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Forest fire effects in beech dominated mountain forest of Iran

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ABSTRACT

Most of world's forests of different climates have a history of fire, but with different severities. Fire regimes for broadleaf deciduous forests have return intervals that vary from many decades (or less) to centuries (or more). Iran has a total of 1.2 million ha of temperate forest in the north, where fires burn about 300–400 ha annually. This study focused on the impact of fire on forest structure, tree species quality, and regeneration composition (specially beech) in the Chelir forest of northern Iran. The results showed that forest fires changed the structure and had different effects on tree species composition between burned and control areas. Thin barked species such as oriental beech (*Fagus orientalis* Lipsky) and coliseum maple (*Acer cappadocicum* Gled.) have been affected more than those with thick bark, like hornbeam (*Carpinus betulus* L.) and chestnut-leaved oak (*Quercus castaneifolia* C.A. Mey). The density of oriental beech regeneration in the unburned area was greater than in the burned area, while the quantity of regeneration of hornbeam, coliseum maple and velvet maple (*Acer velutinum* Boiss) was higher in burned area. Forest fire had a greater effect on oriental beech quality, and changed regeneration composition in the burned area. Fire prevention activities should be considered as a silvicultural treatment for preserving these valuable forests.

1. Introduction

Natural forested landscapes are characterized by a variety of disturbance processes that include wildfire, windthrow, insects and diseases, as well as geomorphic activity such as landslides and debris or snow avalanches (John, 1992). Fire is an important disturbance agent in many forests worldwide, shaping ecosystem patterns and processes (Naveh, 1974; Philips, 1974; Wein and MacLean, 1983; Gill et al., 1990; Coutinho, 1990; Agee, 1993). Fire effects natural ecosystems by consuming plants, altering successional patterns, and changing vegetative resources such as timber, forage, and wildlife habitats (DeBano et al., 1998). Most of world's forests with different climates have experienced fire of different severities. Return intervals for broadleaf deciduous forests vary from several decades (or less) to centuries (or more) (Sanford et al., 1985).

The total forest cover in Iran is 12 million hectares, or 8% of the total land area. About 1.8 million hectares of these forests are located in northern Iran (i.e. the Hyrcanian Forests) on the northern slopes of the Alborz Mountains overlooking the Caspian Sea (Sagheb-Talebi et al., 2004). The Hyrcanian Forests consist of mixed broadleaf deciduous species, and have an uneven topography and very steep slopes like found in European forests (especially Balkan's European beech forests). Fires burn 300–400 ha annually in these forests, while 6000 ha/yr are burned throughout all of Iran's forests (FAO, 2005). The Hyrcanian Forests are normally thought to be fire resistant because of high atmospheric and soil moisture, and major wildfires have been historically rare. However, as a result of recent climatic oscillations and global climate warming, fire occurrence has increased during recent years (Goldhammer, 1999).

Fires in the north of Iran normally occur in autumn when forest floor litter dries as hot-dry winds cause a short period of drought. These are mostly surface fires that rarely exceed 10–30 cm in flame height under normal fuel and humidity conditions. They consume the fine and course litter on the forest floor (Holdsworth and Uhl, 1997; Cochrane and Schulze, 1999; Nepstad et al., 1999). However, these apparently innocuous fires may have serious detrimental effects on both the forest structure (Peres, 1999; Barbosa and Fearnside, 1999) and the vertebrate fauna (Kinnaird and O'Brien, 1998; Haugaasen, 2000; Barlow et al., 2002; Peres et al., 2003) because of their extremely rare occurrence in evolutionary time (Uhl and Kauffman, 1990).

Despite repeated fire occurrences in the Chelir forests in northern Iran, no study has previously investigated the fire effects. This study seeks to answer the following questions: (1) How does fire change the forest structure in the Hyrcanian forest? (2) How does

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the fire affect the most common tree species? (3) How does fire change the forest regeneration?

2. Materials and methods

2.1. Study area

The study area is located in the Chelir area, at the Kheyroud Educational and Research Forest which belonged to University of Tehran (ca. 8000 ha) 30 km southeast of the Nowshahr City in Mazandaran, in northern Iran (36°30′30″ to 36°32′30″N latitude and 51°40′00″ to 51°41′30″E longitude). Elevation within the study area ranges from 1100 to 1350 m, with slopes between 10% and 30%. Common forest soils are deep brown, with clay to clay loam textures derived from calcareous and dolomite rock and the climate is humid with cold winter (Habibi, 1984). Mean annual precipitation at the nearest meteorological station (Nowshahr) is 1380 mm without any dry season. The mean temperature is 24.6 °C during the hottest month, and 7.5 °C during coldest month. Relative humidity varies between 75% and 85% (Salehi et al., 2005). In Hyrcanian forests, Trees (live or dead) are harvested using single-selection or group-selection system based on forest management planning. The management objectives are conservation, rehabilitation, development and exploitation according to sustainable forest management (SFM). In the study area, a forest management planning has not been prepared yet, therefore, harvesting is restricted to slight cutting by villagers. The forest is uneven-aged (generally middle-aged to mature forest) with mixed broadleaf trees. Oriental beech (*Fagus orientalis* Lipsky) and hornbeam (*Carpinus betulus* L.) are the dominant species. No harvesting has been done after the fire in the area. A fire occurred on 9 December 1999, covering 270 ha in 4 days. Data collection was done 6 years later in 2005.

2.2. Data collection

Our study included both burned (called B) and unburned (called UB) areas of 100 ha each. To avoid the fire effect, we selected the UB area well distant (ca. 300 m) from the burned area. We used a random-systematic 100 m × 200 m grid sampling plan placed in E-W direction, with 50 circular plots (each plot is 1000 m^2) within the burned and unburned areas, respectively. In total the study included 100 circular plots. In each plot, habitat factors such as geographical directions, slope percentage, altitude, crown canopy percentage, forest stratum, herbal layer cover percentage, and species were recorded. Diameter at breast height (DBH) of those trees more than 7.5 cm in diameter, and effects of fire on their quality were documented, based on conditions described at Table 1. We documented mortality (defined as the death of all aboveground tissue) based on an examination of cambial damage at the basal of the tree trunk, as well as the drying and abscission of leaves. For the regeneration assessment, we used four subplots within each larger plot. Each subplot was 25 m^2 and was located along one of the four geographical directions within the larger plot. Therefore, we conducted 50 plots and 200 subplots in each area. All seedlings and saplings were tallied as follows: height < 1.3 m, DBH < 2.5 cm, and 2.5 cm < DBH < 7.5 cm. In order to compare B and UB, tree regeneration and basal area densities were expressed on a per hectare basis.

Table 1
Tree's quality classes in burned (B) and Unburned (UB) areas (Lotfi, 1999).

Area	Tree's quality index	Description
B	Undamaged	A tree without any burned or blacked signs
B	Low burned	A tree with burned or blacked signs up to 10 cm aboveground
B	Medium burned	A tree with burned or blacked signs up to 50 cm aboveground
B	High burned	A tree with burned or blacked signs more than 50 cm aboveground and the bark goes dry
UB	Healthy	A tree without any decayed part or bulge
UB	Unhealthy	A tree with decayed part and/or bulge

Table 2
Characteristics of the study areas 6 years after the fire.

	B	UB	P
Slope, %	24.8	29.9	–
Elevation, m	1265	1209	–
Canopy cover, %	66.9	77.9	0.000[a]
Herbal layer, %	56.3	51.5	0.249
Stand density, trees/ha	249	477	0.000[a]
Mean DBH, cm	36.8	23.9	0.000[a]
Mean basal area, m^2	41.7	35.8	0.000[a]

B, burned; UB, unburned.
[a] An asterisk indicates a significant difference between means at the 95% level.

2.3. Data analysis

Kolmogorov–Smirnov tests were used to test normality of all parameters which all of them, excluding mortality, were following normal distribution. Comparisons of canopy cover percentage, herbal layer percentage, mean DBH, basal area between B and UB were conducted by means of independent-samples t-tests while comparison of species density was performed using chi-square test.

Simple linear regression was used to analyze the relationship between mortality and DBH of oriental beech and hornbeam. In order to obtain the normal distributions required by the test, mortality was log transformed. The statistical package used was SPSS 12.0.

3. Results

3.1. Forest structure

Canopy cover and number of trees per ha were higher in UB than B. In B, mean DBH (trees), and mean basal area (trees) were higher (Table 2). Number of trees per hectare in B was approximately one-half that in UB (Table 2).

In case of density, oriental beech and hornbeam were dominants in both study areas. In combination, they occupied 88% in B and 79% in UB (Table 3). Mean DBH of oriental beech, hornbeam, Caucasion alder (*Alnus subcordata* C.A. Mey), and chestnut-leaved oak (*Quercus*

Table 3
Mean DBH (diameter at breast height, cm) and tree density (trees/ha) of living trees in burned (B) and unburned (UB) areas 6 years after the fire. Different letters show significant difference between U and UB in each species.

	DBH mean (cm)		Density (trees/ha)	
	B	UB	B	UB
Fagus orientalis Lipsky	44.7 a	34.2 b	110.8	106.6
Carpinus betulus L.	22.1 a	17.9 b	108.6 b	270.6 a
Quercus castaneifolia C.A. Mey	47.2 a	19.2 b	3.2 b	46.4 a
Alnus subcordata C.A. Mey	58.5 a	39.5 b	12.8 b	43 a
Acer velutinum Boiss	69.3 a	42.6 b	4.4	4.6
Acer cappadocicum Gled.	32.7	24.1	2.6	3.2
Tilia platyphyllos Scop.	10	–	0.4	–
Ulmus glabra Huds.	15.5	15	2	0.8
Mespilus germanica L.	10.3	10	3.4	0.2
Crataegus microphylla C. Koch	10	10	0.4	0.6
Prunus divaricata Ledeb.	–	13	–	1
Total	36.8 a	23.9 b	249 b	477 a