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Effect of Fire on Herbal Layer Biodiversity in a Temperate Forest of Northern Iran

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Abstract: Effects of fire on vegetation are usually the most obvious impacts of burning. Iran has a total of 1.2 million ha temperate forest in the north where fires occur in ca. 300-400 ha annually. These are mostly surface fire and affect mainly undergrowth and young trees. This study focuses on the impact of fire on herbal layer biodiversity in Chelir forest in north of Iran. Biodiversity indices and coverage percent were used for comparing herb's species between burned and unburned area. Biodiversity indices and coverage percent of shade tolerant species in unburned area were higher than burned area. It is necessary to consider recruitment practices such sowing and planting to prevent biodiversity decreasing and promote ecosystem stability.

Key words: Forest fire, biodiversity, temperate forest, herbal layer, Iran

INTRODUCTION

Natural forested landscapes are characterized by a variety of disturbance processes primarily wildfire, windthrow, insects and diseases as well as geomorphic activity such as landslides and debris or snow avalanches (John, 1992). Effects of fire on vegetation are usually the most obvious impacts of burning. Fire affects natural ecosystems by consuming plants, altering successional patterns, and changing vegetative resources such as timber, forage, and wildlife habitats (DeBano *et al*., 1998). Burning alone can result in increased forb abundance (Wienk *et al*., 2004) graminoid abundance, and under story species richness (Busse *et al*., 2000; Laughlin *et al*., 2004). Biodiversity is short for biological diversity and refers to the diversity of life. It is defined as the totality of genes, species and ecosystems in a region (John, 1992). Biodiversity is a concept, which refers to the range of variation or differences among some set of entities within the living world (CBD, 1992).

Iran has a total of 1.2 million ha temperate forest in the north where fire occurs in ca. 300-400 ha annually (Anonymous, 2002). These are mostly surface fire and affect mainly undergrowth and young trees. Despite such fires, there are unfortunately limited scientific studies or published papers about investigation of fire effects on temperate forests in Iran. Undergrowth biodiversity could help scientists determine if forest fire influence the presence or absence of certain plant species. Biodiversity is useful to understand the distribution of new and native species in the study area. The present study was conducted to assess the status of undergrowth in both burned and unburned area by using biodiversity indices.

MATERIALS AND METHODS

Study site: The study area is located Chelir, Iran (36°30' 30" to 36°32' 30" N latitude and 51°40' 00"to 51°41' 30" E). It is located at an altitude of about 1100-1350 m in the top hills of Chelier's Forest, with slope between 10-30%, 30 km southeast of the Nowshahr city in Mazandaran, Iran (North of Iran). The forest type is an uneven aged mixed broad leaves trees consisting of beech (*Fagus orientalis* L.) and hornbeam (*Carpinus betulus* L.) as the dominant species, forest harvesting operation has yet to be conducted in the area. The climate is humid temperate where mean annual precipitation is 1380 mm without any dry season, and mean temperature of hottest month is 24.6°C and the mean temperature of coldest month is 7.5°C. For this study, the fire event occurred in 1999 where 270 ha of forest were burned in 4 days; field data and sample collection was done 6 years later in 2005.

Sampling: Our study areas included both burned and unburned area (each study area has 100 ha) where a

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systematic 100×200 m grid sampling plan placed in E-W direction was carried out using circular plots. A Geographical Positioning System (GPS) was used to locate the center of each plot. Each plot was determined from a 100 m^2 area using species area curve (Gareth, 1991). Therefore, in each study area 50 plots were designated for a total of 100 plots for the study.

Abundance (percent cover) of every undergrowth species in each plot was visually estimated. The extent of plant cover was classified and coded into the following: 0 = 0%, 1 ≤1%, 2 = 1-10%, 3 = 11-25%, 4 = 26-50%, 5 = 51-75%, 6 = 76-100%. These codes were then converted to estimated actual covers by assigning the mid-point of the cover class (Metlen and Fiedler, 2005). The plant species recognition and estimation were collected from June to September 2005.

Measuring biodiversity: We apply the Shannon index (H') as a measure of species abundance and richness to quantify diversity of the woody species. This index takes both species abundance and species richness into account, is sensitive to changes in the importance of the rarest classes (Heuserr, 1998) and is the most commonly used index in plant biodiversity studies (Kent and Coker, 1992). For any quadrat, Shannon index is calculated as:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i \quad (1)$$

where s equals the number of species and p_i equals the ratio of individuals of species i divided by all individuals N of all species.

In addition, we consider the Simpson index (D), a measure of species dominance, and the Shanon-Winer index (E), a measure for evenness of spread. The Simpson index is defined as

$$D = \sum_{i=1}^{s}\left(\frac{n_i\left(n_i - 1\right)}{N\left(N-1\right)}\right) \quad (2)$$

Where n_i is the number of individuals in the *i*th species and N equals the total number of individuals. As biodiversity increases, the Simpson index decreases. Therefore, to get a clear picture of species dominance, we used D' = 1-D. The Shannon-Wiener index is defined as

$$E = \frac{H'}{H_{max}} = \frac{-\sum_{i=1}^{s} p_i \ln p_i}{\ln s} \quad (3)$$

Where H_{max} is the natural logarithm of the total number of species.

All statistical analysis were conducted using SPSS 12.0 (LEAD Technologies Inc. 2003)

RESULTS

Herb's species composition: In both burned and unburned areas, a total of 29 families and 40 species were collected. Within families, Labiatae contains 4 species, Geramineae and Rosaseae each containing 3 species, Asteraseae, Euphorbiaceae, Geraniaceae and Primulaceae

Table 1: Herbs species in both burned and unburned area with family and common name

Family	Species	Common name	Burned	Unburned
Asclepiadaceae	*Vincetoxicum scandens* Sommier and Levier	Swallow-wort	*	*
Aspidiaceae	*Dryopteris filix-mas* (L.) Schott	Male fern	*	*
Aspleniaceae	*Phyllitis scolopendrium* (L.) Neum.	Harts-tongue	*	*
Asteraseae	*Lapsana communis* L.	Nipple wort	*	-
Asteraseae	*Serratula quinquefolia* M. B. ex wild.	Sow-wort	-	*
Berberidaceae	*Epimedium pinnatum* Fisch.	Pannate barrenwort	*	*
Caprifoliaceae	*Sambucus ebulus* L.	Danewort	*	-
Convolvulaceae	*Calystegia silvestris* (Willd.) Roem.	Bearbind	*	*
Crassulaceae	*Sedum stoloniferum* S.G. Gmel.	Stonecrop	*	*
Cruciferae	*Cardamine impatiens* L.	Coralwort	*	*
Cyperaceae	*Carex* sp.	Sedge	*	*
Dioscoreaceae	*Tamus communis* L.	Adder's meat	-	*
Euphorbiaceae	*Euphorbia amygdaloides* L.	Deer's milk	*	*
Euphorbiaceae	*Mercurialis annua* L.	Herb mercury	*	*
Geramineae	*Brachypodium pinnatum* (L.) P.	Beauv	*	*
Geramineae	*Festuca drymeia* Mert. and Koch.	Fescue	*	*
Geramineae	*Oplismenus undulatifolius* (Ard.) Roem and Shult.	Basket grass	*	*
Geraniaceae	*Geranium robertianum* L.	Herb Robert	*	*
Geraniaceae	*Geranium sylvaticum* L.	Wood cud weed	*	*
Guttiferae	*Hypericum androsaemum* L.	Sweet amber	*	*
Labiatae	*Lamium album* L.	White dead nettle	*	*
Labiatae	*Mentha longifolia* (L.) Hudson	Balm	*	*
Labiatae	*Prunella vulgaris* L.	Herb carpenter	*	*
Labiatae	*Calamintha officinalis* Moench.	Calamint savory	*	*
Lamiaceae	*Salvia glutinosa* L.	Sticky sage	*	*
Liliaceae	*Ruscus hyrcanus* Woron.	Butcher's broom	*	*

Table 1: Continued

Family	Species	Common name	Burned	Unburned
Onagraceae	*Circaea lutetiana* L.	Enchanter's nightshade	*	*
Orchidaceae	*Epipactis veratrifolia* Boiss. and Hohen	Helleborine	*	*
Papilionaceae	*Lathyrus vernus* (L.) Bernh.	Spring-vetch	-	*
Primulaceae	*Cyclamen coum* Miller	Apple of the earth	*	*
Primulaceae	*Primula* sp.	Primrose	*	*
Pteridaceae	*Pteris cretica* L.	Cretan brake	*	*
Rosaceae	*Rubus hyrcanus* Juz.	Dewberry	*	*
Rosaceae	*Fragaria vesca* L.	Wild strawberry	*	*
Rosaceae	*Geum urbanum* L.	Common avens	*	*
Rubiaceae	*Asperula odorata* L.	Sweet woodruff	*	*
Scrophulariaceae	*Veronica persica* Poir.	Speed weel	*	-
Solanaceae	*Solanum kieseritzkii* C.A. Mey.	Hight shade	*	*
Violaceae	*Viola odorata* L.	Sweet violet	*	*
Urticaceae	*Urtica dioica* L.	Nettle	*	-

*: Shows presence of species. - : Shows absence of species

Table 2: Herbs species mean cover percentage in plot scale (100 m^2) in both burned and unburned area numbers in parentheses are SE

	Cover percentage (plot scale)		
Species	Burned	Unburned	p
Asperula odorata	7.9 (1.3)a	3.7 (0.8)b	0.005**
Brachypodium pinnatum	8.4 (1.2)	9.6 (1.4)	0.515
Calamintha officinalis	0.05 (0.05)	0.05 (.05)	1.000
Calystegia silvestris	1.6 (0.4)	1.7 (0.5)	0.940
Cardamine impatiens	0.1 (0.07)	0.3 (0.1)	0.142
Carex sp.	5.8 (1.0)	4.2 (0.8)	0.218
Circaea lutetiana	1.6 (0.4)	1.7 (0.3)	0.926
Cyclamen coum	2.0 (0.6)b	4.2 (0.7)a	0.000***
Dryopteris filix-mas	7.2 (1.9)a	2.9 (1.3)b	0.000***
Epimedium pinnatum	1.2 (0.8)	2.7 (0.7)	0.168
Epipactis veratrifolia	0.9 (0.2)a	0.4 (0.1)b	0.027*
Euphorbia amygdaloides	13.6 (1.8)	9.8 (1.4)	0.102
Festuca drymeia	2.8 (0.7)	3.4 (0.7)	0.497
Fragaria vesca	2.5 (0.5)	3.2 (0.6)	0.382
Geranium robertianum	5.4 (1.1)a	1.9 (0.6)b	0.009**
Geranium sylvaticum	0.1 (0.1)	0.1 (0.1)	1.000
Geum urbanum	4.7 (1.2)a	1.1 (0.4)b	0.024*
Hypericum androsaemum	2.6 (0.5)	2.0 (0.1)	0.309
Lamium album	11.2 (1.8)a	5.7 (1.5)b	0.022*
Lapsana communis	0.05 (0.05)	0.00	-
Lathyrus vernus	0.00	0.7 (0.2)	-
Mentha longifolia	2.7 (1.2)	0.1 (0.1)	0.120
Mercurialis annua	3.7 (1.9)a	0.1 (0.1)b	0.001**
Oplismenus undulatifolius	0.9 (0.4)b	6.5 (1.4)a	0.000***
Phyllitis scolopendrium	0.1 (0.1)	0.35 (0.1)	0.082
Primula sp.	0.05 (0.05)b	0.35 (0.1)a	0.028*
Prunella vulgaris	0.1 (0.07)	0.1 (0.07)	1.000
Pteris cretica	0.5 (0.3)	0.7 (0.3)	0.578
Rubus hyrcanus	23.0 (2.9)a	9.7 (1.7)b	0.001**
Ruscus hyrcanus	0.1 (0.07)	0.05 (0.05)	0.562
Salvia glutinosa	0.2 (0.1)	0.1 (0.07)	0.405
Sambucus ebulus	1.0 (0.5)	0.0	-
Sedum stoloniferum	0.9 (0.4)a	0.1 (0.07)b	0.044*
Serratula quinquefolia	0.00	0.1 (0.08)	0.080
Solanum kieseritzkii	4.5 (0.8)	3.4 (0.7)	0.411
Tamus communis	0.00	0.1 (0.07)	0.155
Urtica dioica	0.3 (0.3)	0.00	-
Veronica persica	0.05 (0.05)	0.00	-
Vincetoxicum scandens	0.05 (0.05)	0.15 (0.08)	0.310
Viola odorata	22.9 (2.2)a	9.2 (0.9)b	0.000***

* indicates significant difference between means in 95% level, *** p significant at 1% probability

Table 3: Herb's mean of biodiversity indices in plot scale (100 m^2) in burned and unburned study area

Biodiversity indecies		Mean	Std. deviation	Std. error	Min.	Max.	p
Richness (H')	Burned	2.15	0.33	0.05	0.76	2.73	0.477
	Unburned	2.20	0.39	0.06	0.22	2.71	
Dominance (D')	Burned	0.85	0.09	0.01	0.38	0.96	0.108
	Unburned	0.87	0.04	0.01	0.72	0.95	
Evenness (E)	Burned	0.81b	0.09	0.01	0.42	1.00	0.018*
	Unburned	0.85a	0.06	0.01	0.71	1.04	

* - Indicates significant difference between burned and unburned means at 95% level

have 2 species. Four species (*Lapsana communis*, *Sambucus ebulus*, *Veronica persica*, *Urtica dioica*) were identified solely in burned area and 3 species (*Lathyrus vernus*, *Serratula quinquefolia*, *Tamus communis*) were in unburned area exclusively and the rest were in both area. On the other hand, 27 families with 37 species and 26 families with 36 species were known in burned and unburned area respectively (Table 1).

Herbal cover percentage: Herbal coverage in burned area showed that the dominant species were *Rubus hyrcanus* (23%), *Viola odorata* (22.9%), *Euphorbia amygdaloides* (13.6%), *Lamium album* (11.2%) and in unburned area, *Euphorbia amygdaloides* (9.8%), *Rubus hyrcanus* (9.7%), *Brachypodium pinatum* (9.6%), *Viola odorata* (9.2%) were the most common species. Sixteen species in burned area and 17 species in unburned area had less <1% individual areal coverage. Statistical analysis showed that mean of cover percentage (density) of 13 species were significantly different between burned and unburned area; 10 species in burned area and 3 species in unburned area had higher herbal coverage compared to other contrasting plot (i.e., burned vs unburned) (Table 2).

Biodiversity indices in unburned area were higher than burned area but there were no significant differences in richness (H'), dominance (D') but was in evenness (E) (Table 3).

DISCUSSION

The burned plots in Ponderosa pine/Douglas-fir forest had reduced species richness and cover of the under story in early years after the fire, however after three years, richness increased to the level of the unburned plots. Simpson's evenness increased the first growing season after burning, but was not influenced in subsequent years (Metlen and Fiedler, 2005). In another research that was conducted by Sanghoon *et al.* (1997), cited that richness and evenness indices were higher in burned area than unburned area one year after burning in mixed broad leaves oak forest. Also richness index in burned pine/oak forest was higher in compare with control (Mehta *et al*., 1997). In this study area, after 6 years from burning, it seems that the richness and dominance are the same but evenness is different between both study area (Table 3). However the fire didn't affect on biodiversity but increased herbal species cover especially those which need more light for more growing like *Rubus hyrcanus* and *Euphorbia amygdaloides* but In the unburned study area, shade-tolerant and hydrophile species cover such *Oplismenus undulatifolius*, *Cyclamen coum* and *Primula* sp. were greater than burned area (Table 2). Fire caused happening some gaps in the forest by combusting and felling trees therefore the forest floor was exposed with much extra sunlight (unpublished data). Atrakchaiee (2000) proclaimed that fire increased herbal species cover in burned area but didn't affect on biodiversity indices in temperate forest of northeast of Iran. In pine/oak forest in USA, most post fire under story dominants were previously inconspicuous or absent from the wetter communities and these species increased significantly more than others (Plocher, 1999). The increasing density of *Rubus hyrcanus* and *Sumbucus ebulus* which are known as invasive and fast growth species in northern forests of Iran, shows that it maybe will be increased more in the future and cover forest floor thoroughly, therefore, will inhibit growing of other species and biodiversity will be decreased. For prevention of such undesirable increasing cover of invasive species, we suggest plantation with fast growth tree species like maple and alder that can growth more faster than invasive species and prevail them. This task will be caused either increasing trees crown cover or growing shade-tolerant species and finally biodiversity and ecosystem stability will be increased.

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