مهر سال ۱۳۸۴ انجام و در سال ۱۳۸۵ نیز تکرار گردید. داده‌ها در قالب طرح آماری بلوک‌های کامل تصادفی تجزیه و تحلیل گردید. نتایج نشان داد که تأثیر آتش بر گونه‌های گیاهی مختلف عرصه، یکسان نبوده و گیاهان به زمان‌های مختلف آتش‌سوزی نیز واکنش مشابهی نشان نداده‌اند. درصد پوشش گیاهی گونه مرغوب *Salsola rigida* تحت تاثیر تیمار آتش‌سوزی زمستانه با حداقل اثر منفی همراه بوده است. آتش‌زدن مرتع دو گونه مهم *Artemisia sieberi* و *Stipa barbata* را تقریباً نابود نموده است. دو گونه نامرغوب *Noaea mucronata* و *Cousinia deserti* نیز در اثر آتش‌سوزی بشدت صدمه دیده‌اند، لیکن درصد پوشش گیاهی گونه نامرغوب *Scariola orientalis* تحت تاثیر آتش‌سوزی تغییر معنی‌داری نیافته است ($p <$ ۰/۰۵). هرچند آتش‌سوزی در حذف برخی از گونه‌های نامرغوب عرصه موثر بوده است، لیکن همه گونه‌های مرتعی نامرغوب آن‌را در بر نگرفته است. علاوه بر آن این عمل موجب ارتقاء پوشش گونه‌های مرتعی مرغوب نشده است. بنابراین آتش‌سوزی در مناطق استپی ایران، اصلاح مرتع را حداقل در یک دوره کوتاه‌مدت موجب نمی گردد.

واژه‌های کلیدی: آتش سوزی، درصد پوشش، گونه‌های مرغوب و نامرغوب، اصلاح مرتع، استپ.

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Introduction

The effect of fire as a range management tool has been studied extensively. Bailey (1988) showed that most forbs and grasses have terminal buds that are located on the ground or below, making them highly fire resistant. Kucera (1981) suggests that if periodic fires do not occur in grasslands, shrubs gradually come to dominate the community. That study showed that fire in a bunchgrass-sagebrush community had a devastating effect on shrub presence. Fourteen months after burning, the frequency, density, and cover of both sagebrush and rabbit brush were significantly lower, by approximately 60, 90 and 90%, respectively. In contrast, the most grasses and forbs cover increased due to the decrease of bushes in plant composition (Johnson and Strang, 1983).

Sharifi and Imani (2006) showed that in the semi-steppe rangelands of the Khalkhal province of Iran, the bushes cover decreased in contrast to permanent grasses after fire was applied. They also found that overall vegetation cover gradually decreased. Results from Khodagholi *et al.*, (2001) in the Samirom rangelands of Isfahan Province suggest that fire reduces the shrubs cover and production and leads to the expansion of grasses. Humphery (1962) stated that *Artemisia tridentate* is very sensitive to fire. The plant does not regenerate after fire; its recovery, however, could be accomplished through seeding. In Idaho, USA, *Artemisia tridentate* did not go back to its pre-burn condition even 14 years after fire (Nelle *et al.,* 2000). In contrast, Perevolotsky *et al.*, (2001), Jacobs and Sheley (2003) and Henking *et al.*, (1998) all suggested no significant effect of fire on shrubs. Five years of monitoring the effect of burning on bushes in Mazandaran Province in Iran showed no significant effect on vegetation composition Safaeian and Shokri (1999).

There are interactions between the seasonal timing of prescribed fire and the phonological stage of plants (i.e. actively growing plants are more sensitive to fire than those in hibernation). Most controlled burning is applied when desirable species are dormant and undesirables active (White, 1983). Other studies have shown that autumn burning, under dry conditions, causes more damage to *Artemisia cana* than spring burning under moist conditions (Valentine, 1989). Spring and autumn fires within *Artemisia Purshia* plant communities increase cover and the diversity of forbs and decrease the cover of *Artemisia tridentata* (Pyle and Crawford, 1996). Seasonal burning in the semi-dry rangelands of central Argentina, showed that *S. lenuis* and *P. napostaenes* are reduced by 85% and 55%, respectively, if the fire is applied later than May. (Pelaez *et al.,* 2001) suggest the same average reduction of *Stipa gyneriodies* for all seasonal treatments, even later than May.

As indicated, research results on the effect of fire on different species, climates and seasons are highly variable, leading to the necessity for developing a research project specific to the steppe rangelands of Iran.

Material and Methods

Site Description

The study area is located on the Nir range research station in the Poshtkoh watershed of Yazd Province, Iran. The location of the station is at 54° 11′ 49″ to 54° 12′ 56″ East and 31° 21′ 50″ to 31° 23′ 02″ North, and it encompasses 200 hectares. The station is in the high rangelands of the province at 2110 to 2170 m above sea level. Its general slope is less than 3%, and the average annual precipitation is 130 mm. For the years encompassing the study period—2004, 2005 and 2006—the average annual precipitations were 190, 208 and 128 mm, respectively. The climate of this area is dry and cold (Khalili, 1981). The primary perennial species are *Salsola rigida*, *Artemisia sieberi* and *Stipa barbata* accompanied by *Noaea mucronata*, *Scariola orientalis* and *Launaea acanthodes*. The station is divided into grazing and non-grazing (exclosure) areas

Method

In early April 2004, 1 hectare of the non-grazing area was selected for the study. This area was segmented into four blocks of 125 x 20 m. Each block was

divided into 5 experimental plots of 25 x 20 m. Using a completely randomized block design, each plot was randomly burned in the spring (June 1, 2004), summer (August 10, 2004), autumn (November 1, 2004) and winter (January 10, 2005). Cover percentage was measured on six 20 m long transects in 2005 and 2006. Data were collected and separately analyzed for three typical species, *Salsola rigida*, *Artemisia sieberi* and *Stipa barbata*, and other important accompanying species, such as *Noaea mucronata*, *Scariola orientalis*, *Launaea acanthodes*, *Cousinia deserti*, *Iris songarica* and *Euphorbia spp.* The cover percentage of other perennials, which were categorized as non-important species, was measured together. The same procedure was used for the annuals.

Data for each year were analyzed on the basis of completely randomized block design with four time treatments, and one control in a SAS.12 environment. Means also were compared against a Duncan test.

Results

The growth of burned species was negligible in 2004, with no re-growth in summer, autumn or winter. The actual growth of plants started in 2005, a year after the fire. Analysis of variation showed that the effect of fire treatments on total cover percentage of permanent species is significant. The mean comparisons of cover percentage of different species are given in Tables 1 and 2. The cover percentage of *Salsola rigida*, *Artemisia sieberi*, *Stipa barbata*, *Noaea mucronata*, *Cousinia deserti* and *Iris songarica* changed negatively in response to the fire treatments. For *Scariola orientalis* and *Launaea acanthodes*, however, fire did not show significant effect on cover percentage change ($p<0.05$). Fire destroys *Artemisia sieberi* and *Stipa barbata* the two most important rangeland species of steppe regions and eradicates undesirable species such as *Cousinia deserti* and *Noaea mucronata*. The negative effect of fire for some species, i.e. *Salsola rigida*, could be reduced by deferring the burning time.

Table 1. Mean comparison of cover percentage of different species in 2005.[1]

Treatments	*Salsola rigida*	*Artemisia sieberi*	*Stipa barbata*	*Noea mucronata*	*Scariola orientalis*	*Launaea acanthodes*	*Cousinia deserti*	*Iris songarica*	*Euphorbia sp.*
Spring	0.2 [c]	0.0 [b]	0.0 [b]	0.0 [b]	1.4 [a]	0.3 [a]	0.0 [b]	0.0 [a]	0.0 [a]
Summer	0.3 [c]	0.0 [b]	0.1 [b]	0.0 [b]	1.6 [a]	0.1 [a]	0.0 [b]	0.0 [a]	0.0 [a]
Autumn	1.2 [c]	0.1 [b]	0.1 [b]	0.0 [b]	1.9 [a]	0.7 [a]	0.0 [b]	0.0 [a]	0.0 [a]
Winter	3.5 [b]	0.2 [b]	0.1 [b]	0.0 [b]	1.8 [a]	0.1 [a]	0.1 [b]	0.0 [a]	0.1 [a]
Control	6.6 [a]	3.7 [a]	1.1 [a]	0.1 [a]	1.8 [a]	0.4 [a]	2.3 [a]	0.2 [a]	0.0 [a]

[1]Same alphabet in same column shows no significant differences ($p< 0.05$)

Table 2. Mean comparison of cover percentage of different species in 2006.[1]

Treatments	*Salsola rigida*	*Artemisia sieberi*	*Stipa barbata*	*Noea mucronata*	*Scariola orientalis*	*Launaea acanthodes*	*Cousinia deserti*	*Iris songarica*	*Euphorbia sp.*
Spring	.05 [d]	0.0 [b]	0.0 [b]	0.0 [b]	3.8 [a]	0.0 [a]	0.0 [b]	0.0 [b]	0.1 [a]
Summer	.05 [d]	0.0 [b]	0.2 [b]	0.0 [b]	3.1 [a]	0.0 [a]	0.0 [b]	0.0 [b]	0.3 [a]
Autumn	1.8 [c]	0.2 [b]	0.3 [b]	0.0 [b]	3.4 [a]	0.3 [a]	0.0 [b]	0.0 [b]	0.1 [a]
Winter	3.7 [b]	0.4 [b]	0.1 [b]	0.0 [b]	3.2 [a]	0.0 [a]	0.2 [b]	0.1 [ab]	0.1 [a]
Control	6.1 [a]	3.4 [a]	1.3 [a]	0.1 [a]	1.3 [a]	0.1 [a]	2.0 [a]	0.2 [a]	0.0 [a]

[1]Same alphabet in same column shows no significant differences ($p< 0.05$)

Conclusion

Of the available species, *Salsola rigida*, *Artemisia sieberi*, *Stipa barbata* are important for range managers while *Noea mucronata*, *Cousinia deserti* and *Scariola orientalis* are undesirable. Fire eradicates *Noea mucronata* and *Cousinia deserti* to the benefit of range management. Since burning did not have significant effect on *Scariola orientalis* cover should be considered as a fire resistant species. The negative effect of fire on desirable species, *Salsola rigida*, *Artemisia sieberi* and *Stipa barbata* for instance, raises questions about the viability of its use as a range management tool.

The timing of burns has different impacts on re-growth of the plants. For example, the timing of burning did not have any significant effect on *Artemisia sieberi*, *Stipa barbata*, *Cousinia deserti* and *Noaea mucronata*. The least destructive effects of fire were evident on *Salsola rigida* in winter and the most were in spring and summer. The same result is reported by (Anderson *et al.*, 1970) in that fire effects in the growth phase of *Andropogon* species is more destructive than when plants are dormant. (Nelle *et al.*, 2000) studied 20 separate fire incidents that occurred at different times in Idaho rangelands and found no significant changes of forb abundance. Ruthven *et al.*, (2003) established that summer burning did not reduce woody species. They stated that the effect of fire is site conditional. After a prescribed fire, new species did not grow in the site. This result was in agreement with Khodagholi *et al.*, (2001). Trabaud and Lepart (1980) focused on the effect of fire on ecosystem diversity of Chaparel rangeland in France. They pointed out that three years after the fire, the invasion of exotics becomes increasingly likely because of vegetation reduction and loss of litter. After some years however, the exotics disappear. Results showed that fire almost completely eliminates *Artemisia sieberi*. Sensitivity of *Artemisia tridentate* to fire is also reported by Humphery (1962). Nelle *et al.*, (2000) found that after 14 years the species had not changed. Although, in only a 2-year period in our study we observed the relative elimination of *Artemisia sieberi*; yet, seed transfer from adjacent areas showed the same result as that of Nelle *et al.*, (2000).

Intensity of the fire effect on *Salsola rigida* was different from that on *Artemisia sieberi*. Some researchers believe that resistance to fire is partly related to the placement of buds. In this school of thought when buds are on or under the ground surface, the plant is fire resistant (Bailey, 1988; Humphery, 1962; Valentine, 1990). In contrast, the results of the study showed that *Stipa barbata* was eliminated completely. The same result for *Stipa connata* is given by Blaisdell (1953). Different responses to the same fire treatment by *Salsola rigida* and *Artemisia sieberi* also showed the effect of other factors rather than bud stratum.

Generally, prescribed fire, even in winter over a 2-year period, does not improve the desirable plants in the studied area and the same steppe rangeland of Iran. Improvement of vegetation cover in a short period of time for the study area is far beyond reality due to its gradual recovery in dry areas (O'Connor and Raux, 1995; Sharp *et al.*, 1990; Walker, 1988; West *et al.*, 1984; Yorks, 1992).

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