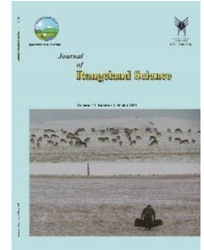

Contents available at ISC and SID

Journal homepage: www.rangeland.ir

Research and Full Length Article:

Impact of *Rosa persica* Controlling Methods on Species Richness and Diversity in Steppe Vegetation, Arak, Iran

Hamidreza Mirdavoodi[A]* and Zia Azdoo[B]

[A] Assistant Professor, Department of Natural Resources, Markazi Agricultural and Natural Resources Research and Education Center, AREEO, Arak, Iran, *(Corresponding author), E-mail: h.mirdavoudi@areeo.ac.ir

[B] Research Expert, Department of Natural Resources, Markazi Agricultural and Natural Resources Research and Education Center, AREEO, Arak, Iran

Received on: 18/06/2020
Accepted on: 11/08/2020

Abstract. *Rosa persica* Michx. ex Juss. is an aggressive plant species in Iranian rangelands. Several controlling methods have been suggested to stop its expansion. This study examined the short-term effects of fire, tilling, cutting, and herbicides as a means of controlling *Rose persica* on the richness, evenness and diversity of *R. persica* communities in rangelands of Iran. The experiment was arranged using asplit-plot design with fire (burning and control) as main plot and four treatments (cutting, tilling and glyphosate herbicide and control) as subplots based on a completely randomized block designwith four replications over three years (2013-2015) in khosbijan, Iran. The Margalef, Sheldon, and Shannon-Wiener indices were used to assess the species richness, evenness, and diversity, respectively. We found that treatments had a different effect on the plant community composition. Prescribed fire coupled with other treatments had a significant effect on species diversity rather than control (P<0.01). This finding indicated the significant effect of prescribed fire on the plant diversity indices. Mean of diversity was higher in burning alone (3.181). The highest value of evenness was related to the chemical treatment without fire (0.582) and the highest richness was related to the control (11.114). Also, the lowest values of diversity, evenness and species richness occurred by cutting without burning (2.582), control area without applying other treatments (0.258) and herbicide without burning (7.921), respectively. Therefore, plant diversity was increased using each treatment. This may be due to reduction of *R. persica* frequency. Despite the increasing of species diversity after applying treatments, it should be acknowledged that due to lack of desirable species gene pools and colonization of ruderal species, the vegetation composition won't be necessarily desirable. Therefore, in *R. persica* communities, the restoration of these communities should be considered after the controlling of the *R. persica*.

Key words: Aggressive species, Chemical control, Diversity, Mechanic control, Prescribed fire

Introduction

Plant communities have been altered over time due to changes in the environment (climate change, natural disturbances, etc.) and human activities (Pickett and White, 1985). Biological invasions and changes in land-use are two major driversof global change affecting biodiversity worldwide (Vilá and Ibáñez, 2011). Invasive species not only alter species composition, but also affect ecosystem functions and services (Davis, 2013; Amiri *et al.*, 2012), and in all causing major changes in ecosystems in many parts of the world (Pyšek and Richardson, 2010). As in recent decades, controlling invasive plants has become an important challenge for managing natural resources (Kettenring and Reinhardt Adams, 2011). Management practices that are used to control invasive species can directly and indirectly alter plant composition, and abundance (Wardle, 1995), and can lead to a change in the composition of the community (Freemark and Boutin, 1995; Pritekel *et al.*, 2006).

Semi-steppe rangelands have some of the highest biodiversity in Iran and constitute high-value natural resources. Past traditional agro-pastoral activities and land-use changes in these rangelands have affected the physiognomy of plant communities; as in many areas, undesirable shrubs now dominate the vegetation of the region (Akhani *et al.*, 2013). *Rosa persica* is one of these species that generally predominates after abandoning dry farming lands in this region, which were previously rangelands and *R. persica* has never been present or seldom dispersed in these habitats (Moghadam, 2000).

Rosa persica (Rosaceae) sometimes known as *Hulthemia persica* (Michx. ex Juss.) Bornm.is a xerophytic species native to the Middle East, from Iran and Afghanistan in the souththrough Central Asiato western Siberia in the north(Phillips and Rix, 1988). More than 400,000 ha (about 0.5%) of vegetation types of Iranian natural resourcesare characterized by dominant and subdominant *R. persica*, which are mostly distributed throughout the dry cold deserts and semi dry super cold regions of Iran (Fayaz, 2013).

It grows in the widest range of conditions of soil, climate and elevation, from 1000 to 2500 m above sea level (Fayaz, 2013). In its natural habitat, it is a deep-rooted weed which is characterized by a relatively uncommon increase in its density and canopy cover as a dominant species in different regions of Iran (Phillips and Rix, 1994). Despite *R. persica* as a native species in Iranin areas where it was not present previously and due to the disturbance created in the rangeland (changing rangeland to dry farming and abandonment of these lands after a period when the crop was decreased or high-intensity grazing for a long time), *R. persica* has increased and formed a uniform vegetation (forming monocultures) (Moghadam, 2000; Ahmadi, 2010; Shahriary *et al.*, 2012); therefore, in these areas, it has been introduced as an aggressive species/or invasive species (Simberloff and Rejmanek, 2011).

This aggression reduces biodiversity and has many economic consequences (Moghadam, 2000). Reducing the population of this species is one of the aims of natural resources management. Controlling this species has become an important challenge for range improvement. In Iran, several controlling methods have been used to stop the expansion of *R. persica* (Mirdavoudi, 2018). Most studies on its removal have focused on the efficacy of different controlling methods on this species and have focused less on vegetation changes after the removal of invasive species (e.g., Kennett *et al.*, 1992; Pakeman *et al.*, 2002; Blackshaw *et al.*, 2003; Papiernik *et al.*, 2003; Perry and Galatowitsch, 2003). There is a lack of information about the effect of different techniques of invasive species control on vegetation dynamics, ecosystem functions in *R. persica*-dominated ecosystems after *R. persica* controlling. Also, there are inadequate data on the revegetation of native species or re-invasion or establishment of a novel invader following *R. persica* controlling to determine the restoration rate of the invaded system. The goal of this study was to gain information about the effects of *R. persica* management practices on plant communities and provide recommendations for the managers of the natural resources. As biodiversity is assumed to reflect ecosystem functioning, managers often use diversity indices as proxies for ecosystem functioning (Margules and Pressey, 2000; Magurran, 2004) since they are often easier to measure than the functions. Therefore, in the present study, we measured species diversity in order to assess the effects of different controlling techniques on vegetation changes in a *R. persica*-dominated rangeland of Iran. We tried to answer the following questions: 1) how do these controllingmethods affect plant richness, diversity, and evenness? 2) Do the controlling methods result in desirable changes in plant community composition?

Materials and Methods

Study area

The study was conducted at the Khosbijan, located 50 km North-West of Arak between 34°08´- 34°10´ N and 49°21´- 49°24´ E. Elevation ranges from 1800 to 2683m. According to the Khosbijan climatology station over a 20-year period (1996-2016), average annual long-term precipitation of the study area is 350.9 mm, and the most rainfalls occur in winter as snow. Fig. 1 shows the average long-term precipitation (seasonally) and actual precipitation of the years of the study. The average annual minimum and maximum temperature is 0.4 and 25.8°C, respectively, and according to the De Martonne method, the climate of the study area is Semi-Dry Super Cold.

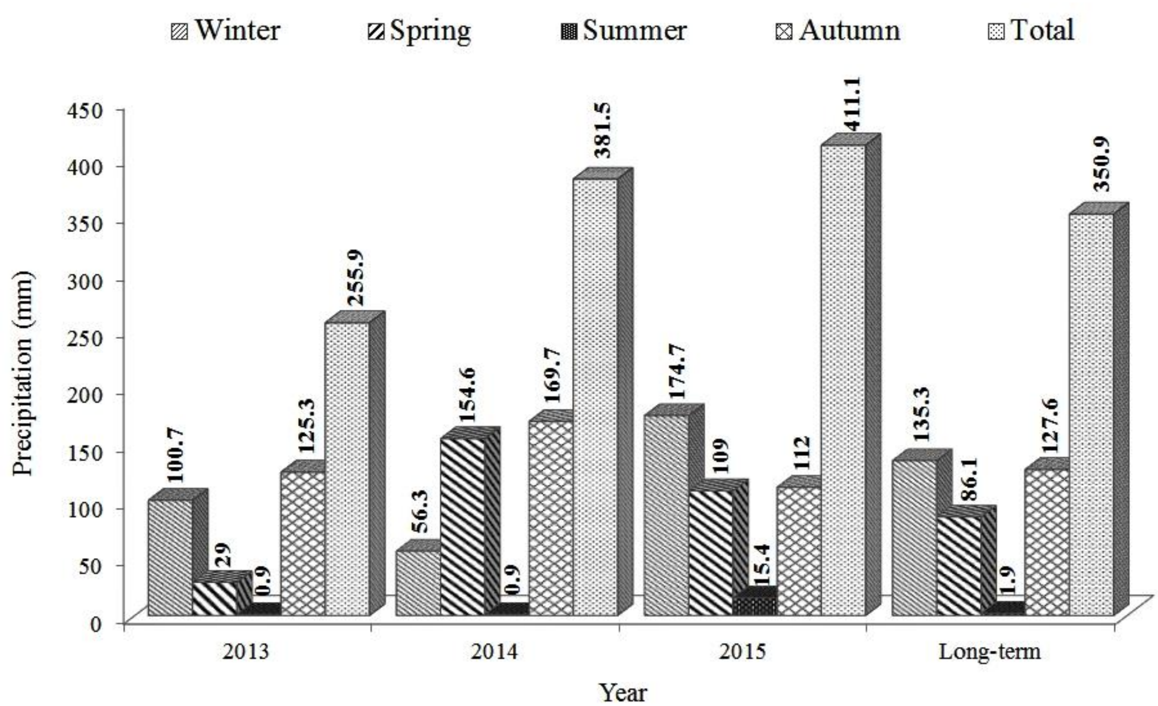

Fig. 1. Annual precipitation (seasonally) in the study area

Based on studies conducted in this area (Anonymous, 2002), the altitude of study area (ranged from 1800 to 2000 m a.s.l.), this region has changed drastically due to various interventions such as dry land farming in the past years (about 100 years ago). Before the change of rangeland to dry land farming in this area, the dominant vegetation was *Astragalus verus-Stipa barbata* along with species such as *Astragalus gossypinus*, *Artemisia aucheri, Bromus tomentellus* and perennial forbs (including *Astragalus* spp. and *Scariola orientalis*). After the abandonment of these agricultural lands (about 60 years ago), *R. persica* has expanded in these degraded rangelands (Anonymous, 2002). This area was protected by fencing to study the trend of vegetation changes by exclosure from 1991.

Experimental Design

In spring (1-April) 2013, an area of two hectares in the *R. persica* community was selected. Half of this area was burned on 15th June 2013 (prescribed fire treatment, only once during flowering), and the remaining area was considered as unburned area. The boundary between the fire and un-fired area was separated by a fire line (was done by disk plowing); the distance of the burned plot from unburned plot was about two meters. We examined the effects of four treatments: 1) undisturbed (control), 2) cutting (was done from the soil surface), 3) tilling (to cut the roots), 4) chemical techniques (glyphosate SL41%, 8 liters per hectare) on vegetation changesin each of these areas.

A split-plot design was arranged using fire effect as the main plot in two levels (burning and control) and four treatments (cutting, tilling and glyphosate herbicide and control) as subplots based on a completely randomized block design with four replications over three years (2013-2015). In each year, the experiment was repeated in a randomly selected area under the same conditions in the *R. persica* community using all treatments. A total of 32 plots were arranged (4 treatments× 2 types of fire × 4 replications) sub-plots at each site (for each year). All treatments were applied at peak growth and flowering time (about 15-June). In 2013, precipitation mainly occurs during December to February and was not during the plants growing season and as a result, annual precipitation was less than the average annual long-term precipitation. The experiment was repeated in 2014 in adjacent, which precipitation mainly occurs during the autumn and spring, and annual precipitation was equal to average annual long-term rainfall. In 2015, about 15 mm of the annual precipitation occurred in early summer (after treatment implementation) and annual precipitation was higher than the average annual long-term precipitation. Due to the impossibility using large equipment in the subplots, small equipment was used to apply the treatments. Herbicide application was undertaken using a backpack sprayer, cutting was done by backpack mower and tilling was done by a rotary (Fig. 2).

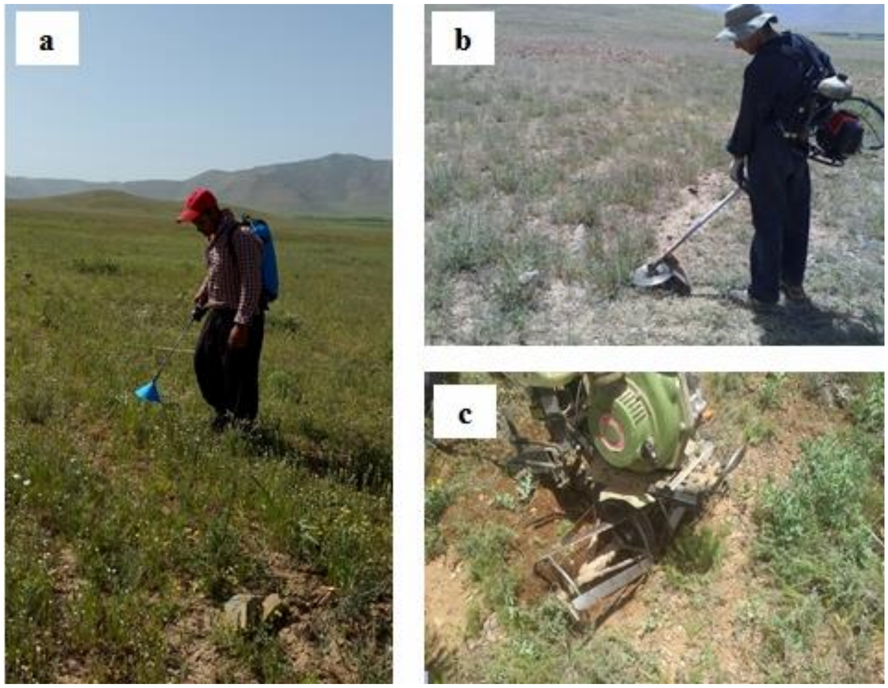

Fig. 2. Equipment used. a: backpack sprayer, b: backpack mower, c: rotary

Because of the high density of *R. persica* in the studied communities (>80% of the relative abundance of species in the plot was related to *R. persica*) as well as the non-selection of target species in the usual methods used by natural resource managers to *R. persica* control (using heavy equipment at landscape-scale), treatments were also applied to other species.

Due to species turnover and heterogeneity in sub-plots, we used a design with greater dispersion of quadrates across each sub-plot (modified from Keeley *et al.*, 2005) (Fig. 3).

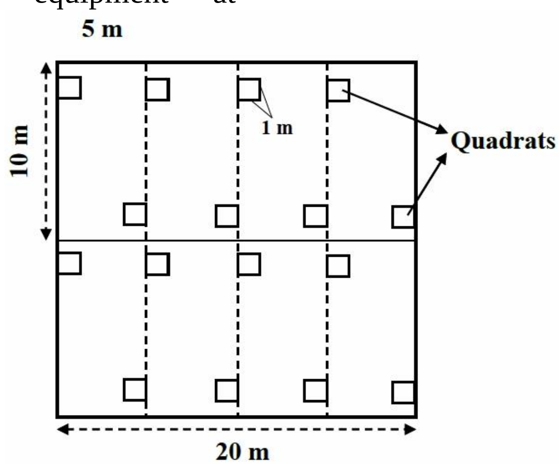

Fig. 3. Sampling area in each sub- plot

The abundances of each species were measured in June according to the plant density in each of the 16 1m^2 quadrates. Data collection was done after three years for each of the years of treatment implementation. Vegetation cover percent of each species was estimated per quadrate than averaged one for a subplot value. Species richness, evenness and diversity values were calculated based on these data for each subplot.

Statistical Analyses

Indicator species analysis (Dufrene and Legendre, 1997) was used to determine the indicator species in each treatment for all of them. The indicator value ($IndVal_{ij}$) was expressed as the product of the mean abundance of species *i* in treatment *j* compared to all treatments in the study (A_{ij}) (relative abundance), and the relative frequency of each species in each treatment (B_{ij}) (fidelity) as follows:

$$IndVal_{ij} = A_{ij} \times B_{ij} \times 100 \qquad \text{Eq. [1]}$$

The significance of the obtained values was tested using the Monte Carlo test ($P < 0.05$) with 1000 permutations (terBraak, 1987) in PC- $ORD_{4.17}$software (McCune and Mefford, 1999). A value of zero for this index indicates the absence of the species within a treatment, and a value of 100 indicates that the species occurs at all subplots within a treatment and is not present in any other treatments. Margalef, Sheldon and Shannon-Weiner indices were used to study richness (D_{Mg}), evenness (E) and species diversity (H′), respectively, using $Past_{2.17}$ software (Hammer *et al.*, 2001) as follows:

$$D_{Mg} = (S - 1) / \ln N \qquad \text{Eq. [2]}$$

$$E = eH' / S \qquad \text{Eq. [3]}$$

$$H' = -\sum_{i=1}^{s} pi \, (\ln pi) \qquad \text{Eq. [4]}$$

Where:

N= number of total individuals,

p_i= the relative abundance of the *i*th species,

S = the number of species and

ln= the natural log (Magurran, 1988).

ANOVA was used to determine differences between treatments of diversity indices using $SPSS_{24}$ and MSTATC software. Duncan's test was used to compare means of treatments.

Results

Altogether 90 vascular plant species belonging to 77 genera and 28 families were recognized. Annual forbs with an abundance of 53.5% were the dominant life form. The abundance of perennial forbs, annual grasses and shrubs were 32.5, 7.8 and 6.2, respectively. From a chorological point of view, Irano-Turanian elements (plant species belonging to this region) were dominant chorotypes (62.8%) and like other degraded rangelands in the semi-arid in Irano-Turanian region, annual life forms are more abundant than other life forms (Zohary, 1973; Hamzeh'ee *et al.*, 2008).

The results show that controlling methods have different effects on community composition as some species are more abundant in certain treatments. The plant species with their significant abundance in each treatment are shown in Table 1. It should be noted that no significant indicator species was observed in the treatment of cutting in the unburned block.

As it can be seen in Table 1, annual forbs and grasses are more frequent in the burned area, coupled with tilling that are mainly opportunistic and ruderal species. Perennial forbs in these treatments were mostly thorny species while the species of control plots were mostly shrubs. The results of the effect of each main and sub-treatmenton diversity indices after treatment implementation showed that prescribed fire was effective in changing diversity indices compared to control (unburned area), and this change was significant ($P<0.01$).

Table 1. List of Indicator species, their life form byapplication of various treatments

Main Plot	Sub plot	Indicator species	Life Form	Lifespan	Value	(P)*
Burned	Tilling	*Boissiera squarrosa* Hochst. ex Steud	Grass	Annual	48.1	0.001
		Turgenia latifolia (L.) Hoffm	Forb	Annual	47.8	0.001
		Rochlia dispermom (L. f.) C. Koch	Forb	Annual	39.2	0.002
		Echinophora platyloba DC.	Forb	Perennial	32	0.002
		Crupina crupinastrum (Moris) Vis.	Forb	Annual	31.9	0.002
		Gundelia tournefortii L.	Forb	Perennial	30.8	0.001
		Bromus danthoniae Trin.	Grass	Annual	29.1	0.002
		Cousinia cylindracea Boiss.	Forb	Perennial	27.1	0.009
		Acinus graveolens (M. B.) Link.	Forb	Annual	26	0.018
		Heteranthelium piliferum (Banks and Soland.) Hochst	Grass	Annual	26	0.001
		Taeniatherum crinitum (Schreb.) Nevski	Grass	Annual	25.9	0.006
		Nardurus subulatus (Banks and Soland.) Bor	Grass	Annual	24.9	0.003
		*Aegilops umbellulata*Zhuk.	Grass	Annual	24.1	0.001
		Holesteum umbellatum L.	Forb	Annual	22.4	0.002
		Cardus pycnocephalus L.	Forb	Annual	21.7	0.009
		*Vicia monantha*Retz. (peregrina)	Forb	Annual	21.2	0.002
		Eryngium billardieri F. Delaroche	Forb	Perennial	19.2	0.001
		Trigonella monantha C. A. Mey.	Forb	Annual	19.1	0.002
		Medicago rigidula (L.) All.	Forb	Annual	18.7	0.01
	Herbicide	*Conringia perfoliata* (C.A.Mey.) Busch	Forb	Annual	64.3	0.001
		*Fumaria asepala*Boiss.	Forb	Annual	63.1	0.001
		Euphorbia inderiensis Less. ex Kar. And Kir.	Forb	Annual	50.7	0.001
		Viola modesta Fenzl.	Forb	Annual	37.6	0.001
		Glucium grandiflora Hohen and Boiss.	Forb	Annual	29.6	0.004
		Androsace maxima L.	Forb	Annual	24.2	0.002
		Callipeltis cucularia (L.) Steven	Forb	Annual	22.8	0.001
		Aethionema carneum (Banks and Soland.) B. Fedtsch.	Forb	Annual	22.1	0.001
		Anchusa italia Retzius.	Forb	Perennial	16.1	0.025
	Cutting	*Zosima absinthifolia* (Vent.) Link.	Forb	Perennial	22.8	0.001
	Control	*Adonis sp.*	Forb	Annual	57.7	0.001
		Anemon biolflor DC.	Forb	Annual	51.8	0.001
		Crepis cf. quercifolia Bornm. and Gauba	Forb	Annual	34.9	0.001
		Scandix stellate Banks and Soland.	Forb	Annual	30.6	0.008
		Lasiopogon muscoides (Desf.) DC.	Forb	Annual	28	0.004
		Linaria simplex (Willd.) DC.	Forb	Annual	25.1	0.013
		Scabiosa olivieri Coult.	Forb	Annual	25	0.011
Unburned	Herbicide	*Hyoscyamus niger L.*	Forb	Annual	96.5	0.001
		Reseda lutea L.	Forb	Perennial	96	0.001
		Scrophularia sp.	Forb	Perennial	50.5	0.001
		Onosma sericeum Wild.	Forb	Perennial	46.9	0.001
		Nigella oxypetala Boiss.	Forb	Annual	20.1	0.05
	Control	*Astragalus gossypinus* Fischer	Shrub	Perennial	61.3	0.001
		Astragalus verus Olivier	Shrub	Perennial	41.7	0.001
		Lathyrus inconspicaus L.	Forb	Annual	34.3	0.001
		Astragalus sp.	Forb	Perennial	25	0.016
		Rosa persica Michx. ex Juss.	Shrub	Perennial	23	0.001
	Tilling	*Bromus tectorum* L.	Grass	Annual	25.2	0.001

*P, probability (from a Monte Carlo permutation test, 1000 random permutations

Result of ANOVA showed that the effect of year (“precipitation” hereafter) on variations of species diversity (regardless of the type of controlling method) showed that precipitation has no significant effect on the species diversity and evenness (P>0.05) (Table 2).

Result of mean comparison between precipitations was not significant for diversity and evenness. But, with respect species richness as the species richness decreased in the first year of experiment, its annual precipitation was below the average annual long-term precipitation (Table 3).

Table 2. Analysis of variance the main effect and interaction effects of various treatments on diversity indices in *R. persica*

Source of variation	df.	Diversity		Evenness		Richness	
		MS	F	MS	F	MS	F
Replication	3	0.484	70.86**	0.048	34.58**	19.15	46.92**
Fire	1	3.5	503.6**	0.098	69.83**	23.337	57.2**
Error (a)	3	0.147		0.018		3.235	
Treatment	3	0.138	19.79**	0.112	80.22**	42.127	103.25**
Fire× treatment	3	0.037	5.26**	0.015	10.83**	1.724	4.226**
Error (b)	18	0.054		0.013		0.942	
Year	2	0.006	0.821ns	0.003	2.291ns	6.437	15.77**
Year ×Fire	2	0.010	1.44ns	0.003	1.989ns	1.007	2.467*
Year× Treatment	6	0.014	1.99ns	0.001	0.921ns	0.546	1.339ns
Year ×Fire× treatment	9	0.005	0.788ns	0.000	0.328ns	0.104	0.254ns
Error (c)	42	0.007		0.001		0.408	
Total	95						

**, * and ns, indicatessignificance at the 0.01 and 0.05 probability levels and no significant, respectively

Table 3. The effect of year (precipitation) on diversity indices

Year	Annual Precipitation (mm)	Diversity indices		
		Diversity	Evenness	Richness
2013- 2014	255.9	2.890 a*	0.497 a	8.914 b
2014- 2015	381.5	2.900 a	0.482 a	9.605 a
2015- 2016	411.1	2.920 a	0.501 a	9.755 a

*Similar letters indicate that there is no significant difference

The interaction between prescribed fire and other treatments was significant for all diversity indices (*P*< 0.01) (Table 2); Result of means comparisons is presented in Table 4.

Prescribed fire coupled with other treatments increased diversity more than that when these treatments were used alone in comparison to control. After three years, result of each experiment showed that using a combination of treatments, the mean diversity was higher than that in burning alone (3.181). The highest value evenness was related to the chemical treatment without fire (0.582) and the highest richness was relative to the control plots [whether burned (11.406) or unburned (11.114)]. Also, the lowest values of diversity, evenness and species richness occurred with cutting without burning (2.582), unburned without applying any other controlling treatments (0.258) and chemical controlling without burning (7.921), respectively.

Table 4. Means of fire by treatments (tilling, cutting, herbicides and control) interaction on diversity indices

Fire	Controlling methods	Diversity indices		
		Richness	Diversity	Evenness
Burned	Herbicide	8.868 ± 0.06c	3.073 ± 0.08ab	0.577 ± 1.07a
	Tilling	10.246± 0.04b	3.129 ± 0.06a	0.526 ± 0.86abc
	Cutting	9.155 ± 0.04c	3.005 ± 0.08b	0.532 ± 0.54ab
	Control	11.406 ± 0.07a	3.181 ± 0.17a	0.467 ± 0.9bcd
Unburned	Herbicide	7.621 ± 0.06d	2.806 ± 0.19c	0.582 ± 1.77a
	Tilling	8.714 ± 0.07cd	2.729 ± 0.21c	0.459 ± 1.4cd
	Cutting	8.281 ± 0.09cd	2.582 ± 0.26d	0.446 ± 1.05d
	Control	11.114 ± 0.08ab	2.734 ± 0.25c	0.258 ± 1.16e

*Similar letters indicate that there is no significant difference

Discussion

This study examined the short-term (three years) effects of fire, tilling, cutting, and herbicides as a means of controlling *Rose persica* on the richness, evenness and diversity of *R. persica* communities in the semi-steppe rangelands of Iran. Results showed that prescribed fire coupled with tilling caused disturbance in vegetation and this provides the conditions for changing species composition in favor of annual species that are sometimes invasive (Keeley *et al.,* 2008; Kettenring and Reinhardt Adams, 2011; Keeley and Brennan, 2012; Ahmadi, *et al.,* 2017; Mirdavoodi *et al.,* 2019). Plant composition changes occurred following the change in open space created in the burned plots (Knnap and Seastedt, 1986; Keeley *et al.* 2003; Gundale *et al.*, 2008; Lohmann *et al.* 2014) and removing of biomass and litter (Ehrenreich and Aikman, 1963). The most important annual species were the *Aegilops umbellulata*, *Boissiera squarrosa*, *Taeniatherum crinitum*, *Heteranthelium piliferum*, *Nardurus subulatus*, *Crupina crupinastrum*, *Turgenia latifolia*, *Rochlia disperma*. Regarding the lack of shrub species such as *R. persica* as indicator species in the burned plot (Table 1), it seems that the fire was effective in reducing the density of shrub species (Tahmasebi, 2013; Lohmann*et al.*, 2014; Mirzaei Mossivand *et al.,* 2015; Mirdavoudi, 2018).

Differences in the species composition using herbicide with and without fire as well as using tilling with and without fire indicate the important role of fire in removing the some species (Johnson *et al.,* 2006), and also fire has significant effect inprevention of seed germination in some plant species in the soil (Endress *et al.,* 2012; Rawson *et al.,* 2013). However, to ensure this, it is necessary to study the soil seed bank condition after using such treatments. Significant presence of *Bromus tectorum* using tilling without fire may cause disturbance in the soil (Van Uytvanck and Hoffmann, 2009). In contrast, there was less density of *Bromus tectorum* in the tilling treatment coupled with fire, so it was concluded that the fire played an effective role in controlling this species as reported previously (Brooks *et al.,*2016). Our findings showed that the species richness was high in the fire treatment without any other treatments, which was in agreement with literature (Hill and French, 2004; Biaou, 2009; Royo *et al.,* 2010; Nuche *et al.,* 2018) and followed by control (unburned without any other treatments), which has been previously reported (Ejtehadi *et al.*, 2002; Mirdavoodi *et al.,* 2015). Despite the lack of significant difference between species richness in burned and unburned without any other treatments, their response on plant composition was not similar so that annual and opportunistic species had mainly increased in the fire treatment as stated by Knnap and Seastedt (1986).

Chemical controlling in the unburned plots caused the greatest reduction in species richness, which is in contrast with the results of Link *et al.* (2017). This treatment led to an increase in annual forbs such as *Euphorbia inderiensis*, *Callipeltis cucullaria*, *Conringia perfoliata*, *Androsace maxima*, *and Aethionema carneum*. However, changes in environmental factors and vegetation types as well as the soil seed bank may be effective in plant composition changes after applying different management treatments (Engel and Abella, 2011; Saito and Okubo, 2012).

The lowest evenness value was observed in the control (without applying any treatment) because *R. species* had occupied a large proportion of the resources available and due to its competitive potency, it may have been especially difficult for other species to reestablish in these habitats (He and Tang, 2008; Link *et al.*, 2017). After treatment implementation on *R. persica*, its diversity increased due to the creation of suitable conditions for the growth of other species. However, due to the expansion of opportunistic or invasive species in these open space area (DeKeyser *et al.*, 2015), some species still had a high abundance in all treatment, but it has led to an increase in evenness; they were in agreement with literature (Murphy and Grant, 2005; Kettenring and Reinhardt Adams, 2011; Rafiee *et al.,* 2014).

Means comparison between treatments showed that fire plays a more important role in changing the species diversity among the treatments used. Despite the difference in annual precipitation in the studied years, there was no significant difference between species diversity and evenness in these years. This was different from the findings of Pritekel *et al.* (2006). Species richness in the first year (2013) of implementation of the study was significantly lower than the two years later. These differences might be attributed to differences in the amount and distribution of precipitation over the years (Pritekel *et al.*, 2006), especially in the growing season of plants.

Applying management treatments to controlling the population of particular aggressive species may also affect desirable species as well as other invading species (Rejmánek, 1989; Hatase *et al.,* 2008). Thus, we need further research in this regard in order to improve management approaches.

Conclusion

Our results highlight that different methods of controlling *R. persica* had a significant effect on the species composition. Increasing germination and growth of other herbaceous species after the decrease of *R. persica* indicate that invasions by *R. persica* have a significant negative effect on plant species in these communities (Flory and Clay, 2009; Mirdavoudi, 2018; Mirdavoodi *et al.,* 2019). This inhibition could be due to competition for resources (nutrients, water and etc.) (Ehrenfeld *et al.*, 2001; Belote and Weltzin, 2006). Treatments used to control Rose may have been effective in providing suitable conditions (litter removal, rapid decomposition of organic matter and stimulate seed germination) to the growth of other species (Ehrenreich and Aikman, 1963; Gundale *et al.*, 2008; Endress *et al.,* 2012; Rawson *et al.,* 2013; Lohmann*et al.,* 2014). The results showed that fire has a greater role in changing plant species richness, evenness and diversity. Thus, we suggest that prescribed fire is one of the most effective components in the integrate controlling of *R. persica*. However, the new species may not be desirable species due to the lack of desirable species genetic pools and colonization of ruderal species in *R. persica* communities.

According to the results obtained in this study, we suggest more emphasis on the species composition in the management of invasive species as a management guideline to better inform ecosystem managers of risk and restoration options, before causing hard-to-reverse transitions. For example, annual species can substantially increase following prescribed fire in *R. persica* communities while the shrubs are lost from the community. Our results are consistent with the observations of Moghadam (2000) who observed that diversity was negatively correlated with *R. persica* vegetation cover. These results suggest that lack of desirable species gene pools and colonization of ruderal species in *R. persica* communities presumably prevented the recovery of desirable species and rehabilitation of rangelands in treated areas. Therefore, the restoration of these communities using desirable species is recommended after the removal of the Rose.

References

Ahmadi, A., Peiravi, M., 2010. Effects of animal age and different months of grazing season on grazing behaviour and diet selection of Zandi ewes grazing in steppe rangelands (case study: Yekkebagh, Qom), Iranian journal of Range and Desert Research, 16 (4), 536-550. (In Persian)

Ahmadi, J., Farzam, M., Lagzian, A., 2017. Investigating Effects of a Prescribed Spring Fire on Symbiosis between Mycorrhiza Fungi and Range Plant Species. Journal of Rangeland Science, 7(2), 138-147.

Akhani, H., Mahdavi, P., Noroozi, J., Zarrinpour, V., 2013. Vegetation patterns of the Irano-Turanian steppe along a 3,000 m altitudinal gradient in the Alborz Mountains of Northern Iran. Folia Geobotanica, 48 (2), 229- 255.

Amiri, M., Solaimani, K., Tamartash, R., Miryaghoubzadeh, M., 2012. Identification of Invasive Species Using Remote Sensing and Vegetation Indices, (Case Study: VazroudRangelands,Iran). Journal of Rangeland Science, 3(1), 59-70.

Anonymous, 2002. Research project of Natural Resources Research Station, Engineer Younesi. 131 p. (In Persian)

Belote, R.T., Weltzin, J.F., 2006. Interactions between two co-dominants, invasive plants in the understory of a temperate deciduous forest. Biological Invasions, 8, 1629-1641.

Biaou, S. H., Sterck, Ir. F. J., Holmgren, M., 2009. Tree recruitment in West African dry woodlands. The interactive effects of climate, soil, fire and grazing. PhD thesis, Wageningen University, The Netherlands. 182 p.

Blackshaw, R.E., Brandt, R.N., Janzen, H.H., Entz, T., Grant, C.A., Derksen, D.A., 2003. Differential response of weed species to added nitrogen. Weed Science, 51, 532-539.

Brooks, M.L., Brown, C.S., Chambers, J.C., D'Antonio, C.M., Keeley, J.E., Belnap, G., 2016. Exotic Annual BromusInvasions, Comparisons among species and ecoregions in the Western United States In: M.J. Germino *et al.* (eds.), Exotic Brome-Grasses in Arid and Semiarid Ecosystems of the Western US, Springer Series on Environmental Management. 11-60 pp.

Davis, M. A., 2013. Invasive Plants and Animal Species: Threats to Ecosystem Services. In, RA Pielke, ed. Climate Vulnerability: Understanding and Addressing Threats to Essential Resources. Elsevier Inc., Academic Press, 51-59.

DeKeyser, E.S., Dennhardt, L.A., Hendrickson, J., 2015. Kentucky bluegrass (*Poa pratensis*) invasion in the Northern Great Plains: a story of rapid dominance in an endangered ecosystem. Invasive Plant Science Management, 8, 255-261.

Dufrene, M., Legendre, P., 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. Ecological Monographs, 67, 345-366.

Ehrenfeld, J.G., Kourtev, P., Huang, W.Z., 2001. Changes in soil functions following invasions of exotic understory plants in deciduous forests. Ecological Applications, 11, 1287-1300.

Ehrenreich, J.H., Aikman, J.M., 1963. An ecological study on the effect of certain management practices, on native prairie in Iowa. Ecological Monographs, 33, 113-130.

Ejtehadi, A., Akkafi, H., GhorshiAlhoseini, J., 2002. Comparison of numerical indicators of diversity at two sites with different grazing management. Iranian Journal of Biology, 13(4), 49-58. (In Persian)

Endress, B.A., Parks, C.G., Naylor, B.J., Radosevich, S.R., Porter, M., 2012. Grassland response to herbicides and seeding of native grasses 6 years post-treatment. Invasive Plant Science Management, 5, 311-316.

Engel, E.C., Abella, S.R., 2011. Vegetation recovery in a desert landscape after wildfires: influences of community type, time since fire and contingency effects. Journal of Applied Ecology, 48, 1401-1410.

Fayaz, M., 2013. Identify of Iran ecological regions, Final report of research, number: 04-09-09-89036. Research Institute of Forests and Rangelands, Tehran, Iran, 170 p. (In Persian)

Flory, S. L., Clay, K., 2009. Invasive plant removal method determines native plant community responses. Journal of Applied Ecology, 46, 434-442.

Freemark, K., Boutin, C., 1995. Impacts of agriculture herbicide use on terrestrial wildlife in temperate landscapes: a review with special reference to North America. Agriculture, Ecosystems and Environment, 53, 67-91.

Gundale, M.J., Sutherland, S., DeLuca, T.H., 2008. Fire, native species, and soil resource interactions influence the spatio-temporal invasion pattern of *Bromus tectorum*. Ecography, 31, 201-210.

Hammer, T., Harper, D.A.T., Pyan, P.D., 2001. PAST: Paleontological statistics software package for education and datd analysis. Palaentologia Electronica, 4(1), 9 p.

Hamzeh'ee, B., Khanhasani, M., Khodakarami, Y., Nemati, P.M., 2008. Floristic and phytosociological study of Chaharzebar forests in Kermanshah. Iranian Journal of Forest and Poplar 16(2), 211-229. (In Persian)

Hatase, Y., Oguri, H., Matsue, M., 2008. Study on vegetation transition and the occurrence of

Coreopsis lanceolata at the middle reach of Kiso River. Journal of the Japanese Institute of Landscape Architecture, 71, 553-556. (In Japanese)

He, F., Tang, D., 2008. Estimating the niche preemption parameter of the geometric series. Acta Oecologica, 33, 105-7.

Hill, S.L., French, K., 2004. Potential impacts of fire and grazing in an endangered ecological community: plant composition and shrub and eucalypt regeneration in Cumberland Plain Woodland. Australian journal of Botany, 52, 23-29.

Johnson, M., Rew, L.J., Maxwell, B.D., Sutherland, S., 2006. The Role of Wildfire in the Establishment and Range Expansion of Nonnative Plant Species into Natural Areas. Bozeman (MT): Montana State University Center for Invasive Plant Management. 80 p. http://www.weedcenter.org/products_pub/Wildfire.pdf.

Keeley, J.E., Fotheringham, C.J., Keeley, M.B., 2005. Determinants of post fire recovery and succession in Mediterranean climate shrublands of California. Ecological application, 15(5), 1515-1534.

Keeley, J.E., Lubin D., Fortheringham C. J., 2003. Fire and grazing impacts on plant diversity and alien plant invasions in the Southern Sierra Nevada. Ecological Application, 13(5), 1355-1374.

Keeley, J.E., Brennan, T.J, Pfaff, A.H., 2008. Fire severity and ecosystem responses following crown fires in California shrublands. Ecological Applications, 8, 1530-1546.

Keeley, J.E., Brennan, T.J., 2012. Fire-driven alien invasion in a fire-adapted ecosystem. Oecologia, 169, 1043-1052.

Kennett, G.A., Lacey, J.R., Butt, C.A., Olsonrutz, K.M., Haferkamp, M.R., 1992. Effects of defoliation, shading and competition on spotted knapweed and bluebunch wheatgrass. Journal of Range Management, 45, 363-369.

Kettenring, K.M., Reinhardt Adams, C., 2011. Lessons learned from invasive plant control experiments: a systematic review and meta-analysis, Journal of Applied Ecology, 48, 970-979.

Knnap, A.K., Seastedt, T.R., 1986. Detritus accumulation limits productivity of tallgrass prairie. BioScience, 36, 662-668.

Link, A., Kobiela, B., DeKeyser, S., Huffington, H., 2017. Effectiveness of Burning, Herbicide, and Seeding Toward Restoring Rangelands in Southeastern North Dakota. Rangeland Ecology and Management, 70, 599-603.

Lohmann, D., Tietjen, B., Blaum, N.,Joubert, D. F., Jeltsch, F., 2014. Prescribed fire as a tool for managing shrub encroachment in semi-arid savanna rangelands. Journal of Arid Environments, 107, 49-56.

Magurran, A.E., 1988. Ecological diversity and its measurement. Princeton University Press, New Jersey, US, 192 p.

Magurran, A.E., 2004. Measuring biological diversity. Blackwell Publishing, Malden, US, 264 p.

Margules, C.R., Pressey, R.L., 2000. Systematic conservation planning. Nature, 45, 243-253.

McCune, B., Mefford, M. J., 1999. Multivariate Analysis of Ecological Data, version 4.17, MjM Software, Gleneden Beach, Oregon, U.S.A. 233 p.

Mirdavoodi, H., Marvie Mohadjer, M., Davis, M., ZahediAmiri, G., Etemad, V., Zandi Esfahan, E., 2015. Are disturbances altering the species composition of Iranian oak woodland? Journal of Biodiversity and Environmental Sciences, 6(1), 499-510.

Mirdavoodi, H.R., Goodarzi, Gh., Yousefi, Y., Famaheini, A., Siahmansour, R., 2019. Investigation on the short-term effect of fire on vegetation changes in a rangeland of Markazi province (Case study: Khosbijan). Journal of Rangeland, 13(1), 52-64. (In Persian)

Mirdavoudi, H.R., 2018. Effectiveness of prescribed fire, mechanical and chemical control in the management of *Rosa persica* in degraded rangelands. Iranian Journal of Applied Ecology, 7(3), 27- 37. (In Persian)

Mirzaei Mossivand, A., Keivan Behjou, F., Zandi Esfahan, E., Ghorbani, A., 2015. Assessment of Fire Effects on Surface Cover Changes and Forage Production (Case Study: Delfan County, Lorestan Province, Iran). Journal of Rangeland Science, 5(1), 60-71.

Moghadam, M.R., 2000. Range and Range Management.University of Tehran press, Tehran, 470 p. (In Persian).

Murphy, R.K., Grant, T.A., 2005. Land management history and floristics in mixed-grass prairie, North Dakota, USA. Natural Areas Journal, 25, 351-358.

Nuche, P., Komac, B., Gartzia, M., Villellas, J., Reiné, R., Alados, C.L., 2018. Assessment of prescribed fire and cutting as means of controlling the invasion of sub-alpine grasslands by *Echinosp artumhorridum*. Applied Vegetation Science, 1-10.

Pakeman, R.J., Thwaites, R.H., Le Duc, M.G., Marrs, R.H., 2002. The effects of cutting and herbicide treatment on *Pteridium aquilinum* encroachment. Applied Vegetation Science, 5, 203-212.

Papiernik, S.K., Grieve, C.M., Yates, S.R., Lesch, S.M., 2003. Phytotoxic effects of salinity, imazethapyr, and chlorimuron on selected weed species. Weed Science, 51, 610–617.

Perry, L.G., Galatowitsch, S.M., 2003. A test of two annual cover crops for controlling *Phalaris arundinacaea* invasion in restored sedge meadow wetlands. Restoration Ecology, 11, 297-307.

Phillips R., Rix, M., 1994. Roses, Pan Macmillan Publishers, London, UK, 19 p.

Phillips, R.; Rix, M., 1988. The Random House Book of Roses. Random House, New York, US, 224 p.

Pickett, S.T.A., White, P. S., 1985. The ecology of natural disturbance and patch dynamics. Academic Press, New York. 472 p.

Pritekel, C., Whittemore-Olson, A., Snow, N., Moore, J.C., 2006. Impacts from invasive plant species and their control on the plant community and belowground ecosystem at Rocky Mountain National Park, USA. Applied Soil Ecology, 32, 132-141.

Pyšek, P., Richardson, D.M., 2010. Invasive Species, Environmental Change and Management, and Health. Annual Review of Environment and Resources, 35, 25-55.

Rafiee, F., Ejtahadi, H., Jankju, M., 2014. Study of Plant diversity at different time intervals after burning in a semiarid rangeland. Journal of Plant Research (Iranian Journal of Biology), 27(5), 854-864. (In Persian)

Rawson, T., Davies, R., Whalen, M., Mackay, D., 2013. Fire-related cues and germination from the soil seed bank of senescent remnants of mallee vegetation on Eastern Kangaroo Island, Austral Ecology, 38(2), 139-151.

Rejmánek, M., 1989. Invasibility of plant communities. In: Drake, J.A. et al (eds) Biological invasions: a global perspective. Wiley, New York, 369-388 pp.

Royo, A.A., Collins, R., Adams, M.B., Kirschbaum, C., Carson, W.P., 2010. Pervasive interactions between ungulate browsers and disturbance regimes promote temperate forest herbaceous diversity. Ecology, 91(1), 93-105.

Saito, T.I., Okubo, K., 2012. Effects of vegetation cutting on the invasive plant *Coreopsis lanceolata* vary with vegetation type. Landscape and Ecological Engineering, 8, 207-214.

Shahriary, E., Palmer, M.W., Tongway, D.J., Azarnivand, H., Jafari, M., Mohseni Saravi, M., 2012. Plant species composition and soil characteristics around Iranian piospheres. Journal of Arid Environments, 82, 106-114.

Simberloff, D., Rejmanek, M., 2011. Encyclopoedia of biological invasions. University of California Press, Los Angeles. 792 p.

Tahmasebi, P., 2013. An investigation on detrimental effect and potential use of fire as a management tool for plant community composition in semi-steppe rangelands, Chaharmahal and Bakhtiari province. Journal of Range and Watershed Management, 66(2), 287-298. (In Persian)

terBraak C.J.F., 1987. The analysis of vegetation-environment relationship by canonical correspondence analysis.Vegatato, 69, 69-77.

Van Uytvanck, J., Hoffmann, M., 2009. Impact of grazing management with large herbivores on Forest ground flora and bramble understory. Acta Oecologica, 35, 523-532.

Vilá, M., Ibáñez, I., 2011. Plant invasions in the landscape. Landscape Ecology, 26, 461–472.

Wardle, D.A., 1995. Impacts of disturbance on detritus food webs in agro-ecosystems of contrasting tillage and weed management practices. Advances in Ecological Research, 26,105-185.

Zohary, M., 1973. Geobotanical Foundation of the Middle East.Vol. 1, Gustav FisherVerlag, Stuttgart, New York, US, 738 p.

تأثیر روش‌های کنترل ورک (*Rosa persica*) بر غناء و تنوع گونه‌ای پوشش گیاهی مناطق استپی اراک، ایران

حمیدرضا میرداودی[الف*]، ضیا آزدو[ب]

[الف] استاد یار، مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی استان مرکزی، سازمان تحقیقات، آموزش و ترویج کشاورزی، اراک، ایران، [*](نگارنده مسئول)، پست الکترونیک: h.mirdavoudi@areeo.ac.ir

[ب] کارشناس ارشد، مرکز تحقیقات و آموزش کشاورزی و منابع طبیعی استان مرکزی، سازمان تحقیقات، آموزش و ترویج کشاورزی، اراک، ایران، پست الکترونیک: Z_Azdoo@yahoo.com

چکیده

گیاه ورک (*Rosa persica* Michx. ex Juss.) به عنوان یکی از گونه‌های فرصت‌طلب و مهاجم در مراتع ایران شناخته شده و روش‌های مختلفی برای کنترل آن به کار برده شده است. در این مطالعه، تأثیر آتش‌سوزی کنترل شده، قطع اندام‌های هوایی، قطع ریشه و استفاده از سم گلای‌فسفات به عنوان ابزاری برای کنترل ورک بر تنوع گونه‌ای در یکی از ورک‌زارها استان مرکزی مورد بررسی قرار گرفت. آزمایش در قالب طرح کرت‌های خرد شده که آتش سوزی و شاهد در کرت اصلی و ۴ تیمار قطع اندام هوایی، قطع ریشه ، سم علف‌کش و شاهد در کرت‌های فرعی قرار گرفتند و بر پایه بلوک‌های کامل تصادفی با چهار تکرار برای مدت سه سال (۱۳۹۴-۱۳۹۲) در منطقه خسبیجان انجام شد. برای ارزیابی تنوع گونه‌ای از شاخص‌های مارگالف، شلدون و شانون-وینر استفاده شد. نتایج نشان داد که تکنیک‌های مختلف مدیریتی تأثیر متفاوتی در ترکیب جوامع داشته‌اند. تلفیق روش آتش‌سوزی با سایر روش‌های کنترلی نسبت به زمانی که این تیمارها به تنهایی استفاده شدند، تأثیرمعنی-داری بر تنوع گونه‌ای داشتند (P<0.01). میانگین تنوع گونه‌ای در تیمار آتش سوزی تنها بالاترین مقدار را داشت (۳/۱۸۱). بالاترین مقدار یکنواختی مربوط به تیمار کنترل شیمیایی بدون آتش سوزی بود (۰/۵۸۲). بالاترین مقدار غنای گونه‌ای در تیمار شاهد مشاهده گردید (۱۱/۱۱۴). همچنین کمترین مقدار تنوع گونه‌ای، یکنواختی و غنای گونه‌ای به‌ترتیب مربوط به تیمارهای قطع ریشه (۲/۵۸۲)، شاهد (۰/۲۵۸) و تیمار کنترل شیمیایی بدون کاربرد آتش‌سوزی (۷/۹۲۱) بود. بنابراین تنوع گونه‌ای در اکثر تیمارهای کنترلی مورد استفاده، افزایش یافت. دلیل این امر را می‌توان به کاهش جمعیت ورک و در نتیجه کاهش توان رقابتی آن نسبت داد. با وجود افزایش تنوع گونه‌ای پس از اعمال تیمارهای کنترلی، باید اذعان داشت که به دلیل عدم وجود گونه‌های مطلوب و تجمع گونه‌های فرصت‌طلب در جوامع ورک، ترکیب گونه‌ها لزوماً مطلوب نشد. بنابراین، احیای ورک-زارها با گونه‌های مطلوب باید پس از حذف این گیاه مد نظر قرار گیرد.

کلمات کلیدی: گونه‌های مهاجم، کنترل شیمیایی، تنوع گونه‌ای، کنترل مکانیکی، آتش‌سوزی کنترل شده